FAMU-FSU College of Engineering
Department of Electrical and Computer Engineering

PROJECT PROPOSAL AND STATEMENT OF WORK

EEL4911C – ECE Senior Design Project I

Project Title: **Synthetic Active Array Radar Aperture (SAR)**

Team #: E11

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Project Executive Summary

The purpose of the electronic Synthetic Active Aperture Radar (SAR) Imager project, sponsored by Northrop Grumman, is to design and develop a low-cost detection system capable of providing a low, but useful, imagery resolution as a learning experience. In theory, the application of the electronic SAR Imager focuses on security applications and its ability to detect potentially threatening objects such as handguns. This project is sponsored through the FAMU-Foundation with a $50,000.00 budget with an expected time line of eight months to completion.
A radar is an object detection system that uses radio waves to measure characteristics of certain objects and is typically composed of antennas in which transmit pulses of radio waves bounce off the target in the designated range. The wave is reflected off the target and returns a wave to the receiving end of the system which is usually a dish, horn, or some form of waveguide usually located at the same site as the transmission of the wave. In a typical radar, the antenna which usually acts as a transmitter and/or receiver is in a static position. The electronic SAR Imager is a more complicated scenario of radar imaging which allows for the detection of a much greater range by movement of the transmission antenna. This can be seen such applications as aircraft topography; the antenna on the plane would transmit signal to a landscape while the antenna is moving. To create a fixed electronic SAR imager, the design will be constructed with multiple stationary antennas that emit or receive pulses to emulate the theory of an SAR.

This project will consist of twenty horn antennas: sixteen receive and four transmit. The antenna structure will consist of two linear antenna apertures. Each aperture will contain eight receive antennas placed between two transmit antennas. Two antenna apertures will be utilized and laid across each other creating a T-shaped design with each horn directed towards the target. Besides the center horn antennas, each horn will be angled directionally towards the target. Overall, the design will create four rows of five antennas being placed orthogonal to each other, creating sixteen phase centers per linear antenna aperture and thirty-two phase centers for the whole design. A phase center is the half-way distance between one transmit and one receive antenna in an aperture and represents a receive antenna's center absorbance point or maximum absorbance point. One transmit is responsible for eight phase centers. When placing receive antennas next to each other, additional maximum absorbance points are created. One aperture may only have eight receive antennas but eight additional phase or maximum absorbance points are created. More phase centers results in a better chance to receiving a return signal. For this project, radar system is required to reach a target twenty feet away and cover a human's body.

The system will be controlled via an FPGA which will sequentially transmit pulse from an antenna and then turn on the receiving antennas/turn off the transmitting antenna pulse to receiving a signal bouncing off the target. This will be done from every orthogonal direction one after the other to give the most data possible. The data would get sampled on a scope and get recorded. If time permits, the FPGA can do more complicated tasks such as storing some of the data that can be output and operated on. This sampled data could then be captured and sent to a PC for image processing. This would most likely be done using software such as Simulink. Overall the goal of this project is to apply engineering design practices and technical knowledge to create a physical schematic of an SAR Imager which would transmit and receive pulse from at least one row of antennas out of the four orthogonal rows.

Contents

1 Introduction

1.1 Acknowledgements

The electronic Synthetic Active Aperture Radar (SAR) Imager team would like to extend thanks to the stakeholders of this project from Northrop Grumman and the FAMU-FSU College of Engineering sponsors. First and foremost to the corporate sponsors at Northrop Grumman, we are most grateful for the generous $50,000 financial contribution to the FAMU Foundation to support research, equipment procurement, and work efforts on the project. In addition to financial contributions, the team also thanks Northrop Grumman for resource support from Peter Stenger, who continually provided technical support, guidance, and direction throughout the duration of the project. We would like to thank Dr. Michael Frank, Dr. Simon Foo, Dr. Shonda Bernadin, Dr. Bruce Harvey, and Dr. Rajendra Arora from the Electrical & Computer Engineering Department for their continued efforts to advise the team in making practical engineering design decisions. Also, we would like to thank Dr. Nikhil Gupta, Dr. Scott Helzer, Dr. Emmanuel Collins, Ricardo Aleman, and Samuel Botero from the Mechanical Engineering department for their contributions in developing professionalism, providing continuous feedback for improvement, and supporting the mechanical design of the SAR Imager system. Finally, we thank Dr. Okenwa Okoli, Dr. James Dobbs, Emily Hammel, and Margaret Scheiner from the Industrial Engineering department for their help in project management, scheduling, and quality engineering.

1.2 Problem Statement

1.2.1 General Problem Statement

The number one priority of this project is to create a physical schematic of a radar system with synthetic-aperture radar theory using COTS (commercial off the shelf) components. The theory behind an SAR Imager requires a mobile transmission and receiving antenna to capture a greater range and/or clearer image of what is being targeted. Since a mobile antenna would require a device which moves the antenna and the team does not have the capability or timeframe to make such a device, we will supplement the framework of a single moveable antenna with a system having multiple antennas to emit and receive signal from different locations. The theory behind emitting and receiving signals on a single target from multiple locations will still be implanted, but instead of using one moving antenna the team will use multiple stationary antennas that emit and receive signals from different locations.

1.2.2 General Problem Solution

The solution will be tackled in several steps. There are three disciplines to this project: Electrical/Computer Engineering, Mechanical Engineering, and Industrial Engineering.

The Electrical/Computer Engineers will design a stationary schematic of a radar system which has twenty antennas overall with sixteen being receive antennas and four being transmit antennas. These antennas will be separated into four rows of five antennas each. Each of these four rows will be placed orthogonal to each other, and there will be an epicenter between these four rows which is where the target will be. The rows of five will be separated by twenty feet in each direction from the target, and the system that controls the emitting and receiving of signal from the antennas will be controlled via an FPGA. It is the job of the Electrical/Computer engineers to design a workable schematic of the system that receive and emit signals from at least one row of antennas. This also includes the programming of the FPGA board, signal processing, and possibly even image processing of data if the project goes further than expected. The Electrical/Computer Engineers will be the ones to determine almost all of the theory and components of the system, thus making them the base of the project.

The Mechanical Engineers will design the physical structure of the antennas and the associated horns that go with them. The Mechanical engineers will work very closely with the Electrical engineer who specializes in antennas to design the proper horn shape and the spacing between each of the antennas. The Mechanical Engineers also have a role in helping the Electrical Engineers set up all of the components and equipment of the system and making sure that they are working properly as well. It is vitally important for the Mechanical and Electrical Engineers to work in close contact since the Mechanical portion of this project deals with the physical design of the antennas which transmit and emit signal.

The Industrial Engineers have a primary role in managing the human factors, risk analysis, the project schedule, and the overall budget of the system. The Industrial Engineers will also be in charge of helping the Electrical Engineers acquire and order the specific components needed for the system. Industrial Engineers will also be in close contact with the school and the sponsor since they will be the ones who actually go and submit the orders for purchase. Industrial Engineers will also be of utmost importance when making administrative decisions within the team due to their knowledge of cost engineering and optimization.

1.3 Operating Environment

The operating environment will be those locations of primary concern for homeland security applications such as airports, public schools, museums, etc. These locations will demand that the SAR Imager properly functions at average room temperature (293.15 – 298.15 K) and within average humidity (30 – 50%) [1]. The SAR Imager should be able to operate in the presence of other electronics and RADARs and not be influenced by them in their main operation: determining the hidden threat of hidden weaponry. This system should be able to operate at a nonstop pace when needed and also be equipped with adjustments to be set-up in the specified location on interest.

1.4 Intended Use(s) and Intended User(s)

1.4.1 Intended Use

The intended use for the SAR Imager will be for theoretical implementation and testing. Tests to check for the transmission and receiving of pulse by the antennas of this project will be the primary use for the system. A mannequin will act as the target to abide by FSU campus medical standards. If time allows, more complicated aspects such as image processing can be used to generate an image.

1.4.2 Intended Users

The intended users for the SAR Imager will primarily be the student members of the team. Any advisors or the sponsor may want to test out the system for themselves to check progress and that is a viable option as well. As a research project, this project only intends for an operating physical schematic of the project, not a fully functional prototype. The end result should have a physical system that transmits and receives signal that is controlled/timed via an FPGA.

1.5 Assumptions and Limitations

1.5.1 Assumptions

This project is based upon the following assumptions:

- The radar should operate at frequencies safe for human interaction.
- The radar must be capable of detecting metal and/or threatening objects on a person's body from a distance.
- The radar must be operating at near real-time.
- The data from the receiver should generate polynomial images on a display screen. Then based on color identification, it should be easy to pin point an object's location. A selected color would represent a received signal, and if that color appears on the screen, an object has been located.
- The field programmable gate array (FPGA) board must have a clock of 100 MHz.
- The FPGA board should have Peripheral Module (Pmod) connectors to add analog-to-digital (A/D) and digital-to-analog (D/A) converters.

1.5.2 Limitations

The decisions in this project are confined by the following limitations:

- The distance to the scene to be imaged must be 20 feet. (REQF-002)
- The area to be imaged, also known as scene extent, must cover the width of a person and should ideally cover the person's torso and legs. However, the scene extent will be based on the type of horn antennas selected. (REQF-003)
- The frequency range should be within the X- or Ku- band operating frequency, which is a range of 8 to 12 GHz for X-band and 12 to 18 GHz for Ku-band. (REQF-001)
- The cross range and down range resolution are determined based on the employed beamwidth and distance between the antennas and target. (REQF-004)
- The down range resolution must be low so it does not take a thorough image of the body, but has enough depth. (REQF-005)
- The pulse width should be at about 20 nanoseconds so the pulse can travel to and from the scene. (REQF-006)
- The number of phase centers for the system is sixteen. (REQF-010)

- The number of antennas to be used for the system is sixteen receive antennas and four transmit antennas. (CONS-001)
- Antennas must be placed close together at equal distances apart and be precisely pointed at target. (CONS-002)
- To use the system for testing, the room must be bigger than 20 feet x 15 feet.

1.6 Expected End Products and Other Deliverables

1.6.1 Synthetic Active Aperture Radar Imager

The SAR Imager system will be designed and physically implemented by April 2015. The sponsor in particular does not have a deadline, but the College of Engineering's deadline for completion of projects is April 2015. The end product of this project will be a testable conceptual design of an electronic SAR Imager. The electronic SAR Imager will have the ability to receive and transmit pulses on at least one row of antennas out of the four orthogonal rows on the whole schematic. A summary of the radar system's components are listed below:

- 1 Field Programmable Gate Array (FPGA) board
- 1 Power Supply
- 4 Transmit Antennas
- 16 Receive Antennas
- 1 Voltage Controlled Oscillator (VCO)
- 1 IQ Demodulator
- 4 Single Pole Double Throw (SPDT) Switch
- 4 Multipliers
- 5 Variable Attenuators
- 4 Power Amplifiers
- 4 Isolators
- 1 Low Noise Amplifier (LNA)
- 1 Dual Active Low Pass Filter (LPF)
- 1 Dual Level Shift
- 1 VGA Display
- 2 Analog-to-Digital Converters
- 1 Digital-to-Analog Converter

1.6.2 Documentation and Configuration Flash Drive

1.6.2.1 Electronic Circuit Schematics

The electronic circuit model developed will be saved in different formats to the Documentation and Configuration flash drive. This will be completed by April 2015.

1.6.2.2 Antenna Structural Schematics

The structural design of the antennas and the supporting system will be be saved to the Documentation and Configuration flash drive. This will be completed by April 2015.

1.6.2.3 Code and Configuration Files

The VHDL code and configuration files developed for the electronic SAR imager will be organized in a .zip file and saved into the Documentation and Configuration flash drive. This will be completed by April 2015.

2 Concept Generation

2.1 Electrical System Design

The electrical system is at the center of the SAR Imager and interacts with each of the subsystems. It is needed to generate the radio frequency (RF) signals, receive the reflected RF signals, process the data, and generate and output imagery. The team evaluated two different models suggested by the sponsor: (1) a simple model that uses test equipment and processes the imagery using a separate program after all of the data has been collected, and (2) an advanced model that processes the imagery as the data is collected.

2.1.1 Simple Model

The Simple Model design shown in Figure 1 is the basic option for an electrical system for the SAR Imager that uses test equipment to handle the major functions, such as generating the pulses and collecting and processing the received data. In this design a function generator is used to output the pulse waveforms that feed into the radio frequency source. On the receiving end, the data is captured and collected by the oscilloscope which will allow for the post-processing of the imagery to be completed using software on a computer. The FPGA in this design is necessary only to provide a stable trigger to control the switches. An advantage to this system is that it does not rely on the FPGA to complete the image processing; therefore, less programming firmware is required for the FPGA. A disadvantage to this design is that it does not allow for imagery data to be processed as it is collected, thus, any necessary adjustments to the hardware cannot be made until the end of the data collection period.

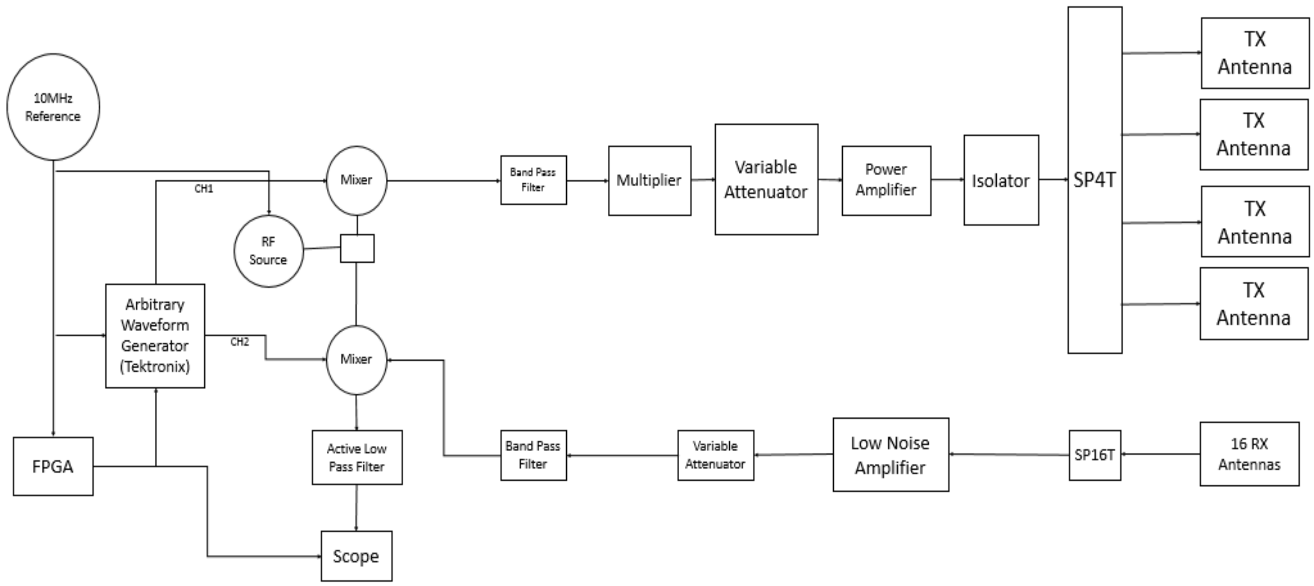

Figure 1: Simple Model using Test Equipment

2.1.2 Advanced Model

The Advanced Design shown in Figure 2 does not include any test equipment and relies heavily on the FPGA. The FPGA is responsible for the signal processing, generation of the pulse waveforms that input into the RF sources, and switching circuitry, as well as outputting the imagery to a display. An advantage to this design is that it does not require test equipment to process the imagery which means any necessary adjustments to the system can be made while the tests are being conducted. A disadvantage to this design is that it requires more processing in the FPGA which creates the task of writing firmware to handle the signal processing.

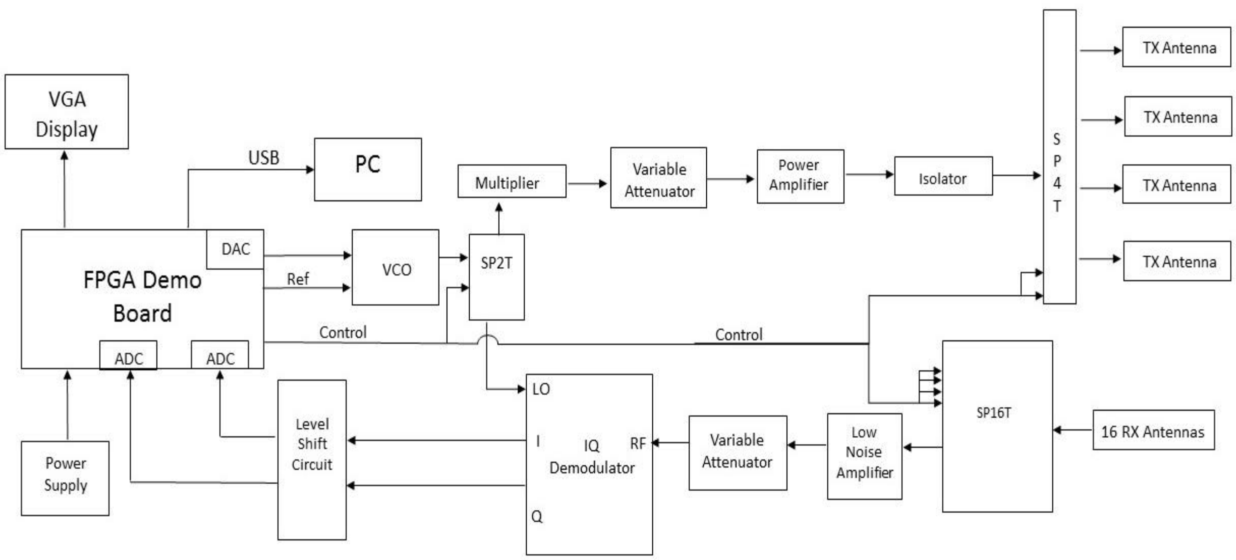

Figure 2: Advanced Model Block Diagram

2.2 Horn Antennas

The twenty horn antennas will provide high efficiency in directional propagation. With the linear alignment of multiple horn antennas, side lobes can be combined, thus creating twice the amount of phase centers. Selecting the necessary horns requires consideration into price, range of frequencies, gain level, and beamwidth in both the electromagnetic and magnetic plane. Primarily, each horn is required to radiate within X-band frequencies: 8 – 12.4 GHz. The best option from the list below is the Advanced Receiver: Model No. MA86551. It radiates the necessary frequencies and is significantly less in price compared to the other two options. However, its gain level is also significantly reduced which does create a larger scene extent.

- Requirements:
  - Quantity: 20
  - X-Band Frequency Range: 8 - 12.4 GHz

2.2.1 Advanced Receiver: Model No. MA86551

The Advanced Receiver horn antenna is a highly affordable X-band horn antenna that will expand the scene extent and provide complex and vivid results. These horn antennas are the preferred option due to their low-cost. The Model No. MA86551 horn antenna is located at the top right corner of Figure 3.

2.2.1.1 Specifications

- Frequency Range: 8-12.4 GHz
- Gain: 17 dBi
- H-Plane (Azimuth) beamwidth: 25°
- E-Plane (Altitude) beamwidth: 25°
- RF Connection: Mates with UG-39/U
- Height: 3 in.
- Width: 3.7 in
- Length: 3 in.
- Weight: N/A
- Price per horn: $20.00

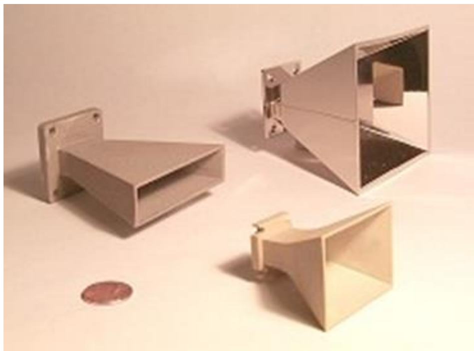

Figure 3: Advanced Receiver: X-Band horn antenna

2.2.1.2 Benefits

- Extremely cheap. The Advanced receiver horn antennas are at an abnormally low starting price for typical horn antenna.
- The RF connection is also easy to come by and relatively cheap.
- Small: The antennas will be easy to assemble onto a structure and do not require a lot of storage space.

2.2.1.3 Drawbacks

- Low gain means the horn antennas beamwidth is much larger, which opposes the initial purpose of scanning a scene extent that is only thirty inches wide.

2.2.2 Advanced Technical Materials: High Band – Model No. 90-443-6

Figure 4 is a visual aid to the high band horn antennas which could be used for the radar system.

2.2.2.1 Specifications

- Frequency Range: 8.20-12.4 GHz
- Gain: 24 dBi
- H-Plane (Azimuth) beamwidth: 10.6°
- E-Plane (Altitude) beamwidth: 8.8°
- RF Connection: WR90
- Height: 7 in.
- Width: 10 in.
- Length: 20.2 in
- Weight: 3.13 lbs
- Price per horn: $465.50

Figure 4: ATM High Band Horn Antennas

2.2.2.2 Benefits

- High Gain value: smaller scene extent and narrower beamwidths
- Necessary X-band frequencies

2.2.2.3 Drawbacks

- Expensive: Buying twenty horns would hurt the budget.
- Size: These are the largest horns out of the three options. Being almost two feet long would cause the design for the holding structure to be larger and more expensive. In addition, finding the necessary storage space for these antennas would be difficult.

2.2.3 Advanced Technical Materials: High Band – Model No. 75-443-6

Figure 4 is a visual aid to the high band horn antennas which could be used for the radar system.

2.2.3.1 Specifications

- Frequency Range: 10-15 GHz
- Gain: 24 dBi
- H-Plane (Azimuth) beamwidth: 10.5°
- E-Plane (Altitude) beamwidth: 8.9°
- RF Connection: WR75
- Height: 5.73 in.
- Width: 8.07 in.
- Length: 17 in.
- Weight: N/A
- Price per horn: $522.50

2.2.3.2 Benefits

- High Gain value: smaller scene extent and narrower beamwidths

2.2.3.3 Drawbacks

- Large in size: Finding the necessary storage space will be difficult
- Slight higher frequency range: Range reaches into the Ku-band frequencies and does not cover the entire X-band frequency range.
- Expensive: buying twenty horns would hurt the budget

2.3 Waveguide-to-coaxial Adapters

A waveguide adapter will be connected to each antenna and converts coax connection to waveguide. Waveguide adapters will be installed directly onto each waveguide horn antenna or onto the waveguide run extension.

- Requirements:
  - Frequency Range: 8-12 GHz
  - Quantity: 20

2.3.1 Flann 16094-NF | WR90 to N-Female Waveguide Adapter X-Band

Figure 5 is a picture of one of the options for a waveguide-to-coax adapter.

2.3.1.1 Specifications

- Frequency Range: 8.2-12.4 GHz
- Square Non-Choke Flange
- WR-90
- N-Female Adapter
- Construction: Brass Alloy
- Price: $129.95

Figure 5: Flann 16094-NF Adapter

2.3.1.2 Benefits

- Coaxial adapter port easily accessible
- Usually ships within 24-72 hours

2.3.1.3 Drawbacks

- Expensive

2.3.2 Omega Laboratories Model 108 - WR90 to N-Female Waveguide Adapter

Figure 6 is a picture of one option for a waveguide-to-coax adapter.

2.3.2.1 Specifications

- Frequency Range: 8-12.4 GHz
- WR-90
- N-Female Connector
- Square Non-Choke Flange
- Construction: Brass Alloy
- Price: $129.95

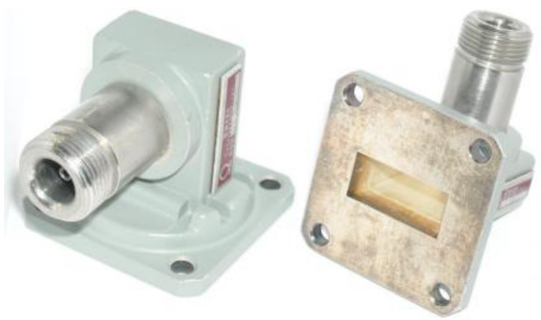

Figure 6: Omega Lab. Adapter

2.3.2.2 Benefits

- Coaxial adapter port easily accessible
- Usually ships within 24-72 hours

2.3.2.3 Drawbacks

- Expensive

2.3.3 WR90 Waveguide Isolator X-Band 8.2 to 12.4 GHz

The Waveguide Isolator Adapter is the preferred option based on its low price and combine capabilities as an isolator. Having the isolator built into the adapter will simplify the radar system, but also creates some complexity with understanding pulse receiving. Figure 7 is a picture of the preferred waveguide-to-coax adapter.

