THESIS PROJECT PORTFOLIO

Hypersonic Atmospheric Reentry Deceleration Experiment (HARD-E)

(Technical Report)

Complacency around Failure in the US Space Program

(STS Research Paper)

An Undergraduate Thesis

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In space travel missions, there is an array of both technical and non-technical factors that determine mission success. Space travel itself is a turbulent process where vehicles and humans travel in extreme conditions for extended periods of time, so intricate engineering efforts are designed to ensure safe passage. However, there are many social, managerial, and political factors that influence the success of missions and must be considered during the space mission process. Despite the best efforts, there have been multiple disasters in the US space program that can be attributed to the lack of both engineering and managerial oversight. In my technical thesis I outline the work we have completed in order to design a nanosatellite CubeSat with the ability to collect and relay hypersonic flight data. In my STS research paper I delve into the political, social, and managerial backgrounds of three major US space program disasters and how they contributed to the mission failures.

For the technical project, our team set out to design a 3U CubeSat, with the rough dimensions of 10 by 10 by 30 centimeters, in order to study hypersonic flight conditions. The CubeSat will be taken into extreme low Earth orbit where it will remain for several days before returning back to the Earth's upper atmosphere at speeds of 8 kilometers per second. The vehicle is designed with a blunt leading edge that will allow it to experience maximum levels of deceleration without prematurely burning up. During atmospheric reentry, the CubeSat will experience extreme temperatures and fluctuations that require an elaborate thermal protection system composed of specially selected materials and an ablative heat shield at the leading edge. Pressure, temperature, and inertial measurements will be taken during atmospheric reentry and transmitted through the CubeSat to the Iridium satellite constellation with 100% coverage of the Earth's surface, allowing communication with the CubeSat to occur no matter where atmospheric reentry takes place. While in orbit, an internal magnetic system will allow the

CubeSat to align with the Earth's magnetic field to help stabilize any tumbling that could occur, and in the atmosphere where aerodynamic effects must be taken into consideration there are flaps at the rear end of the vehicle that will ensure that the CubeSat remains pointed in the correct direction so that the heat shield will be effective. The final technical report for the project is in the form of a funding proposal to NASA and the department of defense, and in the event that funding is secured the project will be continued over the next three years.

For the STS research project, I analyzed three major US space program disasters that resulted directly in loss of life: the Apollo 1 test capsule fire, the Challenger space shuttle disaster, and the Columbia space shuttle disaster. While anyone familiar with the disasters may understand the engineering aspects of the mission failures, I dug into the social, political, and managerial aspects surrounding the incidents in order to see how non-technical aspects led to the missions' demise. In the Apollo 1 test capsule fire, 3 astronauts were killed as the pure oxygen capsule environment caught fire and the interior pressure made opening the hatch impossible. The rushing of the US space program due to political pressure allowed for several crucial engineering mistakes to be made, and these rushed mistakes set the timeline for the space program back greatly. In the Challenger space shuttle disaster, the crew of 7 was killed as a launch in poor weather conditions led to a catastrophic chain of events that saw the shuttle explode seconds after takeoff. In the reviews following the incident, it came out that NASA and contractor management pursued the launch to stay on schedule despite many warnings from engineers that this issue could occur. In the Columbia space shuttle disaster, the crew of 7 was killed during atmospheric reentry due to an issue that had occurred during liftoff 16 days earlier. In the "damning" reviews following the incident, it became apparent that NASA had been aware of the issue and had been allowing it to occur for years, and there also were massive cultural issues within the space program that had led to normalization of deviance over time.

The technical project that I have been working on has gone exactly as planned, and we are on track to have successfully completed a conceptual design review by the end of the year. The CubeSat design that we have developed is on par with what was expected at the beginning of the year and the groundwork for the next two years of the spacecraft design capstone has been laid out. The STS research project that I have been working on has been fruitful as well as the research gave me a clearer understanding of the non-technical factors that have plagued the US space program's disasters over the past 60 years. In the future, research into non-deadly US space program incidents would help paint a fuller picture of how non-technical factors can affect large engineering efforts.