Thesis Project Portfolio

Hypersonic ReEntry Deployable Glider Experiment (HEDGE)

(Technical Report)

The Implications of Hypersonic Weapons Systems for International Stability and Prosperity

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

Hypersonic technology is one of the fastest growing industries in the world, with a market value of nearly $5 billion in 2020 (Meghan, 2022) with continuous growth, more than doubling to a value of $11 billion in 2024 (Austin, 2023). Within this field, several avenues of exploration are available ranging from commercial travel to space exploration to weaponry and many more. However, issues regarding the accessibility and implications of this technology have limited the widespread proliferation of this technology. To address the accessibility concerns, the technical portion of this research will focus on development of a hypersonic satellite system primarily to demonstrate the feasibility of low-cost hypersonic initiatives in a university setting. On the other hand, the STS research will aim to address the implications of the technology, specifically exploring the effects of hypersonic weapons systems on international relations. Before more time and resources are invested into this technology, it is important to thoroughly understand and address these underlying issues to ensure that returns on the investment will lead to improved technological and social prosperity.

For the technical research, the class continued the development of HEDGE, a 3U Hypersonic CubeSat with the goal maintaining low earth orbit and performing hypersonic atmospheric reentry procedures. Being the third group on this long-term project, our collective goal was to assemble the first working prototype with functioning subsystems. As part of the project, I served under the Attitude Determination, Control System, and Orbits (ADACS) sub team where we were tasked with simulating orbital paths, determining attitude from pressure readings, and validating static stability through computational fluid dynamic (CFD) analysis. Through this work, the team was able to map an orbital trajectory, create an attitude determination algorithm, and obtain preliminary stability parameters such as coefficient of drag and center of pressure. As this class was the first group to really create a concrete prototype and obtain relevant mission critical data, much of the findings are very raw and the procedures need thorough refinement, but the results seem to be promising as they appear to agree with theoretical predictions.

For the STS portion, I investigated the effects of hypersonic weapons among world technological leaders as it relates to international relations, specifically relating to national stability during escalated conflicts. With the aid of technological momentum and actor-network theory frameworks, this paper presents evidence regarding the extent of technological enhancement of hypersonic weapons systems, their potential impact on strategic stability, and the complexity that arises in the execution of their global establishment. Through this research, I arrived at the conclusion that the current state of hypersonic weapons technologies appears to have an adverse effect on the maintaining stability due to their limited innovation gaps compared to current counterparts, the possibility of crisis escalation from offensive miscalculation, and the potential of progressive setback resulting from slow pace of development. However, this is not to say the technology will never be ready global establishment, but it will be crucial to address these underlying issues before moving forward with the transition to these systems.

Through these projects, I feel confident that I was able to address several issues arising from the growth of hypersonic technology from a technical and social standpoint. My technical research successfully demonstrated that the learning curve of hypersonic development is manageable enough to initiate a global adoption, while the STS section highlighted areas of concern for world leaders and policy makers to consider making the adoption as beneficial as possible. That being said, my work has only scratched the surface of hypersonic technology and its implications, so it is important for future efforts to include larger scale projects which allow teams to encounter and address even more pressing issues to cover all the bases during this era of innovation.

I would like to give a special thanks to my technical advisor, Dr. Christopher Goyne, and my STS advisor, Dr. Caitlin Wylie, for their guidance on these projects. Their advice has allowed me to conduct a thorough and refined investigation into this topic. Additionally, I would like to thank my peers, friends, and family in supporting me through my academic journey helping me always put forth my best work.