Lab Report 1:
Case Study NASA ESD
Satellite Antennae Performance

Dates of Research: June 4, 2020 - June 10, 2020

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by

Michael Kurts

Project Investigator

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Department of English

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1.0 Introduction

Without a robust and efficient satellite antenna, a satellite becomes space trash. Communications to either the ground from a satellite or back and forth between satellites are paramount for mission success. Propelling a satellite into space without ensuring its full operability wastes millions of dollars, man-hours, and resources.

In this experiment, both dipole and dish antennae were tested at different distances, pitches, and headings to measure received signal strength (RSSI). National Aeronautics and Space Administration's (NASA) Earth Science Division (ESD) partnered with Embry-Riddle Aeronautical University to utilize their Hub™ Simulation Software.

The purpose of the research conducted is to determine which style (dipole or dish) antenna is going to work best for the new GEOS-R geostationary weather satellite.

In this lab report, the findings of NASA's Earth Science Division will be represented by procedures, results, and conclusions.

2.0 Procedures and Data Visualizations

The experiments were conducted from June 4, 2020 to June 10, 2020. They were conducted via Embry-Riddle Aeronautical University's Hub™ Simulation Software. This is a virtual software that allows testing of satellite communications with different parameters.

In the simulations, one geostationary satellite was used as the transmitting station sending signals to other satellites with either dipole or dish receivers. Headings and pitch were measured in degrees, the power was set to 1 watt and captured RSSI (received signal strength indicator) values between 20 and 200 feet of unobstructed distance. All the data processing was handled through Microsoft Excel 2010 and the distances were measured in feet.

The primary theory tested throughout experiments is the Friis Transmission Equation (FTE). The FTE predicts that the strength (RSSI) will depreciate as the distance between the transmitter and receiver increases. FTE assumes a power of one watt, a gain of one watt, and a frequency of 1 GHz. The equation is represented in logarithmic form like this: $P_r = P_t + G_r + G_t + 20\log\left(\frac{\lambda}{4\pi R}\right)$. P_t is the power fed into the transmitting antenna input terminals, P_r is the power available at receiving output terminals, G_r and G_t describe the gain of receiving and transmitting antennae, λ is the wavelength, and R symbolizes the distance between antennae. Calculations of RSSI were accomplished in the experiments by converting dB to watts by using this formula: $10\log\frac{dB}{10}$.

The first experiment averaged the RSSI for a dish antenna over 5 seconds, recorded at 20-foot increments from 20 to 200 feet. The second experiment is the same as the first but utilizes the dipole antenna. The third experiment measured the RSSI for each antenna-type at a uniform distance of 200 feet, transmitting at a power of 1 watt for different angles of heading. The fourth experiment tested the antennae at 200 feet from a one-watt transmission source at various pitches, measured in one-degree increments. Pitches less than -15 degrees and greater than 16 degrees weren't tested due to antenna design limitations.

