Thesis Project Portfolio

HEDGE

Hypersonic reEntry Deployable Glider Experiment (HEDGE)

(Technical Report)

A Social-Constructivist Analysis of Israel's Iron Dome

(STS Research Paper)

An Undergraduate Thesis

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Bachelor of Science, School of Engineering

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Executive Summary

Our technical project centered around the development of HEDGE, our Hypersonic reEntry Deployable Glider Experiment. HEDGE will be a 3-U cubesat which conducts hypersonics testing at relatively low cost. After launch (via a sounding rocket or into low Earth orbit), HEDGE will de-orbit over the course of days or weeks, reporting temperature and pressure data via the Iridium satellite constellation until it disintegrates in the upper atmosphere.

Hypersonics is the domain of aerodynamics concerning flows which exceed five times the speed of sound. At such high speeds, air and spacecraft experience extraordinary loads due primarily to compression heating, but also high chemical reactivity and high dynamic pressures. Recent developments in materials science (and other aspects of aerospace engineering) have led to what has variously been described as a gold rush or an arms race in hypersonics development. To this end, the government of the United States is devoting billions of dollars to hypersonics research. With HEDGE, we hope to provide a cheaper mode of experimentation which will enable university students to gain experience in developing air and space vehicles.

As deputy lead of the Attitude Determination and Control Systems and Orbits team, I worked on the technology which will ensure HEDGE follows its planned trajectory, and report back on how well it did. For the sake of minimizing both cost and possible points of failure, HEDGE is entirely reliant upon passive controls, primarily its aerodynamically stable design, which was evaluated using CFD. We also used STK to evaluate potential trajectories and determined that a polar orbit would ensure the greatest access to the Iridium satellite network, through which HEDGE will communicate with the ground. We developed algorithms to convert the pressure data collected by HEDGE to data on its angle of attack as a function of time, to evaluate its stability post-flight.

My STS paper focuses on a different frontier in missile technology: ballistic missile defense. Specifically, I perform a Social Construction of Technology analysis of Israel's Iron Dome. Iron Dome is a complex technology employed by the Israel Defense Force to defend against simple artillery rockets fired into Israeli territory by Hamas and Hezbollah. It employs radar to detect and track incoming threats, computers to predict where these threats will land, and missiles to intercept these threats before they do.

My analysis is primarily a review of literature produced by Israeli and Palestinian scholars (and scholars of several other nationalities). I identify the key social groups with influence over (or who are influenced by) Iron Dome and study how their perspectives have shaped the development of the technology. Different groups view Iron Dome as a solution to different problems, or even a problem in and of itself. I find that Iron Dome's weaknesses reveal even more about its users' motivations than its strengths.

The most obvious application of my STS research to my technical project is to the field of hypersonic missile defense, which is even younger than hypersonic missile offense. However, the comparison is admittedly apples-to-oranges, because Iron Dome is much more sophisticated than its targets, whereas anti-hypersonic technology would exist on a more even playing field.

While my STS paper highlights some of the problems with missile defense, that field is certainly less ethically fraught than missile offense, which is presently the much more active one when it comes to hypersonics. By the nature of the problem (with missile defense innately involving rapidly moving targets), offense is much easier to solve, and therefore more rapidly deployable. The United States has therefore been driven to develop offensive hypersonic capabilities for the sake of deterrence. As I worked on both aspects of my thesis, I thought frequently about the ethics of this. I hope that the hypersonic technology that I have helped in some small part to develop will never have to be used. How difficult and slow does defense development have to be before offensive development can be justified as deterrence?