AMEND – Machine Learning

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Executive Summary

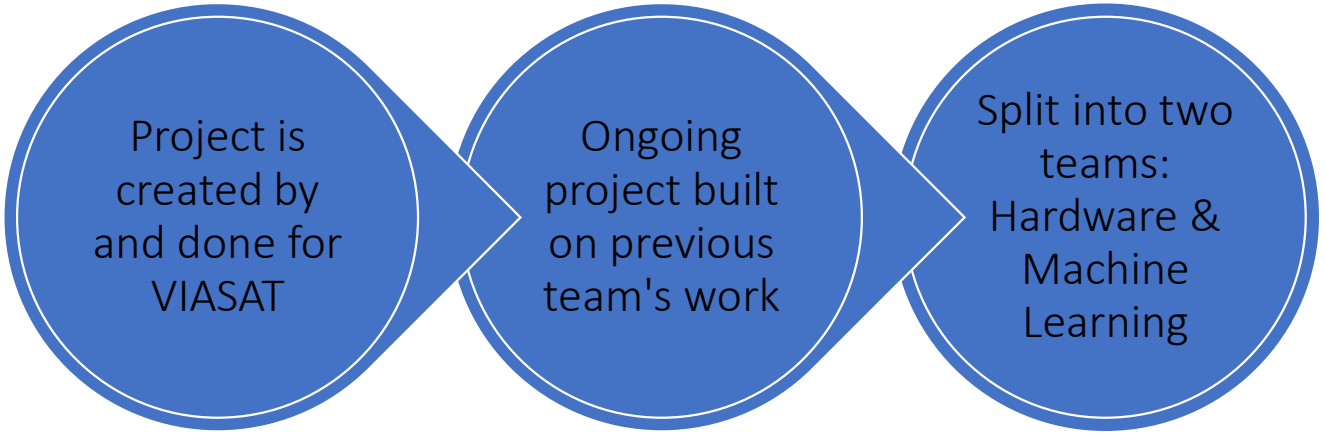
Main Goal: Track satellites to maximize Gain-to-Noise

Develop controls **to** physically move ground dishes to point in proper direction

Normally controls are done with traditionally calibrated PID systems

Now implementing with machine **learning** techniques based on simulation databases

Logistical Background



Project Description

We want to design and implement a ML algorithm to accept a wide range of RF inputs and generate PID parameters to take predictive actions.

The goal is to create increasingly accurate PID parameters that produce improved corrective actions for the tracking system.

Main steps to take:

Create Matlab database that will hold data points generated from the existing RF model

Develop method of extracting data from the RF model

Implement a way to transfer this data into the ML algorithm

Technical Specifications

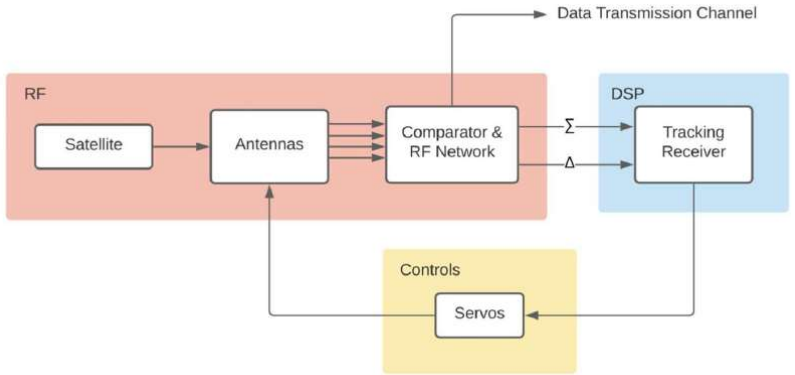
Minimum RF Input Bandwidth	200 MHz
Desired RF Input Bandwidth	3 GHz
I/Q Signal Bandwidth	10 MHz
Minimum SNR on Main Horn After Processing	7dB
Maximum Latency	0.5s
Control System Update Rate	50 Hz – 1kHz
Maximum Trackable Satellite Speed (Azimuth)	$15°/s$
Maximum Trackable Satellite Speed (Elevation)	$3°/s$
Maximum Mean Squared Tracking Error	0.01°RMS

