Thesis Project Portfolio

Hypersonic Atmospheric Reentry Deceleration Experiment (HARD-E)

(Technical Report)

The Commercial Space Industry: How High-Speed Broadband Satellite Internet Will Affect Rural Consumers

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

CubeSats are increasingly becoming a part of the technological portfolio of both engineers and consumers. Not only are they used in scientific and research missions as a cheap and quick way of launching an orbiting satellite, but their low-cost and easy deployment means that they are a target for businesses seeking novel ways of providing service to and connecting with consumers. This portfolio discusses the methodologies and findings of two research studies that both investigate novel ways that CubeSats can and are being deployed. The technical topic seeks to lay out a design for a CubeSat capable of reentering the earth's atmosphere and collecting hypersonic flow data, while the science, technology, and society (STS) research topic seeks to understand the current and future impacts of using CubeSats to provide internet to rural consumers. Both projects are heavily focused on CubeSats, although the technical project seeks to understand and address the engineering challenges associated with them, while the STS research seeks to understand the societal impact of the technology.

The primary objective for the technical project is to design and implement a 3U CubeSat that will be launched into low Earth orbit and collect data as it reenters the atmosphere at hypersonic speeds. Additional primary objectives include delaying atmospheric burnup and collecting and transmitting sufficient and reliable data to the UVA ground station. The use of CubeSats offers undergraduate students the opportunity to be involved in the space mission engineering process in a cost-effective manner over a short term. Proving the feasibility of CubeSats for hypersonic flight experiments has the potential to promote Aerospace Engineering to the general public, which may improve funding, resources, and general interest for future projects. The project has a number of functional and operational requirements necessary for success, and must satisfy the mission constraints. The CubeSat must be able to survive extreme

conditions so that the electronics and sensors necessary for control, data collection, and transmission do not fail when exposed to extreme temperatures and high forces, and so that the CubeSat can gather and transmit sufficient data to the University. Extreme condition survival and full power throughout the mission reduce the risk of component failure, data collection, and data transmission failure. The technical deliverable will be completed in proposal format for potential submission to NASA for funding of the fabrication and testing of the 3U CubeSat design. The purpose of this document is to outline the plan that this project team will follow to solve the technical problem presented. The document will discuss the technical problem and its objectives, the technical approach, program management, the resources available to the team, and desired outcomes.

Meanwhile, the STS research paper focuses on the emerging role of CubeSats in consumer internet applications. Faster satellite internet is being driven by large "mega-constellations" of low-cost CubeSats that stay in low-Earth orbit (LEO). Although satellite internet already exists, it uses relay stations that sit in geostationary orbit - an orbit that stays in a fixed position relative to the ground. This orbit is quite far away from Earth compared to LEO, leading to large lag times of up to half a second, making voice and video calls difficult, and multiplayer gaming and high-speed financial training impossible. By placing satellites in LEO, the issues with lag time can be remedied, allowing high speed broadband and low latency times, along with the ability to cover rural areas, which historically lack reliable broadband access. Therefore, the research question is asking: What are the sociotechnical factors arising from the commercialization of space that will impact the average consumer? In order to analyze the research question, Actor-Network Theory (ANT) and historical case studies are used. The historical case studies provide context and examples of how previous advances in technology,

both internet and non-internet, impacted rural consumers, while ANT is utilized to analyze the relationships among the current stakeholders in the internet satellite industry.

Although each individual project focuses on separate aspects of CubeSats, by working on both together a more detailed understanding of the engineering implications can be found. The technical report provides important context for why engineering decisions are made in the way that they are, while the STS portion shows what the human impacts of those decisions can be. As good engineers know, understanding the societal impacts of design decisions is important to making sustainable and positive products. By analyzing all aspects of the engineering process in the portfolio, it lays a groundwork for how engineers can think about their designs wholistically.