Tangitek Capstone 2020

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EM Characterization of Radar Absorbing Materials

Team 5

Concept of Operations

- Material that absorbs EM radiation has many uses (stealth tech, radiation shielding, etc).
- To determine how well RAM material functions:
  - Insertion loss parameters (prior Capstone completion)
  - Reflection coefficient (prior Capstone completion)
  - RCS Measurements (⟵ this is us)
- Testing takes a very long time (last year took several weekends, rotating shifts). Solution:
  - Automate test procedure
- Covid interruptions refocused our deliverables away from hardware
  - Simulations, manuals, and repositories to pass along for future generations

Goals

- RCS measurements and simulation in HFSS
- Utilize VEE Software to automate data collection from VNA
- Update motor and turntable setup for testing
- Integrate VEE/Pi/Motor to completely automate testing process
- Improve previous NRL Arch apparatus to make more stable, easier to transport and store

The team

What were we each responsible for?

Jose Alvarez

Implement VEE software to interface with VNA to make measurements automated

David Eding

NRL Arch reconstruction for testing and measurement, HFSS simulation, Test plan

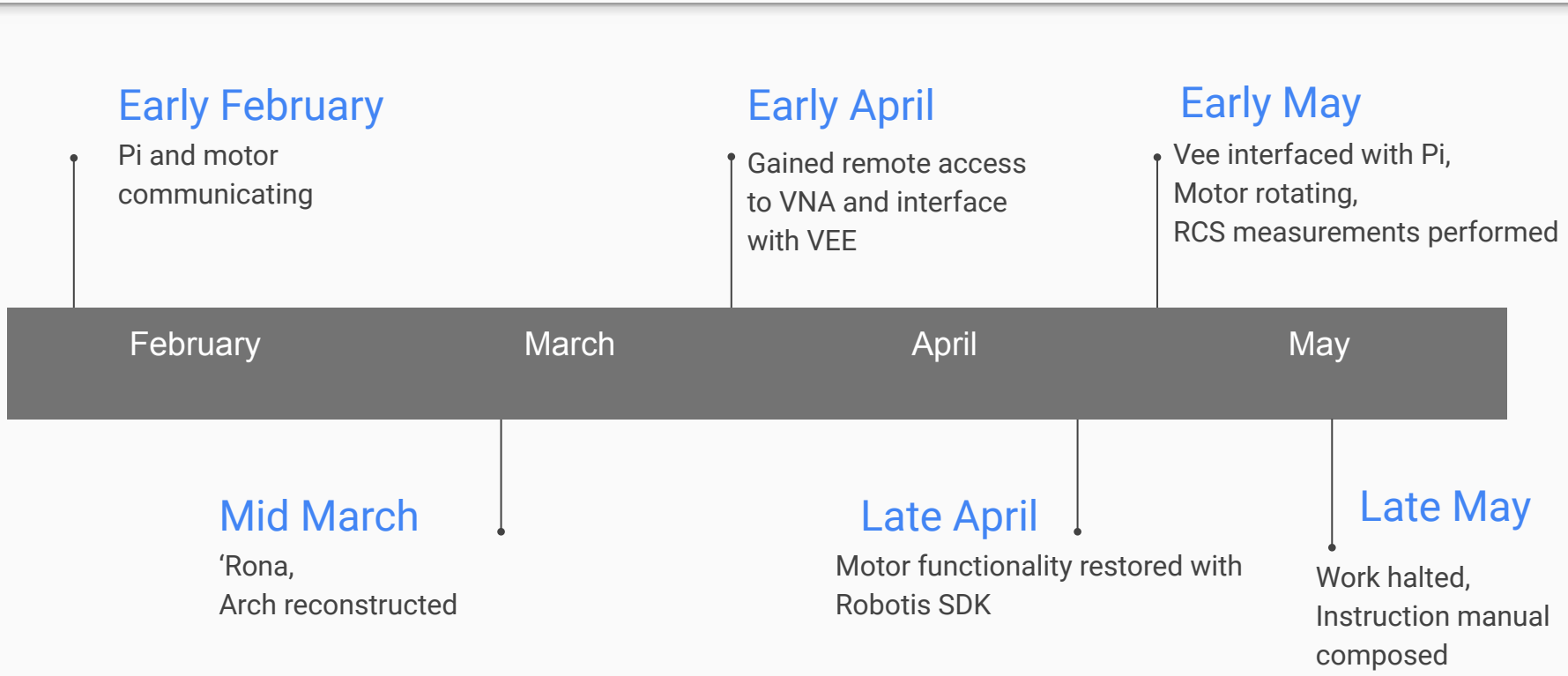
Kirk Jungles

Radar Cross Section(RCS) theory, measurement, and simulation

Chris Toner

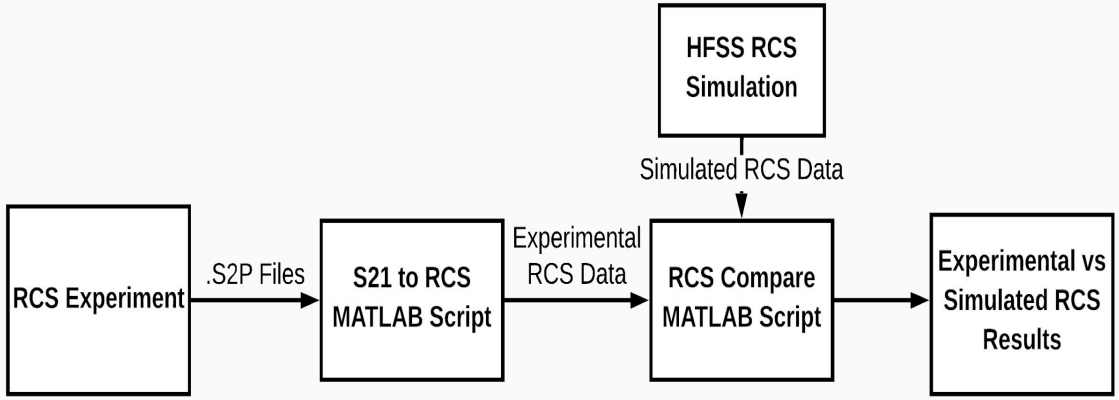
Upgrading motor and turntable, interfacing VEE Software with Raspberry Pi

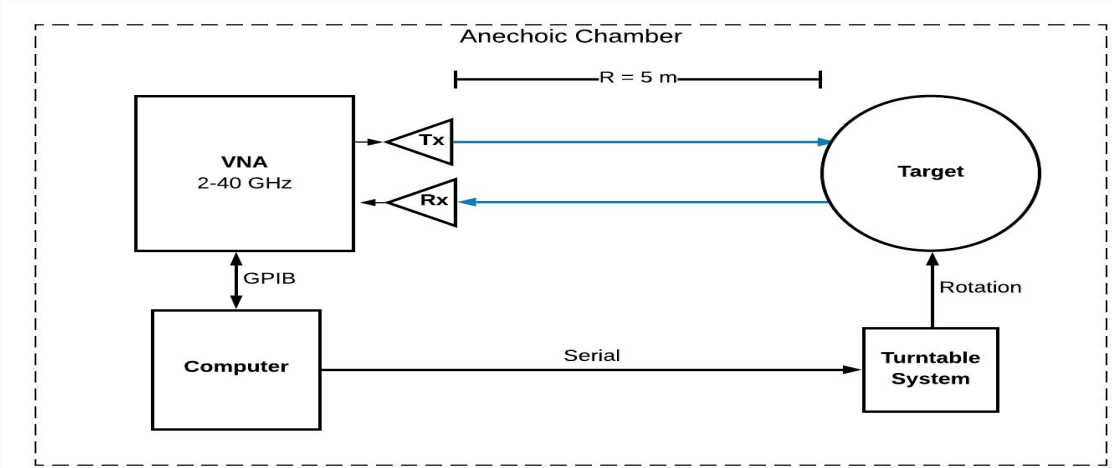
Milestones


Early February
Pi and motor communicating
Early April
Gained remote access to VNA and interface with VEE
Early May
Vee interfaced with Pi,
Motor rotating,
RCS measurements performed
February
March
April
May
Mid March
'Rona,
Arch reconstructed
Late April
Motor functionality restored with Robotis SDK
Late May
Work halted,
Instruction manual composed

