HEDGE

Hypersonic ReEntry Deployable Glider Experiment

(Technical Paper)

The Socio-Political Impact on the Development of Hypersonic Technology

(STS Research Paper)

A Thesis Prospectus Submitted to the
Faculty of the School of Engineering and Applied Science
University of Virginia – Charlottesville, Virginia
In Partial Fulfillment of the Requirements of the Degree
Bachelor of Science, School of Engineering

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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

Throughout history, technological development has been achieved through many different driving forces. On that same note, Andy Hargreaves states that **"**Implementation of technological change must involve critics as well as advocates." This describes the progression of technological development in a way that highlights its never-ending "advancement" independent of the factors for or against it. A quote by Gen. O.P. Smith simplifies this by saying that "We're not retreating, we're just advancing in a different direction." In today's world, the relevance of Hypersonic Technology has surged, especially in the realm of National Security and Defense. But why does this matter, and what does Hypersonic Technology look like? This leads me to the purpose of both my Technical Paper and STS Research Paper.

The primary goal of my technical project is to establish a greater understanding of the physical effects a vehicle traveling at hypersonic speeds experiences through the use of a microsatellite system called a CubeSat. Hypersonic flight can be defined as exceeding Mach 5, or 5 times the speed of sound (John Anderson, 2012). For context, Hypersonic vehicles offer several advantages, including rapid response times, enhanced maneuverability, and quick travel times. These lead to many applications, both civilian and military. Some of the current uses are military missiles, rocket propulsion, space exploration, and general commercial use. In recent years, hypersonic technology has been revealed to pose significant engineering challenges, which include managing extreme temperatures and ensuring stable flight control. These complications have led to great international competition and a new "race" towards rapid development of hypersonic technology. A microsatellite is a satellite that ranged from 10-100 kg and a CubeSat is a subclass that uses a standard size and form factor of one unit or "1U" that measures 10x10x10 cm (NASA). The purpose of this method of testing is for university students

to conduct critical hypersonic research and experimentation at a low cost, and with greater accessibility in order to garner interest in this field.

The goal of my STS Research Paper is to better understand and highlight the socio-political impact on the development of hypersonic technology and examining those influences to determine what effect they have. This project will mainly consist of researching the history behind hypersonic technological development and why the US specifically has lagged behind other countries in this regard, as well as gathering different perspectives on this topic from various groups of individuals around UVA. I plan on conducting this research by utilizing the Co-Production of Science and Social Order STS framework.

Technical Topic

This project is specifically referred to as the Hypersonic ReEntry Deployable Glider Experiment (HEDGE). My class will be continuing the development of this project and aim to have a complete, fully functional prototype by the end of the school year. The project is split into multiple sub-teams: Program management, Communications, Software and Avionics, Power, Thermal, and Environment, Attitude Determination and Control System (ADACS) and Orbits, and Structures and Integration. Our project also includes a small Electrical/Computer Engineering capstone design team to aid in the circuit board design and manufacturing.

Overall, the primary objectives for the technical project are to demonstrate the feasibility of CubeSats as a platform for hypersonic glider flight research, to demonstrate that undergraduate students can conduct hypersonic glider flight experiments at lower cost and with greater accessibility than traditional programs, to provide an opportunity for undergraduates to gain hands-on experience and generate interest in the spaceflight industry, and to finally collect and transmit sustained flight data for the mission. I am a member of the Structures and

Integration Team, and it is our job to ensure that the spacecraft deploys form its CubeSat configuration in Extremely Low Earth Orbit (ELEO) to a re-entry configuration, which will withstand the hypersonic environment while gathering data, and finally burn up in the atmosphere once testing is concluded. We will work with the other teams to make sure that all aspects of the design seamlessly integrate, and that the overall design of the spacecraft is able to comfortably house the other teams while also performing as optimally as possible. Attached below are images of what the tentative conceptual design will look like.

