Thesis Project Portfolio

Hypersonic ReEntry Deployable Glider Experiment (HEDGE)

(Technical Report)

Satellite Constellations and Their Effect on Radio Astronomy

(STS Research Paper)

An Undergraduate Thesis

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Executive Summary

The accessibility of space has opened the doors for a rapid expansion in the number of satellites being launched and deployed. While this is great for research, industry, and exploration efforts, some side effects include limitations on operations. My technical portion focuses on HEDGE, or Hypersonic ReEntry Deployable Glider Experiment, which is a CubeSat project being worked on as a capstone at the University of Virginia. The goal of the mission use the decreased cost of access to space to test different materials during a hypersonic, meaning over five times the speed of sound, reentry. My STS portion of the paper focuses on the dynamic between astronomers and satellite constellation operations in the context of how radio frequency is allocated and how interference between the two is managed. The goal of the paper is to discover what is being done currently to ensure interference between the two doesn't get worse and who is responsible for that work. These pieces tie together in that both of them are focused on the increasing availability of access to space. One side explores how it can be used for testing new technologies, while the other focuses on how interference could be created by these new satellites.

HEDGE has the goal of proving that hypersonic material testing can be accomplished by college students at a low cost. The mission uses the CubeSat form factor which means that it is effectively made out of 10x10x10 cm blocks. For this mission three of these are put together which is referenced by a 3U form factor. HEDGE will be launched into space where it will then reenter through the atmosphere and burn up before reaching the ground. There will be four material test panels that will each have a pressure tap and thermocouple to give pressure and temperature data. To accomplish this mission and keep it low cost the goal is to use COTS, or commercial off-the-shelf, components that are much cheaper than having to custom build.

The capstone project was divided up into separate teams to ensure that each area of the mission would get the attention required to fully integrate everything upon completion. Much of the work itself has focused on background research, trade studies, simulation, and prototyping. My focus on the team is working on the communications aspects of the mission. Keeping in line with the use of COTS components, we are using the Iridium Communications Network which allows the use of components that are easy to purchase and integrate within HEDGE. It will allow us to relay the data from the mission to the Iridium satellites in orbit before HEDGE ultimately burns up.

My STS portion of the paper takes a different angle to the work I am completing for HEDGE but at a much wider scale. Each of these CubeSats or satellites placed into orbit is transmitting information to each other and the ground. This results in interference within the radio frequency for others trying to look up at the sky from Earth, such as radio astronomers. The goal of the STS portion of my paper is to explore how the rapid expansion of these satellites is having an impact on radio astronomers. It will also explore how radio frequencies are currently allocated and what is being done to prevent interference from occurring. The paper uses Actor-Network Theory to analyze the two independent networks of radio astronomers and satellite operators and how they compare.

The paper conveys the number of actors involved on each side to try and help each to get more frequency allocated to them. A few case studies are highlighted to show what has been done in the past when inference has occurred and what might be learned from them. One of these case studies is from the Iridium Satellite Constellation and their struggles with managing interference which ties into the technical portion of the paper as Iridium is the communications network that will be used. The paper then looks into what the current issues are and what is being

done to correct those. One of the main issues is unintentional interference which is interference at frequencies that aren't assigned or designed to be transmitted onboard the satellites. The analysis completed in the paper shows that there are many involved who each think they can help with frequency coordination which has made it difficult to regulate. The argument is made that a central organization should take the role of coordinating between astronomers and satellite operators, especially as the number of satellites continues to rise. The paper also goes into different methods that might be implemented to help resolve the issues faced by both parties.

Table of Contents