Hypersonic ReEntry Deployable Glide Experiment (HEDGE) Power, Thermal and Environmental Systems

Understanding the Current and Future Impacts of Hypersonic Weapons Development on International Relations and Politics

A Thesis Prospectus
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By
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

In recent years, hypersonic technology has become a matter of huge importance to the whole of society. Due to its potential use as a seemingly unbeatable weapon, many nations have invested significantly in furthering the development of these technologies. This research has even extended to the University of Virginia, where studies are currently being conducted to test hypersonic technologies in many capacities. My research also focuses on testing hypersonic systems and understanding the political impacts which they have on the rest of society.

The primary purpose of my technical project in Spacecraft Design is to further understand what physical effects a hypersonic vehicle experiences during travel as well as whether microsatellite systems can be used to perform this research. This will be done by designing and launching a CubeSat which will reconfigure into a hypersonic reentry vehicle. This vehicle will record multiple pieces of data during reentry into earth's atmosphere, such as the temperature and pressure experienced throughout the hull. This scientific question is important to understand because the data can be used to confirm current models we have of hypersonic aerodynamics. Also, determining whether inexpensive CubeSats can be used can inform other institutions whether they should use similar systems to perform future research.

I will also be conducting research on how hypersonic weapons development has affected the world politically, as well as future repercussions it might have. The project will mainly consist of research on historical occurrences as well as connecting with current analysts and researchers to understand future impacts. Researching this specific social question is important as it will serve to explore the importance of investing in hypersonic technology in the first place.

This prospectus will explain in more detail the research which I will conduct, why it is important, and what groups this research will impact. Additionally, the overall methodology for

conducting this research will be explained along with the timeline in which the studies will be performed.

Technical Project

The primary purpose of the technical project is to develop an inexpensive hypersonic reentry vehicle which can be used to validate currently existing hypersonic aerodynamic models as well as explore the validity of using inexpensive hypersonic research vehicles in general. This project is specifically referred to as the Hypersonic ReEntry Deployable Glide Experiment (HEDGE). This project has already been started by a previous Spacecraft Design class, and they developed this project up to the conditional design review. Our current class will be furthering the development of this project through the preliminary and critical design reviews.

Within this project, I am a member of the power, thermal, and environmental design group. It is the job of this team to ensure that all subsystems on the HEDGE platform are receiving their power needs, that the spacecraft remains intact during reentry, and that HEDGE remains within temperature ranges where systems can function. Success in this task, coupled with success of the other functional teams, will display HEDGE as a proof of concept for a hypersonic CubeSat and allow for the collection of temperature and pressure data in a hypersonic environment.

To achieve the primary objectives of this design team, goals for each subsystem must be met. The power subsystem must be able to adequately generate, store, and distribute power throughout HEDGE. To do this, determining a power source, finding minimum power necessary, and creating a power budget will be required. For the thermal subsystem, an optimal heat shield and structure material must be chosen. Lastly, for the environment, choosing the right

temperature and pressure sensors will allow for the collection and transmission of data points while in orbit and through re-entry.

To achieve these goals, different analysis methods will be crucial in making design decisions. The most important method is testing to ensure that HEDGE can withstand its mission. Since many different resources will be used in these methods, contacting external sources will aid in viability and equipment necessary for these tasks. Some of these resources which may potentially be used for testing include the NASA Langley Research Center's Hypersonic Wind Tunnel and UVA's Aerospace Research Laboratory. Another method to develop HEDGE is to use prior knowledge. Last year's HEDGE team's Conceptual Design Review will be used as a basis and a steppingstone for further research and implantation for the CubeSat. External databases for materials and electronic components will also be consulted frequently in order to guide the design process. Finally, collaboration between each subsystem will be pivotal in decision making and staying on the timeline.

