Thesis Project Portfolio

Student Researched and Developed High Power Rocket

(Technical Report)

Sustainability in a Commercial Space Race

(STS Research Paper)

An Undergraduate Thesis

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Bachelor of Science, School of Engineering

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Sociotechnical Synthesis

The development of modern rocketry has paved the way for human exploration in space. Through a cultivated understanding of disciplines such as aerodynamics and propulsion, the development of launch vehicles has seen relatively rapid advancements over the past decades. From simply establishing momentary contact to low earth orbit to now knocking on the door of interplanetary colonization, the scope of human spaceflight is an ever-evolving landscape. These advancements in aerospace have established an increasing sense of normalcy within spaceflight, with crewed trips to space stations or the deployment of satellites to orbit becoming routine. The technical project encompasses the design, prototyping, construction, and testing of a high-powered rocket. The STS portion of my research focuses on sustainability within human spaceflight. More specifically, my research uses STS frameworks to investigate how society can collectively promote sustainability amid a rapidly expanding industry sector of commercialized or privatized space exploration.

The primary objective of my technical project was to design, construct, and test a high-powered rocket that would carry and deploy an experimental payload at an intended apogee of 4,000 feet. The project's development was sectioned into three different avenues: propulsion, aerostructure, and mechatronics. The design process entailed many flight simulations, comprehensive fluid dynamic analysis, and other predictive tests that allowed the team to adjust the design iteratively. The central aspects that must be considered throughout the design of a launch vehicle include stability during flight, the ability to withstand forces from the propulsion and atmosphere, and overall efficiency. In addition, onboard avionics and communication systems were an integral part. Underlying all these aspects is the need for a cohesive assembly of all the various components. Proper integration required that all components were designed with the necessary considerations of other components. After finalizing the design, our team constructed all of the necessary parts and components for assembly, with most of the fabrication being conducted in-house.

In my STS paper, I investigated the effect of growing commercialization within the spaceflight industry and how sustainability can be promoted during a period of increased space exploration due to privatization. The research conducted analyzed the network of interactions within the private space sector to garner an understanding of how we should navigate issues of sustainability while allowing an innovative industry to continue to develop. My research examined the impact that rocket launches have on the environment and how propulsive devices affect the atmosphere. The overwhelming vast majority of rockets being used are sources of harmful emissions in the form of combustion components that are expelled into multiple layers of the atmosphere during propulsion. These harmful emissions include greenhouse gases and black carbon. Evidence has shown these emissions to be heat-absorbing and ozone-depleting, imposing a detrimental warming effect on the entire planet. These issues have been largely undermined in the past due to the limited scope of global space launches, but the rapid increase in the prevalence of spaceflight that has been catalyzed by commercialization has brought these

issues of sustainability to new heights of significance. I learned that there is an inadequacy in the level of international and domestic regulation regarding privatized spaceflight, and the existing regulation does not properly encompass many of the circumstances presented in the current state of spaceflight. Through the use of the Actor-Network Theory, I arrived at the conclusion that spaceflight companies need to primarily continue enhancing research in innovative technologies, new international and domestic regulations need to be created, and private companies in spaceflight need to be more geared towards partnership for the collective betterment of innovation.

My technical capstone and STS research were not isolated endeavors but rather a comprehensive exploration of the various aspects of spaceflight. The basis of rocketry exists in each respective avenue, and multiple facets concerning the nature of spaceflight discussed in the STS research portion were directly encountered during the spacecraft design capstone project. More specifically, underlying aspects of launch vehicle efficiency, as well as the dynamic of having to work with regulatory bodies, were integral to both sides of the research.