2.3.3.1 Specifications

- Frequency Range: 8.2-12.4 GHz
- Price: $79.95

Figure 7: Waveguide plus Isolator Adapter

2.3.3.2 Benefits

- Inexpensive
- Includes an isolator to prevent excessive leakage.
  - Leakage would increase the noise figure levels of the system.
- Usually ships within 24-72 hours

2.3.3.3 Drawbacks

- Isolator is a non-reciprocal one way device where input to one of the ports goes to a load and is isolated from other port

2.4 FPGA

A Field Programmable Gate-Array (FPGA) is needed to control the tasks in the system electronically. The FPGA should have an appropriate clock speed of at least 100 MHz, a VGA port, a Pmod interface, and a USB port. The FPGA should have a clock speed of at least 100 MHz because the higher the clock speed the better the quality. The switching edge needs to be 10ns per sponsor recommendation. The clock speed needs to be 100 MHz to guarantee the 10ns switching capability. Alternating the switches on and off does not occur instantaneously which creates a rise time and settling time. Additional time is needed for settling stability. The VGA port would be solely for the displaying images. The Digilent Pmod interface is used to connect low frequency, low I/O pin count peripheral modules to the host controller boards. This includes the Digital-To-Analog (D/A) and Analog-To-Digital (A/D) converters that are only compatible with Digilent's FPGAs and microcontrollers. The USB port would be useful because it allows the FPGA control to get plugged into a PC. The PC is used to compile the FPGA code that controls the system.

2.4.1 Digilent Nexys 2

The Digilent Nexys 2 is the sample our sponsor gave us in terms of what to look for in an FPGA. It was first developed in 2007 and can be seen in Figure 8 [2].

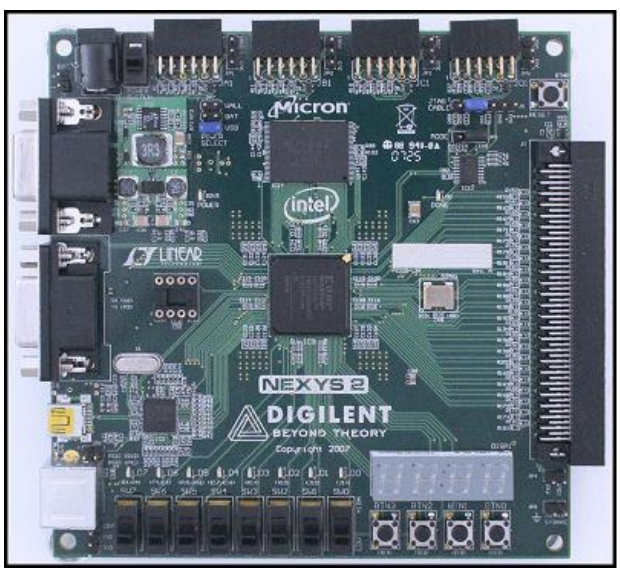

Figure 8: Digilent Nexys 2

2.4.1.1 Specifications

- 500K-gate Xilinx Spartan 3E FPGA [2]
- USB-powered
- 8 LEDs, 4-digit 7-seg display, 4 buttons, 8 slide switches
- 50MHz oscillator plus socket for second oscillator
- VGA, PS/2, and serial ports
- Four 12-pin Pmod connectors

2.4.1.2 Benefits

The Digilent Nexys 2 is a low cost FPGA, with a price range from $140 for the academic discount to $180 for the regular price. The sponsor is also very familiar with this FPGA, saying it is a reliable device thus recommending it.

2.4.1.3 Drawbacks

The 50 Mhz clock speed is not enough for what is desired in this project. This could possibly be supplemented by using a clock multiplier to increase the clock speed if nothing else could be found, but this is undesirable. The Digilent Nexys 2 is also an old model. Since no new devices are made, only left over stock is available for sale.

2.4.2 Digilent Nexys 3

The Digilent Nexys 3, shown in Figure 9, is a newer version of the sample FPGA that our sponsor gave us. It is very similar to the Digilent Nexys 2 in terms of characteristics, with minute upgrades and differences [3].

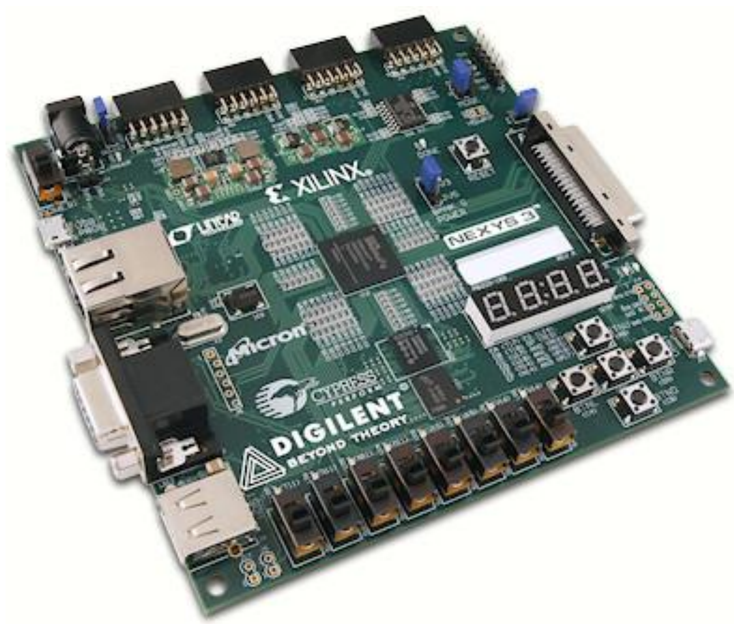

Figure 9: Digilent Nexys 3

2.4.2.1 Specifications

- 8-bit VGA port [3]
- 100MHz CMOS fixed frequency oscillator
- On-board USB2 port for programming & data transfer
- GPIO includes 8 LEDs, 5 buttons, 8 slide switches and 4-digit seven-segment display
- 16Mbyte Cellular RAM (x16)
- 8-pin Pmod connectors for lower speed and lower pin-count I/O.

2.4.2.2 Benefits

Very similar to its earlier model the Digilent Nexys 2. This means it has good reviews and our sponsor is somewhat familiar with the brand/model. Has the necessary clock speed of 100 MHz that is desirable for this project.

2.4.2.3 Drawbacks

Price range is from $139 for the academic discount to $279 for the regular price. The clock is also fixed at 100MHz, which can be a problem if the clock speed needs to be easily adjusted.

2.4.3 Digilent Nexys 4 Artix-7

The Digilent Nexys 4 Artix-7, shown in Figure 10, is the newest version of the sample FPGA that the sponsor gave the team. It is very similar to the Digilent Nexys 3 in terms of characteristics, with noticeable upgrades and minute differences [4].

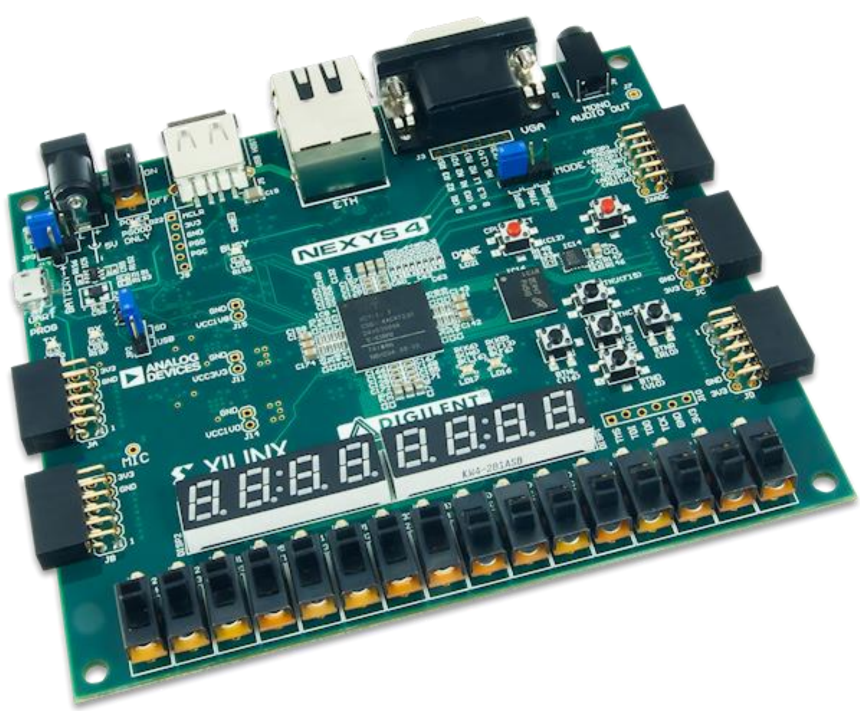

Figure 10: Sigilent Nexys 4 Artix-7

2.4.3.1 Specifications

- Internal clock speeds exceeding 450MHz [4]
- On-chip analog-to-digital converter (XADC) 12-bit VGA output
- 16 user LEDs
- Four Pmod ports
- USB HID Host for mice, keyboards and memory sticks
- Two 4-digit 7-segment displays

2.4.3.2 Benefits

Very similar to the Digilent Nexys 3. This means it has good reviews and our sponsor will be familiar with the brand/model. Has the necessary clock speed of 100Mhz, and has the capability of having internal clock speeds of exceeding 450 MHz. The greater the maximum clock speed the FPGA has the better since the signal will come out cleaner.

2.4.3.3 Drawbacks

The price of the Nexys 4 Artix-7 is the highest among the Nexys line of FPGA's. The price range is $159 for the academic discount and $320 for the regular price.

2.5 D/A and A/D Pmod Converters

The Digilent brand of FPGA's and microcontrollers has a unique Pmod interface which allows for simplification of peripherals. This allows for hardware interface of certain devices (such as A/D and D/A converters) to be pre-designed and the modules can be easily assembled without trouble (no soldering or physical modification of board required). Since the device being used is an FPGA, software configuration is still a must for the components to work, even though the physical layout can just be plugged in.

2.5.1 Digilent PmodDA1 8 bit

Figure 11 depicts an image of the D/A converter module that converts signals from digital to analog at up to one MSa per second. The DA1 uses a 6-pin header connector and as less than one square inch is small enough to be located where the reconstructed signal is needed. [5]

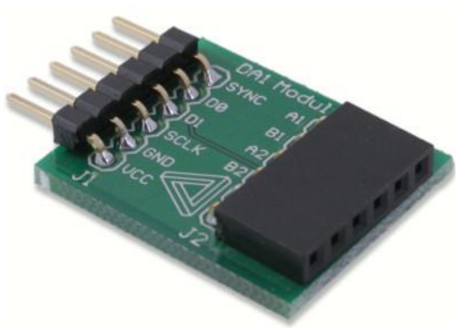

Figure 11: Diglent PmodDA1 8 bit.

2.5.1.1 Specifications

- Four D/A conversion channels
- 6-pin header and 6-pin connector
- Very low power consumption
- Equipped with two AD7303 digital to analog converters

2.5.1.2 Benefits

Allows for onboard connecting of a D/A converter by plugging the PMODA1 into the onboard Pmod connector slot. The Pmod connector slot is located on the Nexys 2, Nexys 3, and Nexys 4 models of Digilent FPGA's.

2.5.1.3 Drawbacks

Very limited Selection of D/A converters to be Pmod compatible. This was the only 8 bit A/D Pmod connector that digilent has for sale.

2.5.2 Digilent PmodAD1 Two 12-bit

Figure 12 depicts an image of the A/D converter module that converts signals from analog to digital at up to one MSa per second. The DA1 uses a 6-pin header connector and as less than one square inch is small enough to be located at the signal source. [6]

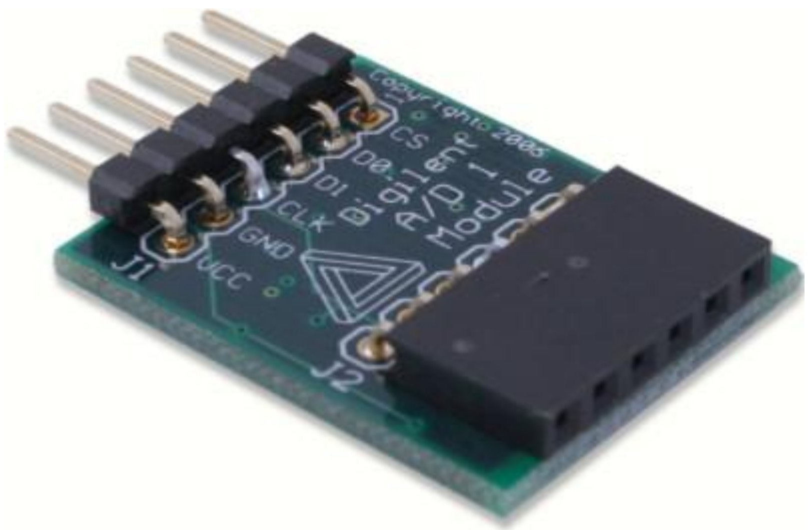

Figure 12: Digilent PmodAD1 Two 12-bit.

2.5.2.1 Specifications

- 6-pin header connector
- 6-pin connector
- Very low power consumption

2.5.2.2 Benefits

Allows for onboard connecting of a A/D converter by plugging the PmodAD1 into Pmod connector. The Pmod connector slot is located on the Nexys 2, Nexys 3, and Nexys 4 models of Digilent FPGA's.

2.5.2.3 Drawbacks

Very limited selection of A/D converters to be Pmod compatible. This was the only 12 bit A/D Pmod connector that digilent has for sale.

2.6 Voltage Controlled Oscillator (VCO)

An oscillator is an electronic circuit that generates a periodic signal. The signal can be in the form of either a square pulse or a sinusoidal. A voltage controlled oscillator is type of oscillator that uses an applied voltage to control the frequency of the periodic signal that is generated. In this electrical system for this design the VCO generates a high frequency pulse wave of the X-band that powers the system.

2.6.1 Hittite Microwave Corporation HMC-C028

The HMC-C028, as shown in Figure 13, is a wideband voltage controlled oscillator that meets the minimum specifications of the design. It was considered because of its operating frequency range, power output, and connector style. [7]

2.6.1.1 Specifications

- Operating frequency range: 5-10 GHz
- Provided generation ratio: 0.2 MHz/V
- Output power: +20 dBm
- Phase noise: -95 dBc/Hz
- Single Positive Voltage Supply +8V to +15V
- Operating Temperature: -40°C to 85°C

Figure 13: HMC-C029

2.6.1.2 Benefits

The HMC-C028 is a chassis mount module; it can be easily mounted to a structure. This is the preferable packaging type for the design. In addition it comes with replaceable SMA connectors allowing ease changeability if they are damaged.

2.6.1.3 Drawbacks

The HMC-C028 has a typical return loss of 15 dB. This will contribute to the overall loss in the transmission path and will have to be accounted. It requires a voltage supply of at least 8V @ 185 mA. This voltage is a high relative to the reference voltage of the FPGA.

2.6.2 RFMD VCO-520S/STC

The VCO-520S/STC, depicted in Figure 14, is a hybrid assembled voltage controlled oscillator. It was considered because its operating frequency meets the minimum specifications of the design. The VCO-520S/STC is also a chassis mount module. [8]

2.6.2.1 Specifications

- 4900MHz to 5900MHz VCO
- 5V Operation
- -1dBm Typical Output Power
- -77dBc/Hz at 10kHz
- -102dBc/Hz at 100kHz
- -122dBc/Hz at 1000kHz

Figure 14:RFMD VCO-520S/STC

2.6.2.2 Benefits

The VCO-520S/STC is a chassis mount module which is the preferred package type. It has relatively low supply voltage in comparison to the output of the FPGA. Also the output impedance of this module is 50 Ω; this important because most devices have an input of impedance of 50 Ω, thus impedance matching between this and a receiver is not a concern.

2.6.2.3 Drawbacks

The VCO-520S/STC has a low output power. The maximum value is 2 dBm. If this VCO was the driver to a device that need a higher amount of input power, an amplifier would be needed

2.7 IQ Demodulator

The theory behind IQ demodulation is to represent the input RF signal as a combination of two double sideband modulated quadrature carrier signals. The IQ demodulator samples the input RF signal twice however at a phase difference of 90°. This allows the relative phase of the components of the signal to be measured. The I output of the IQ demodulator is the real part of the signal while the Q output is the imaginary part of the signal. Together these signals provide the amplitude and phase shift of the input RF signal.

2.7.1 Polyphase Microwave Quadrature Demodulator – AD60100B

The AD60100B, shown in Figure 15, is a quadrature demodulator that converts the RF signal that is input to the baseband I and Q outputs whenever a LO signal is applied. The frequency range of the LO/RF signal is 6-10 GHz. [9]

2.7.1.1 Specifications

- LO/RF Frequency: 6 – 10 GHz
- I/Q Bandwidth: 275 MHz
- Input IP3: +22 dBm

Figure 15:AD60100B

- Input P1dB: +12 dBm
- Amplitude Imbalance: ±0.1 dB
- Phase Error: - 2 Degrees
- LO Power: +5 dBm
- DC Supplies: +5V @ 110 mA, -5V @ 40 mA

2.7.2 SigaTek I Q Demodulator – QD27A11

The QD27A11, depicted in Figure 16, is an IQ demodulator that converts the RF signal that is input to the baseband I and Q outputs whenever a LO signal is applied. The carrier frequency LO is 4-6 GHz.

2.7.2.1 Specifications

- Carrier frequency range: 4-6 GHz
- RF frequency range: LO±DC-300
- Maximum conversion loss: 9 dB
- Maximum Amplitude balance: 1 dB

Figure 16: QD27A11

2.7.2.2 Benefits

The QD27A11 module is a chassis mount device and can interface with SMA connector devices. Its operating frequency is within the design specifications therefore the frequency of any input signals do not have to be increased or decreased.

2.7.2.3 Drawbacks

This has a conversion loss of the QD27A11 is 9 dB which is higher than the AD60100B. This will have to be accounted for in the calculations.

2.8 Switches

The switches are very important components in the electrical system. They provide the capability of generating a switched output which gets delivered to multiple components by a single driver. The speed at which the output is switched between the loads is based on the frequency of the control signal.

2.8.1 Single Pole Double Throw (SPDT)

The single pole double throw creates a short circuit between the each of the two RF channels and the common channel. The SPDT switch is needed in this electrical system because it allows the VCO to provide an input to both the transmit path and the IQ Demodulator.

2.8.1.1 Hittite HMC-C058

The Hittite HMC-C058, depicted in Figure 17, is a high isolation non-reflective SPDT switch. It has an operating frequency of DC to 18 GHz. [10]

2.8.1.1.1 Specifications

- Operating Frequency Range: DC – 18 GHz
- Operating Temperature Range: -55°C to 5°C
- Maximum Insertion Loss:
  - 2.4 dB @ DC-6 GHz
  - 2.8 dB @ DC-10 GHz
  - 5.5 dB @ DC-18GHz

Figure 17: HMC-C058

2.8.1.1.2 Benefits

The HMC-C058 is a module component with replaceable SMA connectors. It offers high isolation with low insertion loss as well as fast switching speeds (3 ns Fall/Rise times.) The HMC-C058 is non-reflective and has an impedance of 50Ω.

2.8.1.1.3 Drawbacks

The HMC-C058 has return losses which have to be accounted for in the design.

2.8.1.2 UMC SW-L010-2S

The SWL0102S, shown in Figure 18, is an absorptive SPDT that has an operating frequency range of 2-12.4 GHz.

2.8.1.2.1 Specifications

- Operating Frequency Range: 2 – 12.4 GHz
- Operating Temperature Range: -55°C to 95°C
- Maximum Insertion Loss:
  - 1.8 dB @ 2-6 GHz
  - 2.0 dB @ 6-12.4 GHz

Figure 18: SW-L010-2S

2.8.1.2.2 Benefits

The SWL0102S is an absorptive switch having an internal impedance of 50Ω. This is ideal for impedance matching. It is also a module with SMA connectors, this type of packaging is preferred for the electrical design. This switch also has a low insertion loss.

2.8.1.2.3 Drawbacks

The SWL01012S has return loss which must be accounted for in the calculations.

2.8.2 Single Pole Four Throw (SP4T)

The single pole four throw switch creates a short circuit between the each of the four RF channels and the common channel. The SP4T switch is needed in this electrical system because it allows the four receive antennas to be driven by a single source which reduces the number of transmit paths from four to one.

2.8.2.1 Hittite HMC-C071

The HMC-C071, shown in Figure 19, is a SP4T non-reflective switch. It has an operating frequency range of DC to 20 GHz.

2.8.2.1.1 Specifications

- Operating Frequency Range: 2 – 12.4 GHz
- Operating Temperature Range: -55°C to 95°C
- Maximum Insertion Loss:
  - 1.8 dB @ 2-6 GHz
  - 2.0 dB @ 6-12.4 GHz

Figure 19: HMC-C071

2.8.1.1.2 Benefits

The HMC-C071 is a non-reflective design, it has an inter impedance of 50Ω. This module has replaceable SMA connectors, high isolation and fast switching times.

2.8.1.1.3 Drawbacks

The HMC-C071 has return losses which must be accounted for in the calculations.

2.8.2.2 UMC SW-L010-4S

The SWL0104S, shown in Figure 20, is an absorptive SP4T which has an operating frequency range of 2-12.4 GHz.

2.8.2.2.1 Specifications

- Operating Frequency Range: 2 – 12.4 GHz
- Operating Temperature Range: -55°C to 95°C
- Maximum Insertion Loss: 2.2 dB

Figure 20: SW-L010-2S

2.8.2.2.2 Benefits

The SWL0104S is an absorptive design with an internal impedance of 50Ω, which is desirable for impedance matching. This switch also has SMA connectors; this is the preferred package type for the electrical system.

2.8.2.2.3 Drawbacks

This module has loss that must be accounted for in the calculations.

2.8.3 Single Pole 16 Throw (SP16T)

The single pole sixteen throw switch creates a short circuit between the each of the 16 RF channels and the common channel. The short circuit switches between each of the 16 RF channels based on the frequency of the control signal. This will allow for a signal to be received from each of the 16 receive antennas. This also reduces the number of receive paths from 16 to one.

2.8.3.1 UMC SW-L010-16S

The SWL01016S, shown in Figure 21, is an absorptive SP16T switch that has an operating frequency range of 2-12.4 GHz.

2.8.3.1.1 Specifications

- Operating Frequency Range: 2 – 12.4 GHz
- Operating Temperature Range: -55°C to 95°C
- Maximum Insertion Loss: 4.7 dB
- Minimum Isolation:
  - 65 dB @ 2-6 GHz
  - 55 dB @ 6-12.4 GHz

Figure 21: SWL01016S

2.8.3.1.2 Benefits

The SWL01016S is an absorptive design and has an internal impedance of 50Ω. It also has SMA connectors which is the preferable packaging type for this electrical system. Its high insertion and low loss make it an ideal choice for an SP16T switch.

2.8.3.1.3 Drawbacks

Although it has a low insertion loss, the loss must still be accounted for in the calculations.

2.8.3.2 AMC MSN-16DR-05

The MSN-16DR-05, shown in Figure 22, is a SP16T switch which has the operating frequency range of 0.5 GHz to 18 GHz.

