Program Management: Hypersonic Reentry Deployable Glider Experiment (HEDGE)

Analysis of Impacts on Early Missile Warning due to Hypersonics Development

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Aerospace Engineering

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December 6, 2023

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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

Research into hypersonic technology has been of interest to both the civilian and government sectors for over 60 years, with many experimental aircraft, engines, and reentry vehicles developed (Van Wie, 2021). The civilian sector benefits from this research in which there could be potential developments into supersonic or, ambitiously, hypersonic commercial flights, significantly reducing travel time internationally. Conversely, these technological developments could pose existential threats to civilization. Over the past decade, China and Russia, referred collectively in this paper as our adversaries, have made significant advancements into hypersonic weapons research outpacing the United States Government (USG). Since 2014, China has publicly demonstrated its medium-range ballistic missile with a hypersonic glide system that showed "a high degree of [targeting] accuracy in testing" and "performed 'extreme maneuvers' and 'evasive actions' in previous test flights" (Missile Defense Project, 2021). Additionally, President Biden confirmed in spring of 2022 that Russia operationalized and deployed hypersonic missiles in their war with Ukraine.

The threat these weapon systems pose have essentially launched us into a new arms race with China and Russia. With the geopolitical stage nearing a new Cold War, the United States now stands on the edge of a precipice if it does not quickly close the missile gap and solve the hypersonic missile warning and defense issue. I will address in the technical project some of the problems involved with developing hypersonics technology. The success of this mission would provide a proof-of-concept that undergraduate university students can contribute to national security concerns through the acquisition and development of low-cost CubeSat technology.

My STS project will delve into the societal implications of our adversaries' developments in hypersonics technology impacting our early missile warning capabilities, and directly

threatening our national security, by drawing on actor-network theory (ANT). As global relations continue to deteriorate, and the threat of a wider-reaching conflict becomes ever more probable, it is imperative that the USG make a whole of government approach to address this national security concern. The 2022 Missile Defense Review states "hypersonic weapons, designed to evade U.S. sensors and defensive systems, pose an increasing and complex threat due to their dual (nuclear/conventional) capable nature, challenging flight profile, and maneuverability (Department of Defense, DoD, 2022, p. 2). Figure 1 demonstrates the launch and impact life of a typical ballistic missile hypersonic glide weapon.

