Thesis Project Portfolio

Hypersonic ReEntry Deployable Glider Experiment

(Technical Report)

A More Nimble Satellite

(STS Research Paper)

An Undergraduate Thesis

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

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Daniel Fisher

Spring, 2023

Department of Mechanical and Aerospace Engineering

Contents of Portfolio

Executive Summary

Hypersonic ReEntry Deployable Glider Experiment

(Technical Report)

A More Nimble Satellite

(STS Research Paper)

Prospectus

Executive Summary

The realm of space exploration was once considered the exclusive domain of national governments and space programs. With the rise of small satellites in the past decade, the space economy has undergone a radical transformation. In 2021, 94% of all spacecraft sent to orbit were small satellites. Almost 70% of that amount were part of the SpaceX Starlink or OneWeb constellations, reflecting how commercial space launch providers have become the primary actors in the space economy. This has opened the potential for conducting research in space using small satellites, especially CubeSats, and more broad access to orbit with commercial launch vehicles. CubeSats are small satellites with standardized 10×10×10 cm units (U) that have become popular in the past decade especially for commercial and academic activities in space. The STS research thesis and the technical design project aim to address how small satellites and commercial launch vehicles can be leveraged to enable a more broad population to access space. By examining the historical development of small satellites and the current state of the industry, with a focus on CubeSats, the potential applications and limitations of using small satellites for orbital research can be explored.

The Hypersonic ReEntry Glide Vehicle project (HEDGE) is a proof of concept mission to determine the feasibility of using CubeSats for low-cost hypersonic flight testing. The project aims to demonstrate that undergraduate students can conduct hypersonic experiments at lower costs and with greater accessibility than traditional programs. The project, at time of writing, will have completed the critical design review step of NASA's project life cycle, ensuring that the design is mature enough to proceed with fabrication. The mission has five objectives, with three primary and two secondary objectives. The primary objectives focus on demonstrating the feasibility of affordable CubeSats as a platform for hypersonic glider flight research, showing a

materials screening method for hypersonic flight conditions at a low cost, and demonstrating that undergraduate students can conduct hypersonic glider flight experiments at lower cost and with greater accessibility than traditional programs. The secondary objectives focus on integrating undergraduates into an industry, government, and university partnership involving complex systems engineering and program management with multiple stakeholders and conducting STEM and hypersonics outreach to the community and potential engineering students. HEDGE is aligned with the goals of the US government, including the Department of Defense (DOD) and NASA, for the development of hypersonic technologies, with both military and civilian applications, and for real-world hypersonic testing at a low cost that can assist with the DOD and NASA's short and long term goals.

The STS research thesis aims to explore the emergence of small satellites, particularly CubeSats, as a means of democratizing access to space. The relationships between the various actors in the space ecosystem, including CubeSat developers, governments and regulatory bodies, commercial launch providers, and users of CubeSats, will be examined. The rise of small satellites has been driven by both advances in technology and a growing interest in space among a wider range of actors. Through an STS approach, the thesis will provide a critical analysis of the implications of the democratization of space through CubeSats and questions whether this can truly be considered a reality. By providing insight into the relationships between actors in the space ecosystem surrounding CubeSats in this rapidly-evolving field, a better understanding of how new entrants to the industry are shifting the traditional power dynamics surrounding access to space can be achieved.

The rise of small satellites and commercial launch providers has transformed the space economy, allowing more actors to access space and conduct research with lower costs and

greater accessibility. CubeSats have become a popular and standardized platform for commercial and academic activities in space, with potential applications in various fields, including hypersonic flight testing. HEDGE, which aims to demonstrate the feasibility of using CubeSats for low-cost hypersonic flight testing, is in a state in which future undergraduate cohorts can continue work on the project and plan fabrication. The STS research surrounding the democratization of space raises questions about power dynamics at play and who or what groups are able to conduct research in orbit. There are potential limitations and concerns that need to be addressed by future STS research, such as the regulatory environment and potential space debris. Future research and development in this field should focus on addressing these challenges and maximizing the potential benefits of small satellite technology with these concerns in mind.