2.8.3.2.1 Specifications

- Operating Frequency Range: 0.5 – 18 GHz
- Operating Temperature Range: -55°C to 85°C
- Maximum Insertion Loss:
  - 6.5 dB (reflective),
  - 7 dB (absorptive)
- Minimum Isolation: 60 dB

Figure 22: MSN-16DR-05

2.8.3.2.2 Benefits

The MSN-16DR-05 has a high insertion and low insertion loss. This module also has SMA connectors. Another benefit to this switch is it has the capability to switch from absorptive to reflective. This allows for the option of impedance matching.

2.8.3.2.3 Drawbacks

A drawback to this switch is its insertion loss is relatively high and must be accounted for in the calculations.

2.9 VHDL Software Generators

The FPGA is the brain of the radar system and having the proper software is crucial. The main programming language used for the FPGA is VHDL, but MathWorks and National Instruments offer HDL code converters which could make the overall programming of the FPGA simpler but still challenging and a learning experience.

2.9.1 MathWorks: *HDL Coder*

MathWorks' HDL code converter incorporates Simulink and MATLAB functions to resemble the block diagram of the system design. Figure 23 represents the MathWorks icon. [11]

2.9.1.1 Benefits

- Simulink – Block diagram coding structure
- Incorporates MATLAB functions
- Works with Altera and Xilinx
- Code-to-model and model-to-code traceability for DO-254

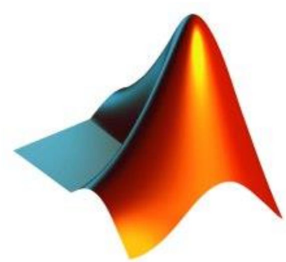

Figure 23: MathWorks: HDL Coder

2.9.1.2 Drawbacks

- Simulink is complicated and lacks detailed instructions
- Actual HDL code translate is known to fail

2.9.2 National Instruments: *LabVIEW*

LabVIEW resembles MathWorks' Simulink block diagram coding applications, but it is configure to work directly with FPGA boards. Figure 24 represents the LabVIEW icon. [12]

2.9.2.1 Benefits

- Graphical system design
- IP Libraries and HDL Code Reuse
- Basic Xilinx and NI functions
- Rapid algorithm development
- Online, detailed video trainings that include FPGA programming

Figure 24: LabVIEW

2.9.2.2 Drawbacks

- Requires using money from the budget

2.9.3 Software Selection

MathWorks' HDL Coder only translates C coding language to HDL and then has to be inputted into an FPGA programming application. However, National Instruments' LabVIEW is meant for the purpose of coding FPGA. LabVIEW will translate C code to HDL and acts as an FPGA programming application. Thus, LabVIEW is the preferred option for this radar system.

2.10 Structure

In order to hold the horns and electrical components together a structure must be designed. The goal of the design is to scan an object at least twenty feet away from the structure using twenty horn antennas.

2.10.1 Design 1

In order to have thirty two phase centers from the horn antennas, a T-shape structure as shown in Figure 25 is an ideal design. It involves making the structure out of an aluminum based metal. It is a universal T-shape structure which can be ground or wall mounted.

2.10.1.1 3-D Model

The idea for the design is to have the horns placed onto a structure for ease of adjustment in a T-shaped alignment. The structure holding the horns would be aluminum 6061. The horn structure will need to be assembled due to the large size of the antenna structure. A bracket type mechanism will be placed on the back of the horn structure to attach a removable box for the electrical components. This is ideal for the electrical engineers to work away from the structure. The horn structure will also have two mounting configurations where it can be secured with a detachable ground mount or with a detachable wall mount. Below in Figure 25 is a rough model of the T-shape electronic SAR imager ground mount as a unit without the electrical box.

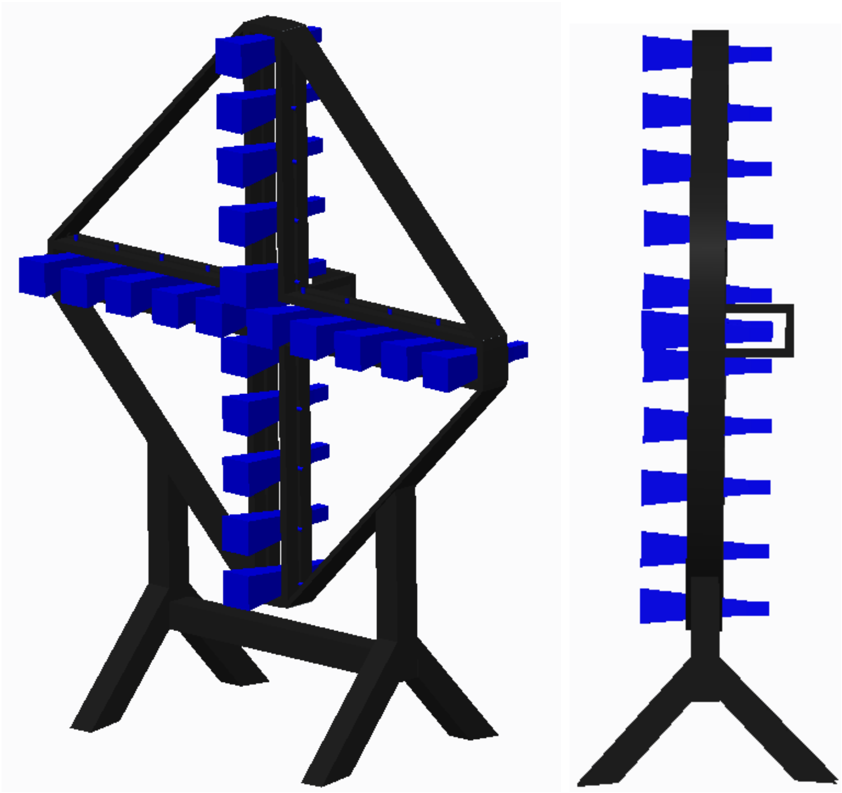

Figure 25: T-Shape SAR Imager Ground Mount

2.10.1.2 Benefits

- Ease of alignment of the horns to focus on object area.
- Ease of distancing the horns correctly away from each other.
- Weight of aluminum is light for this structure.
- Strength of the aluminum will support the horns.
- Universal mounting (ground or wall) in which horn structure detaches from stand.
- Detachable electrical components box.
- One reference frame for the horns.

2.10.1.3 Drawbacks

- Hard to secure wires from horns for minimum vibrations.
- Cost of aluminum can be expensive.

2.10.2 Design 2

2.10.2.1 3-D Model: Horn Structure

This design depicts a cylindrical web shape structure as shown in Figure 26. Although, the t-shape does fit the ideal situation, the cylindrical web shape can result in a more defined reception of signals pulses. The calculation needed for this structure can be costly with time which may make it less valuable to project goals. This structure will prove beneficial with its ability to be mounted on a wall or held vertically by a tripod shown in figure 28.

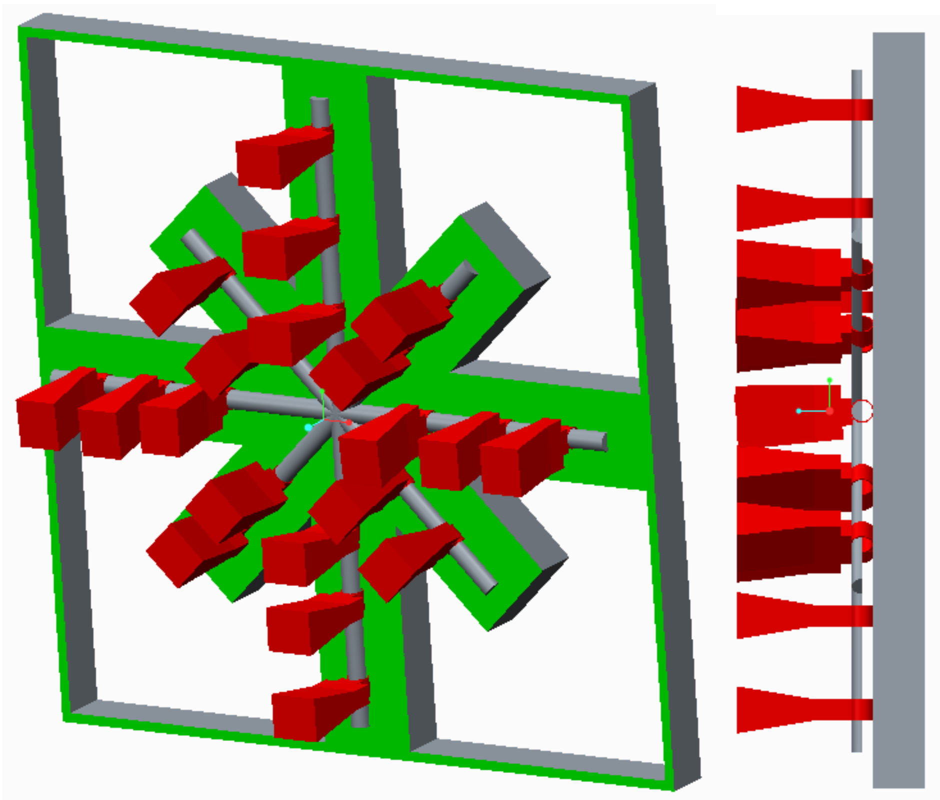

Figure 26: Cylindrical Web Horn Structure

2.10.2.2 Benefits of Horn Structure

- Less adjustment to the degree of the horns for alignment adds to the beam strength.
- Reduces weak spots in signal between phase centers.
- Concentric-circular array shows no variation, providing for better side lobe control as well as more efficient array aperture usage.
- The web produces a more accurate boresight toward the target.
- Creates a larger bore sight with a revolved beam angle with less deteriorated signal sections.

2.10.2.2.1 Material Benefits

- Cost
  - Galvanizing is lower in first cost than many other commonly specified protective coatings for steel.
  - Even in cases where the initial cost of galvanizing is higher than alternative coatings, galvanizing is almost perpetually cheapest in the long term.

- Reliability
  - The life expectancy of galvanized coatings on typical structural members is far in excess of 50 years in most rural environments, and 20 to 25 years plus, even in severe urban and coastal exposure.
  - A galvanized coating has a unique metallurgical structure which gives outstanding resistance to mechanical damage in transport, erection and service.
  - Galvanized Steel has comparable strength using less material that that of other metals
- Ease of use
  - Once the steel has been galvanized, it is ready to be cut, assembled and prepped for construction. This material can be easily obtained.

2.10.2.3 Drawbacks of Horn Structure

- Must use two reference frames to align the horns to a center focal point.
- The area of the main beam will be relatively small with the amount of horns used.

2.10.2.3.1 Material Drawbacks

- Fabrication
  - Galvanized steel is coated with a layer of zinc. Zinc melts at about 900℉ and vaporizes at about 1650℉. Since steel melts at approximately 2,750℉ and the welding arc temperature is 15,000 to 20,000℉, the zinc will vaporize before the welding pool has been created.
- Lacks a bottom flange to the T-Shape of the support beams. This will decrease the tensile resistance weakening the metal over a period of time.
- This metal is heavier than Aluminum.

2.10.2.4 3-D Model: Cover for Horn Structure

The design for the cover of the horn structure, depicted in Figure 27, provides an additional method for mount the electronic SAR Imager on a wall.

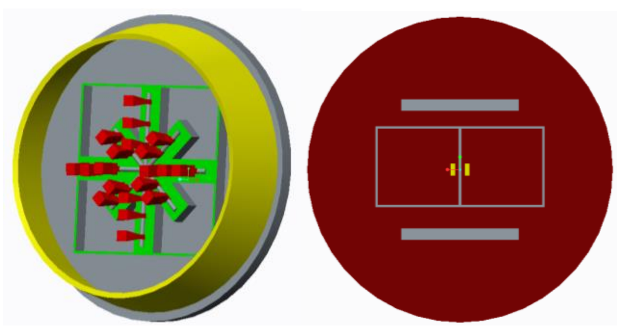

Figure 27: Cover for Cylindrical Web Horn Structure

2.10.2.5 Benefits of Cover for Horn Structure

- The cylinder provides a stable body with surfaces that can be used as a reference to align the antennas.
- The cylinder structure provides a place for components on the back of the structure.
- The body provides protection from outside elements that could disrupt the alignment of the horns.
- The Structure provides a component to place structure on a wall mount or hold upright on a tripod.

2.10.2.5.1 Material Benefits

- Cost
  - Providing that the College of engineering possesses a 3D Printer. The cost of the material will be inexpensive.
- Ease of use
  - The material will be split in to a determined amount of pieces. This makes the assembly of the structure simple whether using bolts or welding. The plastic will be manufactured accurately to the design.

2.10.2.6 Drawbacks of Cover for Horn Structure

- The structure will have to be disassembled to realign horns or for maintenance on horns.

2.10.2.6.1 Material Drawbacks

- Reliability
  - Due to the hardness of plastic, the elasticity is very minimal. This results in a cracks in the plastic under pressure in various situations.

2.10.2.7 3-D Model: Tripod Stand for Horn Structure and Cover

The tripod will be custom made to hold the weight of the Design as a whole being able to rotate as a ball joint. This tripod will allow the structure to be placed in any position. The structure will have access to any plane in space. Below in Figure 28 is a rough model of the tripod stand for the SAR imager.

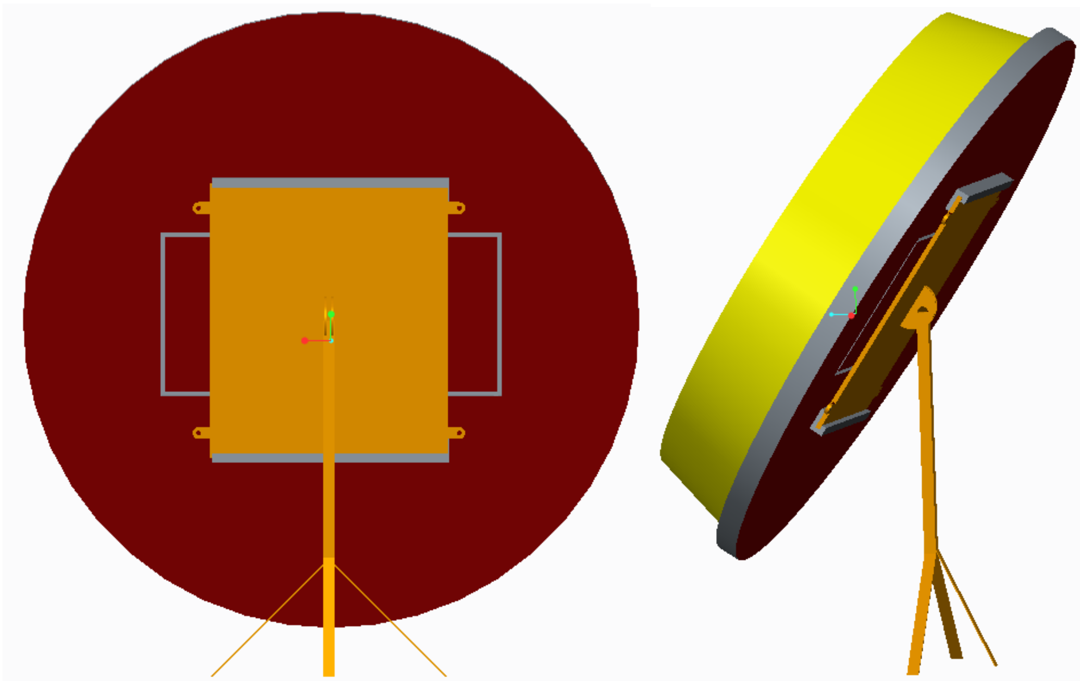

Figure 28: Tripod Stand for Horn Structure and Cover

2.10.2.8 Benefits of Tripod Stand

- The ball joint on the extension of the tripod will allow the Structure to be placed in any plane reference
- The tripod assortment fits in the wall mount component. Easily removing the plate from the tripod and placing on the wall allows for a two in one design.

2.10.2.9 Drawbacks of Tripod Stand

- The structure must be taken from the tripod to access the electrical components.

2.11 Alignment Laser

The alignment laser will be used to assign a desired position of the antenna horn. Each horn must be directly aimed at one target 20 feet away. This alignment laser will be placed directly on top of the antenna horn. This will be done by finding the exact center of the horn and placing a removable material around the horn to create a rectangle shape. The laser will be place on the direct center of the material. Figure 29 shows a simple laser that displays a dot for alignment. The cross project will calculate the offset to a target for precision alignment. The Green Line Generating Laser Module, shown in Figure 30, projects a determined length of the two lines at a given distance. The green laser is five times more visible to human eyes than red laser of the same output power, making the green cross line generating laser module a versatile alignment solution for alignment and positioning in all lighting conditions. Figure 31 is a more advanced laser capable of multi-plane alignment.

2.11.1 Monster Military G768BC Adjustable Focus Green Laser Pointer

Figure 29: Green Dot Laser Pointer

2.11.1.1 Benefits

- Small.
- Cost is fairly low.

2.11.1.2 Drawbacks

- Only creates a dot.
- Harmful to human eyes.

2.11.2 Focusable Green Line Generator Module

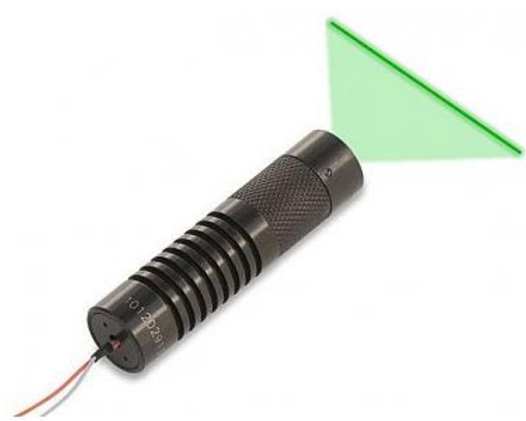

Figure 30: Green Line Laser Pointer.

2.11.2.1 Benefits

- Alignment along an axis.
- Small size
- Cost is fairly low.

2.11.2.2 Drawbacks

- Alignment only along one axis.
- Harmful to human eyes.

2.11.3 Quarton Laser Module VLM-532-47 LPT

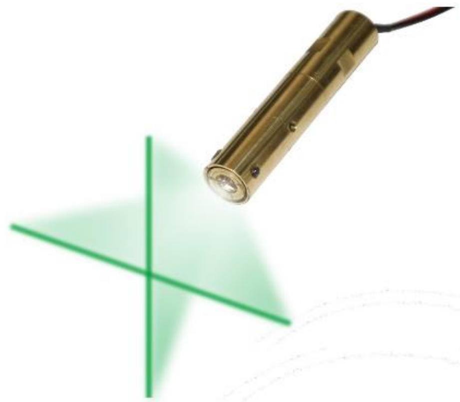

Figure 31: Green Cross Laser Pointer.

2.11.3.1 Benefits

- Alignment along two axis's.
- Small size.
- Cost is fairly low.
- Creates low divergence laser

2.11.3.2 Drawbacks

- Harmful to human eyes.

3 Proposed Design

3.1 Design Overview

This project mostly rests on the selection of certain key components such as the FPGA and antennas. The FPGA is the electronic controller of the radar system. The radar system's functionality is based on the complexity of the FPGA programming. The FPGA will control the timing and generate the pulse to which the antennas transmit RF signals.

The antennas are the next key components of the system. The transmit antennas will emit a pulse, then after a certain designated time period the receiving antennas will receive a reflection of the pulse that was emitted. Instead of the pulse data being shown on an oscilloscope, it will be stored onto the FPGA and used for image processing. Image processing will most likely be done with a program such as LabVIEW which would allow for translating C code written in LabVIEW to VHDL for image processing.

In the event none of the physical tests on the system would be successful (such as the pulse reception and transmission), the designing process would still be thoroughly documented and explain why the test was unsuccessful. In this case the results for the project would be pure simulations, leaving room for improvement if a new team wanted to start working on the project from where the current team left off.

3.1.1 Electrical System

The proposed design for the electrical system is intended to generate a RF signal, transmit that RF signal through antennas, receive scatter reflected from the target, process the received scatter and generate an image based on the characteristics of the received signals. In order to complete these tasks the electrical system contains four main subsystems that simplify the design as well as allow for the completion of the tasks. The four subsystems include the FPGA, the signal transmit path, the signal receive path, and the power distribution.

3.1.1.1 FPGA

The FPGA has multiple responsibilities. It must generate a reference signal for the Voltage Controlled Oscillator (VCO) to use a phase reference, generate a clock pulse to control the switching circuitry, and receive the phase and amplitude of the signals from the receive signal path. It must also output those values to the computer for image processing, receive the imagery from the computer and output the imagery to a VGA display.

3.1.1.1.1 FPGA Demo Board Major Components

- Two Analog to Digital Converter
- One Digital to Analog Converter

3.1.1.1.1 Physical Schematic of Circuit

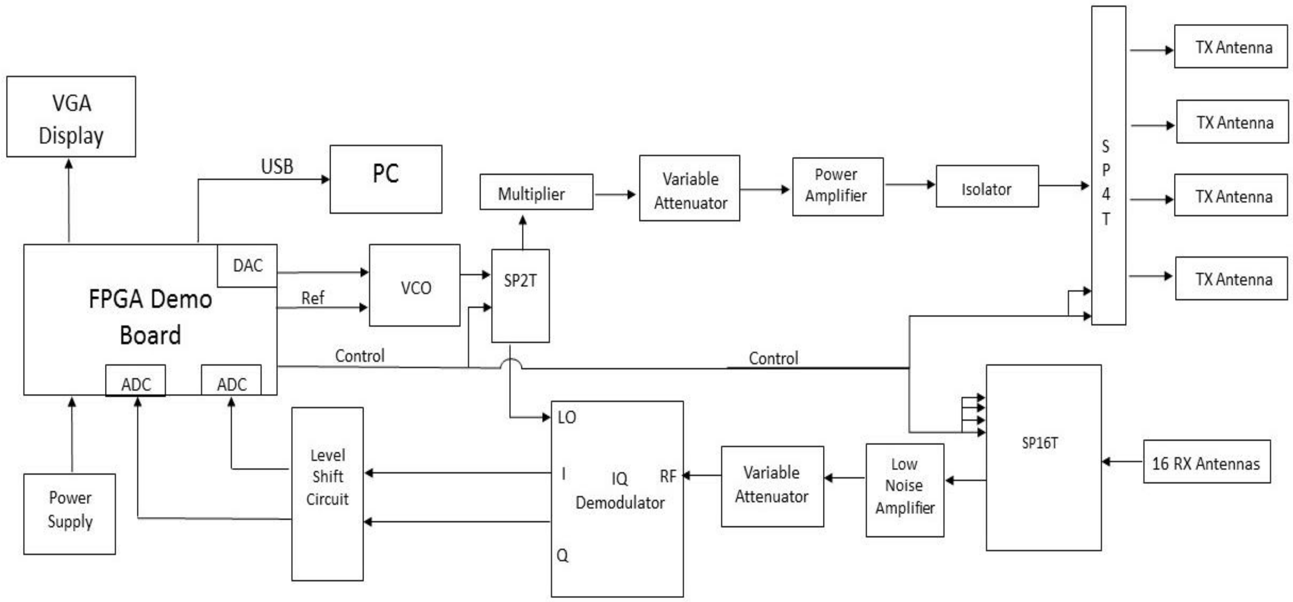

Figure 32: Physical Schematic of the Circuit.

Below is a general guide through the circuit and what each component does. This is what each of the components in concept generation are expected to do in Figure 32.

1. Code gets downloaded into FPGA to create digital signal that maps out the pulse. Creates reference to allow VCO to use it as a phase reference. FPGA will be used to control switches in this schematic.
2. Digital Analog converter gets digital signal and emits an analog voltage
3. VCO takes supply voltage to create high frequency RF pulse.
4. Output from VCO goes to SP2T switch.

The output of the switch is controlled by the input frequency. When the input signal high, the switch is open and when the input is low, the switch is closed.