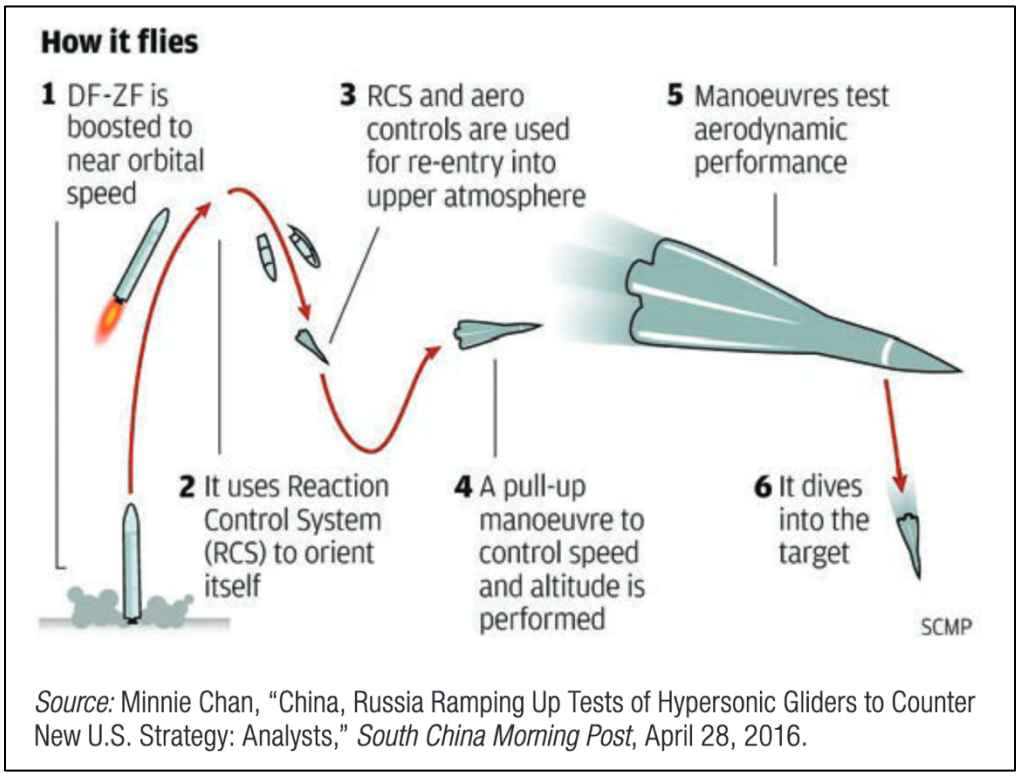

Figure 1: Dong Feng-17/ZF Hypersonic Glide Vehicle (HGV) ballistic profile (U.S.-China Economic And Security Review Commission, 2017)

While the technical and STS topics focus on different problems related to hypersonics research, they address two crucial parts of our national defense strategy: strategic deterrence and defending the US homeland against that same technology. The technical project will provide

valuable scientific data that will help further offensive hypersonic research. The STS project will investigate the consequential vulnerabilities in the USG's early missile warning defense architecture.

Technical Project

The fiscal year 2023 DoD budget request lists hypersonics as a defense-specific critical technology; technologies that require prioritized research, experimentation, and prototyping to ensure homeland defense and project power to our adversaries (Office of the Under Secretary of Defense, Comptroller, 2022, p. 4-5). The USG recognizes the national security implications due to lack of technological maturation in the field of hypersonics. Hypersonic missiles have become a serious national security concern in the past decade due to China and Russia pursuit of these weapons systems. Understanding the behavior of materials traveling at hypersonic speeds is crucial in order to successfully develop and field a weapons system that can deter our adversaries. Since our nation's adversaries have a significant lead in the development of this technology, it is imperative that the USG places significant importance on development of these weapons systems.

A major issue the DoD has in developing these systems is the length of time a major acquisition program takes; the typical timeline takes roughly 10 to 20 years to operationalize. Unlike our adversaries, most US hypersonic weapons programs are not designed to include nuclear payloads (Sayler, 2023b). This poses an additional challenge to the acquisition lifecycle since it is more technically challenging to develop as the weapons system needs to be highly accurate in targeting (Sayler, 2023b). However, the acquisition lifecycle of a program can be shortened through promoting research grants. A more accepted research and development technique is to test technologies using CubeSats. My technical project, the Hypersonic Reentry

Deployable Glider Experiment (HEDGE) program, will help bridge some of the gap related to hypersonic glide research and development.

There are three primary mission objectives for HEDGE: demonstrate the feasibility utilizing low-cost CubeSat technology for defense research and development, where HEDGE supports hypersonic glide research; demonstrate low-cost material screening methodology for hypersonic flight conditions; demonstrate that undergraduate university students can contribute national security research and development goals, in which HEDGE is a low-cost, accessible hypersonic glide experiment.

The goal for HEDGE is to study the aerodynamic effects of hypersonic reentry through the atmosphere. As the Project Management Team, our job is to ensure objectives are met by helping organize the other functional teams to align with projected timelines. Unlike most CubeSats, HEDGE requires an atmospheric reentry to conduct its mission, and thus it will be launched into very Low Earth Orbit (LEO), below 200 km in altitude, so that it reenters the atmosphere soon after launch. The goal of this experiment is to transmit crucial scientific data back for analysis on conditions HEDGE experienced as it reentered the atmosphere at hypersonic speed. Its primary mission payloads are pressure transducers and thermocouples, which are used to collect the necessary reentry physics data. Its secondary communications payloads are an Iridium 9603 transceiver and Taoglas antenna, which are required for communications through the Iridium constellation and facilitate data delivery to the Iridium ground station. The HEDGE team will have access to the data once it is received by the ground station.