Table 1. Technical specifications as requested by Viasat

Design Approach

Existing Infrastructure

- Matlab/Simulink model that simulates dynamic response of antenna tracking system in time domain
  - Model will be used to reliably generate data that can be used to train the ML algorithm
- Work will be in close conjunction with AMEND Analog team
  - Analog team will focus on improving model to add features that will yield more accurate data



Block diagram for existing RF model

Ideation and Tradeoffs

- Solution will be implemented within MATLAB/Simulink using its native toolbox
  - Implementing solution within MATLAB toolbox is not computationally ideal
- There are two primary “blocks” within the project
  - Database populated by the existing RF model
  - ML algorithm that outputs improved PID controller parameters

Engineering Analyses and Experiment

- Expensive ground stations – current PID parameters shall be compared to historical PID parameters from Viasat.
- Will utilize previous test scenarios as a means of quantifying the effectiveness of the ML algorithm.

RF model – Input Parameters – ML Algorithm – PID Parameters Outputted

- Quantity of interest for algorithm testing – root mean squared error of updated PID parameters

Codes and Standards

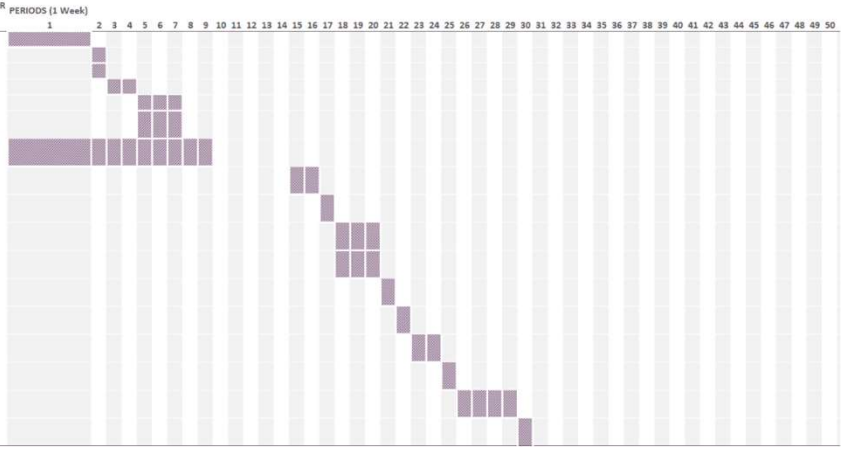
- 1st regulation to consider – FCC standard 15.209 – intentional emissions of RF energy.
  - The design model of the tracking system should not radiate RF energy, unless done so unintentionally due to non-idealities associated with the system. That said, it is unlikely that this regulation should affect the design.

- 2nd regulation to consider – FCC part 25 – carrier frequency tolerance, power radiation, frequencies incorporated into design, and antenna (ground station) angle of elevation.

Schedule

ViaSat Amend Gantt

ACTIVITY	START	DURATION	FINISH	PREDECESSOR
1. Draft Project Summary	15-Oct	1	22-Oct	
2. Team Survey 1	23-Oct	0.3	25-Oct	1
3. Project Design Standards & Codes	22-Oct	1	29-Oct	1
4. Project Job Budget & Costing	29-Oct	2	12-Nov	2,3
5. Final Project Summary Form	29-Oct	3	22-Nov	4
6. Project Proposal	29-Oct	3	22-Nov	4
7. Design Notebooks	14-Oct	7	3-Dec	
8. Revise Proposal	10-Jan	2	24-Jan	5,6,7
9. Determine Sensor Settings	24-Jan	1	31-Jan	8
10. Servo tuning scenario generation	31-Jan	3	21-Feb	9
11. AMEND model scenario generation	31-Jan	3	21-Feb	9
12. Database format for inputs/outputs	21-Feb	1	28-Feb	10, 11
13. Populate database for scenarios	28-Feb	1	7-Mar	12
14. Use measured data to create servo system model	7-Mar	2	21-Mar	13
15. Examine offset/noise modeling for measurements	21-Mar	1	28-Mar	14
16. Develop "flawed" model and search for "best fit"	28-Mar	4	2-May	15
17. Expo Presentation	3-May	1	10-May	16