<u>Transmit path:</u>

1. Frequency multiplier multiplies frequency by 2
2. Variable attenuator reduces power of the signal without distorting the waveform. This is to
3. Power amplifier amplifies the power of the signal. This is to get the power of the decreased waveform from the attenuator to a desired amplitude.
4. Isolator is used to restrict power from flowing in reverse direction. This is done to make sure that power is not received by the transmit antennas.

5. SP4T is controlled by two control signals from the FPGA. This will control which antenna is the one to emit the signal.

Receive path:

1. SP16T switch is controlled by four clock signals from the FPGA. This will control what signal from the specific receive antennas will be gathered.
2. Signal from the switch goes through a low noise amplifier to provide a low noise gain as close as possible to the antennas. This is done because in order to get the most accurate signal, the received noise must be reduced by increasing the gain before the receive signal distorted.
3. Variable attenuator reduces power of signal without distorting waveform.
4. The IQ demodulator will determine the phase and the amplitude of the RF signal. This is done because the phase and the amplitude of the signal reflected to determine if the signal is noise or an actual image.
5. Given I and Q can be a positive and negative voltage around Q, this needs to be able to be sampled by an A/D converter by recognizing negative voltages. The shift level circuit is needed so that zero is the mid-range of the A/D converter. Anything less than the zero point is a negative voltage while anything above that is a positive voltage.
6. A/D converters change analog signal to digital signal
7. FPGA stores data from A/D converter that then sends to the PC for image processing.
8. A program such as Labview will be coded in C to generate image. This would hopefully take care of most of the signal processing.
9. Image gets downloaded to FPGA from the PC and gets output to the VGA display.

3.1.1.2 Transmit Signal Path

The signal transmit path is a very important concept in this design. This subsystem is designed to emit an RF signal capable of reaching a minimum distance of 20 feet from the antennas. In order to complete that task the signal transmit path was designed with the several electronic components described in this section.

3.1.1.2.1 Transmit Signal Path Design Components

- Voltage Controlled Oscillator (VCO)
- Single Pole Double Throw (SPDT) Switch
- Multiplier (2x)
- Variable Attenuator
- Power Amplifier
- Isolator
- Single Pole Four Throw (SP4T) Switch
- Four Transmit Antennas

3.1.1.3 Receive Signal Path

The receive signal path is the subsystem that detects the energy that is reflected off of the object and sends that pulse information to the FPGA. This subsystem is important because it lets the FPGA know whether or not a potential threatening object has been detected.

3.1.1.3.1 Receive Signal Path Design Components

- Sixteen Receive Antennas
- Single Pole Sixteen Throw (SP16T) Switch
- Low Noise Amplifier
- Variable Antenna
- IQ Demodulator
- Level Shift Circuit

3.1.1.4 Power Distribution Design

The power distribution design is the source of power for all of the components in the electrical system design. This design will be based on the required input power for each of the components listed above. The goal is to be able to use a battery supply as the main source of power for this design, however the contingency plan is to use a DC power supply that will convert the AC power from a standard wall outlet to DC. The highest required input voltage for all of the devices is +12V. This will be the set power supply for the entire electrical system. Once this voltage is set on the breadboard, there will be circuits that reduce this voltage to the amounts needed by each component. The power distribution circuit will be implemented on a solder less breadboard.

3.1.2 Antenna Design

The antenna design will consist of two linear antenna apertures, each consisting of eight receive and two transmit antennas – totaling out to be four transmit and sixteen receive antennas. The antenna apertures will be constructed into a T-shaped structure, Figure 33 illustrates the design. For each aperture, eight receive antennas will be linearly aligned, spaced six inches apart from each antenna's center point. A transmit antenna will be placed on both ends of the aperture, spaced three inches from the neighboring receive antenna. Figure 34 illustrates the design of one aperture. The construction of one antenna aperture creates sixteen phase centers – a phase center is a maximum absorbance point of a reflected signal and is located between one transmit and one receive horn antenna. Every horn antenna will be directed towards the target's scene extent, so that each horns' beamwidth will cover the scene extent from twenty feet away. Beamwidth is the angle where the magnitude of the main beam decreases by fifty percent (-3dB). The horns used for the design will be X-band horn antennas with a seventeen decibel gain level (17 dB), which easily covers the scene extent of a human body and more.

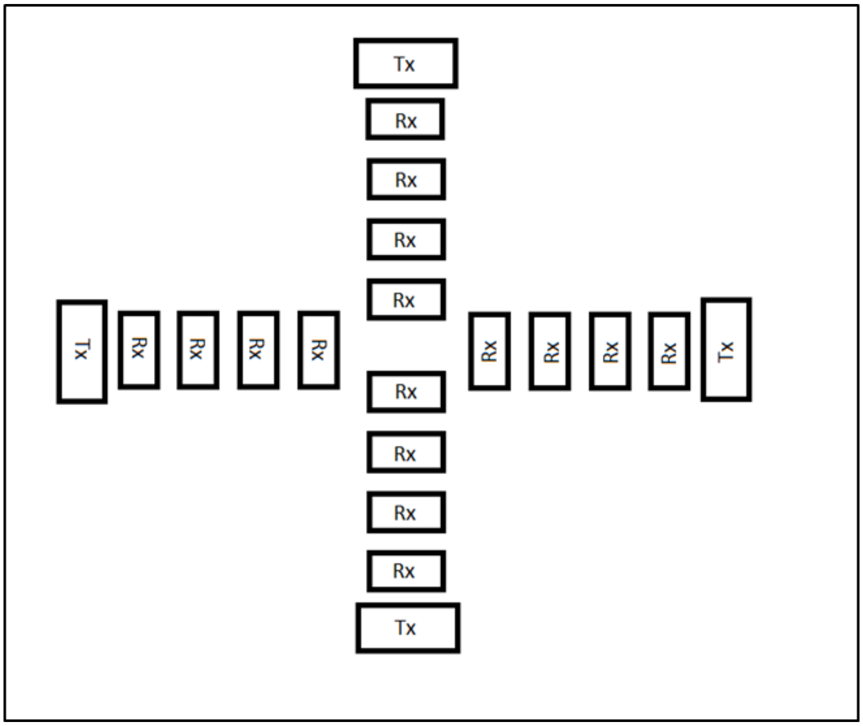

Figure 33: Overall Antenna Design

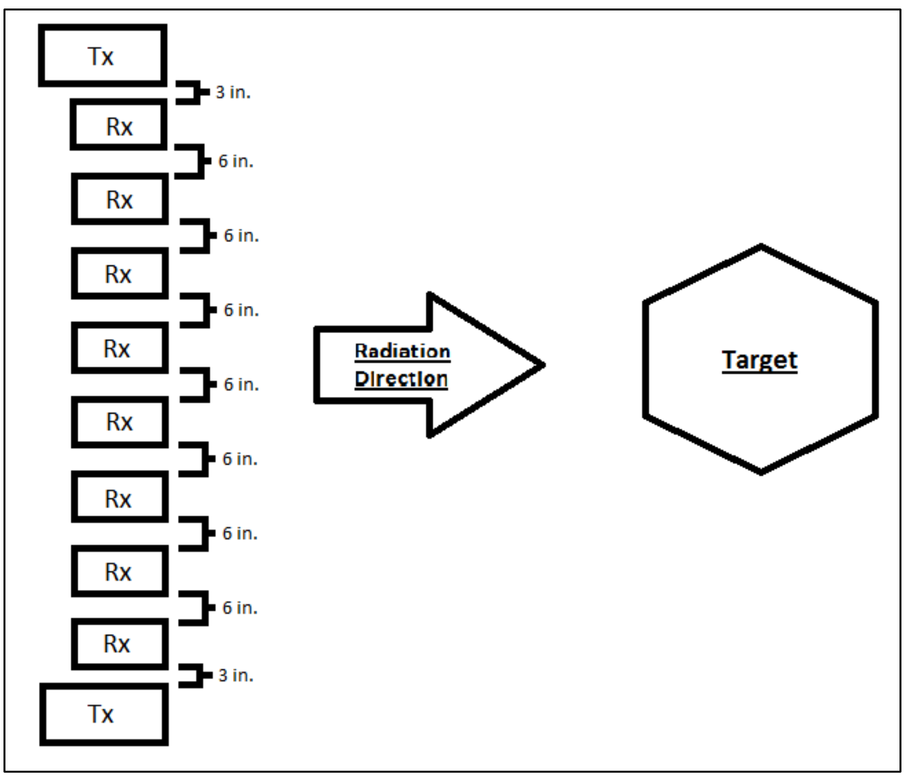

Figure 34: One Antenna Aperture Design

3.1.3 Structure

The T-shape structural design shown in Figure 35 will be the most applicable for the project. This is ideal because of the 16 phase centers created from the arrangement of the horn antennas. The horn structure will be detachable from the stand support allowing the horn structure to be placed on the ground or on a wall. The structure will be made of aluminum based metal due to its lightweight, overall strength, and machinability.

3.1.3.1 3-D Model of T-Shape Horn Structure

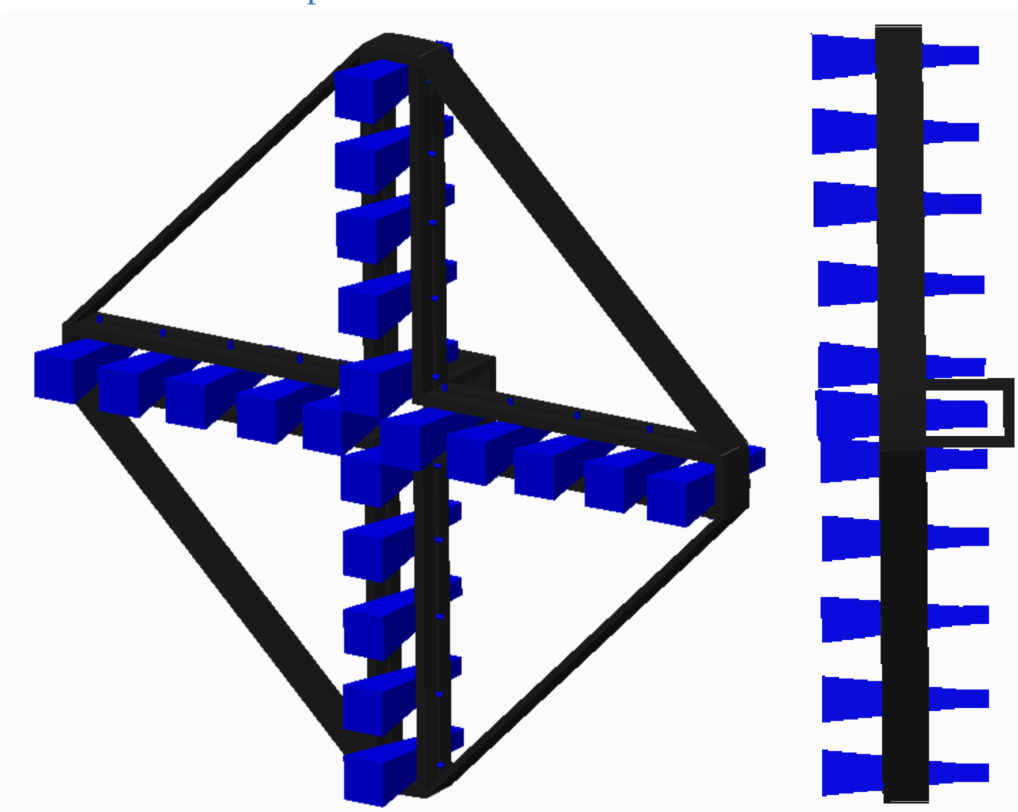

Figure 35: T-Shape Horn Structure

4 Statement of Work (SOW)

4.1 Task 1: Project Management

Responsible Engineer: Jasmine Vanderhorst

The electronic SAR Imager team is an interdisciplinary group comprised of three Electrical Engineers (EE), one Electrical & Computer Engineer (ECE), two Mechanical Engineers (ME), and two Industrial Engineers (IE). The electrical design and computer programming of the radar system will be led by the EE and ECE disciplines. The mechanical integrity of the antenna structure and support for the device will be the responsibility of the ME team members. The IE members will have the responsibility of project management, project budget, quality, scheduling, procurement, testing facilities, and website design.

Jasmine Vanderhorst (IE), Project Manager and Webpage Developer, will be responsible for planning and scheduling appropriate tasks to ensure timely completion of the electronic SAR Imager conceptual design. She will also be responsible for overseeing the project process and assessing any risks and issues that may affect the timeline or quality of the project. She has developed a project schedule with assignable tasks and responsible person(s) for each component of the project (See Section #). All milestones and critical path items have been identified and tentatively scheduled, but are still subject to change for specific Spring 2015 dates and deadlines. She will also have the responsibility of webpage development and maintenance, ensuring that the team has the latest information, diagrams, drawings, and technical documents uploaded to the website in a timely mater.

Matt Cammuse (EE), Assistant Project Manager and Antenna Engineering, will be responsible for scheduling and overseeing the electrical engineering aspects of the project. He is responsible for identifying the electrical contributions and determining the proper timelines for completion. Communication between the assistant project manager and project manager is critical for scheduling the overall milestone timelines. In addition, he will be leading the overall antenna design for the project, which includes determining the necessary type of horn antennas to purchase and the antenna aperture's dimensional values. His full comprehension of the antenna structure's theoretical characteristics will help explain the various performance results during testing.

Malcolm Harmon (ME), Assistant Project Manager, will be responsible for work done by both mechanical partners to be sure we are directed in the correct path. Communication with our sponsor will be relayed through him from a mechanical aspect. He is relied upon to communicate with the Project Manager about scheduling of task goals and completions. It is vital that Malcolm has good communication between the Project Manager and the remaining Assistant Project Managers. This is critical because every component of our project is a vital factor to completion of other milestones in the project. His technical duty is to create multiple designs with the Co-Lead Mechanical Engineer, Mark Poindexter. This involves Creo Parametric 2.0, CAD and other software that prove suitable. All material needed for the Mechanical Engineers will be submitted from Malcolm to the Project Manager with justifications to why this part is suitable for our project.

Patrick Delallana (ECE), Lead Engineer and Programmer, will be responsible for scoping the completion of the entire project. The responsibilities of the lead engineer include, but are not limited to, programming of the FPGA, signal processing, and the communication between individuals of different disciplines to aid in the completion of tasks. The Lead Engineer will have knowledge in every technical aspect of the project, and will be of major resource to Julia, the signal processing engineer. In addition to the tasks specialized for the Lead Engineer, he will provide help to any team member who is facing challenges with their designated tasks. It is the responsibility of the Lead Engineer to mitigate any risks or issues associated with the technical aspects of the project.

Benjamin Mock (IE), Co-Lead Industrial Engineer and Treasurer, will be responsible for the procurement of all meeting rooms, testing facilities, and various necessary equipment regarding the former tasks. His largest responsibility will be ensuring that the engineering design is performed concurrently and that all aspects of each sub-function are designed with the capabilities and constraints of the overall end product and subassemblies. He is also responsible for the group's ability to effectively communicate their designs in a tactful manner whilst drafting and presenting all deliverables of the team. He will also share responsibility with Jasmine in constructing a House of Quality and Voice of the Customer decision tree. He will also share responsibility with Jasmine in assessing project issues and risks associated with the timeline, budget, or overall project progression. Benjamin also assumed the role of team Treasurer in accordance with the Industrial Engineer's responsibility of procuring all equipment and necessary technologies for the testing and design of the SAR Imager. He will be responsible for communication with Ms. Donna Butka for purchasing through the FAMU Foundation and establishing and maintaining a working budget through the entirety of the project scope.

Joshua Cushion (EE), Radio Frequency (RF) Engineer and Co-Lead Engineer, will be responsible for calculating the radar range equations. The radar range equations are calculated using the performance characteristics set by the customer requirements. He will also be responsible for performing the Advanced Design Simulation (ADS) of the system. The ADS involves creating a mathematical model of the transmit and receive paths and performing the simulation using equations that model the characteristics of the device in both paths. He is also responsible for working with Julia on designing the electrical system which involves selecting hardware as well as designing a power supply for the system.

Julia Kim (EE), Signal Processing Engineer and Document Control, will be responsible for the signal processing analysis aspect of the project by calculating the signal-to-noise ratio (SNR). She will also be responsible for implementing Fast Fourier transform type algorithms to do calibration and image formation. She will also be assisting Joshua with the design of the system circuit that includes all the required components for the imager. Julia is also responsible for document control for the project. She is responsible for meeting minutes from any correspondence with project sponsors and advisors. She is responsible for making the minutes available to all team members, reviewers, advisors, and project coordinators via the group blog. She will also be working with Jasmine to ensure proper document control on the website.

Mark Poindexter (ME), Co-Lead Mechanical Engineer, will help the Antenna Engineer with alignment of the horns to the object area. He also shares responsibility with Malcolm for designing the structure to hold the horns, the components box for the electrical components, and the supports to hold the horn structure. Mark will also share responsibility with Malcolm for detailed professional design drawings using Professional Engineering (Creo Parametric 2.0) software. He will have responsibility for choosing the material of the entire structure with Malcolm. Mark will also share responsibility with Malcolm for the construction of the SAR Imager as a whole unit with help from the entire team on a need to need basis. Mark will be responsible for building a frame to house the radar absorbing foam material. Mark will also support Jasmine with any Mechanical Engineering guideline for the team webpage.

4.1.1 Objectives

The project management objective of the electronic SAR Imager team is to design a low cost, fully functional electronic synthetic active aperture radar imager with low resolution imaging for prototyping and research purposes for Northrop Grumman. To ensure successful implementation of requirements set by Northrop Grumman the team will use the skills and expertise in engineering principles as well as a steep learning curve about the applications of SAR imaging. With this knowledge the team shall produce electronic antenna hardware, low resolution non-nude like images, and safe testing strategies for the conceptual design.

Additional project management objectives includes the ability to ensure the project is delivered under the budget of $50,000. In addition to fiscal responsibility, the team will ensure the project is delivered in a timely manner by meeting deadlines and all major milestones as set by the respective engineering departments and the team Gantt chart. The team shall also provide quality solutions in reducing errors in calculations and testing, improving the effectiveness of low resolution imaging, and appropriate risks management for any issues that arise. The team will also implement internal controls for communication and conflict resolution in the case that any issues arise throughout the duration of the project. Lastly, the team shall know, understand, and implement any ethical, confidentiality, and safety standards imposed by both FAMU and FSU as well as Northrop Grumman.

4.1.2 Approach

To successfully complete the design of the electronic SAR imager project, the team will allocate the technical and mechanical tasks into several subtask to be handled by the appropriate engineer. The subtasks include, but are not limited to power circuitry, VHDL programming, component procurement, assembly and component testing, as well as reporting. Each subtasks is critical to the progression of the project and overall completion of a successful conceptual design. To ensure each tasks is thoroughly accomplished, the Lead Engineer and Co-Lead Engineers will work together in conjunction with the Industrial Engineers to make sure all scheduled tasks have been examined and implemented correctly. It will be the responsibility of the Project Managers to ensure adequate communication of expectations and understanding of project deliverables and milestones. Each team member, however, is accountable for the necessary progression of work in their specific technical area as well as documenting the necessary steps, guidelines, or procedures associated with their process. Each team member will be responsible for keeping the team abreast of important information or accomplishments achieved throughout the project.

4.2 Task 2: Treasurer

<u>Responsible Engineer: Benjamin Mock</u>

4.2.1 Objective

The objective of the Treasurer role is to establish a singular line of communication between all stakeholders, vendors, and team members and establish a system that is easily reviewable concerning all financials and expenditures.

4.2.2 Approach

The Treasurer will approach these objectives by presenting reports at each internal team meeting, biweekly stakeholder meeting, and weekly sponsor meeting if necessary. All expenditures will be filed through Ms. Donna Butka in the Electrical Engineering Department.

4.2.2.1 Subtask 2.1: Budget Implementation & Control

4.2.2.1.1 Objective

The objective of Budget Implementation and Control is to create and maintain a living document that highlights all aspects of the $50,000 budget. This document will highlight all expected expenditures, budgeting for subassemblies, and clearly specify all necessary overhead.

4.2.2.1.2 Approach

The Budget will be implemented in four categories Expected Costs, Realized Expenditures, Ordered Costs, and Overhead. These will aid in determining the current status of the budget. The Budget will be mapped out over an Excel spreadsheet and it will be customized to highlight the largest expenditures and note all necessary information to identify every component. It will be controlled in relation to the Gantt chart and ensuring that all purchases are processed and recorded with Ms. Donna Butka and the Excel spreadsheet.

4.2.2.1.3 Verification

The Project Manager will ensure that all purchasing and procurement as well as all funds are appropriately secured relative to the project timeline. The PM will also be responsible for performing necessary audits at each internal Gate review, to ensure that all items and receipts have been properly documented.

4.3 Task 3: Product Procurement

<u>Responsible Engineer(s): Benjamin Mock & Jasmine Vanderhorst</u>

4.3.1 Objective

The primary objective for Product Procurement is to integrate the manufacturing lead times of all components with the product schedule to ensure the successful completion of the product. The secondary objective of product procurement is to establish a singular line of communication between the team and all vendors, and stakeholders relative to those concerns.

4.3.2 Approach

This task will be approached by contacting all vendors of all proposed components and determining their lead time and then creating a trade-off decision matrix concerning their respective. All team members needing the procurement of a component will submit their explicit request in writing to the Co-Lead Industrial Engineer so that they may contact Ms. Donna Butka and the necessary vendors to ensure a successful purchase order is completed.

4.3.2.1 Verification

The Project Manager will audit all purchase orders for all components to ensure that the lead time presented by the manufacturers are noted relative to the project timeline. All team members that submit requests will be notified of any and all challenges or successes with the product procurement.

4.3.2.2 Subtask 3.1: Vendor Inquiry

4.3.2.2.1 Objective

The objective of vendor inquiry is to ensure that a manufacturer can meet the necessary qualifications in order to utilize the budget provided to the project through the FAMU-Foundation and assess all lead time and prices when deciding on component selection.

4.3.2.2.2 Approach

The approach to vendor inquiry will be done by team members submitting a list of all components, model numbers, and distributors so that the Co-Lead Industrial Engineer may contact these vendors and determine the necessary information listed below.

- They must be willing to accept purchase orders.
- They must provide a W9 or a W.BEN.
- They must provide a quote for university pricing.

4.3.2.2.3 Verification

This will be verified when the Industrial Engineer receives an inquiry request from any team member by them asking and ensuring that these components fit into the specified design of the SAR Imager. Once the necessary information has been acquired form the vendor the Industrial Engineer will notify either Ms. Donna Butka for purchasing or the respective team member for an alternate component.

4.3.2.3 Subtask 3.2: Product Purchasing

4.3.2.3.1 Objective

The objective of product purchasing is to ensure that all components are ordered in such a manner that they are delivered with enough time for them to be tested within the imaging apparatus.

4.3.2.3.2 Approach

Product purchasing will be done in conjunction with the Co-Lead Industrial Engineer and Ms. Donna Butka of the Department of Electrical and Computer Engineering. Once the vendor inquiry was been successfully completed and the lead computed into the Gantt chart by the PM an ordering date and expected delivery date will be determined. From these dates and the simulation and testing milestone along the Gantt chart, products will be ordered to ensure proper completion of all tasks.

4.3.2.3.3 Verification

Product purchasing will be verified by the Project Manager and all necessary team members with which the ordered part will directly be utilized by. They will determine the most appropriate date that they need to have their parts received by, and they will aid in ensuring that the Co-Lead Industrial Engineering has purchased their requested components.

4.4 Task 4: Facility Procurement

Responsible Engineer: Benjamin Mock

4.4.1 Objective

The objective of Facility Procurement is to ensure that the appropriate environment is secured for all aspects of the project in which the team will need to meet or performs test.

4.4.2 Approach

It shall be the responsibility of the Co-Lead Industrial Engineer to ensure that the appropriate facilities are available and secure within at least two weeks ahead of the expected meeting time.

4.4.3 Verification

The Co-Lead Industrial Engineer will send reminders one week in advanced to all affiliated parties to ensure that the requested facility is still available and relay this information to the Project Manager.

