Thesis Project Portfolio

Hypersonic ReEntry Deployable Glider Experiment

(Technical Report)

An Anecdotal Analysis of Modern Hypersonics Programs

(STS Research Paper)

An Undergraduate Thesis

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Executive Summary

The hypersonic speed regime (Mach 5+) is one of the most violent and turbulent environments that engineers have to contend with when designing a flight vehicle. However, it also has the most strategic potential for an air-based weapon system. Thus, it has gained the interest of many academic and non-academic minds alike. This is a conflict of interest in ways, as often times the United States defense programs recruit from large pools of undergraduate and graduate level students, whose main focus or interest may not lie in defense. History has shown that large, nationwide programs, such as the modern day hypersonics programs, tend towards some form of misinformation, deception towards true intentions, or even manipulation and coercion, in order to attract talent. Many colleagues of mine would much rather not work for the defense complex because of their moralistic standpoint, yet many find themselves in a position of defense research or work, simply due to the large number of defense stake-holders in the field of hypersonics research. What I want to investigate is to what extent are modern day hypersonics programs pushing their narrative, how they push that narrative, and how the aerospace students at UVA respond.

My technical research question tests the feasibility of a CubeSat (cube satellite) to act as a hypersonic reentry vehicle, as well as to show the ability for undergraduate students to perform hypersonic experiments at lower cost and with greater accessibility than traditional programs. To do this, the Hypersonic Re-entry Deployable Glider Experiment (HEDGE) was introduced, which is a proof of concept mission is a concept experiment utilizing a CubeSat for low-cost hypersonic flight experiments and data acquisition. This mission is that it is a multi-year long, class-cooperative capstone. We began the year familiarizing ourselves with the mission, and the previous work done. Our class was split into multiple sub teams in order to account for all aspects of the mission. My personal contributions to the project consisted of generating a power circuit diagram that logically mapped out power and communications relays within the CubeSat, electrical power system (EPS) selection, and calculating net power generation from our selected solar panels. Overall, all aspects of the mission gained much more specificity over the course of this year. The improvements included finalized dimensioning, hinge deployment methodology, material selection, electronics selection, etc. A final prototype demonstration consisting of a 3D printed chassis and electrical components minus battery will be performed to prove limited functionality at the end of Spring 2023.

For my STS research question, I wanted to investigate how hypersonics programs centered around defense interfaced with universities and its students. Specifically, I wanted to gauge how aware 4th year aerospace students and Aerospace Research Lab (ARL) researchers are of the implications of their work related to defense hypersonics. To do so, I conducted an interview where I asked each candidate a series of questions. These questions probed the candidates to think about his/her relationship with the defense complex, making them consider if they had ever thought about where their funding came from, and the potential of their work having a direct military application. What I gleaned from this experiment was heartening. Most students were quite well aware of how they stood with respect to hypersonics defense, and understood the implications of his/her actions. I also learned that there are, though less abundant, hypersonics research opportunities that currently do not have a direct militarization application, and instead do in fact highlight the interesting phenomena that occur at such high speeds, temperatures, and pressures.

From an STS standpoint, I feel like I understand the relationship between the defense complex, and the university student much better. I was also glad to learn from my research that most hypersonics projects going on at ARL are very communicative about objectives. Defense is often something that gets glorified in the name of defending a nation, and while I do believe that to be intrinsically important and valuable, the way that defense programs go about advertising and recruiting should be in a way that shows transparency with regards to the expectations and intentions of the program, and in a way that limits dishonest practices. For my technical project, my graduating class of 2023 will not see the conclusion of this project, which plans to conclude in the Spring of 2025. When my class and I took up the project in the Fall of 2022 semester, many details had not yet been specified. Electronics had not been purchased or prototyped, a detailed computer aided design (CAD) model had not been drawn up yet, and many issues about satellite relay communication and solar power generation had not yet been resolved. The project began the year in the conceptual design review (CoDR) phase of development, and now at the end of the Spring of 2023 semester, HEDGE has concluded the critical design review (CDR) phase, which means that full scale prototyping can begin immediately. This year was definitely a design heavy year, with theoretical work and calculations encompassing most of the work, so I’m happy that we were able to draw useful conclusions and make effective design choices. Overall, we are right on schedule for fabrication to begin next semester, contingent upon the successful prototype demonstration.