Thesis Project Portfolio

HEDGE
Hypersonic ReEntry Deployable Glider Experiment
Critical Design

(Technical Report)

A Wicked Evaluation of the Debris Crisis and the Militarization of Space

(STS Research Paper)

An Undergraduate Thesis

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Executive Summary

Introduction

As space becomes more accessible, its utility for mankind rapidly expands. To include commercial and scientific endeavors, but also national militaristic and strategic pursuits. The STS research project focuses on the sustainability of earth's orbit, due to these strategic pursuits and consequential space debris production. The Hypersonic Re-Entry Deployable Glider Experiment (HEDGE) is a space fairing vehicle launching into earth's lower orbit for two weeks, residing and technically contributing to the same heavily populated and polluted low earth orbit (LEO) the research project analyzes. Socially, HEDGE as whole is an academic pursuit inspired by an emerging national and strategic interest in the utility of hypersonic technology. The capstone project aims to provide proof of function and valuable data to the scientific hypersonic community, indirectly providing that same information to the U.S. DoD, in order to develop technologies for competition with other world powers. The same world powers are militarizing space, conducting destructive tests, and funding missions akin to HEDGE into orbit. From a technical perspective, the research and capstone projects dive into space as a place of utility and stewardship, socially the projects are connected through similar stakeholders and military involvement.

Capstone Project HEDGE

HEDGE is a multi-year, undergraduate capstone project that designs, constructs, and launches a 3U cube-satellite. The primary mission objectives of the satellite are to achieve hypersonic flight in LEO for a relatively low cost and provide a method for material testing at hypersonic conditions. The Attitude Determination and Control System (ADACS) and Orbit team work towards ensuring stable flight during re-entry and a method to determine attitude, for

the determination of mission success. To accomplish attitude determination the flush air data sensing method (FAD) is integrated and designed into the satellite to measure the attitude of the craft, using pressure and velocity measurements to determine the angle of attack and side slip. Using oblique shock relations on a 2D wedge, across expected Mach numbers, we were able to provide proof of concept that the FAD system can determine qualitative stability given two pressure values. HEDGE's mission timeline in regard to the orbit is predicted using analytical models from MATLAB and STK estimating the space craft's orbital lifespan, path, and altitude from launch through re-entry and expected burn-up.

STS Research: Space Debris

Space debris continues to grow and pollute earth's orbit, hindering current and future space endeavors. The developing impact and status of this space debris is the subject of the research project. To include the analysis of military tensions within space as a domain and on the ground, that increase the growth of space debris as a result of anti-satellite testing or outright conflict. The research answers the question: how will the orbital environment be sustained into the future, when nations can receive a strategic advantage at the expense of increasing space debris? To frame the appropriate answer and analysis, Wicked Problem theory is used to account for the multitude of stakeholder's perspectives and interests, to include a nation's military, the scientific community, and commercial pursuits. The research provides an analytical model of growth and probability of debris-on-debris collisions, an identification of stakeholders' activity and interests, and proposed solutions to protect and defend the orbit through international legislation and subsequent enforcement. This research contributes a cross analysis of the social sciences and technical understanding, to provide appropriate solutions to maintain a clean orbit for generations to come.

Conclusion

Through the simultaneous completion of each project, I have developed a basic understanding of the system and general engineering components that are required of engineers and managers to produce space-faring technology. Framing the feasibility and timeline of proposed technological solutions to space debris, as well as introducing common practice design requirements and mission conditions that limit the possibility for debris. Socially, as HEDGE gained third-party interest in regard to funding and the material testing data, connections between educational institutions, commercial companies, and militaries materialized, showing the prevalence of the capstone project and its potential use outside of academia, good or bad.