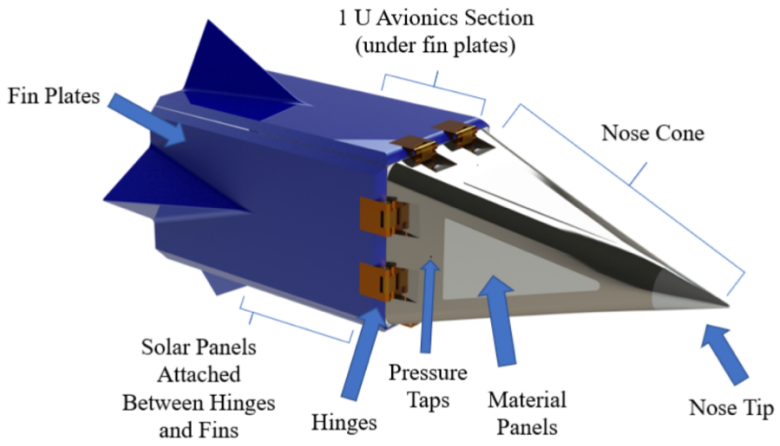

Figure 1: Spacecraft CAD Design

The previous year's HEDGE teams Conceptual Design Review will be used as a basis for further research so that we can build upon their findings and continue to fix any problems they encountered to make sure that this design is fully functional and ready to operate as expected. Below you will find an image of a typical 1U CubeSat for reference.

Figure 2: CubeSat (Samarrai, 2019)

STS Topic

My STS research project will be focusing specifically on hypersonic technology and the socio-political influences that have accompanied its progression. I will be attempting to obtain an understanding of how socio-political factors and differing opinions has affected the development of hypersonic technology, and how they could continue to affect this development in the future. Possible socio-political factors include National Security and Defense Policy, International Relations and Competition, Public Perception and Awareness, and Political Leadership. This is important because in coming to an understanding of how different social and political entities view and respond to the development of hypersonic technology, conclusions can be made that could help guide future policies and research allocations to achieve a desired outcome (whatever that may be).

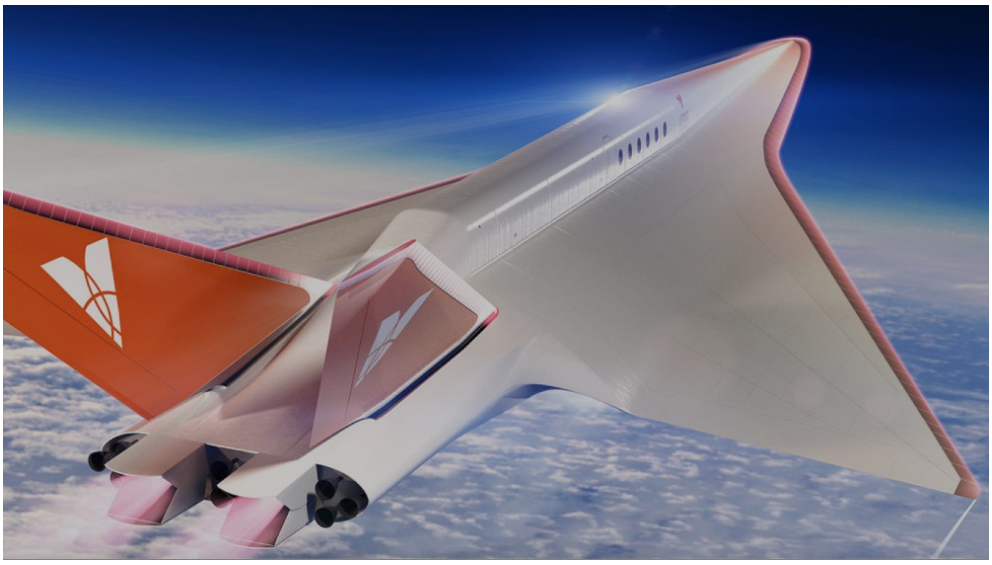

Figure 3: Hypersonic Airliner Concept (Verdon, 2023)

Due to the massive scope of this topic and the broad influence that hypersonic technology has for both military and civilian applications, there is an exorbitant number of social and political groups/organizations impacted by this technology and its development. Because of the large number of impacted individuals, this naturally leads to a large number of stakeholders with regards to the development of this technology. This also means that there are groups of people who are inherently more impacted than others. The only countries who are investing major resources into hypersonic research and development are the United States, Russian, and China; all of which are notable, more developed countries. Depending on how you look at it, the people who are most affected by this technology are either the people living in these countries, due to their "responsibility" and "aid" in its development, or those who are not a part of these countries and who do not possess the technology and thus are at greater risk of it being used against them in instances such as military weaponry. Identifying relevant social and political groups is important because it helps narrow down those most impacted and those stakeholders who are the most influential.