RCS Measurement

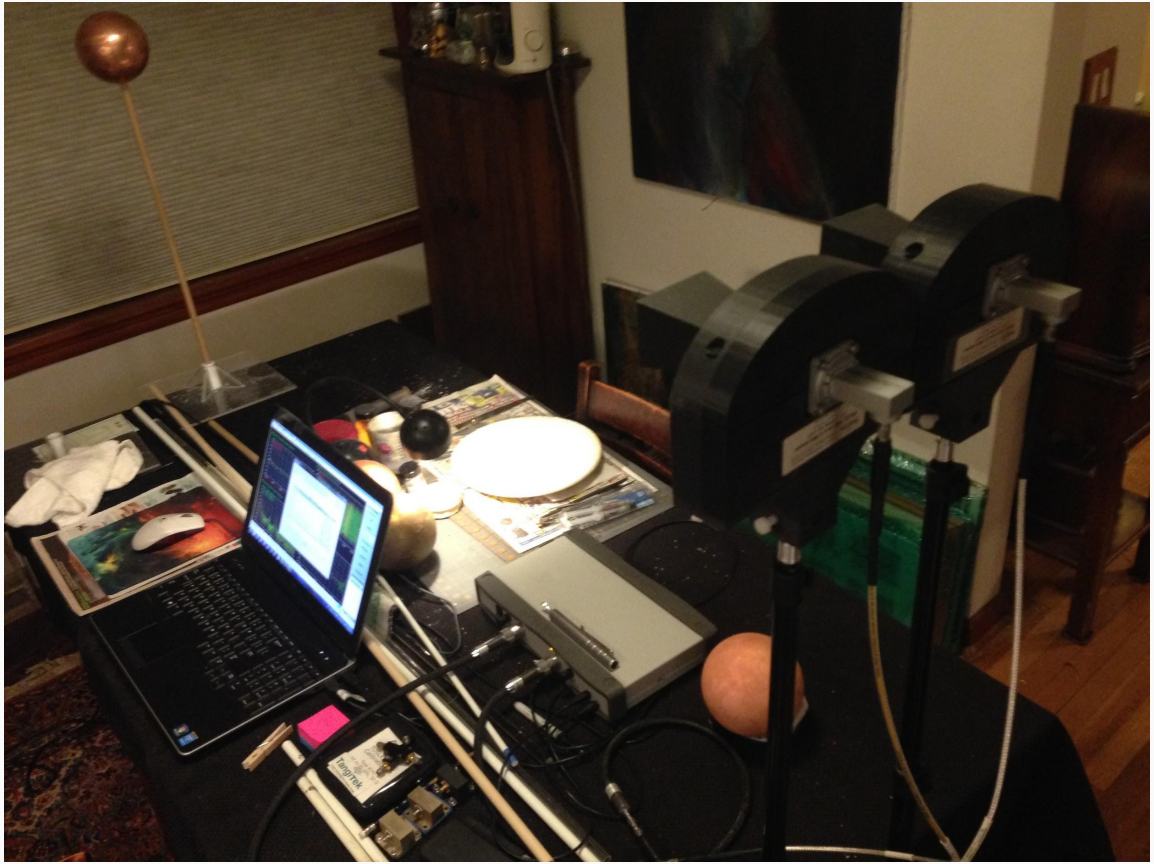
- Proposed system uses VNA measurements in Anechoic Chamber
- Collected S21 data processed in MATLAB and compared to HFSS simulation results