4.4.3.1 Subtask 4.1: Weekly Team Meeting Room Procurement

4.4.3.1.1 Objective

The objective of the Weekly Team Meeting Room Procurement will be to ensure that the internal team meetings are held in a facility that allows the team to communicate effectively and work cohesively towards their agenda's goals.

4.4.3.1.2 Approach

This will be approached by the Co-Lead Industrial Engineer in conjunction with the Gantt chart so that all functions of the project are considered when securing the appropriate facility for the weekly internal team meetings. Generally, these meetings will occur within room A207 every Tuesday at 7:00pm.

4.4.3.2 Subtask 4.2: Weekly Sponsor Meeting Room Procurement

4.4.3.2.1 Objective

The objective of this subtask is to ensure that an appropriate room is selected for the weekly sponsor meeting and that that facility is equipped with the necessary technologies to expedited communication.

4.4.3.2.2 Approach

This task will be completed by contacting Communication and Multimedia Services (CMS) with the FAMU-FSU College of Engineering and securing the conference room A329. All stakeholders will be notified of the meeting every week should they need/desire to attend.

4.4.3.2.3 Verification

This will be verified via the Project Manager and CMS to ensure that the room is available at the specified times and so that all technologies are also available when desired.

4.4.3.3 Subtask 4.3: Facility Procurement

4.4.3.3.1 Objective

The objective of Facility Procurement is to ensure that all testing and storage facilities related to the project are secured within a timely fashion and that all team members are made aware of such policies concerning access to these facilities.

4.4.3.3.2 Approach

Communication between Frank Allen of the High Performance Materials Institute (HPMI) and the team will be established by the Co-Lead Industrial Engineer. Their joint efforts will determine the availability of storage for the electronic SAR Imager and its components will be determined based on space availability at the HPMI. Testing facilities will be established in a controlled environment at the specified room temperature and relative humidity that can support the testing of such a system at a range of 20ft; this will be solidified as the team approaches its testing phases.

4.4.3.3.3 Verification

The process will be verified by the Project Manager and the Lead Engineer to ensure that the secured facilities are the most appropriate for the needs of the team.

4.5 Task 5: Industrial Engineering

Responsible Engineer(s): Benjamin Mock & Jasmine Vanderhorst

4.5.1 Objective

The objective for Industrial Engineering relative to the completion of the electronic SAR Imager will be to ensure that all design are conceived relative to the voice of the customer and the constraints of all subassemblies as they are defined. Industrial Engineering will also assume the roles of Project Manage and Treasurer to expedite the processes of project completion and component procurement.

4.5.2 Approach

The approach behind Industrial Engineering will be through the scientific utilization of the Gantt chart and processed gate design reviews for quality assurance and compatibility engineering. Reviews at all internal team meetings will ensure that all tasks are being completed thoroughly and on-time and that all functions of the design are conscious of the other assemblies on the Imager.

4.5.2.1 Subtask 5.1: House of Quality

4.5.2.1.1 Objective

The objective of the House of Quality (HOQ) is to establish a precedence of the functional requirements as they relate to the customer requirements and provide a tool for analyzing the SAR Imager in conjunction with overall quality.

4.5.2.1.2 Approach

This will be done through a Microsoft Excel template and will relate each functional requirement's correlation to the subsequent requirements. The HOQ also establishes the strength of the relationship between the customer requirements and the functional requirements and compares those relationships to competitors.

4.5.2.2 Subtask 5.2: Voice of The Customer Tree

4.5.2.2.1 Objective

The objective of the Voice of the Customer Tree is to establish the customer requirements (wants) with the processes and constraints of the functional requirements and project plan (hows).

4.5.2.2.2 Approach

This will be approached by the Co-Lead Industrial Engineer and the Project Manager to translate the voice of the customer into the tasks and schedules of all team members.

4.6 Task 6: Risk Management

<u>Responsible Engineer: Benjamin Mock</u>

4.6.1 Objective

The objective of this task is to identify and minimize all potential risks to the successful completion of the project with regards to the Gantt chart and project deliverables. The accounted risks will include evaluations from all stages of the project including: project planning, component analysis and procurement, simulation and testing, facility acquirement, concurrent design and analysis, document control, and reporting.

4.6.2 Approach

Risk management involves assessment and preventative management to ensure that all risks are identified and mitigated so that they do not progress to issues. The Industrial Engineer will be responsible for ensuring that each team member is aware of all risks pertaining to the functions and sub-functions of the portion of the project in which they are working. Both the particular team member and the Industrial Engineer will retroactively and proactively analyze all past and future risks from the given analysis and provide a report to the project manager so that the entire team will be made aware at the following meeting.

4.6.2.1 Subtask 6.1: Initial Risk Assessment

4.6.2.1.1 Objective

The objective of the initial risk assessment will be to identify and understand all potential threats to successful completion of the Needs Analysis and Requirements Specifications Report and the Project Proposal Report. These risks will be clearly stated in both reports and provide the team with starting points to allow all project stakeholders to overcome the presented challenges.

4.6.2.1.2 Approach

This will be accomplished through analyzing the project scope and the capabilities and qualifications of all team members and using this information to assign all tasks and responsibilities. By aligning these duties in a Gantt chart, this will allow the Project Manager to hold accountable all members' actions and mitigate all potential risks relative to the project timeline.

4.6.2.2 Subtask 6.2 Continual Risk Assessment

4.6.2.2.1 Objective

The objective of the continual risk assessment will be to provide a living procedure for the team to analyze the risk of all decisions made throughout the project and provide a system for the team to effectively handle all issues that may occur, both externally and internally.

4.6.2.2.2 Approach

The Industrial Engineer will act as the risk manager at all team meetings to ensure that all risks are identified before and after each design gate has been completed. This will be completed by analyzing Appendix 3 *The House of Quality* to ensure that all changes, design implementations, etc. are documented to show how all risks might affect all areas of the conceptual design for the SAR Imager.

4.7 Task 7: Antenna Design

Responsible Engineer: Matthew Cammuse

4.7.1 Objective

The objective of this task is to create an appropriate antenna design for one antenna aperture that will create sixteen phase centers that are equally spaced from each other. Then, combine the antenna apertures to create an overall T-shaped antenna structure. In addition, select the necessary horn antennas with gain and beamwidth values that will cover the scene extent from twenty feet.

4.7.2 Approach

The first step is to determine the appropriate azimuth and altitude beamwidth values for a scene extent twenty feet away using basic trigonometry techniques, which correlate to the necessary gain value for the each horn antenna. However, the selected horn antennas will be selected based on price and relative gain levels. The appropriate theoretical horn antennas may not be utilized. To create sixteen phase centers for one aperture, each horn must be appropriately spaced to reduce the effect of grating lobes. Spacing will be based on the width of the determined horn antennas, but the distance between each antenna is small.

4.7.2.2 Subtask 7.2: Structural Design

4.7.2.2.1 Objective

The objective of this assembly is solely dependent on the Antenna Engineer's design. Every component of the SAR Imager must be aligned in a way that will correlate with the calculations provided for the signal pulse. The assembly must also be large enough to hold all of the horns with an equal distance between each. Providing an easy access compartment on the back of the Imager, the assembly will be able to house all of the electrical components as well. In order to have this structure properly held upright, the assembly will consist of a component that will allow it to be held on a tripod. For versatility, the component will have access to a wall mount as well.

4.7.2.2.2 Approach

The mechanical engineers will first receive the calculation results from the electrical engineers. This will provide an exact location to where each horn has to be aligned and the size of the structure. After the results have been received, the mechanical engineers will begin their separate calculations in order to construct the assembly.

4.7.2.3 Subtask: Structure

4.7.2.3.1 Objective

The objective of this task is to construct a body to hold both the electrical components as well as the mechanical components. This structure will allow for access to either a vertical stand or a wall mount.

4.7.2.2.3.2 Approach

The nature of the arrangement of the antenna horns requires a unique structure to hold them appropriately. This will drive the structure to hold the electrical components in a container that is not available as a commercial-off-the-shelf good, therefore, it is the plan of the team to design and print a container that efficiently holds all components.

4.7.2.4 Subtask: Frame

4.7.2.4.1 Objective

The objective of this task is to construct a frame using a design that will hold all twenty antenna horns. This frame must allow the horns to have three degrees of freedom. On a conventional axis frame, the horn must be able to slide up and down the x axis, and rotate about the y and z axis.

4.7.2.4.2 Approach

It is the plan of the team to ensure that the necessary attachments for the antenna horns on the structure are adjustable.

4.7.2.5 Subtask: Horn Alignment

4.7.2.5.1 Objective

The objective of this task is to align the horns at the correct angle towards the scene extent.

4.7.2.5.2 Approach

A laser will be purchased and used to align each horn. This laser will have a cross projection for precision alignment. There will be a custom mechanism added to the waveguide to provide three axis of adjustment.

4.8 Task 8: Electrical Design

Responsible Engineer: Joshua Cushion and Julia Kim

4.8.1 Objective

The objective of this task is to design a hardware system capable of generating and receiving the necessary pulses that will be used to detect objects within a distance of twenty feet from the transmit and receive antennas. In addition, the electrical system will be able to perform signal processing in order to generate and display the detected image on a VGA display.

4.8.2 Approach

To calculate the parameters given by the radar range equations, perform simulations of transmit and receive signal paths and to determine components capable of producing these parameters as calculated.

4.8.2.1 Subtask 8.1: Simulations

4.8.2.1.1 Objective

The objective is to simulate transmit and receive signal paths for the electrical system.

4.8.2.1.2 Approach

This will be completed using mathematical models for non-linear circuit behavior. Both paths will be simulated separately. The transmit path will consist of cascaded elements such that the output power for a device will be used as the input power for the device that it is fed into.

4.8.2.2 Subtask 8.2: Determining Radar Range Equation Parameters

4.8.2.2.1 Objective

To calculate values for transmit power, receive power, and noise figure. This is necessary in order to determine if the electrical system is capable of transmitting and receiving signals.

4.8.2.2.2 Approach

Using the radar range equation shown below and inputting the values from the component specifications and the simulations of the transmit and receive paths.

$$\frac{S}{N} = \frac{P_t G^2 \lambda^2 \sigma}{(4\pi^2) R^4 k T_S B_n L}$$

Radar Range Equation

S: Received Signal Power (W)
N: Receiver Noise Power (W)
P_t: Transmit Power (W)
G: Antenna Gain
λ: Wavelength (m)
σ: Radar Cross Section (m^2)
R: Distance to target (m)
k: Boltzman's Constant = 1.38E-23 J/°K
T_S: System Noise Temperature (°K)
B_n: Noise Bandwidth of Receiver (Hz)
L: Total System Loss

4.8.2.3 Subtask 8.3: Component Selection and Analysis

4.8.2.3.1 Objective

To select components that fit the design requirements and are capable of performing as designed.

4.8.2.3.2 Approach

Based on the transmit and receive signal path simulations as well as the radar range equation calculations, the components will be chosen by looking at the datasheets and verifying they have the desired specifications.

4.9 Task 9: Field Programmable Gate Array Control Processing

Responsible Engineer: Patrick Delallana

4.9.1 Objective

The objective of this task is to electronically control the SAR Imager system via the Field Programmable Gate Array (FPGA) board.

4.9.2 Approach

The approach for this task will be to separate it into different subtasks in order to make it more manageable.

4.9.2.1 Subtask 9.1: Code for Pulse Generation

4.9.2.1.1 Objective

The objective of the code for pulse generation is to generate a 20 nanoseconds pulse with a 40 nanoseconds period.

4.9.2.1.2 Approach

The code will be written in VHDL and simulated first on ModelSim. After a successful simulation, the code will be tested on an FPGA board to see if it can generate the desired pulse.

4.9.2.2 Subtask 9.2: Timing

4.9.2.2.1 Objective

The objective of the timing is for the FPGA to have accurate timing for the system to control the single pole multiple throw switch.

4.9.2.2.2 Approach

The approach for this task will be to make a timing diagram with all the pulses that need to be controlled. This will map out the pulses relative to each other. This will allow the FPGA to control some of the sampling data that is received, and the receiving data will then be stored onto the FPGA.

4.9.2.3 Subtask 9.3: Information Storage in Memory

4.9.2.3.1 Objective

The objective of this task is to store the data captured by the receiver into the FPGA.

4.9.2.3.2 Approach

After the timing of the FPGA is correctly calibrated the receiver would have the analog signal turned into digital signal for the FPGA to store. The configuration of the A/D converter may have to be done.

4.9.2.4 Subtask 9.4: Output to Display

4.9.2.4.1 Objective

The objective of output to display is to capture the memory that was received from the A/D converter and stored into the FPGA to send it to a PC for processing.

4.9.2.4.2 Approach

There are programs that allow for easier image processing of data. The desired approach is to program a software that allows for image processing, such as Labview in C that will translate code in VHDL for this purpose. If this cannot be done, a simple scope can be used instead.

4.10 Task 10: System Assembly

Responsible Engineers: Patrick Delallana, Julia Kim, Joshua Cushion, Matt Cammuse, Malcom Harmon, Mark Poindexter

4.10.1 Objective

The objective of this task is to set up all the electrical and mechanical components of the system after it has been designed. This will allow for proper testing of the system.

4.10.2 Approach

The mechanical engineers Malcom Harmon and Mark Poindexter will work on the setup of the antennas and the electrical engineers will work on the setup of the electrical components.

4.10.2.1 Subtask 10.1: Mechanical Assembly of Antennas and Equipment

4.10.2.1.1 Objective

The objective of this subtask is the mechanical set up of the antennas and equipment.

4.10.2.1.2 Approach

Mechanical engineers will set up the mechanical components of the system. They will work on the antenna set up with the antenna engineer to assure proper spacing and also make sure the components for the rest of the schematic can be properly fit in the designated location.

4.10.2.2 Subtask 11.2: Electrical Assembly of Components

4.10.2.2.1 Objective

The objective of this task is to set up the system with the electrical components as designed.

4.10.2.2.2 Approach

All of the Electrical Engineers will work on connecting the electrical components of the system to match the design schematic. The Electrical Engineers may also assist the Mechanical Engineers for the antenna set up as well.

4.11 Task 11: System Testing Plan

Responsible Engineer(s): All ECE and ME team members

4.11.1 Objective

The objective of this task is to have a detailed system testing plan that would be required for the team to achieve the learning goal.

4.11.2 Approach

The approach for the system testing plan would be to divide the previous tasks into tests in order to verify that the radar system is being set up successfully. The tests will be repeated as needed until

4.11.2.1 Subtask 12.1: Transmit Pulse

4.11.2.1.1 Objective

The objective of this task is to check if the transmit antenna emits a signal.

4.11.2.1.2 Approach

The approach to this task will be done by using an RF meter to check if a signal is detected.

4.11.2.2 Subtask 12.2: Receive Pulse

4.11.2.2.1 Objective

The objective of this task is to check if the receive antenna receives a signal.

4.11.2.2.2 Approach

The approach for this task will be done by checking to see if receiver picks up any sort of signal.

4.12 Task 12: Result Evaluation

Responsible Engineer: All team members

4.12.1 Objective

The objective of this task is to check the results of the overall project with the desired results from the project proposal. Electrical Engineers will check for pulse transmission/receiving and imaging results while Mechanical Engineers will check for physical layout of components and antennas. Industrial Engineers will examine the overall budget of the project at the end.

4.12.2 Approach

All Engineers will be responsible for comparing the results of the tests to what was desired in the project proposal. If the results do not match what was desired, this should be thoroughly explained why and give another outlook to how this could be completed in a future project. This is a very important part of the report because this will give the audience proof that the engineers on the team understood the entire project.

4.12.3 Outcomes of Task

The outcomes of the Result Evaluation will be documented and this is covered in 4.12 Task 12: Project Documentation.

4.13 Task 13: Project Documentation

Responsible Engineer(s): All team members

4.13.1 Objective

For the task of project documentation, the objective is to provide project updates to all stakeholders, including our Northrop Grumman sponsor and advisors. The presentations will be condensed versions of the report as there is limited time for presentations. If needed, all documentations will be available in the group website and in the group blog on Blackboard.

4.13.2 Approach

The approach for project documentation is to have and provide a thorough analysis and progress on all aspects of the project. This task allows team members to make appropriate choices and decisions and for the team sponsor and faculty advisors to keep track of the team's progress and formulate feedback.

4.13.2.1 Subtask 13.1: Weekly Meeting Minutes

Responsible Engineer: Julia Kim

4.13.2.1.1 Objective

The objective of the weekly meeting minutes is to have a log of all the meetings held, which include internal team meetings, team meetings with the sponsor, team meetings with advisors/coordinator, and they will provide the team with documentations of project discussions and decisions.

4.13.2.1.2 Approach

The approach taken for this task is to have a detailed record of the decisions made by the team during all of the meetings held. They will be used to make sure that everyone on the team is on the same page and that suggestions and advice given by the sponsor and advisors are taken into account.

4.13.2.1.3 Outcomes of Task

Team members will have access to all meeting minutes so a member would be able to catch up if he/she misses a meeting. If a team member is having trouble remembering something that was said previously during a meeting, he/she would be able to look it up in the minutes.

4.13.2.2 Subtask 13.2: Project Reports and Presentations

Responsible Engineers: All team members

4.13.2.2.1 Objective

The objective is to work on milestone reports that help and guide the team during the design and implementation processes and provide them to the Northrop Grumman sponsor and team advisors and coordinator. There are five reports throughout the year with due dates assigned by the coordinator.

4.13.2.2.2 Approach

The approach for this task is to work through each milestone report in detail with information available. In these reports, the team will propose the chosen design and prepare a top-level diagram for it, plan out detailed schedule and budget plans, analyze risk assessments, etc. The reports will be submitted on the group blog on Blackboard and on the website and emailed out to all faculty advisors and sponsor in order for them to keep track with our progress.

4.13.2.2.3 Outcomes of Task

After each report is completed, the team sponsor and faculty advisors and coordinators will be updated on the team's progress.

4.13.2.3 Subtask 14.3: Testing Reports

Responsible Engineer(s): All team members

4.13.2.3.1 Objective

The objective for the testing results is to provide the sponsor and the faculty advisors on the status of testing realized.

4.13.2.3.2 Approach

The approach for the task is to write reports for every test realized by the testing team as they go through the testing plan developed. The reports will be uploaded on the group blog so that interested parties can go through them. If there are any unsuccessful tests, the team will inform the group and provide detailed results. Suggestions for a successful test will be discussed and the best solution will be implemented and retested.

4.13.2.3.3 Outcomes of Task

The team will have a logbook of all testing reports that contain details on the testing realized. If there are any failed tests, the testing report will contain details on what failed and suggest solution to the problem.

5 Risk Assessment

The following section will analyze the potential risks to completion of the project as defined in its scope and schedule. Each risk will analyze the overall assessment of each challenge as well as provide the team's mitigation strategy to prevent the challenge from becoming an issue.

5.1 Component Procurement Risks

5.1.1 Faulty Lead Time Estimate

5.1.1.1 Assessment

Faulty lead time estimate strain the project plan and testing plans because it is impossible to test parts that one does not have access too. All team members and all subassemblies are at risk to this relatively uncontrollable situation.

5.1.1.2 Mitigation Strategy

It is the plan of the team to take lead and delivery times in to consideration when purchasing components and to pre-order items with enough time to be able to react to such a situation.

5.1.2 Procurement Policy Difficulties

5.1.2.1 Assessment

The selection of components also depends on the vendor's ability to provide information as described in section 4.3.2.2.2. This difficulty will cause a delay in ordering the part and potentially require the team to choose a non-optimal alternative should the vendor be unable to provide the requested information. The FAMU-Foundation also only reimburses purchases made by FAMU students, of the eight member team, only one is a registered FAMU student; this requires that all non-procured purchases must be charged in their name.

5.1.2.2 Mitigation Strategy

It is the plan of the team to ensure that all components that are considered have vendors that are compatible as previously prescribed. It is also the plan of the team to submit in advanced to the Treasurer all non-procurable purchases requests, so that the Project Manager will have ample time to purchase the needed parts in their name for reimbursement through the FAMU-Foundation.

5.1.3 Faulty Components

5.1.3.1 Assessment

Components that are delivered may not always be up to the quality expected upon ordering. Should these faulty components be delivered they may delay assembly and testing plans.

5.1.3.2 Mitigation Strategy

It is the plan of the team to pre-order products, but should a faulty part arrive the manufacturer will be contacted immediately and a resolution shall be made. For parts that are of minimal price and susceptible to damage, multiple will be ordered to prevent the hassle.

5.1.4 Necessary Background Research

5.1.4.1 Assessment

The scope of this project requires that the team become familiar with material and content that has not previously been mastered. Although this risk is common to most projects within the engineering profession it may cause unanticipated delays in designing for it will require the responsible engineer to first become familiar with the *new* material before an appropriate decision can be rendered. These delays, if not adequately prepared for, may cause a disruption in the project's time line.

5.1.4.2 Mitigation Strategy

It is the plan of the team to intensely define what is not yet known amongst all of its team members and provide the most accurate estimate for the time needed to master and/or be advised on the content unfamiliar to the team.

5.1.5 Unanticipated Tool Procurement

5.1.5.1 Assessment

During the testing and assembly stage it may be that a tool is necessary for the completion of the task at hand but that the team does not have that tool on stock or available to them at the time of use. This situation would potentially cause a delay in the testing and assembly phases and thusly a delay in the overall project time line.

5.1.5.2 Mitigation Strategy

It is the plan of the team to ensure that all tasks are designed with the production and testing phases in mind. The concurrent engineering practice will ensure that the electronic SAR Imager is built on schedule and with as few threats to the overall quality as possible.

5.1.6 Fragile Components

5.1.6.1 Assessment

It is the nature of electrical components to be fragile and easily damaged when exposed to unnecessary strains, such as bending or dropping. These components may become compromised in their ability to successfully operate as demanded thusly also compromising the overall completion of the testing and assembly of the electronic SAR Imager.

5.1.6.2 Mitigation Strategy

As noted in section 5.1.3.2 multiple components will be ordered where deemed appropriate by the responsible engineer in conjunction with the Treasurer. For components that are not justifiable in ordering multiples the storing and care for these devices will be accompanied by the purchasing and implementation of necessary containers, if they are not already provided.

5.1.7 Non-Integrated Circuit Components

5.1.7.1 Assessment

Some electrical components may be produced in a way that requires them to be soldered into a specific location instead of the breadboard compatible components preferred by this conceptual design. Soldering and the necessary subassemblies that may require it could affect the overall quality of the components themselves and their placement within the entire system.

5.1.7.2 Mitigation Strategy

It is the plan of the team to generally procure electrical components compatible with breadboards to mitigate the risk wherever possible.

5.1.8 Component Failure

5.1.8.1 Assessment

It is the nature of components to degrade over time, given the quality of the manufacturers some components may fail in ways not previously mentioned in the risk assessment. These failures may cause delays with the testing and overall schedule of the electronic SAR Imager. This risk will also cause the need to procure a replacement device that may affect the teams' overall budget and projected savings.

5.1.8.2 Mitigation Strategy

It is the plan of the team to procure products from secure and trusted vendors as detailed in the section 4.3.2.2.2 and to test all received products to ensure that they are operational with respect to their role within the electronic SAR Imager.

5.2 Facility Procurement Risks

5.2.1 Proper Storage

5.2.1.1 Assessment

The lack of proper storage may cause a lack in proper inventory control and ultimately an inability to appropriately test and store the electronic SAR Imager. This may cause significant delays in terms of project completion and may force the components of the system to be stored in various locations through the FAMU-FSU College of Engineering and the High Performance Materials Institute (HPMI).

5.2.1.2 Mitigation Strategy

The Industrial Engineer and the Project Manager will meet with Frank Allen, Operations Director of HPMI, to discuss the options available to the team for storage within the facility. All considerations will be given to the procurement of components and the eventual assembly of all components when portioning the correct amount of space.

