Thesis Project Portfolio

Student Researched and Developed High Power Rocket

(Technical Report)

Orbital Debris; Problems, Solutions, and Impacts on the Design and Implementation of Orbital Infrastructure

(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

Timothy Meighan Edinger

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Department of Mechanical and Aerospace Engineering

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Executive Summary

As modern living has grown more reliant on orbital infrastructure such as GPS and satellite imaging, so too have a number of threats to this technology, namely orbital debris. The nature of this relationship dictates that as orbital infrastructure proliferates, the threat of orbital debris grows alongside it, as debris are created with the natural deterioration and collision of these satellites, causing a cascading trend of destruction until orbital infrastructure is rendered unusable. My STS research paper examined this issue of orbital debris and infrastructure, summarizing the extent of research done on this issue and reaching a conclusion on recommended action to resolve the issue before it reaches a critical level. My technical research report focused on a tangentially related issue, the design of a sounding rocket for my aerospace engineering capstone project. The research report examined the process of designing and manufacturing the rocket, as well as delving into sustainable and environmentally friendly design of rockets, specifically pertaining to the generation of orbital debris. These two topics are connected, as one of the main findings in my STS research paper was that rocket design was an important factor in diminishing the growth of the orbital debris population, a topic that was specifically discussed in my technical research paper.

My technical research topic paralleled much of the work that was done during my capstone project in order to construct the rocket. This means that my research paper focused a lot on the theory behind the design choices that were made pertaining specifically to the rocket and the competition it was designed for, but also on the environmentally friendly side of design. Despite these environmentally focused changes not being incorporated into our design, they still provide a good foundation for future design to combat the growth of orbital debris. The main findings of this design were as follows: To reduce the generation of orbital debris, removing stages from rockets, reinforcing the structure of satellites, and adding the capability for graveyard orbits are among the most impactful changes that could be made.

My STS research instead focused more on a more holistic approach to examining the issue of orbital debris, splitting the research into three main topics: the projections of orbital debris growth, the economic impact of orbital debris on orbital infrastructure, and countermeasures to the growth of orbital debris. Current research on projections of orbital debris is somewhat divisive in conclusion, though most scholar agree on two things - that at current rates of satellite launch the population of orbital debris is expected to continue increasing, and that if the current population of orbital debris continues to increase, a critical level will eventually be reached, resulting in the destruction of many satellites in low earth orbit. Economic projections explore a different facet of this relationship, the economic viability of satellite launches in an orbital environment with varied amounts of orbital debris. Most of these papers designed economic models in order to predict the trends of costs of satellite launches vs the number of orbital debris in order to determine the economic incentives of launches that minimize debris, compliance with regulatory guidelines, and usage of active debris removal technology. These economic projections all found that it was in the long term economic interest of companies involved in orbital infrastructure to abide by guidelines that reduce debris generation, but also that there was short term economic benefit to disregarding these suggestions in favor of cheaper alternatives.