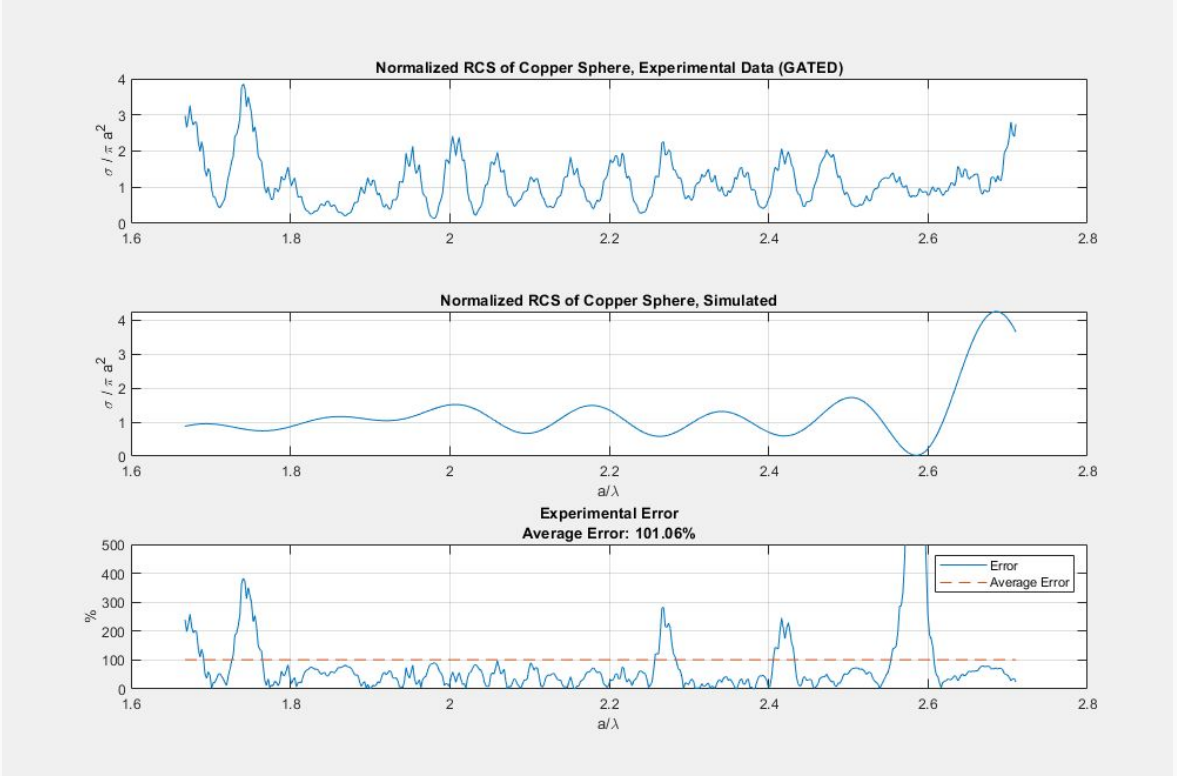
Actual RCS Measurements

- Global pandemic resulted in experimental difficulties
- Kent Thompson (Tangitek) living room used in lieu of anechoic chamber
- Near-field effects and other experimental artifacts abound



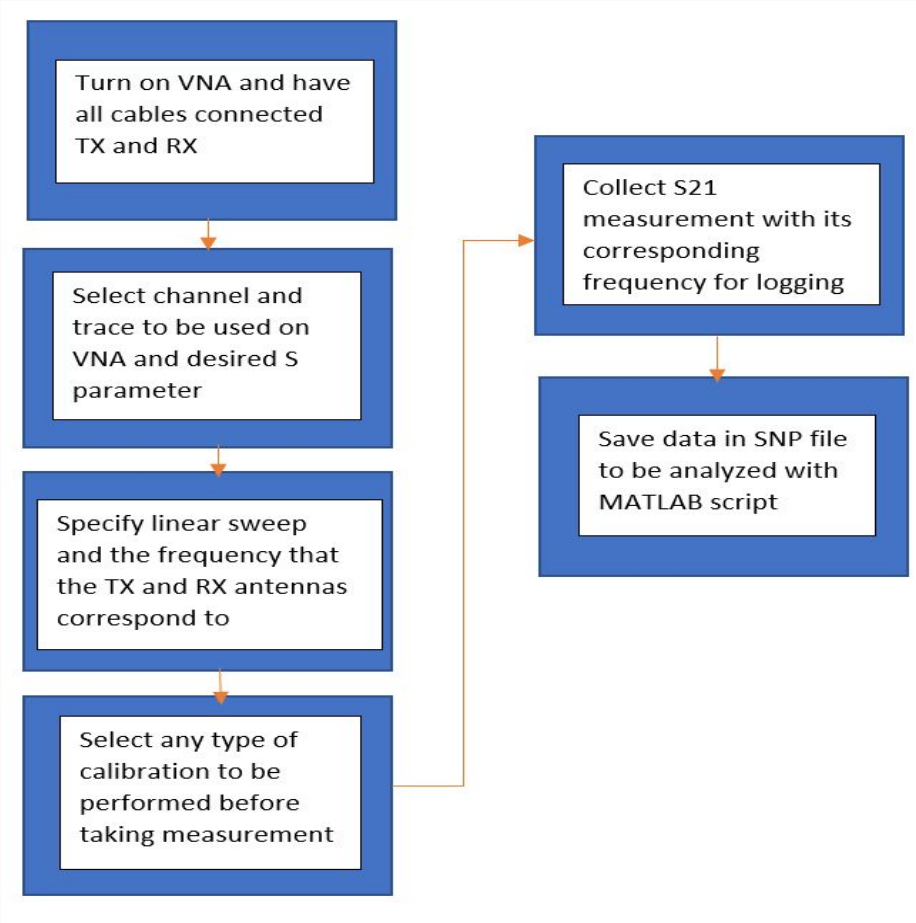
RCS Simulation and Measured Results

- Experimental RCS with raw data was very poor (Norm. RCS ~50)
- Time-domain Gating yielded improvement (Norm. RCS ~1)
- Better experiment may yield more accurate results
- Procedure seems reasonable