5.2.2 Component Tolerance to Electrostatic Discharge

5.2.2.1 Assessment

The electrical components of the electronic SAR Imager may be sensitive to Electrostatic Discharge (ESD). The potential lack of tolerance to ESD may cause the component to suffer from Catastrophic Damage or Latent Damage. [13] These damaged parts may cause a delay in the testing of the component as they may have to be reordered.

5.2.2.2 Mitigation Strategy

It is the plan of the team to order a surplus of smaller components that are more susceptible to these types of damages should their unit price be relatively cheap. It is also the plan of the team to acquire antistatic wrap, if the component is not supplied with a long term containing device, to aid in the prevention of damage while storing and using these components. The team will also purchase and utilize a grounding wire to prevent the component from short circuiting while being utilized by the engineers assigned to install them.

5.2.3 Facility Availability

5.2.3.1 Assessment

The procurement of meeting and testing facilities is necessary for the completion of this project and its deliverables. The lack thereof may delay the progression of the project along its timeline.

5.2.3.2 Mitigation Strategy

It is the plan of the team to book all appropriate facilities within at least two weeks' notice to ensure facility availability. It is also the plan of the team to send reminders to the necessary operators to ensure that this facility is still available as the meeting/testing approaches and to notify all team members of any necessary changes.

5.2.4 Testing Safety

5.2.4.1 Assessment

The use and production of microwaves induces a radiation. These radiations levels could distort the components that may be sensitive to electromagnetic interference (EMI) and the Federal Communications Commission demands the radiation levels do not exceed $10\frac{mW}{cm^2}$.

5.2.4.2 Mitigation Strategy

The team plans to measure the expected output of the radiation as provided in Bulletin 56 and Bulletin 65 of the FCC. The team also plans to develop an apparatus to absorb the extraneous waves associated with the use of RADA, this material will be constructed on RADAR absorbing material.

5.3 Design & Control Risks

5.3.1 Inaccurate Team Scheduling

5.3.1.1 Assessment

There will be ad hoc assignments, tasks, departmental requirements, and other activities that arise during Fall 2014 or Spring 2015 that will need to be added to the schedule. There is a risk that the project timeline may shift if there is an influx of adjustments that need to be made. The accuracy of the schedule is dependent upon each team member communicating their respective tasks and deadlines that need to be met across multiple departments.

5.3.1.2 Mitigation Strategy

To ensure the schedule is as up to date as possible, the schedule will be reviewed in the weekly internal team meetings to ensure each team member's tasks are accurately represented and progress recorded. The scheduled will also be reviewed after each completed milestone to ensure the team understands the upcoming deliverables and associated project tasks. Before changing the schedule each team member will assess the change and ensure it does not adversely affect the other activities in the project.

5.3.2 Presence of Noise

5.3.2.1 Assessment

Without accounting for noise, the signal being processed can be distorted or altered beyond what is truly being measured. This could result in a faulty image projection and an ultimate misreading of the test subject by the user.

5.3.2.2 Mitigation Strategy

It is the plan of the team to calculate all expected, generated noise by all components where applicable and devise the necessary strategies to minimize its effect on the overall quality relative to signal processing and image generation.

5.3.3 Heat Generated

5.3.3.1 Assessment

Designing without consideration of heat generated may cause error in the processing of the signal. The heat generated may also minimally affect the structural integrity of the SAR Imager's containing apparatus.

5.3.3.2 Mitigation Strategy

It is the plan of the team to analyze the heat generated of the components and design the most ideal arrangement to both maximize the efficiency of the signal processing and minimize the overall heat generated. Cooling fans may also be ordered and installed in the event that it is the most optimal solution.

5.3.4 Component Vibration

5.3.4.1 Assessment

The component vibration that occurs during use may have a threatening affect to the alignment of the antenna horns, for this reason it is apparent the specific care should be used in the design of the components' placemen with in the SAR Imager.

5.3.4.2 Mitigation Strategy

It is the plan of the team to visually judge the vibration of the components during the testing phases and make note of all observations so that these qualities may be used as advice in the placement of these components within the SAR Imager to prevent them from distorting the received signal.

5.3.5 Limited Idle Time on Gantt chart

5.3.5.1 Assessment

The scope and time line of the project are very limited in their room for incompletion and inaccuracy, these makes it more challenging to addresses issues that may arise that could affect the completion of the project and its deliverables. The lack of idle time also requires that the team members be as interdependent as possible when completing all tasks and may make it difficult for the team members to distribute the work to be completed amongst the members.

5.3.5.2 Mitigation Strategy

It is the plan of the team to be organized in groups to complete the necessary functions and tasks required for the completion of the project and all of its deliverables. The arrangement of the Gantt chart in Appendix iii also highlights the gaps between tasks. The Project Manager will also ensure that all tasks are being completed in a timely manner and encourage all team members to ask for help when it may be needed.

5.3.6 Horn Structure, Attachment, & Mounting

5.3.6.1 Assessment

Horn structure and alignment are key elements in the electronic SAR Imager's ability to send and receive signals with as little distortion as controllably possible. The alignment of the horns depends heavily on how the horns are attached to the body of the electronic SAR Imager, so these designs will not be finalized until the antenna horns have been received. It may be that structure apparatus evolves once the attachment and adjusting phases have been analyzed by the actual structure of the horns received.

5.3.6.2 Mitigation Strategy

It is the plan of the team to design an attachment apparatus that is generally noted for its flexibility in the design process. It is also the plan of the team to implement laser guided adjustments to ensure an accuracy of the horn placement and installation.

5.3.7 Part Machining

5.3.7.1 Assessment

The components of the containing apparatus and overall structure or the electronic SAR Imager may need machining of a unique part that is not a commercial-off-the-shelf good. The purchased order may require a lead time that compromises the project time line and overall testing schedule.

5.3.7.2 Mitigation Strategy

It is the plan of the team to contact the particular machining center to understand its capacity and overall lead time to machine the requested time and note these with respect to the Gantt chart. Decisions will be rendered by the responsible engineer in conjunction with the project manager and all other responsible engineers that this decision may directly affect.

5.3.8 Team Member Scheduling Conflicts

5.3.8.1 Assessment

The team is comprised of eight students, all of which have varying class and work schedules. There is the risk that not all team members will have the availability to meet at the scheduled team, sponsor, and advisor meetings. The absence of team members during scheduled meetings will lead to loss work time and non-value added processes of explaining the missed content and reviewing information multiple times. This risk also affects the project's scheduled tasks and assignments. If team members miss meetings there is a risk that certain deadlines will not be met due to missed assignments.

5.3.8.2 Mitigation Strategy

For meeting purposes, Project Managers will send out a doodle survey to each member of the team and ask the respondents to enter all of their availability as well as restricted times. Based on the results of the survey, the optimal meeting time will be chosen based on all or the majority's ability to meet on selected days or times. Any team member not present will be able to view meeting minutes on the group blog via black board or via the team website reference page: eng.fsu.edu/me/senior_design/2015/team27/

5.3.9 Missed Project Deadlines

5.3.9.1 Assessments

Complications may arise within the project such as additional calculations and analysis, rework for failed test, reordering for damaged, lost, stolen, or faulty equipment, or some external factor with each of the team members. Team members may have an overloaded work schedule that hinders their ability to submit multiple assignments at the designated time. Team members may lose files or documents due to saving complications or crashed computer systems.

5.3.9.2 Mitigation Strategies

To prevent missed deadlines there will be at least two group members responsible for the deliverables of the project in conjunction with the project manager. These partnerships within the team will ensure that all the tasks and subtasks are not the sole responsibility of one team member. In the case that one team member does not have the availability to work on the assignment there is another person already listed as the responsible team member along with team project manager's assistance. Since there will be multiple people working on the assignments, the most up to date version of the assignment will be saved on the team dropbox account. There will also be copies of the assignments saved on the individual team member's computers, school accounts, flash drives, etc. Finally when the assignment is complete and corrected of all errors it will be posted to the team website.

5.3.10 Software Development Risks

5.3.10.1 Assessment

During the design process, the software design may be inadequate or incomplete as far as the scope of the project is hoped to reach. This may delay the testing strategies of the project time line.

5.3.10.2 Mitigation Strategy

It is the plan of the team to ensure that the VHDL code encompasses all the constraints and needed outputs for all components.

6 Qualifications and Responsibilities of Project Team

6.1 Team Qualifications

6.1.1 Jasmine Vanderhorst

Jasmine Vanderhorst is a senior at Florida Agricultural & Mechanical University (FAMU), studying Industrial Engineering. Her course work in Engineering Management, Industrial Tools, Quality Control, Operations Research I & II, Accounting, and Business Ethics made her a good selection for the Project Manager. This coursework has required her to develop project budgets, schedules, cost analysis, and various quality tools. She is also Six Sigma Green Belt Certified. In addition to her course work, Jasmine has held four internships in various fields that allowed her to apply several engineering and management principles. In her first three internships at Plant Vogtle Nuclear Power Station she was responsible for managing a construction zone and tracking project completion, contractor oversight, and project conformance to design along with daily reporting on any quality or safety concerns. In her fourth internship she was a technology consultant and program management analyst for Demand & Release Management, Risk & Issue Management, and Transition Gate Management. She held the responsibility for team coordination, documentation, and scheduling. In addition to her mandatory tasks, she built a communications website with a centralized document repository and training modules for team members to reference for any business need.

6.1.2 Matthew Cammuse

Matt Cammuse is a senior at Florida State University (FSU), majoring in Electrical Engineering. Since 2011, Matt has interned each summer at the NAVSEA's Naval Surface Warfare Center Dahlgren Division (NSWCDD) and been a part of the Electromagnetic and Radio

Frequency Department. He is overall familiar with communication and radar system designs and testing procedures, data analysis software development with MATLAB, and the structural configuration of LINUX. For this project, his affiliation with testing and understanding high powered phased array antennas conducting at microwave band frequencies, will be vital for the design and comprehension of the SAR Imager system. While attending the FAMU-FSU College of Engineering, Matt completed multiple classes which will benefit to the project's demands: Electromagnetic Fields I & II, Digital Communications, Digital Logic, Microprocessors, Circuits I & II, and C++ Programming. These classes combined with his work history and research into antennas and radar systems should allow Matt to be highly beneficial to his team and the project.

6.1.3 Malcolm Harmon

Malcolm Harmon is a senior at Florida State University studying Mechanical Engineering, Mathematics, and Physics. He was chosen as the Assistant Project Manager because of his vast experience in not only the mechanical studies but previous leadership experiences. He has taken coursework that has made him proficient in Pro E, Creo Parametric, and AutoCad. He has a vast knowledge in three-dimensional software which will be critical in displaying the conceptual designs of the SAR. Malcolm has also received a certification in AutoCad after completing a vigorous three year training course to advance his technical skill set. He has also studied Materials and Mechanics in his time at FSU where he earned an A for the final grade. He has a deeper understanding of the stress and strain factors of materials used for this project. He will be able to calculate the stress of each material chosen compared to the stress needed to ensure the antenna structure and supports do not collapse. Malcolm also has been employed as a building manager, being held responsible for a group of four to five employees. From this experience he has learned how to communicate effectively with varying personalities and opinions without making anyone feel undervalued or uncomfortable. He has earned the respect of his peers and coworkers not only by title but by leading by example.

6.1.4 Patrick Delallana

Patrick Delallana is a senior at Florida State University studying Electrical Engineering, Computer Engineering, Physics, and Mathematics. The specialization of Patrick's tasks as the Lead Engineer will mostly include FPGA programming and signal processing. Patrick has experience working at CAPS (Center for Advanced Power Systems) in which his work includes handling and assembling different hardware, reading through older publications to maximize efficiency of a research group, and programming different DSP's to receive and emit signal. Courses that have been taken that would prove useful for this project would include Digital Logic, Object Oriented Programming, Data Structures, Control Systems, Digital Communications, Advanced Circuits, and Microprocessors. Patrick's background in courses and experience with a graduate level research group qualifies him for the position of Lead Engineer.

6.1.5 Benjamin Mock

Benjamin Mock is a senior at Florida State University studying Industrial Engineering. He was selected as the Co-Lead Industrial Engineer for his proficiencies in the academic subjects of Manufacturing Process and Engineering Materials, Engineering Management, and Human Factors and Ergonomics. His research with Dr. Samuel Awoniyi provided an additional outlet for project and time management, technical writing, and risk forecasting. His experience as Treasurer for the FAMU-FSU Chapter of the Institute of Industrial Engineers and as an executive member of Kappa Kappa Psi, National Honorary Band Fraternity gave him the skills of operating with budgets exceeding $17,000. His experience with preparing and executing presentations through Industrial and Manufacturing Engineer Tools and as the Southeast District Parliamentarian for his Fraternity made him most suitable for the risk management portions of all deliverables.

6.1.6 Joshua Cushion

Joshua Cushion is a senior at the Florida State University, majoring in Electrical Engineering. His responsibilities for this project included generating mathematical models of the transmit and receive paths that simulate the performance of the components in each, performing the radar range calculations that take into account the performance characteristics of the design, as well as selecting the electrical components which involved designing a power supply. Joshua has developed a knowledge of electronic devices from taking courses that include Electronics I & II and the labs, as well as Power Electronics. Aside from school Joshua has developed skills in digital and analog circuit design and analysis during his summer internships at Lockheed Martin. Some of his experiences included: designing power supply circuitry and loads for electronic devices, performing evaluations of power integrated circuits (ICs), performing signal integrity analysis on digital circuit card assemblies and troubleshooting electronic hardware failures at both the component level and system level.

6.1.7 Julia Kim

Julia Kim is a senior at Florida State University majoring in Electrical Engineering. Her technical responsibilities include Signal Processing and Power Analysis. For the signal processing aspect of the project, she will be implementing Fast Fourier transform type algorithms to do calibration and image formation. She has taken a class on Signal and Linear Systems Analysis and Digital Communication Systems that will help her in that part of the project. Her power analysis background comes from her technical elective classes, which are Power Electronics, Fundamentals of Power Systems, and Power Systems I. She will also be assisting Joshua with the design of the system circuit that includes all the required components for the imager. She has taken classes on Advanced Circuits with Computers and the accompanying lab and Electronics. She is assuming the duty of Document Control and will take minutes at all scheduled meetings of the design team and make them available to all members, reviewers, advisors, and the project coordinator through the group blog and team website.

6.1.8 Mark Poindexter

Mark Poindexter is a senior at Florida State University majoring in Mechanical Engineering. His background fixing vehicles and any small to large machines aimed him into the mechanical engineering field. Hands on experience gives him a big advantage to design and build a structure for the horns, components box, and support system. During his time at the College of Engineering he has taken several classes that specifically qualify him for the project with the most significant being ME Tools/ME Tools Lab, Mechanical Systems I & 2, and Dynamic Systems 2 for the design drawings using Professional Engineering (Pro E) software.

7 Schedule

This section describes an overview of the main activities the project team will complete in both the Fall and Spring semesters. Phase 1 is complete and Phase 2 is under way. The activities on this list are subject to change as the complexity of the project increases and more tasks are required. Phases 3-6 will be completed in the Spring semester. To view the Gantt Chart please refer to Appendix 4.

Task Name	Duration	Start	Finish
Phase #1 - Define Project	**18 days**	**Fri 9/5/14**	**Tue 9/30/14**
Defining the SAR project	8 days	Fri 9/5/14	Tue 9/16/14
Develop Code of Conduct	5 days	Mon 9/8/14	Fri 9/12/14
Initial Sponsor Meeting	1 day	Tue 9/16/14	Tue 9/16/14
Identify Member Duties	3 days	Wed 9/17/14	Fri 9/19/14
Prepare Needs Analysis & Requirements Specifications	7 days	Thu 9/11/14	Fri 9/19/14
Milestone #1 NARS Report Due	0 days	Mon 9/22/14	Mon 9/22/14
Prepare and Practice NARS Presentation	4 days	Mon 9/22/14	Thu 9/25/14
Milestone #1 NARS Presentation Due	0 days	Fri 9/26/14	Fri 9/26/14
Phase 2 Planning	4 days	Thu 9/25/14	Tue 9/30/14
Phase #2 - Preliminary Analysis & Design	**17 days**	**Thu 10/2/14**	**Fri 10/24/14**
Simulation: Generate Pulse	7 days	Thu 10/2/14	Fri 10/10/14
Component Selection	10 days	Thu 10/2/14	Wed 10/15/14
Preliminary Calculations: Radar Range Equations - Performance Characteristics	9 days	Fri 10/3/14	Wed 10/15/14
Simulation/Mathematical Model Transmit & Receive Paths	9 days	Fri 10/3/14	Wed 10/15/14
Antenna Design	8 days	Mon 10/6/14	Wed 10/15/14
Design System Block Diagrams	5 days	Tue 10/7/14	Sat 10/11/14
Design Team Website	5 days	Tue 10/7/14	Sun 10/12/14
Industrial Engineering Deliverables	**8 days**	**Tue 10/7/14**	**Thu 10/16/14**
Develop House of Quality	8 days	Tue 10/7/14	Thu 10/16/14
Develop Voice of the Customer Tree	8 days	Tue 10/7/14	Thu 10/16/14
Develop Preliminary Project Budget	8 days	Tue 10/7/14	Thu 10/16/14
Milestone #2 Project Proposal (PP) & Statement of Work (SOW) Report	0 days	Mon 10/20/14	Mon 10/20/14
Prepare & Practice PP & SOW Presentation	4 days	Mon 10/20/14	Thu 10/23/14
Tallahassee Visit from Pete Stenger	0 days	Tue 10/21/14	Tue 10/21/14
Milestone #2 Project Proposal & Statement of Work Presentation	0 days	Fri 10/24/14	Fri 10/24/14

Phase 2A Planning	6 days	Fri 10/17/14	Fri 10/24/14
Phase #2A - System Level Designs	**20 days**	**Mon 10/27/14**	**Fri 11/21/14**
Task 1: Design Power Supply Circuitry	9 days	Mon 10/27/14	Thu 11/6/14
Task 2: Signal Processing Algorithms	9 days	Mon 10/27/14	Thu 11/6/14
Task 3: FPGA Programming	9 days	Mon 10/27/14	Thu 11/6/14
Task 4: Structural Design	6 days	Thu 10/30/14	Thu 11/6/14
Detailed Pro E Structural Design	2 days	Wed 11/5/14	Thu 11/6/14
Task 5: Frame Design	6 days	Thu 10/30/14	Thu 11/6/14
Detailed Pro E Frame Design	2 days	Wed 11/5/14	Thu 11/6/14
Task 5: Radar Absorption Frame	6 days	Thu 10/30/14	Thu 11/6/14
Prepare Report	7 days	Thu 11/6/14	Fri 11/14/14
Milestone #3 System-Level Design Review	0 days	Mon 11/17/14	Mon 11/17/14
Prepare & Practice System Level Design Presentation	4 days	Mon 11/17/14	Thu 11/20/14
Milestone #3 System-Level Design Presentation	0 days	Fri 11/21/14	Fri 11/21/14
Phase #3 - Component Ordering (43 parts)	**30 days**	**Mon 11/10/14**	**Fri 12/19/14**
Procure Storage Facility	5 days	Mon 11/10/14	Fri 11/14/14
Task 1:FPGA Board (1 each)	2 days	Mon 11/10/14	Tue 11/11/14
Task 2: Power Amplifier (4 each)	28 days	Tue 11/11/14	Thu 12/18/14
Task 3: Horn Antennas (20 each)	14 days	Tue 11/11/14	Fri 11/28/14
Task 4: Low Noise Amplifier (1 each)	8 days	Mon 11/17/14	Wed 11/26/14
Task 5: I-Q Demodulator (1 each)	8 days	Mon 11/17/14	Wed 11/26/14
Task 6: Digital-To-Analog Converter (1 each)	7 days	Mon 11/17/14	Tue 11/25/14
Task 7: Analog-To-Digital Converter (2 each)	7 days	Mon 11/17/14	Tue 11/25/14
Task 8: Single-Pole-Double-Throw Switch (2 each)	7 days	Mon 11/17/14	Tue 11/25/14
Task 9: Frequency Multiplier (2 each)	7 days	Mon 11/17/14	Tue 11/25/14
Task 10: Single-Pole-Four-Throw Switch (1 each)	7 days	Mon 11/17/14	Tue 11/25/14
Task 11: Single-Pole-16-Throw Switch	7 days	Mon 11/17/14	Tue 11/25/14
Thanksgiving Break	4 days	Wed 11/26/14	Sun 11/30/14
Task 10: Personal Computer (1 each)	7 days	Mon 12/1/14	Tue 12/9/14
Task 12: Display Screen (1 each)	7 days	Mon 12/1/14	Tue 12/9/14
Task 13: Voltage Controlled Oscillator (1 each)	7 days	Mon 12/1/14	Tue 12/9/14
Verify all components received and correct	3 days	Wed 12/10/14	Fri 12/12/14
Christmas Break	18 days	Mon 12/15/14	Wed 1/7/15
Spring: First Week of School	8 days	Wed 1/7/15	Fri 1/16/15
Phase #4 - System Assembly	**18 days**	**Wed 1/7/15**	**Fri 1/30/15**
Team Meetings - Spring Deliverables & Milestones	6 days	Thu 1/8/15	Thu 1/15/15
Verify All Components in Secure Storage	5 days	Mon 1/12/15	Fri 1/16/15

Connect FPGA Board, CPU, and Display	5 days	Mon 1/19/15	Fri 1/23/15
Construct Electrical Circuit	7 days	Mon 1/19/15	Tue 1/27/15
Attach Power Supply	3 days	Tue 1/27/15	Thu 1/29/15
Attach To Structural Supports	2 days	Thu 1/29/15	Fri 1/30/15
Phase #5 - System Testing	**15 days**	**Mon 2/9/15**	**Fri 2/27/15**
Test FPGA Programs	5 days	Mon 2/9/15	Fri 2/13/15
Test Power Supply	5 days	Mon 2/9/15	Fri 2/13/15
Test Circuit Components	5 days	Mon 2/9/15	Fri 2/13/15
Analyze Connectivity	5 days	Mon 2/9/15	Fri 2/13/15
Record and Analyze Tests	11 days	Fri 2/13/15	Fri 2/27/15
Phase #6 - Result Evaluation	**35 days**	**Mon 3/2/15**	**Fri 4/17/15**
Document Project Progress	5 days	Mon 3/2/15	Fri 3/6/15
Finalize Project	15 days	Mon 3/9/15	Fri 3/27/15
Finalize Report	11 days	Sat 3/28/15	Fri 4/10/15
Present Project Results	5 days	Mon 4/13/15	Fri 4/17/15
Final Exam Week	5 days	Mon 4/27/15	Fri 5/1/15
End of Year: Graduation	0 days	Sat 5/2/15	Sat 5/2/15

8 Budget Estimate

The operating budget for the SAR Imager team, as provide by Northrop Grumman through the FAMU-Foundation, is set promptly at $50,000. The theoretical budgeting for the cost of personnel is depicted in Table 1. The current expected budget for components is depicted in Table 2. The following budget estimate will include the hypothetical estimates of budgeting allocation and employee salaries as determined by the following assumption:

- The mean salary for the role of the engineer is set at $30.00.
- The average employee fringe benefit exists at 29.00%.
- All team members provided 12 hours of work, weekly.
- All team members provide work for 30 weeks, two semesters.
- Overhead will be set at 20% of the total operating expenditures.