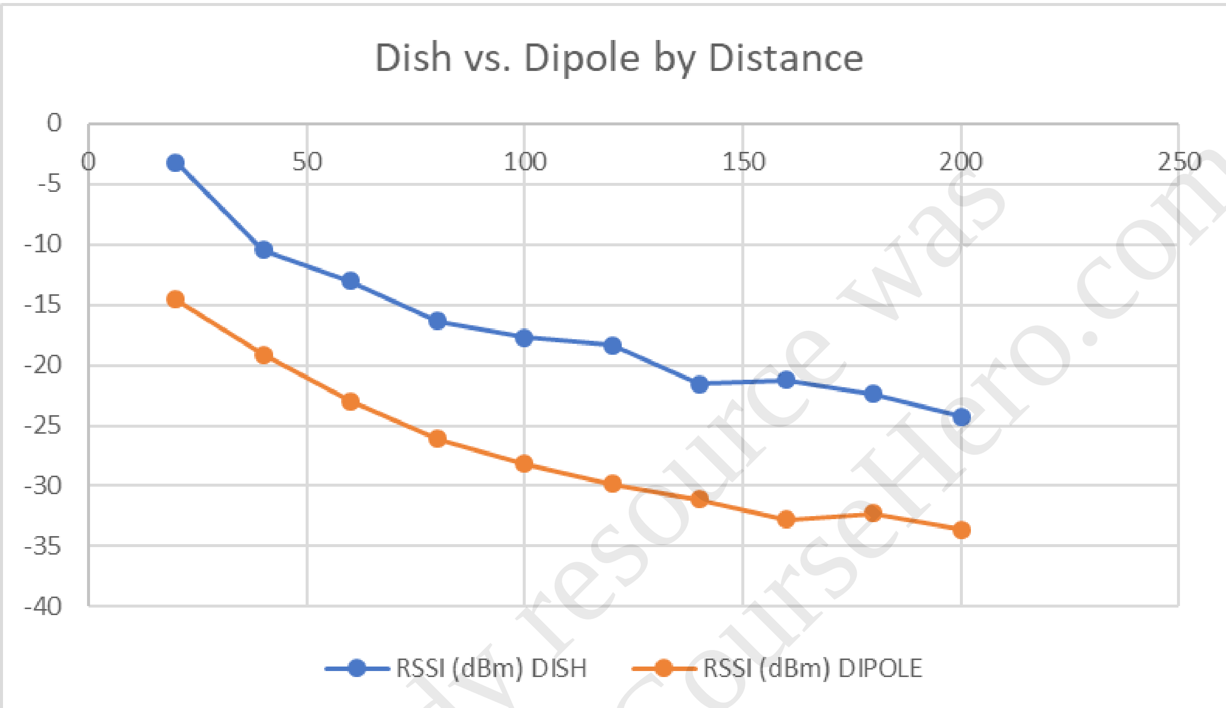

Figure 1: This is the data collected by Lucas DeLeon and his team displaying dish and dipole RSSI's by distance at intervals of 20 feet up to 200 feet.

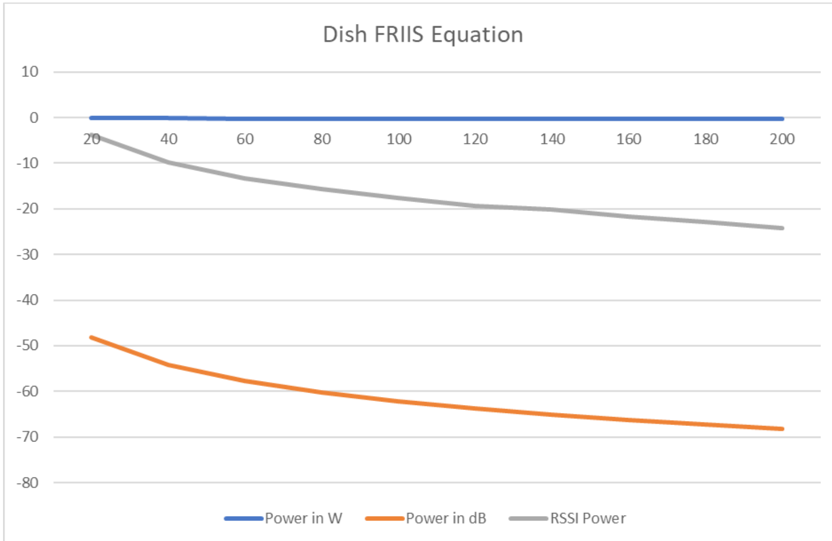

Figure 2: This displays the FRIIS equation from the Dish antenna experiments. It is important to note that the FRIIS equation assumes a power of one watt, a gain of one watt, and a frequency of 1 GHz.