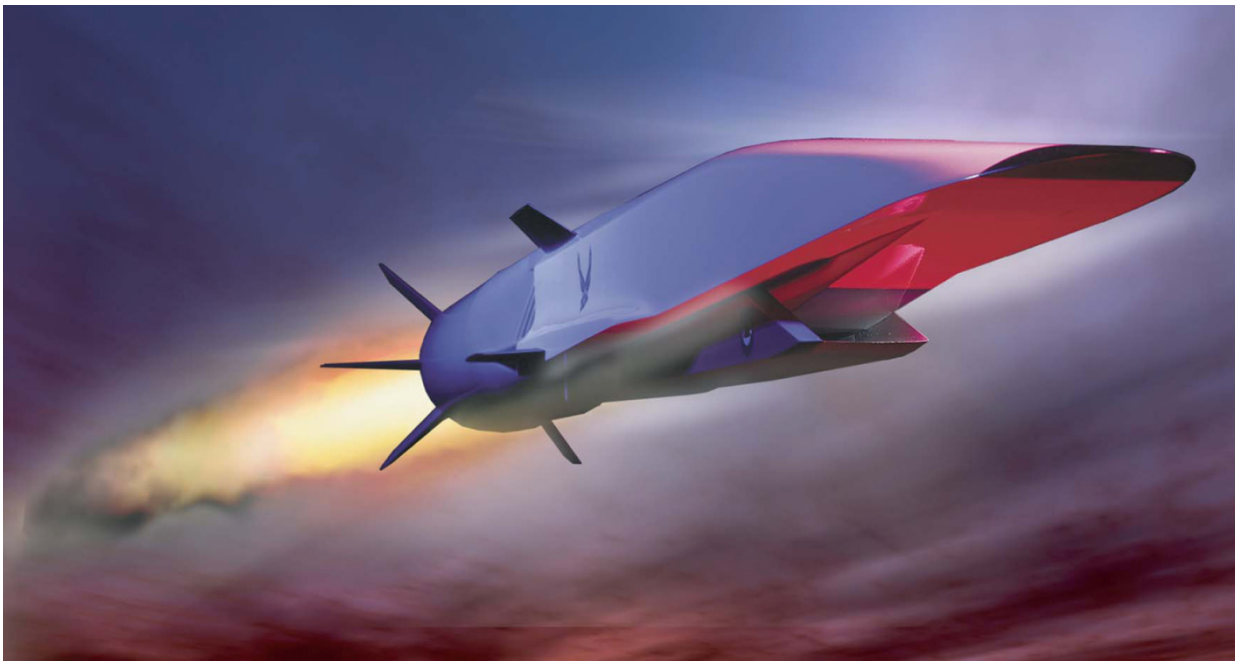

Figure 4: X-51A Waverider (USAF, UVA Article, 2022)

In order to perform adequate research into the aforementioned social and political groups, a variety of research methods and frameworks will need to be utilized such as historical and literary analysis and the relationship that stems from the Co-Production of Science and Social Order. The Co-Production of Science and Social Order highlights the idea that the production of scientific knowledge, the shaping of societal values, and political policies/governance structures are interconnected and mutually influential. I believe using this framework to analyze how all of these factors influence the development of hypersonic technology will further my understanding of the principles of this framework. Some of these key principles are Mutual Influence, Social Constructs, Policy and Government Implications, Science as a Social Activity, Controversies and Debates, and Ethical Considerations.

Due to the large-scale effects of the development of hypersonic technology, analyzing public policy will be hugely beneficial in order to gain a decent consensus of what the general public opinion on this topic is. Analyzing data and opinions from various stakeholders is

extremely important in understanding the inherent differing ideas with regards to hypersonic development. I plan on additionally doing my own case study at the University of Virginia by interviewing different stakeholders with varying levels of experience and familiarity with regards to hypersonic technology. For example, I would gather the opinions of an Aerospace Engineering professor, who concentrates in Hypersonic Research, and the opinions of a Public Policy Professor or Sociology Professor. I believe being able to see both sides of the coin and being able to draw worthwile conclusions will help not only myself, but the audience reading this paper to remain neutral and open to interesting different perspectives. I plan on conducting these interviews by the end of the semester in order to follow up with individuals if necessary in a timely manner, and also to give myself as much time as possible to draw conclusions from my data. At the end of my study, I can expect to make valuable conclusions regarding several domains such as the inner workings of the aerospace and defense industry, military and civilian policy, national security, environmental concerns, commercial applications, and national competition.

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