•

Personnel				
Engineer	Job Title	Billable Hours	Hourly Rate	Total Expense
Jasmine Vanderhorst	Industrial Manager	360	$30.00	$10,800.00
Joshua Cushion	Electrical Engineer	360	$30.00	$10,800.00
Patrick de la Llana	Electrical Engineer	360	$30.00	$10,800.00
Mark Poindexter	Mechanical Engineer	360	$30.00	$10,800.00
Malcolm Harmon	Mechanical Engineer	360	$30.00	$10,800.00
Benjamin Mock	Industrial Engineer	360	$30.00	$10,800.00
Julia Kim	Electrical Engineer	360	$30.00	$10,800.00
Matthew Cammuse	Electrical Engineer	360	$30.00	$10,800.00
			Subtotal	$86,400.00
Employee Benefits			29.00%	$25,056.00
Total Personnel				$111,456.00

Table 1: Theoretical Personnel Expense

Expenditures	Product Number	Distributor	QTY	Unit Cost	Total Cost
FPGA	Xilinx Spartan-3E FPGA	Digilent Inc	1	$140	140
VCO	HMC-C028	Hittite	1	$69.95	69.95
Power Amplifier	SPA-120-41-01-SMA	Fairview Microwave	1	$2,420.27	2420.27
Antenna Horns	MA86551	Advanced Receiver	20	$20.00	400
Low Noise Amplifier	SLNA-120-38-22-SMA	Fairview Microwave	1	$1,512.67	1512.67
Digital/Analog Converter	PmodDA2	Digilent Inc	1	$28.99	28.99
Analog/Digital Converter	PmodAD1 Two 12 bit	Digilent Inc		$37.00	0
Frequency Multiplier	ZX90-2-50-S+	Mini-Circuits	1	$41.95	41.95
SPDT Switch	HMC-C058	Hittite	1	$69.95	69.95
SP4T Switch	HMC-C071	Hittite	1	$79.95	79.95
SP16T Switch	UMC SW-L010-16S	Universal Microwave Cmpts	1	$25.95	25.95
Variable Attenuator	HMC-C053	Hittite	2	$6.00	12
IQ Demodulator	AD60100B	Polyphase Microwave	1	$1,225	1225
Operating Subtotal					5838.83
Overhead					1167.766
Total Operating Expenditure					7006.596

Table 2: Expected Component Expenditure

9 Deliverables

There are three main types of deliverables for the project, which are the hardware, the software, and the reports. The hardware and software will be worked on throughout the two semesters, and they will be presented to all stakeholders. The reports are milestones to be fulfilled for the course, and they will be completed for each due date and turned in to all project stakeholders. They serve as guides for students to develop the project. The deliverables have the end purpose of serving as a learning experience as they help the team understand the concepts of a radar system in a hands-on manner.

9.1 Hardware

The hardware for the project consists of the physical representation of the radar schematic and its structure. The physical representation will be put together with the procured electrical components.

9.2 Software

The software for the project comprises of the working VHDL code to transmit and receive a pulse and the Pro ENGINEERING drawings of the radar system structure.

9.3 Reports

9.3.1 Needs Analysis and Specifications Requirements

The Needs Analysis and Specifications Requirements (NARS) report is the first milestone report due that serves as an introduction to the project. In this report, the customer's needs and wants are identified, the major system-level requirements are specified, a preliminary test plan is formulated, the preliminary schedule and budget are determined, and the preliminary risk is assessed.

9.3.2 Project Proposal and Statement of Work

The Project Proposal and Statement of Work report gives an overview of the detailed qualifications/responsibilities of all the team members, the concept generation and selection, the preliminary system-level design, a more detailed schedule for the whole year, a more detailed budget with estimated components pricing, and a more detailed risk assessment.

9.3.3 System-Level Design Review

The System-Level Design Review is the third milestone, and it should be more detailed than the previous reports. The previous concept generation and selection should be reviewed, and if there have been any important new selections made, information should be provided. A more detailed system design should be presented with a detailed top-level schematic diagram of the system and any design sketches of major subsystems. If there have been any updates to the schedule or to the budget, they should be included. There should be a more detailed risk analysis and it should be divided into technical, schedule, and budget risks, and for each identified risk, the probability, severity and mitigation strategy should be designated.

9.3.4 Detailed Design Review

The Detailed Design Review should provide any updates made from the System-Level Design Review. If there have been any major new concept selections or alterations, then it should be presented in the report. The design of the overall system and components must be well detailed, and any updates to the top-level schematic diagram or design sketches for major subsystems should be presented. Any updates to the schedule and/or budget should be detailed out in the report. A complete test plan must be described with a list of all conducted and planned tests, detailed plans for different key tests, and results of all tests and simulations completed by then.

9.3.5 Final Presentation

The Final Presentation report will be a very important deliverable. It should include all individual design contributions of each team member with an overview of the design process used and the final design elements created. A summary of the final status of the project should be reported in detail, with checklists or tables of measurements showing final results of tests and experiments, a review of the system needs and requirements met by the conceptual design, a final budget showing all expenditures, and a list of all final deliverables delivered to customer.

9.3.6 Team Website

The final website will house all final documentation, diagrams, reports, and correspondences from the duration of the project. The website will be central, coherent document repository that holds all publicly accessible material in a well-organized manner. This website will be accessible through the university public html files hosted on the College of Engineering servers. The website will also be archival meaning it will remain accessible for a minimum of 3 years. The website will also have dated entries for documents as well as time stamped logs for any possible announcements or blog entries. This will ensure timely updating of the website and continuous improvement of the website. The website will be neatly formatted and well-illustrated. Illustrations will include but are not limited to photographs, diagrams, videos, renderings, formulas, tables, graphs, etc. These components will make the website visually compelling and technically informative. Lastly, the website will include all finalized deliverables and meeting minutes to ensure all information relevant to the project is readily available to advisors, sponsors, and the client Northrop Grumman.

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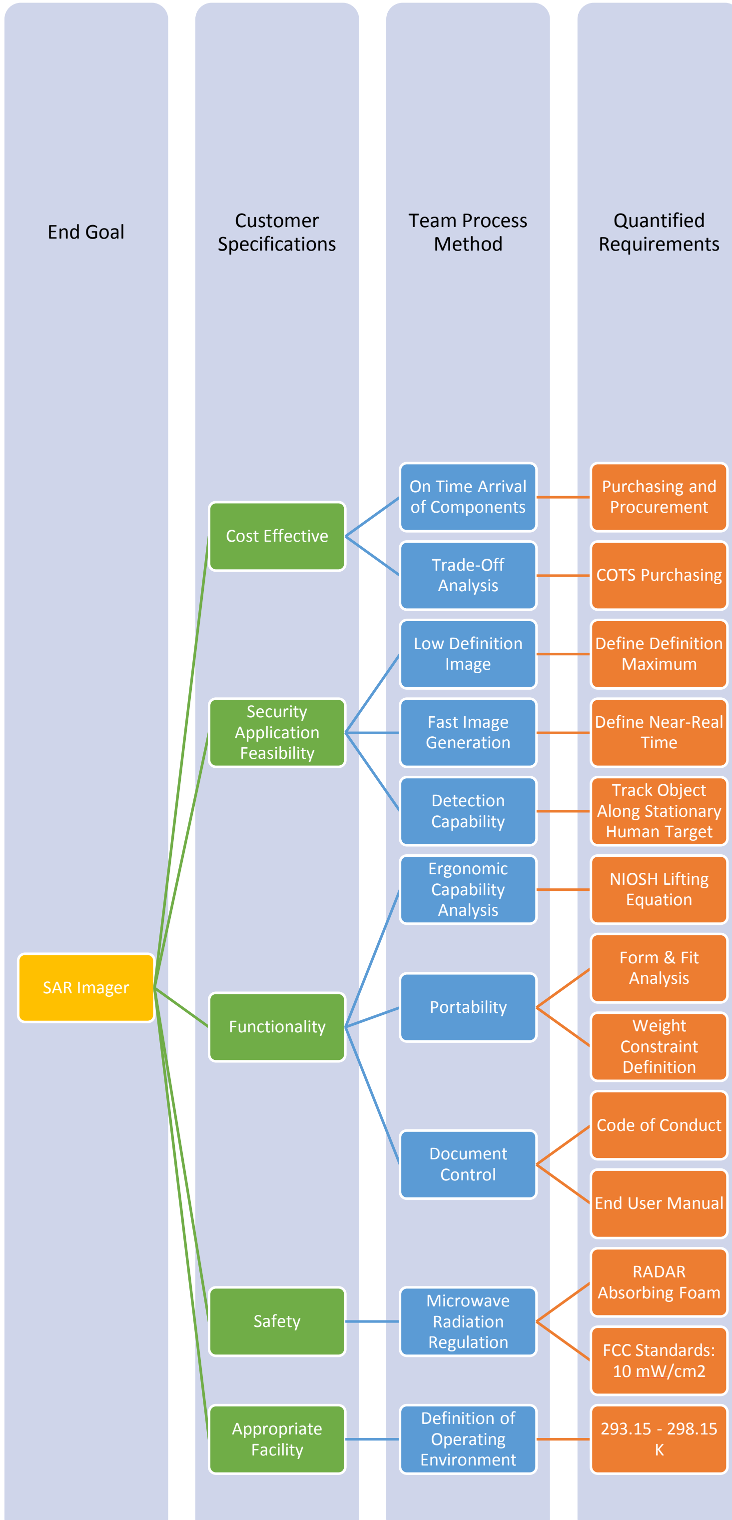
Appendix

A1 Voice of the Customer Tree



A2 Team Resumes

Jasmine L. Vanderhorst

2320 Continental Avenue Tallahassee, FL 32304

Mobile Contact: 678-849-0868 Email: Vanderhorst_91@yahoo.com

Education:

Florida A & M University **Expected Graduation: May 2015**

- Senior— Industrial Engineering Cumulative GPA 3.09
- Dean's List Fall 2009, Honor Roll Spring 2010, Dean's List Spring – Fall 2013, and Spring 2014
- 2011 Society of Women Engineers Fundraising Chair (SWE), National Society of Black Engineers (NSBE) member, Institute of Industrial Engineers (IIE) member
- 2014 Engineering Ambassadors Vice President, 2014 IIE Fundraising Chair

Training & Certifications:

Six Sigma Green Belt Certification with the IIE **February 2011**

Engineering Experience:

Accenture – Technology Consulting Intern **May – August 2014**

- Project/Program Management Support – PMO Analyst
- Consolidate weekly Risks and Issues Reports
- Manage Change Control Log, track final decisions, and distribute to key stakeholders
- Develop a website for Demand and Release Management organizations
- Build training modules and process flow maps for Demand Management
- Create a tool for tracking deliverables for Transition Gate requirements
- Create projects and manage daily tasks for a high school intern from KIPP Atlanta High School Skills To Succeed Program

Southern Nuclear Company (SNC) – Student Co-Op Program at Plant Vogtle 3 & 4 **2012-2013**

- 1st Semester: January – May 2012 (Construction Engineering Field Coordinator)
    - Track & trend schedule adherence for Turbine Building & Balance of Plant zones.
    - Produce daily production reports for Units 3 & 4 Cooling Tower Foundations
    - Analyze deviations and concerns through technical evaluations and corrective action program
    - S.T.E.P. Sustainability Team Member- Safety and Behavioral Monitoring Program

- 2nd Semester: August – December 2012 (Construction Engineering Field Coordinator)
    - Verify installation of mechanical/exothermic couplers in accordance with design documents
    - Track embed and anchor bolt installations for Nuclear Containment base mat foundation
    - Perform documentation verification of control records for permanent plant equipment
    - Audit drawings issued for construction to verify current revision in document control
    - Created formalized work process for future co-op students called Responsibility Logs to plan their semester assignments and record training progress

- 3rd Semester: May – August 2013 (Construction Oversight Safety & Health Department)
    - Created a metric trending positive and negative patterns in the Log of OSHA Recordable Injuries & First Aids
    - Participated in Root Cause Analysis of a Critical Lift Incident Investigation
    - Created a Material Safety Data Sheet (MSDS) training document
    - Inspect site chemical storage and verify MSDS information as part of corrective actions
    - Inspect fall protection systems including fall arrest lanyards, life lines, and scaffolding

Matt Cammuse

1111 Nanticoke Cir., Tallahassee, FL 32303•(813) 892-1307•mgc11@my.fsu.edu

Education

Bachelor of Science in Electrical Engineering — Graduation Date: December 2015
GPA: 3.125/4.0

Relevant Coursework

Digital Communications	VHDL Programming	Digital Logic	Micro-processing
Signals and Linear Systems	MATLAB Level 1	Electromagnetic Fields 1 & 2	C++ Programming
		Power Series Fundamentals	

Experience

COOP – Naval Surface Warfare Center Dahlgren Division (NSWCDD), July 2011 – Present

Radio Frequency and Electromagnetic Department — Dahlgren, VA

- Shadowed communication and radar engineers
- Traveled to multiple antenna test sites to understand testing techniques and setup parameters
- Learned how to operate LINUX for external and internal usage
- Learned MATLAB programming, including object oriented programming techniques
- Learned LATEX programming

SLM Member – Student Lead Ministry Member

- Raised over $2000 for funding international and national mission trips and hospitals in Guatemala
- Organized multiple retreats throughout the year: Beach Retreat and Winter Retreat

Senior Leader – Wesley Foundation

- Responsibly for fifteen different sub-organizations a part of the Wesley Foundation
- Planned two leadership lock-ins

Relay for Life Captain

- Led the Wesley Foundation's Relay for Life team to raised $3,400 for the American Cancer Association
- Placed third in the spirit points within Florida State University

Skills

LINUX	LATEX	Quartus II FPGA Design Software	C++
MATLAB	Microsoft Office	VHDL	Assembly
NI Multisim			

Affiliations

Member of the FSU Wesley Foundation — Fall – 2011
Member of IEEE — Fall – 2013
Virginia Boys State Alumni — Summer – 2010

Leadership Roles

Senior Leader of the Wesley Foundation — Fall 2014 – Spring 2015
Relay for Life Captain — Fall 2013 – Spring 2014
Family Group Leader — Fall 2013 - Present

Mechanical Engineering 228 Dixie Dr. Apt 2506 Tallahassee FL, 32304
mjh11f@my.fsu.edu 954-600-5554
Malcolm Harmon

Education:

Florida State University: **Tallahassee, FL**
Bachelor of Science in Mechanical Engineering: Anticipated Grad Date: May 2015
Minor in Math: August 2013 - Minor in Physics: December 2013
Broward College: **Davie, FL**
Associate of Arts in General Engineering: August 2011
Jacksonville University: April 2010 **Jacksonville, FL**

Engineering Experience:

- Design a small scale refrigeration system **Tallahassee FL, June 2014 – Present**
  - Powered entirely by natural sunlight with minimal environmental impact and minimal cost
  - Produced and designed 3-Dimensional models
  - Utilized Creo program to create engineering drawings for part manufacturing

Relative Coursework:

- Vehicle Design: Examines the primary features of vehicle design that relate to performance
- Mechanical Systems: Team projects involving design and manufacturing of new mechanical systems
- Dynamics: Analytical solutions of linear/nonlinear algebraic and ordinary differential equations
- Thermal Sciences: Thermal Dynamics, Fluid Mechanics, and Heat Transfer

Student Projects:

- Constructed Sterling engine in a workshop
  - Manufactured engine parts
  - Designed virtual parts in Pro-e software
- Built Gear reduction hoist system to hoist 10 lbs.
  - Calculated gear stresses, forces, and factor of safety

Skills:

- Developed critical thinking skills for decision-making
- C++: numerical computation and programming; 3-D modeling; Adams: multi-body dynamics software

Work Experience:

OGLESBY UNION, FSU: Building Manager (26 hr/wk) **Tallahassee FL, January 2014 – Present**
- Oversee and manage a multi-million dollar facility
- Interact with our clients in a professional manner that provides the correct advisement with any situation
- Provide direction, leadership, and knowledge to all student staff in Guest Services
- Train new employees, advise current employees

OGLESBY UNION, FSU: Setup Worker **Tallahassee FL, May 2012 – December 2013**
- Ensure that all meeting, conference, banquet, and event rooms are in accordance with the guests' request
- Made certain all requested audio-visual equipment is setup and functioning properly for the guests

MICHAELS ARTS AND CRAFTS: Sales Associate**,** Cashier **Plantation FL, September 2010-July 2011**
- Use excellent customer service techniques to ensure all customers are satisfied, while remaining ahead of work schedule

Achievements **Tallahassee FL, September 2013**

- Invited to dinner with the **STATE SENATOR** Chris Smith and **Assistant Chief of Police** Anthony Williams of Fort Lauderdale for outstanding volunteer work ethic with Last Hope Rescue

Club Membership:

- Member in National Society of Black Engineers: August 2012 - Present
- Member in American Institute of Aeronautics and Aerospace: January 2014 - Present

Volunteer Experience:

Florida State University **Tallahassee, FL August 2013 - September 2014**
- FSU Audio/Visual Electronics: Tallahassee, July 2012
  - Installed 20 new audio speakers into FSU Ballroom ceiling
  - Striped wires to create a connection to all 20 speakers

Last Hope Rescue **Tallahassee, FL August 2013 – Present**

- Help foster abandoned dogs

Patrick N. de la Llana
6225 NW 113 court Doral, FL 33178
(305)206-1111
Pnd10@my.fsu.edu

PROJECTS/RELEVANT EXPERIENCE:

- **CAPS (Center for Advanced Power Systems) May 2014-Present**
  - Programmed different DSP's to receive/emit signal
  - Dealt with hands on hardware application of test bed (soldering, testing, etc.)
  - Researched older publications to help maximize efficiency of group
- **Personal Tutor 2012-Present**
  - Tutored individuals on subjects ranging from Calculus 1-3, Differential Equations, Circuits, Electronics, C++, Java, and/or any of the physics or math courses required for degrees attained.
  - Holds around 10 tutoring sessions on a monthly basis.
  - Frequently conducts sessions with up to 7 people at one time (three times a month)
- **Electronic Lock Project: Microprocessors September-December 2013**
  - Used HCS12 MC9S12C microcontroller to create an electronic lock which displayed up to 3 unlock codes
  - Served as software and hardware engineer in project that consisted of an LCD keypad and a stepper motor controlled via C and Assembly.
- **Personal Stereo and Stereo Balance Indicator June 2013-Augsust 2013**
  - Built a personal desktop stereo from scrap materials bought from internet and electronic stores
  - Added a stereo balance indicator to the final design to show which speaker has more current running through. Indication was shown via LED's connected to stereo

SKILLS:

- Proficient in speaking of Spanish and Russian
- Knowledge of C++, VHDL, Assembly, Java, MATLAB
- Knowledge of how to use electronic simulation software MULTISIM and QUARTUS (8 bit arithmetic logic unit), etc.

EDUCATION:

Florida State University, Tallahassee, FL 2010-2015 Spring
Bachelor of Science in Electrical Engineering
Bachelor of Science in Computer Engineering
Bachelor of Science in Physics
Bachelor of Science in Mathematics

GPA: 3.1

Benjamin Adam Mock

Local Address
534 A W Virginia Street
Tallahassee, FL 32301
(386) 295 - 9600
bam11h@my.fsu.edu

Permanent Address
1237 Killarney Drive
Ormond Beach, FL 32174
(386) 492 - 6024
mockben@live.com

Education	**The Florida State University,** **FAMU-FSU College of Engineering, Tallahassee, FL** **Bachelor of Science in Industrial Engineering,** **Cumulative G.P.A. 3.48 Major G.P.A. 3.81**	**May 2015**
Honors/ Awards	President's List - Dean's List - Florida Academic Scholar - Alpha Pi Mu, Industrial Engineering Honor Society - Tau Beta Pi, The Engineering Honor Society: Prospective Member - Kappa Kappa Psi, National Honorary Band Fraternity - Ronald J. Sergeant Chapter Involvement Award	
Experience	**Undergraduate Researcher, Florida A&M University** Professor Samuel Awoniyi, FAMU-FSU College of Engineering Applied nonlinear optimization theory to analyze the packaging techniques of major food and beverage manufacturers. Measured and analyzed commercial-off-the-shelf products to determine the overall products' sustainability in green manufacturing.	**Summer 2014 - Present**
	Southeast District Parliamentarian Kappa Kappa Psi, Southeast District Assisted the Southeast District President in operating the town hall meeting for all chapters comprised within the seven state district. Advised the Jurisdiction Committee with revising the Southeast District Constitution and worked with the National Delegation to promote efficient district communication.	**2013-2014**
	Treasurer Institute of Industrial Engineers, FAMU/FSU Chapter Maintain a working budget of program funds and ensure that all members are eligible nationally for participation. Aid the President in ensuring all monies are appropriately disbursed.	**2014-Present**
Other Leadership Experience	**Row Leader** - Marching Chiefs **Chapter Historian**, **Chapter Parliamentarian**, **Service Chair**, **Continuing Membership Education Chair** - Kappa Kappa Psi **Involvement Chair Spring 2014** – Engineers Without Borders	
Campus Involvement	Marching Chiefs, 4th year member - Seminole Sound Athletic Pep Band, 4th year member - Kappa Kappa Psi - Alpha Pi Mu - Institute of Industrial Engineers - Society for Manufacturing Engineers - Engineers Without Borders - Tau Beta Pi: Prospective Member	
Skills	Six Sigma – Green Belt Certification; Microsoft Suite; AutoCAD; SolidWorks; MATLAB; C++; Operations Research; Manufacturing Processes; Human Safety and Ergonomics; Statistical Quality Control; Engineering Management; Materials	

Joshua Cushion

904-982-5706 Jlc10e@my.fsu.edu

EDUCATION

Bachelor of Science in Electrical Engineering — Graduation Date: May 2015
Florida State University, Tallahassee, Florida — GPA: 3.35/4.0

RELEVANT COURSEWORK

C++ Programming	Electromagnetic Fields I	Digital Communications
Electronics I with Lab	Circuit Analysis I and II with Labs	Digital Logic Design with Lab (VHDL)
Microprocessor-Based Systems Design with Lab	Design and Analysis of Control Systems	Intro. to Field Programmable Logic Devices (VHDL)

EXPERIENCE

Intern – Electrical Engineer (Digital Hardware Design) — May 2014 – August 2014
Lockheed Martin Missiles and Fire Control: Research and Development — Orlando, Florida

- Evaluated the performance of DACs, ADCs, and other power integrated circuits (ICs)
- Designed power supply circuits for several LDO voltage regulators based on application specifications
- Designed multiple switching loads to test the accuracy of load regulation of several LDO voltage regulators
- Tested and troubleshot multiple analog circuits integrated as single units
- Captured data using a multi-channel high frequency data acquisition system
- Wrote test procedures for multiple IC designs

Intern – Electrical Engineer (Digital Hardware Design) — May 2013 – August 2013
Lockheed Martin Missiles and Fire Control: F-18 IRST/MFP — Orlando, Florida

- Performed pre-route and post-route signal integrity analysis on multiple circuit card assemblies (CCA)
- Conducted power, stress and voltage tolerance analysis on ICs and other electronic components
- Designed voltage biasing circuits using MOSFETS, diodes and BJTs for equipment used to test hardware
- Captured analog and digital circuit schematics using Mentor Graphics: DxDesigner
- Wrote and updated test procedures and test requirements for several CCAs

Intern – Electrical Engineer (Digital Hardware Design) — May 2012 – August 2012
Lockheed Martin Missiles and Fire Control: JSF-EOTS — Orlando, Florida

- Debugged and troubleshot hardware failures at both the CCA and electronic component assembly levels
- Created hardware troubleshooting tests using Universal Scan Tool (JTAG)
- Operated hardware testing equipment: oscilloscopes, multimeters, power supplies and function generators
- Debugged synchronization boundary failures in VHDL code using Cadence: SimVision
- Reviewed source code in C++

SKILLS/SOFTWARE

Mentor Graphics: DxDesigner, HyperLynx, and PCB Planner, Quartus II FPGA Design Software, NI Multisim, MATLAB, VHDL, C++, Assembly, Microsoft Office

Affiliations

Member of INROADS Inc. — Fall 2011 – Present

- Professional leadership development workshops
- Career-skills building training, courses, and seminars
- Community Service Activities

Member of Eta Kappa Nu Electrical & Computer Engineering Honor Society — Fall 2013 – Present
Member of National Society of Collegiate Scholars — Spring 2011 – Present
Member of Phi Eta Sigma National Honor Society — Spring 2011 – Present

Leadership Roles

National Society of Black Engineers (NSBE) – Mentor — Fall 2014
INROADS – Community Service Committee — Summer 2014
Lockheed Martin MFC – Summer Intern Ambassador — Summer 2013, 2014
Microprocessor Design Course – Team Project Lead — Fall 2013
Electronics Lab Course – Team Project Lead — Fall 2013

JULIA KIM YOON

415 Chapel Dr., Tallahassee, FL 32304
Mobile phone number: (978) 810 – 8231
Email: jk09k@my.fsu.edu

EDUCATION

Florida State University
Tallahassee, FL
Bachelor of Science, Electrical Engineering
May 2015

EXPERIENCE

LG Electronics
Panama City, Panama
Data Analyst February 2011 – July 2012

- Carried out monthly data analysis for incoming calls for the U.S. Mobile Communications department in order to study what the most frequent problems were with the products and worked with the engineers to determine solutions.
- Worked with visiting engineers to train customer service representatives in new products and any problems with existing products.