STS Project

As mentioned before, my STS research project specifically focuses on hypersonic weapons technology, particularly looking at hypersonic missiles and aircraft. Looking at this technology, I am trying to understand how the development of these weapons has affected political decisions and relations between nations, and how they could continue to affect them in the future. The primary reason why this question is important is to assess the necessity of continuing the development of hypersonic weapons. Due to the sheer amount of resources that are required to research the technology needed to develop these weapons, it is important to understand whether investing public or private resources into this field is worth the political outcome. Also, understanding how other political entities respond to hypersonic weapons

development could help guide future policies and research allocations in the future to achieve a desired political outcome.

Due to the scope of this topic, there are a huge number of social groups impacted by this technology. In fact, to some extent, the entire world is affected in some way by the development of this technology. Since these hypersonic weapons could be used to carry nuclear warheads in a more covert fashion, the use of these weapons has the potential to harm people in almost every nation in the world. However, there are certain groups which are more impacted than others. Since only developed first world nations will have the resources to create hypersonic weapons, people living within these nations are more likely to be impacted because their country could be viewed as more of a direct threat. Some of these nations (which are currently developing hypersonic weapons) include the United States, Russia, and China. However, many more NATO allies and opposing allied nations also contribute to hypersonic weapons development and could likewise be viewed as a threat. Because of this, the research I will be conducting will mostly be focusing on target nations which are currently developing hypersonic weapons. However, contributing nations will also be reviewed in some detail as well if necessary. Identifying and focusing on these social groups is important because it helps narrow down the research. This will make it much simpler to research topics in depth and focus specifically on the groups which are more relevant to this issue.

In order to research these social groups, a variety of research methods and frameworks will be utilized. In terms of methods, historical and current literature analysis will be used to understand how past political actors have developed hypersonic weapons and responded to their development. Current literature is also important to review to see what current organizations think about present political developments surrounding hypersonic weapons. Along with

reviewing literature, I also want to interview professionals in the realm of hypersonics to understand their perspective. I think interviewing individuals will allow me to gain insight on hypersonic policy the media won't always describe. There are also a large number of hypersonic specialists who either work at UVA or are in contact with UVA. When looking at frameworks for analysis, I will mostly be using public policy analysis. Since this research mainly aims to determine the very large scale effects of hypersonic weapons development on world policy, looking at overarching public policy will be more beneficial than just reviewing singular case studies or social groups.

The timeline for this project is relatively short. I aim to conduct in depth research into my key texts as soon as possible and isolate information which might be useful to answer this research question. This analysis can even be completed by the end of this semester. I also want to try and reach out to any possible interview candidates by the end of this semester to ensure I am able to gain insight from them in a timely manner. Once this information is collected, I will start the actual construction of my research paper by the beginning of my second semester. This will give me plenty of time to not only integrate the information which I possess at the time into my research, but I will also have time to seek out additional information sources if they are needed. From there, I will ensure that I have a full draft of my research paper by the STS 4600 provided deadline, and I will make corrections to any subsequent drafts when necessary.

Key STS Texts

Hypersonic weapons and US National Security is a report on hypersonic weapons technology written by the Mitchell Institute on Aerospace Studies (Hallion, 2016). It discusses the potential benefits of this technology to US national security as well as how the US should

move forward with its development. This report is important to my research because it describes potential future impacts of hypersonic weapons development on national security.

Facing the Heat Barrier: A History of Hypersonics is a book published by NASA (Heppendheimer, 2017). It describes the history of hypersonic technology development over several decades. This will be informative as it provides some of the background information as to why certain hypersonic technologies were developed.

Hypersonic weapons: Background and issues for Congress is an advisory report to congress composed by the Congressional Research Service (Sayler, 2022). It details the progress of development of hypersonic weapons by the US, China, and Russia. This will be useful to understand the hypersonic capabilities of countries other than the US.

Hypersonic Weapons: DOD should clarify roles and Responsibilities to Ensure Coordination across Development Efforts is another advisory report written to congress by the US Government Accountability Office ("Hypersonic Weapons: DOD Should Clarify," 2021). This source discusses new ways the DoD can invest in hypersonic technology development. It will be useful to my research in providing current information on how the US is investing in hypersonic weapons currently.

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