Program management is an essential component to ensuring that our hypersonic capabilities are meeting requirements so that the US can close the hypersonics gap with our adversaries. One of the most important responsibilities of program managers is to keep projects

on schedule and on budget. These aspects of program management are of more significance in relation to a project that is as expensive as the one being undertaken by the DoD. According to a 2023 Congressional Budget Office report, in addition to the $8 billion spent since 2019 on hypersonic missile development, the DoD is requesting $13 billion over the next five years for developing hypersonic weapons programs with an additional $2 billion for actually procuring missiles. Adherence to schedule is not only necessary to keep up with our adversaries, but also to keep costs down since it "is generally accepted by many project practitioners that cost overruns are directly related to schedule delays" (Majerowicz & Shinn, 2016).

Given HEDGE's end goal to test conditions around hypersonic reentry via CubeSat technology at low cost, it is essential that we, as the program management team, monitor the budget to ensure we extract the maximum utility for each dollar spent and keep the class on-schedule to keep costs down and prove to our prospective sponsor(s) that relatively cheap, hypersonic flight is possible with our methods. Therefore, the goal of program management is to improve the organizational processes through communication, guidance, and optimization. There is an emphasis on not only the subsystems and how everything fits together but also how the design will be implemented by society and industry standards. I have been assigned to the program management team as the Chief Compliance Officer (CCO), where I am expected to assist the other functional teams in following industry standard practices and US regulations, and ensuring our program has the required licenses in place prior to integration with the launch vehicle in 2025.

STS Project

In a fiscal year 2024 defense authorization subcommittee senate hearing, Air Force General Glen D. VanHerck, Commander, North American Aerospace Defense Command (NORAD) and United States Northern Command, testified that he "believe[s] the greatest risk for the United States stems from our inability to change at the pace required by the changing strategic environment" (DoD, 2023). This is the general sentiment amongst pentagon leadership and Congress, particularly due to the advances Russia and China have made to include potential nuclear armament of these systems (Sayler, 2023b). Unlike Intercontinental Ballistic Missiles (ICBMs), hypersonic missiles travel through the atmosphere rather than a suborbital trajectory. This significantly decreases the advanced notice the ballistic missile early warning architecture provides, posing a serious national security threat.

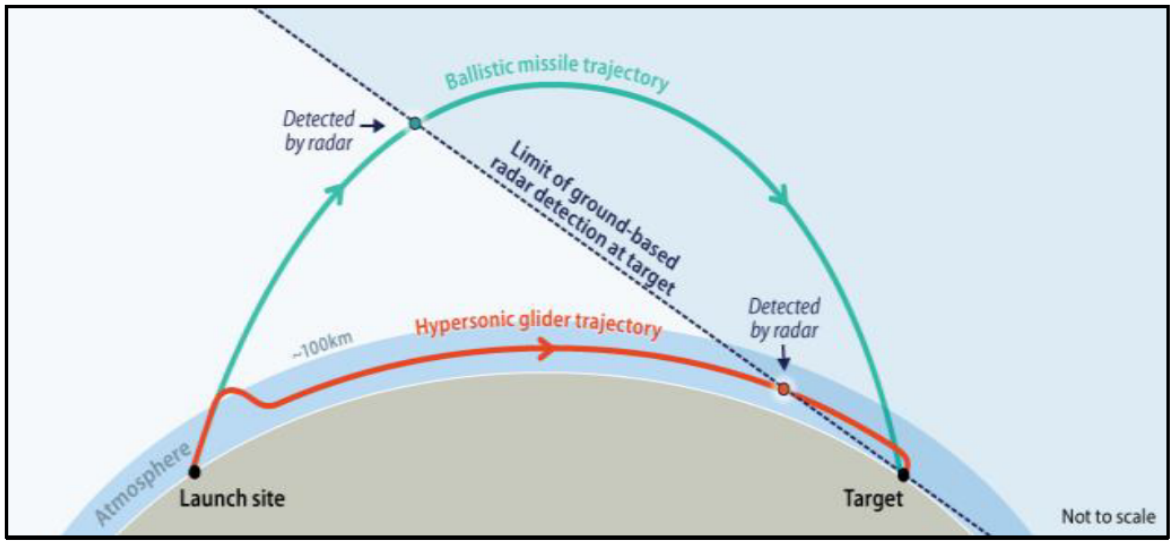

Figure 2: Ground-based detection of ballistic missiles and hypersonic weapons (Sayler, 2023b)