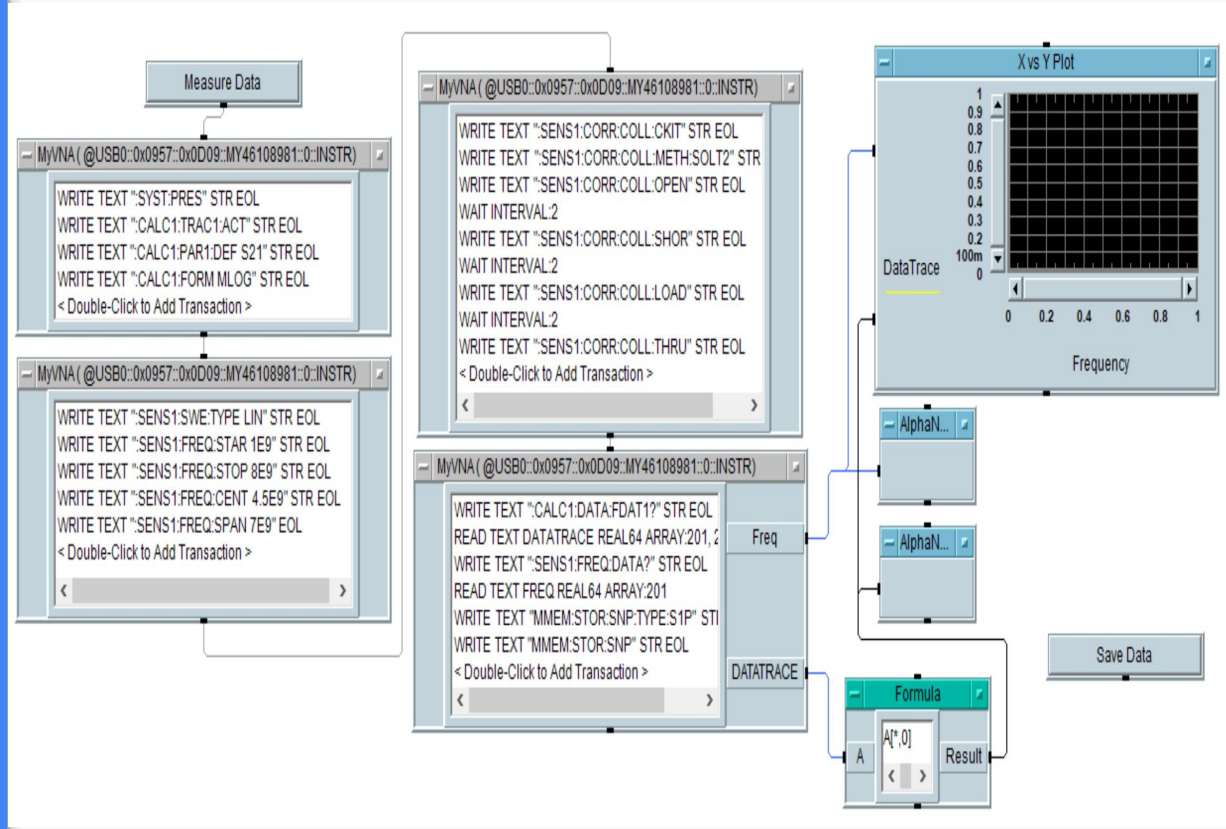
Algorithm for VNA Measurements

- Brief outline of what VEE program should look like
- Connect horn antenna for desired frequency band and specify frequency for linear sweep
- Specify S parameter we want for measurements and in this case S21
- Collect data for S21 with corresponding frequency
- Save data as SNP file for data comparison