Human Resources January 2010 – February 2011

- Performed incentive bonus calculations for the LG Electronics employees monthly.
- Reorganized the method bonuses were calculated by using Excel and making the process more efficient.
- Worked with recruiter in selecting new employees and preparing for their entry.

Customer Service Representative July 2009 – January 2010

- Provided technical support to customers with mobile phone issues.

ACTIVITIES AND HONORS

- Member of Tau Beta Pi Engineering Honor Society, IEEE, and the Society of Hispanic Professional Engineers (SHPE).
- Current Secretary of Eta Kappa Nu Electrical Engineering Honor Society.
- Public Relations Officer for Panamanian Students Association (PTY at FSU) during Spring/Fall 2013.

TECHNICAL SKILLS

- Knowledgeable in Microsoft Word, Excel, PowerPoint, Access, and Visual Studio C++; MATLAB; Multisim; and Quartus II (VHDL).
- Fluent in English, Spanish, and Korean.

RELEVANT COURSES

- EEL4243 – Power Electronics (Currently Taking)
- EEL4710 – Introduction to Field Programmable Logic Devices (Currently Taking)
- EEL4213 – Power Systems I (Spring 2014)
- EEL4515 – Digital Communication Systems (Spring 2014)
- EEL3216 – Fundamentals of Power Systems (Fall 2013)
- EEL4746 – Microprocessor Based System Design (Fall 2013)
- EEE3300 – Electronics (Fall 2013)

Mark Poindexter Jr.
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Tallahassee FL, 32308
(850)896-7990
Mpp12b@my.fsu.edu

Objective

To obtain an internship in the engineering industry gaining experience in the real world.

Education

Florida State University, Tallahassee, FL — May 2015
Overall GPA: 3.37, **Bachelor of Science, Mechanical Engineering**

Gulf Coast State College, Panama City, FL — May 2012
Overall GPA: 3.21, **Associates of Arts, Pre-Engineering**

Honors

GCSC Mathematics Department: Award of Excellence — May 2012
GCSC Presidents List: Award of Academic Excellence — May 2012

Current Courses

Senior Design Project I
Thermal-Fluids Laboratory
Energy Conversion Systems for Sustainability

Skills

- Knowledge in Creo Parametric (Pro E), Working Model, AutoCAD, MATLAB, Mathcad, Microsoft Visual C++ Express, Code::Blocks, Microsoft Word and Excel
- Hands on experience working on vehicles
- Handyman experience

Employment

Sally's Carwash Inc., Panama City, FL — May 2007 – July 2009

- Fixed all carwash equipment in need of repair including pumps and electrical equipment
- Maintained premises to look desirable for customers
- Handled all money up to $10,000 a month

Freedom Oil Change and Carwash, Lafayette, LA — January 2007 – April 2007

- Greeted customers for friendly environment
- Changed oil, rotated and balanced tires, transmission flushes, radiator flushes, changed fuel filters
- Easily sold extra work performed on vehicles by detailed explanation to customer of why work needed to be completed

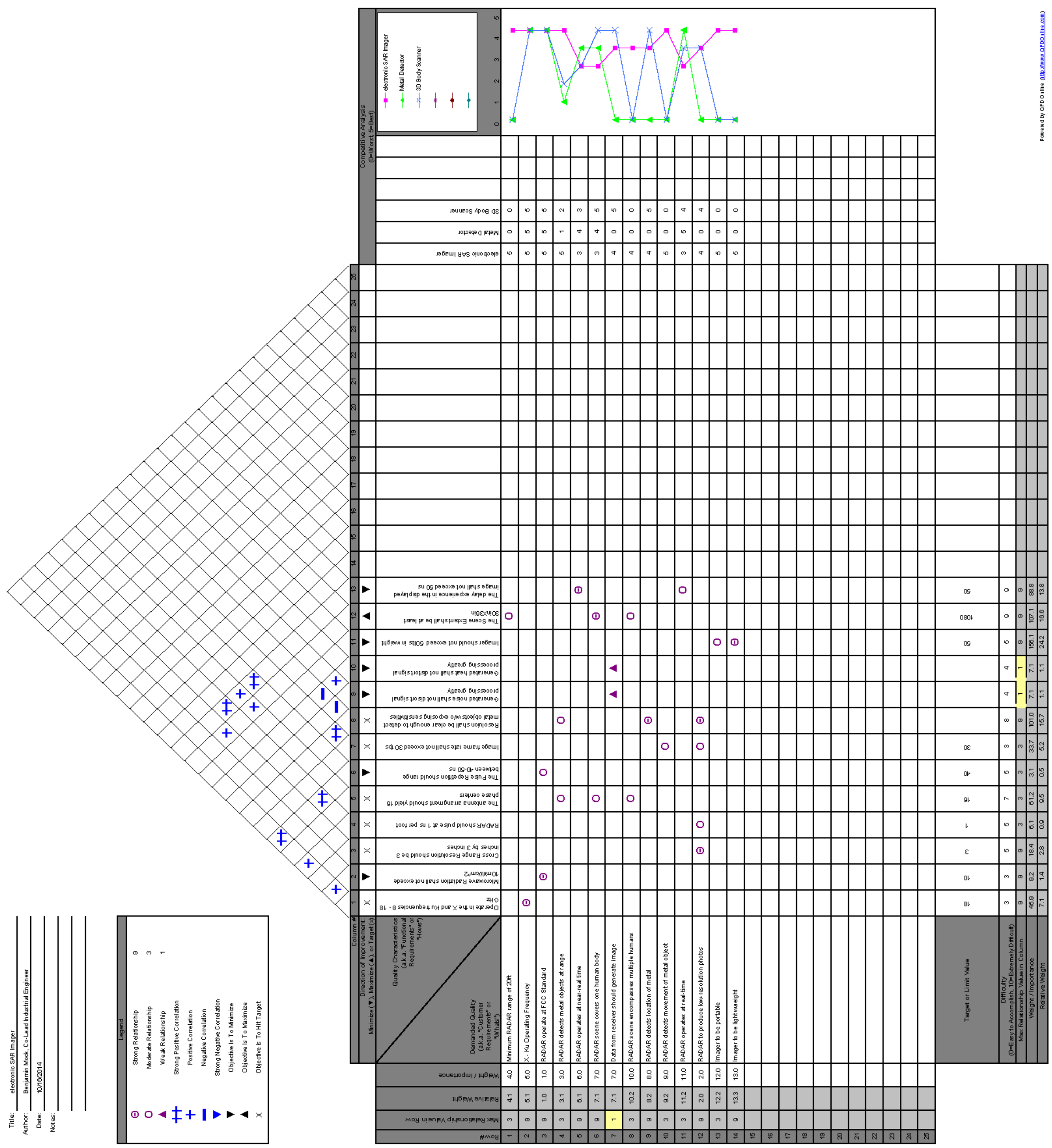
Eclipse Resurfacing, Panama City, FL — March 2006 – January 2007

- Designed quality decorative resurfacing concrete to customers
- Resurfaced pool decks, driveways, porches, patios, and business entries with different designs similar to brick, tile, stone, marble, and acid stain which come from concrete material excluding acid stain
- Acid stained a 20,000 square foot Ace Hardware store with personalized logo made from concrete material

Mark's Ten Minute Oil Change, Panama City, FL — December 2004 – January 2006

- Greeted customers for welcoming environment
- Changed oil, rotated and balanced tires, changed transmission filters and fluid, radiator flushes, changed fuel filters
- Effortlessly sold extra work completed on vehicles by detailed explanation to customer of why work needed to be done

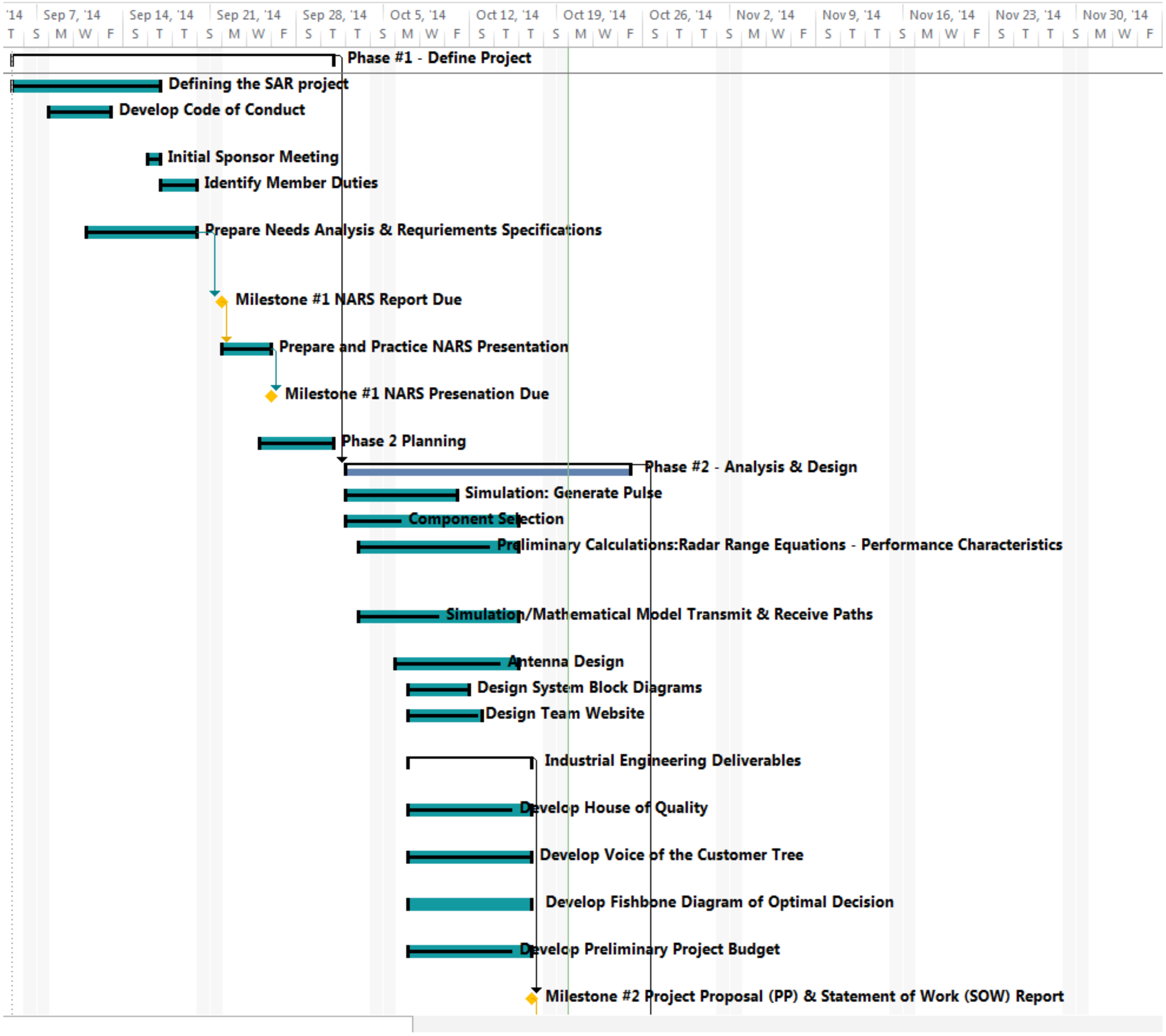
A3 House of Quality

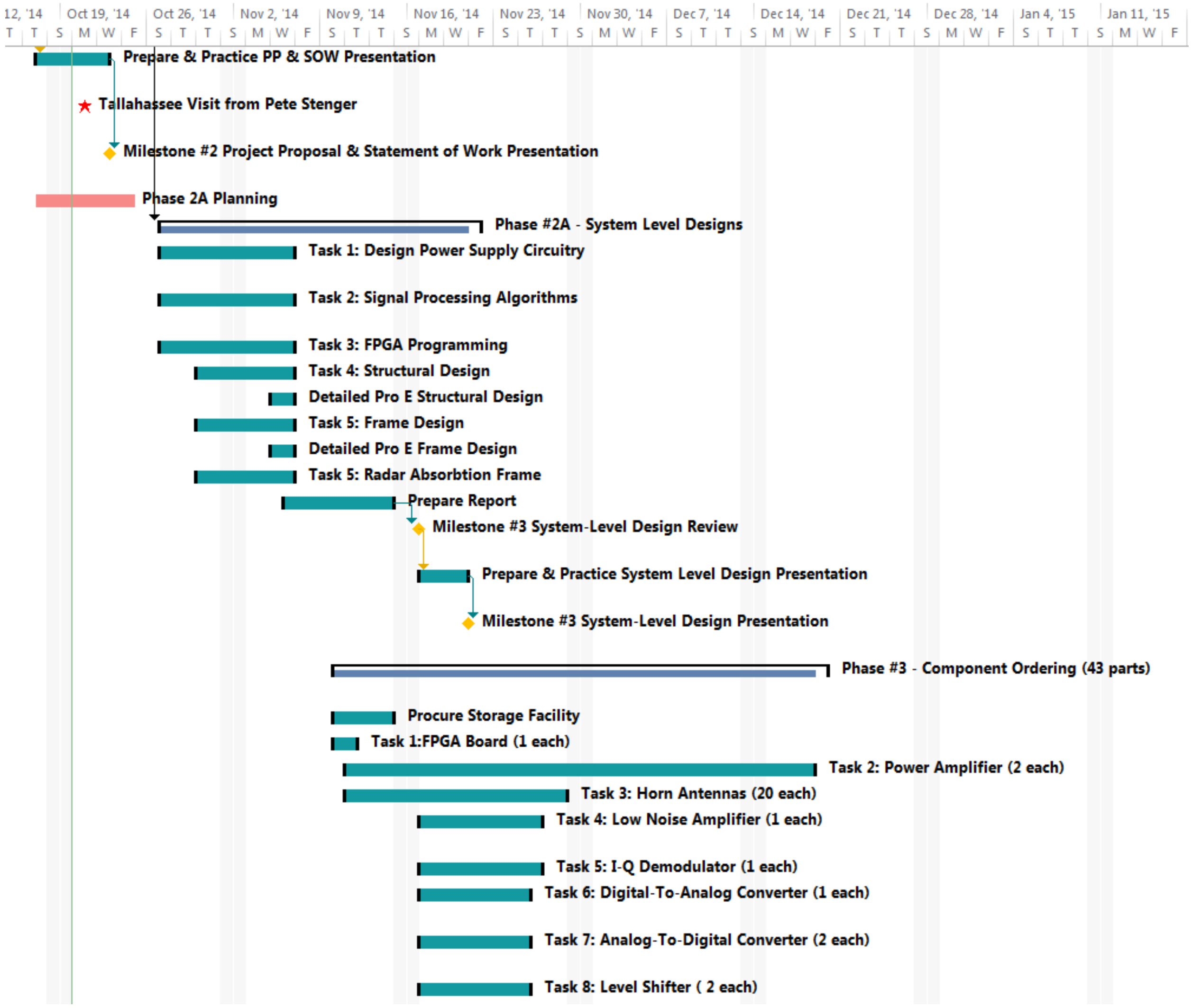


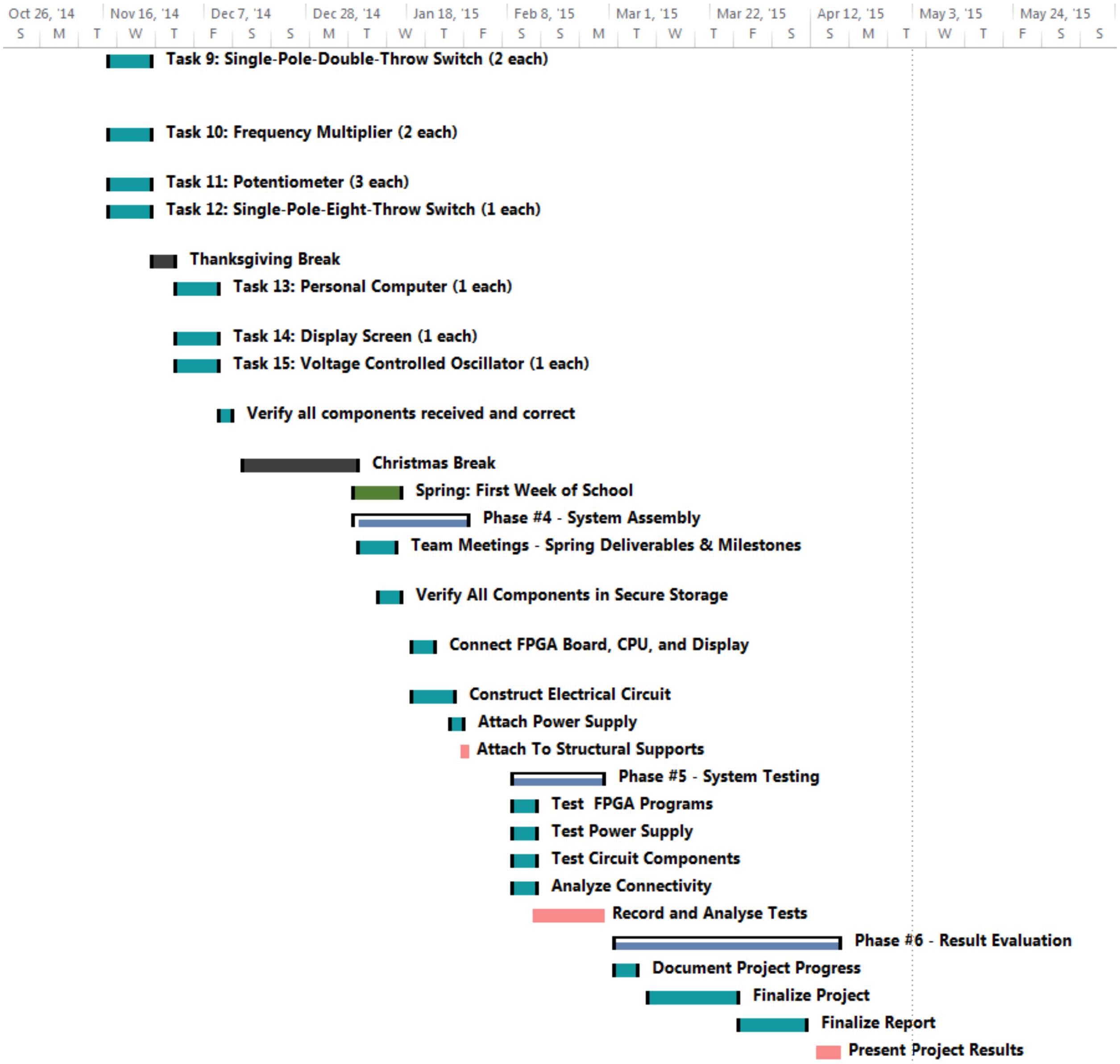
Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality	electronic SAR Imager	Metal Detector	3D Body Scanner
1	3	4.1	4.0	Minimum RADAR range of 20ft	5	0	0
2	9	5.1	5.0	X - Ku Operating Frequency	5	5	5
3	9	1.0	1.0	RADAR operate at FCC Standard	5	5	5
4	3	3.1	3.0	RADAR detects metal objects at range	5	1	2
5	9	6.1	6.0	RADAR operates at near-real time	3	4	3
6	9	7.1	7.0	RADAR scene covers one human body	3	4	5
7	1	7.1	7.0	Data from receiver should generate image	4	0	5
8	3	10.2	10.0	RADAR scene encompasses multiple humans	4	0	0
9	9	8.2	8.0	RADAR detects location of metal	4	0	5
10	3	9.2	9.0	RADAR detects movement of metal object	5	0	0
11	3	11.2	11.0	RADAR operates at real-time	3	5	4
12	9	2.0	2.0	RADAR to produce low-resolution photos	4	0	4
13	3	12.2	12.0	Imager to be portable	5	0	0
14	9	13.3	13.0	Imager to be lightwaeight	5	0	0

Column #	1	2	3	4	5	6	7	8	9	10	11	12	13
Direction of Improvement	x	▼	x	x	x	▼	x	x	▼	▼	▼	▲	▼
Target or Limit Value	18	10	3	1	16	40	30				50	1080	50
Difficulty	3	3	5	5	7	5	3	8	4	4	5	9	9
Max Relationship Value in Column	9	9	9	3	3	3	3	9	1	1	9	9	9
Weight / Importance	45.9	9.2	18.4	6.1	61.2	3.1	33.7	101.0	7.1	7.1	156.1	107.1	88.8
Relative Weight	7.1	1.4	2.8	0.9	9.5	0.5	5.2	15.7	1.1	1.1	24.2	16.6	13.8

A4 Gantt Chart




12, '14
Oct 19, '14
Oct 26, '14
Nov 2, '14
Nov 9, '14
Nov 16, '14
Nov 23, '14
Nov 30, '14
Dec 7, '14
Dec 14, '14
Dec 21, '14
Dec 28, '14
Jan 4, '15
Jan 11, '15
Prepare & Practice PP & SOW Presentation
Tallahassee Visit from Pete Stenger
Milestone #2 Project Proposal & Statement of Work Presentation
Phase 2A Planning
Phase #2A - System Level Designs
Task 1: Design Power Supply Circuitry
Task 2: Signal Processing Algorithms
Task 3: FPGA Programming
Task 4: Structural Design
Detailed Pro E Structural Design
Task 5: Frame Design
Detailed Pro E Frame Design
Task 5: Radar Absorbtion Frame
Prepare Report
Milestone #3 System-Level Design Review
Prepare & Practice System Level Design Presentation
Milestone #3 System-Level Design Presentation
Phase #3 - Component Ordering (43 parts)
Procure Storage Facility
Task 1:FPGA Board (1 each)
Task 2: Power Amplifier (2 each)
Task 3: Horn Antennas (20 each)
Task 4: Low Noise Amplifier (1 each)
Task 5: I-Q Demodulator (1 each)
Task 6: Digital-To-Analog Converter (1 each)
Task 7: Analog-To-Digital Converter (2 each)
Task 8: Level Shifter (2 each)


Oct 26, '14
Nov 16, '14
Dec 7, '14
Dec 28, '14
Jan 18, '15
Feb 8, '15
Mar 1, '15
Mar 22, '15
Apr 12, '15
May 3, '15
May 24, '15
Task 9: Single-Pole-Double-Throw Switch (2 each)
Task 10: Frequency Multiplier (2 each)
Task 11: Potentiometer (3 each)
Task 12: Single-Pole-Eight-Throw Switch (1 each)
Thanksgiving Break
Task 13: Personal Computer (1 each)
Task 14: Display Screen (1 each)
Task 15: Voltage Controlled Oscillator (1 each)
Verify all components received and correct
Christmas Break
Spring: First Week of School
Phase #4 - System Assembly
Team Meetings - Spring Deliverables & Milestones
Verify All Components in Secure Storage
Connect FPGA Board, CPU, and Display
Construct Electrical Circuit
Attach Power Supply
Attach To Structural Supports
Phase #5 - System Testing
Test FPGA Programs
Test Power Supply
Test Circuit Components
Analyze Connectivity
Record and Analyse Tests
Phase #6 - Result Evaluation
Document Project Progress
Finalize Project
Finalize Report
Present Project Results