The current US early missile warning architecture consists of two primary components: ground-based radar and space-based sensors. The ground-based architecture was born during the height of the Cold War due to fear that the Soviet Union could conduct a surprise attack, and thus the system provides 360-degree coverage of the US homeland. The Upgraded Early

Warning Radar (UEWR) program is primarily designed to detect and track ICBMs and Sea Launched Ballistic Missiles (SLBMs) (United States Space Force, USSF, 2020). However, ground-based radars are only capable of tracking objects that are above the horizon. The response to this was the development of geosynchronous orbit (GEO) and highly elliptical orbit (HEO) space-based infrared missile warning systems, which provides that over-the-horizon indications and warning not possible with ground-based radar.

It is well established given the billions of dollars poured into decades of research and development that the current technological systems available are effective against traditional ballistic missile trajectories. However, while our missile warning architecture is very successful, the current systems available are more vulnerable than they seem because of our adversaries' developments into hypersonic technologies. Hypersonic missiles have faint heat signatures making it difficult for GEO and HEO space-based infrared to detect and track (L3Harris, n.d.). To address this, the DoD is investing in a robust overhead missile warning architecture to include medium-Earth orbit (MEO) and low Earth orbit (LEO) systems to quickly detect, track, and predict targets with an emphasis on hypersonic vehicles that would otherwise evade ground, GEO, and HEO sensors, and through a Hypersonic Ballistic Tracking Space Sensor (HBTSS) program (L3Harris, n.d.; Sayler, 2023b). Though the DoD plans to address the hypersonic missile warning problem, it is still behind the development capabilities our adversaries have achieved. If our adversaries' development into technologies we are also vested into are not accounted for, then the US military, and by extension our national policy makers, will not have a full understating of the limitations affecting the current missile warning architecture.

I argue that the current missile warning architecture, though effective against traditional ballistic missile technology, is underperforming because of the development of hypersonic

missiles by our adversaries and its potential use as a delivery vehicle for nuclear payloads have not been adequately accounted for. The overall purpose of my STS research project is to thoroughly analyze the historical development of the missile warning architecture, the motivating geopolitical impacts that shaped the architecture, and how our adversaries have made advancements that threaten the viability of the system today. My research will be guided by actor-network theory (ANT), a framework that suggests a heterogeneous network is influenced by human and non-human elements, and studies the activity of network builders who construct these heterogenous networks to accomplish a specific goal (Cresssman, 2009). Applying this framework, I will describe the process by which the US missile warning network was created and refined, and how adversarial actors actively work against this network to threaten its viability. This will give an understanding to both human and non-human actors of the network, which include allied and adversarial government institutions, the bureaucratic processes, and technological limitations. This analysis will be supported through publicly available official government reports, press releases, corporate reports, and official government statements and hearings.

Conclusion

While the field of hypersonics has been researched and experimented with for over 60 years, there are still technological difficulties that need addressed to achieve operationalized offensive and defensive weapons systems. The end state of technical project to prove that undergraduate university students and contribute to national security research and development, while giving students insight into industry standards and applicable experience. The STS project will delve into how the USG's early missile warning network, meant to prevent a surprise nuclear strike and enforce our stance of mutually assured destruction, has become vulnerable due

to our adversaries' technical achievements in hypersonics development; this will be analyzed through the actor-network theory framework. The combined results of the technical and STS analysis will provide a holistic understanding how the development of technological disruptive weapons systems has sociotechnical implications for our society, and global and national security.

Word Count: 2072

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