Thesis Project Portfolio

Space Debris Tracking CubeSat

(Technical Report)

Analysis of the Challenges in Enforcing Effective Space Legislation in an Expanding Space Economy

(STS Research Paper)

An Undergraduate Thesis

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Swar Shah

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Department of Mechanical and Aerospace Engineering

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Sociotechnical Synthesis

Throughout my senior thesis capstone project and sociotechnical research, my work focused on the parallels associated with developing and designing a space debris tracking CubeSat (a NASA initiative aimed at facilitating access to outer space), and the current state of outer space legislature that allows problems such as space debris to exist. While designing crucial systems of a satellite, such as the radar and detection system, and creating apparatuses to test the detection feasibility, I explored various factors that have led prior issues in space such as economic inequalities and a lack of enforcement, to grow and become exacerbated. The capstone project of the space debris tracking CubeSat culminated in using a radar system to detect various sized space debris from various distances, and moving at different translational speeds. The sociotechnical research resulted in revealing issues in addressing the challenges mentioned above, through a technological momentum lens.

Going further in-depth into our capstone project, the goals of our project as well as the mission objectives are as follows: develop a proof of concept for the sensor, create simulations and environmental modeling that can verify what is actually going to be detected by the sensor and ensure a substantial amount of debris can be detected in orbit. Additionally, the sensor must be able to detect debris that is smaller than ten centimeters in size, eliminate false positives, and calculate certain debris orbit characteristics such as altitude and velocity. Some other main portions of our project included designing a 3-dimensional, solid model in SOLIDWORKS to observe the full layout and integration of the CubeSat and all of its major subsystems. The final phase of the project involved developing a physical prototype that would simulate the orbital motion of space debris of various sizes under ten centimeters. This would enable our group to determine whether certain debris moving at certain speeds could be tracked by our utilized

detection system. The physical prototype involved a DC motor that would have a shaft mount through which a fishing line would be tied, and this line would be tied to a sphere coated in reflective paint of a specified size. The fishing line length would vary to change the translational speed of the debris, and when running the motor, we calculated the angular and translational velocities of the orbit, and would compare these to what the radar system would detect. However, due to some complications with the radar detection system that we designed, we were unable to proceed with the last part of the final phase of the project.

My STS research paper explores the past, present, and future evolving challenges involving the regulation of outer space amid a current period of immense technological advances and the growing privatization of the sector. The paper touches on some of the earliest space legislation, such as the 1967 Outer Space Treaty, aimed to maintain peace and cooperation in space during the Cold War. However, this treaty had issues such as vague language and a lack of effective enforcement, which led to nations interpreting terms to their advantage, especially when dealing with debris management and responsibility. Through the concept of technological momentum, I analyzed how the past and ongoing developments in space and related technologies have made it difficult for a change in legislation to be implemented, as the evolution of technology has moved too fast for legislation to keep up. Additionally, prior legislation was mostly focused on limiting threats during wartime, rather than focusing on long-term inclusivity and safety. From this paper, I have deduced that the current legal framework is far too outdated to manage the current state of outer space, especially with the rise of private companies, and this is only going to cause further problems and accidents in the future. By looking deeper into certain challenges such as balancing conflicting needs while promoting economic growth, along

with ensuring private companies do not operate with profit as the main purpose, but instead the production and diffusion of space technology to the rest of the world.

While working on both the research and the physical project in tandem, I uncovered and realized ideas that I would not have realized if I worked on both projects independently of one another. For example, when performing this research, I realized that the potential of the technology that we were developing in our CubeSat could be extremely beneficial, due to the growing number of space debris and likelihood of collisions in the future. Additionally, when designing this CubeSat, I thought about the potential improvements that could be made to the safety of Earth orbits, from the ability to detect such small debris that can pose harmful threats to delicate and extremely important space infrastructure.