Thesis Project Portfolio

Hypersonic ReEntry Deployable Glider Experiment (HEDGE) Critical Design

(Technical Report)

The Social and Commercial Evolution of the Global Positioning System

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

The central topic of my thesis portfolio is the development of satellite technology. My STS thesis and my technical capstone each focus on the development of different satellite systems. My STS research focused on the development of the Global Positioning System (GPS), and more specifically, how this satellite system evolved from a focused military technology to having broad use across society. In my technical project, I worked with a group to design a satellite that will perform hypersonic flight research. This project is motivated by the goal of decreasing the price of this type of research, which is currently extremely expensive and subject to large government and military spending. Each of these dives into a different facet of satellite development. While my STS project takes a historical view on a specific satellite system, my capstone dives into the design process of one novel satellite. Like GPS, hypersonic vehicles have immediate military use but could expand to serve future commercial applications.

My capstone project is known as the Hypersonic ReEntry Deployable Glider Experiment (HEDGE). This mission seeks to prove that it is feasible to use a CubeSat, a standardized small satellite, to perform low-cost hypersonic flight experimentation. Hypersonic flight, which occurs when a vehicle travels at speeds above five times the speed of sound, has been historically expensive because of its advanced material requirements and novelty relative to other systems. This year, my group completed the critical design of the HEDGE system, which leaves the satellite system ready to be fabricated, assembled, and tested by the next group of students. To complete its mission, HEDGE will be launched into Earth orbit by a launch provider in CubeSat configuration, reconfigure into glider shape using hinged fins, experience orbital decay, then relay temperature and pressure data back to Earth during the reentry phase, during which the vehicle will travel at hypersonic speeds. Ultimately, HEDGE will burn up in the atmosphere after

collecting data. This data collection will be useful for testing materials in hypersonic flight conditions. Our group has been split into six subsystem teams that have collaborated to integrate the HEDGE system design. These teams are communications, software and avionics, attitude determination and control system (ADACS), power, thermal, and environment, and structures and integration. Throughout this project, iterative design processes were used to create a satellite that will be able to achieve its objectives of lowering the cost and increasing accessibility to hypersonic flight research.

My STS research paper examines how GPS developed from military research programs to an omnipotent tool in society. In my research, I used the sociotechnical framework of diffusion of innovation to analyze this topic. This framework details the key stages of the innovation development process and how social groups and communication channels combine to induce the diffusion and adoption of a technology. Through this analysis, I found that the diffusion of GPS from its initial military intentions to broader society was the direct result of choices, actions, and communication between the U.S. military, government, and civilian engineers and users. An important part of GPS that favored original military intentions was a feature known as Selective Availability (SA), which provided the military with more precise signals than civilians. This was a meaningful design decision that impacted the commercialization of GPS. Diffusion of GPS to civilians began in 1984 when the Department of Commerce chose to allow surveyors to use the developmental system while it was not quite finished. This created demand in the industry, allowing commercial research and development to begin and accelerate faster than the government would have been able to alone. Surveyors also began to use differential GPS techniques that circumnavigated SA, undermining the system and increasing technological advancement. This action, combined with the use of commercial

receivers in the Persian Gulf War in 1990 due to military desperation for supply, led to the Federal Government recognizing the importance of civil GPS usage, resulting in a mandated independent study on the future of GPS. The findings of this study showed that SA was detrimental to the future of GPS and led to a 1996 Presidential Decision Directive that announced the plan for discontinuing SA. By removing SA, civilians gained increased precision and availability which led to a commercial boom in applications, opening GPS to many industries. These important events and interactions in the development process led to the expansion of GPS applications which brought immense benefits to civilians from its initial military-focused investment.

Having worked on these two projects in tandem, I have found meaningful connections between the projects. From my STS research experience, I learned things about the military-funded nature of GPS that made me reflect on my technical project experience. Designing new technological systems brings about many unsolved issues, which lead to even more issues. I found solace in the shared experience of design work being difficult, which is part of why hypersonic flight research has been historically expensive. In looking deep into my technical project, it influenced me to want to look more intently into how the technical details of GPS developed consequently to specific events. By doing this research together, I noticed common experiences during satellite development and practiced better research and design methods.