Thesis Project Portfolio

Hypersonic ReEntry Deployable Glider Experiment (HEDGE)

(Technical Report)

The Kessler Syndrome; The Invisible Hand that Guides Satellite Development and Space Regulation

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

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Protecting the Low Earth Orbit Environment for Future Space Operations

When conducting space operations for research purposes, it is important to not only consider the research being done and the knowledge being acquired, but it is also important to consider protecting the future space environment to allow for expansion of resources people depend on, such as telecommunications and GPS services. My technical work focuses on the launch environment of the Hypersonic Re-Entry Deployable Glider Experiment (HEDGE). This is a Hypersonic Glide Vehicle (HGV) that tests how materials react in a hypersonic environment made in the affordable CubeSat form factor. This means ensuring that the spacecraft does not destroy itself in harsh launch conditions and is not deployed as useless debris once it reaches space so that it could perform its mission and follow proper end-of-life disposal procedures. My research paper focuses on why it is important to prevent the accumulation of debris in space. My technical work prevents HEDGE from becoming another piece of debris to prevent the growth of the debris field which has affected multiple societal entities highlighted in my research.

As part of the Environment subteam, my technical project verifies the current HEDGE design through a series of vibration simulations and transient structural simulations to recreate an extreme launch environment. Using charts from the Falcon 9 User's Manual and acceleration telemetry data from a launch, simulations were performed in Ansys Mechanical, solving for deformations and stresses on the spacecraft structure. Finding where the structure experienced the most stress and deformation would highlight critical areas on the spacecraft during launch. By ensuring these critical areas do not experience stresses that would compromise the structure, the spacecraft would be cleared for launch. If these components failed during launch, the spacecraft would be deployed as useless debris.

My STS research considers the importance of LEO and why the mitigation of orbital debris growth in this environment must be considered instead of blindly expanding our satellite capabilities. I used the STS framework of technological momentum to examine the case of the Kessler Syndrome. Hughes' technological momentum states that a system has grown to such a size and complexity over time that it has influenced the society that originally designed and built this system. The Kessler Syndrome is the growth of an orbital debris field so large that it renders the LEO environment unusable for space operations. The Kessler Syndrome is a byproduct of technological momentum. Humans have grown to rely on the communication services provided by satellites and have continuously sent satellites to space to meet this demand, adding to the debris field. This dependence has grown so that it has forced engineers to account for the harsher space environment, changed space regulations to ensure proper end-of-life disposal to prevent the growth of debris, and shifted the focus of commercial entities to space sustainability. My research argues why it is important to not blindly upkeep the demand of satellite communication without considering how the growth of this system has already affected the entities in charge of its design, regulation, and commercialization.

Working on the STS research paper has emphasized the importance of following space regulations to prevent the addition of debris at LEO. Satellites started as an experimental technology, but within less than a century, have grown to provide internet connectivity and instant communication to people at even the most remote locations; disregarding the importance of this environment by mindlessly adding to the field of debris would ignore the complexity this system has gained over the years and ignore the society that relies on this system. I understand that the work I do is not only important to our organization's mission, but it is also important to future space operations and the people who rely on satellites for communication.