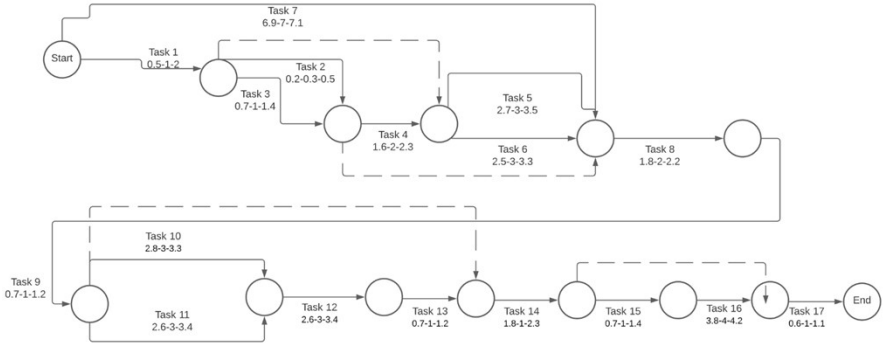


Paths

1-2-4-5-8-9-10-12-13-14-15-16-17
1-2-4-6-8-9-10-12-13-14-15-16-17
1-2-4-5-8-9-11-12-13-14-15-16-17
1-2-4-6-8-9-11-12-13-14-15-16-17
1-3-4-5-8-9-10-12-13-14-15-16-17
1-3-4-6-8-9-10-12-13-14-15-16-17
1-3-4-5-8-9-11-12-13-14-15-16-17
1-3-4-6-8-9-11-12-13-14-15-16-17

Critical Path:
1-3-4-5-8-9-10-12-13-14-15-16-17

PERT Chart



1.Expected duration of the project: **23.09 weeks**
2.Expected standard deviation for the critical path: **.414**
3.Probability of finishing project one week prior to design expo: **99.99999999987202 %**

Marketing and Cost Analysis

- Given the project is internal to Viasat, there are no competitors to be aware of. The closest we have is a previous iteration of the AMEND project's model to further build upon.
- **Estimated Program Cost =** $31,020 * 3 **= $93,060**
- Our estimated program cost utilizes the "Rule of Three" that we were given, which accounts for all costs supplementary to our labor cost.
- With the minimal physical materials needed from the project, cost of labor is as follows:

First Semester - 12 weeks	Total Number of Hours	Cost
Assignment Completion	24	$1,056
Industry Sponsor Meetings	6	$264
Faculty Advisor Meetings	6	$264
Second Semester - 15 weeks		
Coding/Engineering	90	$3960
Industry Sponsor Meetings	7.5	$330
Faculty Advisor Meetings	7.5	$330
	Total Labor Cost per Engineer	**$6,204**
	Total Labor Cost for 5 Engineers on Team	**$31,020**

Division of Labor

- Our team roles have been divided in the following manner:

1. Webmaster/ Git Coordinator – Tyler Cole
2. RF Insider – Mikias Balkew
3. Documentation/Viasat Coordinator - Shreyas Mhasawade
4. DSP insider - Adrija Bhattacharya
5. Expo Coordinator - Chris Rothmann

Division of Labor Cont. - Individual Roles

Real time ML

Calibration with ML

ML for servo control

Satellite infrastructure

Antenna Parameters