Program Setup in VEE

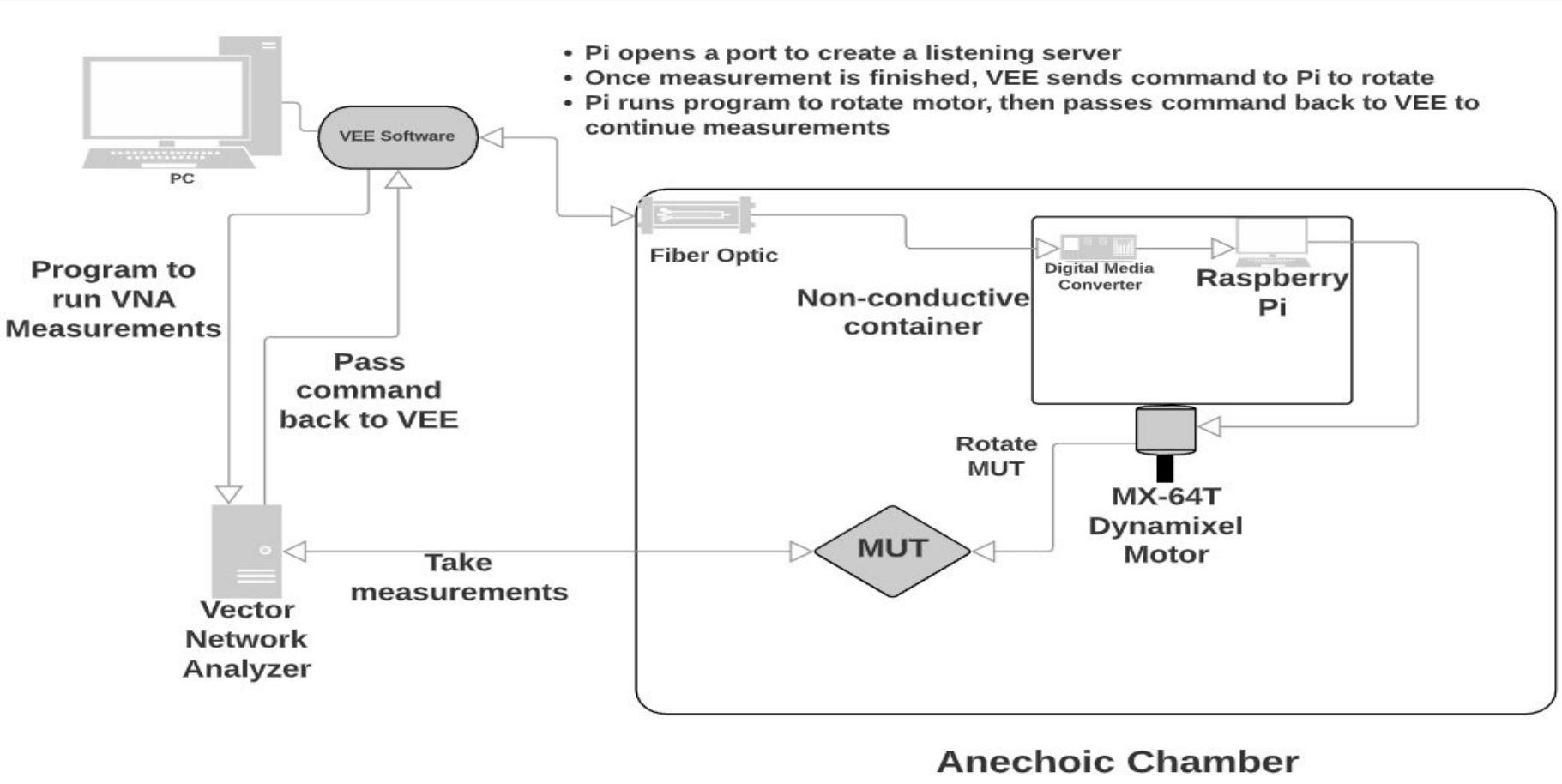
- The goal of using VEE software was to make the RCS data gathering as automated as possible
- The only button that needs to be pressed on VNA is the “ON” button
- Commands within the blocks are direct IO commands gathered from VNA manual
- Each block was separated by its use such as channel/trace setup, frequency setup, calibration, and data interpretation



