Thesis Project Portfolio

Hypersonic ReEntry Deployable Glider Experiment (HEDGE)

Private Influence Over Public Security: Privatization, Regulation, and National Security in the Aerospace Industry

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

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Bachelor of Science, School of Engineering

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The sociotechnical synthesis of the technical thesis on the technical and STS research theses provides a comprehensive examination of both the scientific and societal dimensions of the project. The HEDGE report meticulously details the collaborative efforts from the University of Virginia undergraduate capstone class, describing our innovative approach to hypersonic flight experimentation using CubeSat technology. Through exploration of subsystem design, prototyping, and analysis, the report showcases the integration of technical expertise and student enthusiasm in advancing aerospace engineering capabilities. In contrast, the STS research paper situates the HEDGE project within a broader sociopolitical and ethical context, shedding light on the implications of hypersonic technology development. By contextualizing HEDGE within the landscape of defense modernization priorities and international competition, the STS paper critically examines the societal implications of democratizing access to hypersonic research. Together, these documents offer a holistic perspective on the sociotechnical dynamics driving contemporary aerospace innovation, speaking to the future risk and capabilities, both commercial and defense. They highlight the importance of interdisciplinary dialogue and ethical reflection in navigating the unique intersection of innovation, science, technology, and society.

Hypersonic ReEntry Deployable Glider Experiment (HEDGE)

The Hypersonic ReEntry Deployable Glider Experiment (HEDGE) represents an initiative in the realm of hypersonic research, with profound implications for both military and civilian applications. Led by a collaborative effort among undergraduate students from the University of Virginia's aerospace and mechanical engineering programs, HEDGE seeks to

validate the feasibility of employing CubeSats for low-cost sustained hypersonic flight experimentation. By leveraging CubeSat form-factor technology, we aim to demonstrate that hypersonic flight experiments can be conducted affordably and accessibly, marking a significant advancement in hypersonics testing.

My research specifically was centered around my role as team lead for the ADACS (Attitude Determination and Control Systems) & Orbits subsystem. The ADACS team plays a pivotal role in ensuring the stability and success of HEDGE's mission. With primary objectives centered around optimizing stable flight upon reentry and establishing communication with the Iridium satellite constellation, our team navigates various constraints, including weight and volume limitations. Through passive methods and the implementation of an aerodynamically stable design, we aim to achieve highly stable flight without the need for active control systems, thereby minimizing power consumption and complexity. Prototyping and analysis efforts include the development of an attitude determination algorithm and fluid analysis through computational fluid dynamics (CFD) simulations. These endeavors enable us to predict and evaluate critical parameters such as drag properties and orbital lifetime, essential for ensuring the efficacy and longevity of HEDGE's mission. Mission timelines are to be determined with future investors and launch vehicle providers still in question. Still, the work of this year's HEDGE capstone class will serve as the blueprint for future classes to construct future iterations of the design.

The US Aerospace Industry's Private Influence Over Public Security

My research paper provides an in-depth analysis of the US aerospace industry, with a focus on the increasing involvement of private entities and growing implications for national

security. Through an extensive literature review and analysis of key legislative milestones, industry developments, and policy debates, the paper identifies regulatory oversights resulting from the rapid expansion of private sector actors. Examining the historical progression of the industry analyze shifts from its majority government-mandated conception to the current landscape characterized by substantial private sector participation. The landscape for potential innovation, market opportunities, and technological power is found to be unstable.

Applying Langdon Winner's theory of technological politics, I explore the existing dynamics between technology, politics, and societal impact within the aerospace sector. Legislative changes, like the Commercial Space Launch Act of 1984, created an environment ripe for extensive growth. The following lack of legislation has resulted in issues such as unregulated orbital debris, vulnerabilities in life-saving infrastructure, and further demonstrated oversights. Findings relevant to inadequate security measures are increasingly significant with continued efforts from foreign entities to compromise our satellite and various space systems. This analysis uncovers nuanced insights into the regulatory framework, highlighting challenges arising from the rapid expansion of private sector actors, including concerns regarding national security and regulatory effectiveness.

To conclude, I argue that the observable evidence necessitates robust regulatory frameworks that more effectively balance fostering innovation and ensuring national interests are safeguarded. I highlight the importance of ongoing collaboration among government agencies, private enterprises, and international stakeholders to address these concerns and ensure responsible and equitable utilization of space resources. Through this sociotechnical thesis, I aim to contribute to informed policy discussions, stimulate further research into the sociopolitical

dimensions of aerospace governance, and stress urgency with respect to known threats to national security.