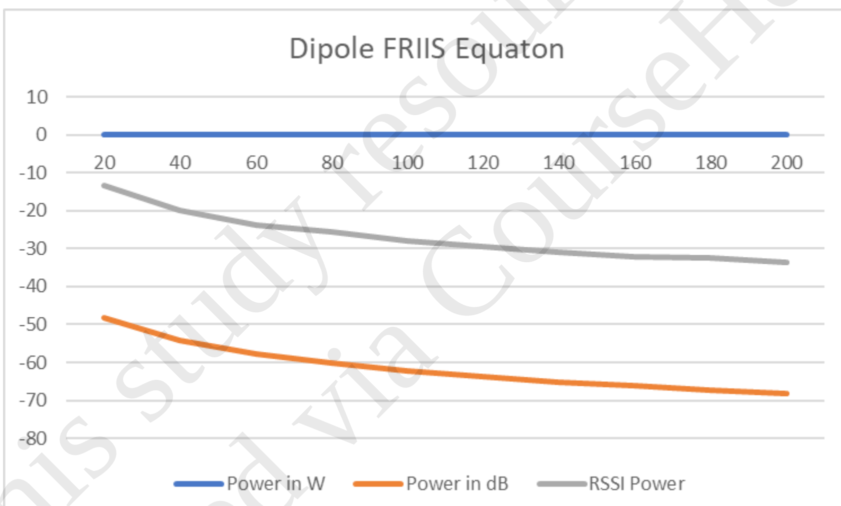

Figure 3: This displays the FRIIS equation from the Dipole antenna experiments. Like in Figure 2, the FRIIS equation assumes a power of one watt, a gain of one watt, and a frequency of 1 GHz.

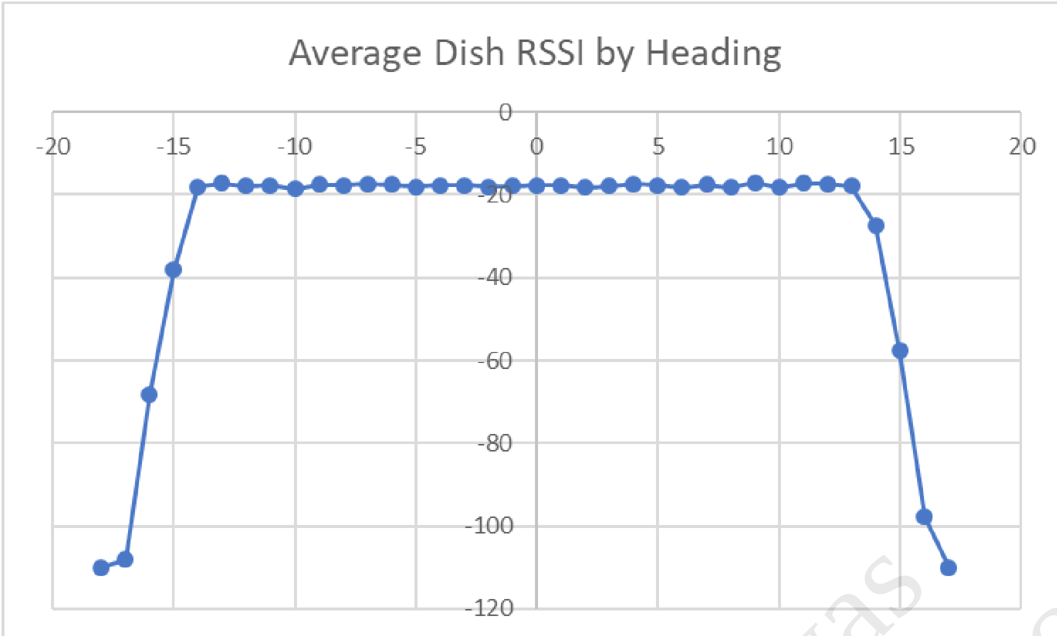

Figure 4: This scatter chart shows the average dish antenna RSSI based on the heading. The X-axis represents the RSSI value and the Y-axis represents the heading in degrees.

3.0 Results

The results of the experiments conclusively demonstrate that RSSI is inversely proportional to the distance between transmitter and receiver. From the figures above, you will notice that the experiments show an optimal, overlapping zone of headings in which the RSSI remains constant. Outside of that zone, the RSSI values drop along with communications. This was able to show us what range of heading presented an operational view for the communication array.

4.0 Conclusions and Recommendations

Upon completion of these experiments and given GEOS satellite mission parameters, we can recommend dish type receivers with confidence. This research is important as it simulates exactly what satellites will be experiencing through their communications based on different pitches, headings, and power settings.