Thesis Project Portfolio

Student Researched and Developed Rocket

(Technical Report)

Suborbital Space Tourism: A Case Study on Virgin Galactic and the Environmental Impacts of the Emerging Industry

(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

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Spring, 2024

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Sociotechnical Synthesis

Throughout my four years at the University of Virginia (UVA), I have culminated knowledge in aerospace engineering and engineering ethics to prepare me for my capstone class and my undergraduate Science, Technology, and Society (STS) thesis. The technical project is the result of my efforts in the Spacecraft Design class with Professor Haibo Dong and Professor Michael McPherson. A class of thirty students, including me, worked on the technical project to deliver a final report on the design, analysis, and tests. I worked on the STS research paper throughout my fourth year and with Professor Joshua Earle. The following details the specifics of the senior capstone design project and the research gathered for the STS undergraduate thesis.

The technical design project was to research, design, and prototype a high-powered rocket to achieve a 4,000ft altitude and deploy a payload while allowing for student research and experimentation. Three main sub-teams–Aero-structures, Propulsion, and Mechatronics & Control–worked on the high-powered rocket. As the Propulsion Team Lead, our sub-team's main concern was designing, fabricating, and testing the 75mm motor hardware and propellant to ensure that the rocket would reach the target apogee. There is a delicate balancing act between each sub-team because any shifts in the weight of other team's designs would affect the amount of outputted thrust required for our motor. Furthermore, there were several changes in the constraints within the course itself that ranged from differing budgets, certain safety constraints from UVA Environmental Health & Safety, and timing limitations. After several iterations, we designed, fabricated, and tested a final product through non-energetic means. The motor was 21" long, and 3" in diameter, and consisted of a snap-ring casing to hold the closures and nozzle. We chose a 3" diameter to adhere to the standard typically found in commercially available high-powered motors. Team members used computer simulations to determine the geometries and

chemical formula for the propellant, and they fabricated the motor using equipment at UVA. The final product showcased the class's abundant knowledge of aerodynamics, structures, and project management, along with many more engineering skills.

The STS research paper is a Technological Momentum analysis of the emerging suborbital space tourism industry with a specific focus on its environmental effects. The journey to space was exclusive, limited to a select few who underwent rigorous training and scrutiny under federal programs like Gemini and Apollo. However, with technological advancements, space travel is becoming more accessible through various companies, including Virgin Galactic, offering different methods to get to space. The increased accessibility to space stems from more capital going into the space industry, particularly in the commercial sector. Although traveling to space is exciting, it is important to consider the environmental effects of many launches happening within a short period. Firstly, I address the significance, history, and future of space tourism, focusing on Virgin Galactic as a case study because of its significant presence in space tourism. Then, I highlight the environmental impact of the rapidly rising space industry, particularly regarding launch vehicle propulsion systems, which historically harm the Earth's atmosphere. By utilizing the Technological Momentum framework, I examine the environmental consequences of increased space activities and provide recommendations for regulations to balance technological innovation with environmental preservation. Through this analysis, I show that space tourism's rise is inevitable, highlighting the need for proactive environmental regulations to mitigate its adverse effects on the Earth.

The rocket that is the focus of my technical project will have extremely negligible effects on the immediate environment of the launch site. Even so, I believe there is a connection between the STS topic and the results of my capstone. The main difference between the two is

the scale and the project objective. The propulsion system proposed for the technical project is a very common propulsion system used in full-scale launch vehicles: ammonium perchlorate composite propellant (APCP). Furthermore, many launch vehicles used in the emerging space tourism industry have a very similar silhouette to the capstone class's rocket, but at a much larger size. Although we are working with smaller rockets, it is important to consider the socioeconomic and environmental effects of all our products as we apply our engineering expertise to our respective careers. Overall, the ethical analysis of the space tourism industry will apply to the technical project, simply at a different scale.