Raspberry Pi and Dynamixel Motor

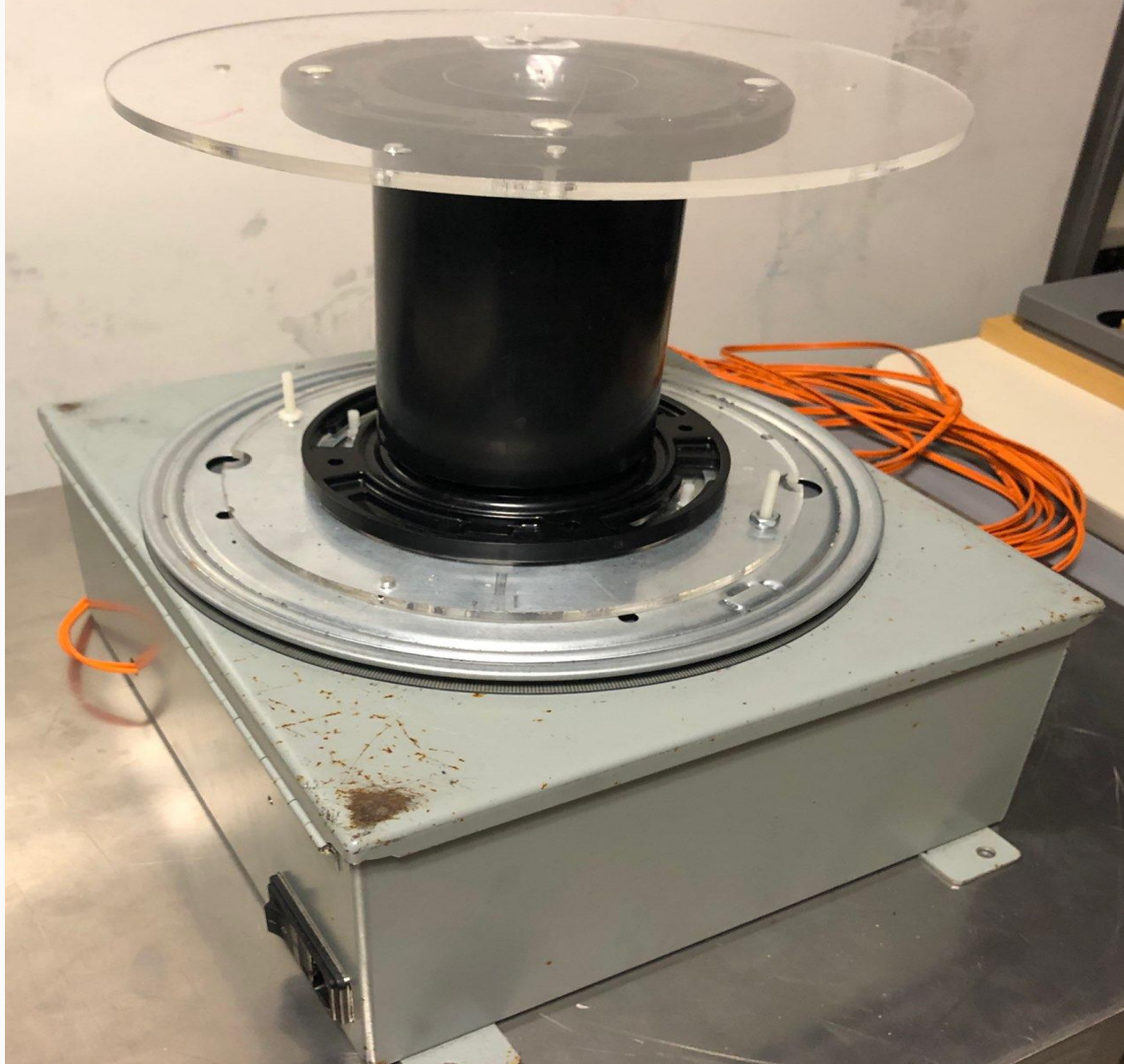
- Improve resolution and ease of programming
  - U2D2: USB-to-Dynamixel proprietary adapter for serial communication
  - Better Dynamixel motor → MX-64T 0.088° resolution
  - Robotis SDK and API builds out entire motor interfacing library complete with example programs; open-source git repo
- Integration of VEE and Motor
  - If VEE collects data, can it run in a loop and command motor to turn?
  - Cross-platform communication
  - Raspberry Pi set up as server, VEE socket protocol
- Ultimate goal?
  - Run VEE Program for data collection
  - VEE sends rotation commands
  - ***Set it and forget it baby***

Dynamixel Motor Automation Flow



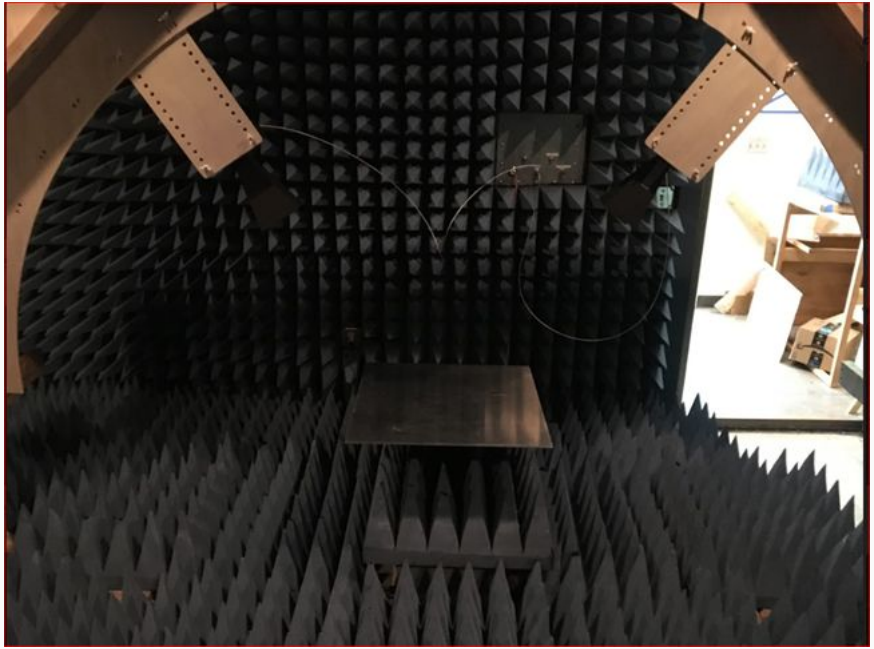
Test Plan for Motor

- Objective - Successfully communicate with the motor through the Raspberry Pi to rotate turntable
- Pretest - Preparation conducted on software, to get code running
- Test Equipment - Check is performed on power supply, micro USB, servo movement, Raspberry Pi to ensure accuracy
- Test System - Range of accuracy test in angles will be performed with increment in different test cases



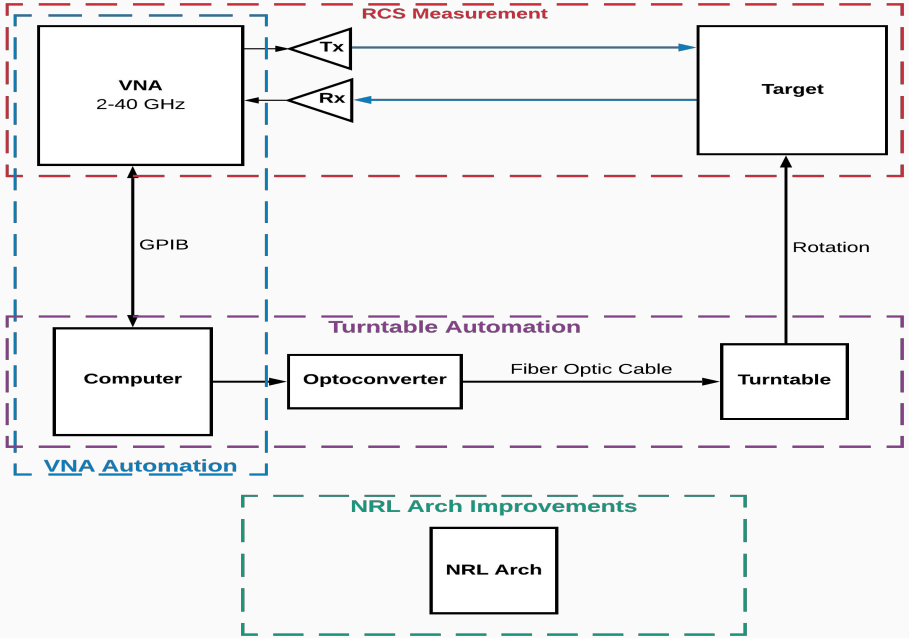
Naval Research Laboratory (NRL) Arch

- The NRL Arch system uses two antenna horns connected to a transmitter
- The microwave energy transmitted from one horn travels to and reflects off the target, collected by the receiver horn
- NRL Arch has been improved for
  - Stability
  - Ease of travel/storage
  - Improved horn alignment
- Our material would have been tested and then compared to TangiTek Materials across a variety of rotation angles
- Improvements are for future material iterations by Tangitek to retest reflection measurements



Final Delivery

- Instruction manual and documentation for:
  - RCS simulations in ANSYS HFSS
  - RCS Measurement Procedure
  - Automated control of VNA using VEE
  - Automation of measurement and motor rotation process
  - Improved NRL Arch structure
- Future capstones may integrate our separate achievements into one automated system



Appendix Keywords for Q&A

- ***Anechoic Chamber:*** *sound-proof chamber on PSU campus*
- ***API:*** *Application Programming Interface, "keywords" or functions for writing C++ for motor*
- ***HFSS:*** *High-frequency structure simulator for RCS simulation, run in Ansys*
- ***NRL Arch:*** *Naval Research Laboratory Arch design for hanging antennas for reflection measurements*
- ***RCS:*** *Radar Cross Section Measurements*
- ***Robotis SDK:*** *Open-source Software Development Kit made by motor manufacturer*
- ***VEE:*** *Object-based programming software, made by Keysight, for collecting test data*

Team Github: https://github.com/KirkJungles/TangitekCapstone2020