Thesis Project Portfolio

The Development of a Data Acquisition Hardware System for a CubeSat Satellite

(Technical Report)

The Relevance of a Satellite Hardware System and Impact of CubeSat Mission Success

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

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Introduction

Both my technical and STS research are very related to one another. The technical component revolves around the development of a CubeSat satellite data acquisition hardware system. The STS portion gauges the novelty of the CubeSat hardware system, which includes data acquisition and transmission components, through technical standards research and a patent review and considers the impact of the entire project on the field of hypersonic flight. The technical part of this paper summarizes the methods and findings of my capstone project completed in the Department of Electrical and Computer Engineering at the University of Virginia. Aspects of this extensive capstone project, such as the patent review and existing standards research were completed for the project's final deliverable and serve as the basis for the STS component of the paper. During the capstone class, when groups were formulating project ideas, the CubeSat project, which involved the Department of Mechanical and Aerospace Engineering, was presented as a potential option. At the time, I was intrigued by the idea of developing hardware systems for satellite applications, so I accepted the proposal and began working with three other group members and the entire Spacecraft Design class.

Project Summaries

In the technical portion of my thesis, I describe the research associated with the development of a data acquisition hardware system for a CubeSat satellite. Many of the technical specifications for the project along with the overall goal were communicated by the Spacecraft Design class before any engineering work was completed. This included a high-level block diagram of the system along with component requirements, such as thermocouples, pressure

transducers, and analog-to-digital converters. Throughout the paper, I indicate how these specifications were ultimately converted to a physical PCB and tested. Since pure hardware testing (connectivity tests, oscilloscope measurements, etc.) does not effectively reveal proper transmission of data, a software library from the class, Introduction to Embedded Engineering, was improved upon by another capstone group member and used for testing. One of the larger testing goals was defined by a changing simulated input signal creating an expected corresponding output in serial peripheral interface data packets. This project demonstrated proper functionality for all four of the thermocouples requested by the Spacecraft Design class and one out of the four pressure transducers.

In the STS component of this paper, I examine the relevance of the CubeSat hardware system through technical standards research and a patent search and briefly explore the potential impact of the entire CubeSat project. While examining existing patents, I first indicate the requirements for patentability before highlighting three patents that are related to the CubeSat's hardware system. After exploring the details and applications of these designs, I evaluate the "patent-ability" of the hardware system using the initially outlined definition. In considering the potential relevance of the system, I also examine how the project can comply with various existing spacecraft electronics standards. Regarding the societal impact of the overall project, I briefly explore the ultimate outcome of the CubeSat mission along with tangential implications.

Conclusion

The STS paper enhances the technical portion of this paper by providing a motivation behind the project's completion, which can otherwise be somewhat ambiguous at first-glance. By

the end of this paper, the reader will receive evidence for the relevance and patentability of the CubeSat hardware system, a brief overview of the larger impact of the CubeSat, and the technical details and methods regarding hardware system development.

Acknowledgement

I would like to first thank the three lab partners whom I completed this project with: Luke Bulmer, Yul Goodman, and Connor Schichtel. Luke and Connor were primarily responsible for the software and hardware integration of the Iridium Transceiver, which was designed to permit data transfer back to the UVA ground station. Yul was responsible for the software verification of the data acquisition electronics. I worked very closely with Yul towards the end of the project in ensuring the functionality of pressure transducer and thermocouple systems.

I would also like to thank Prof. Christopher Goyne of the UVA Mechanical and Aerospace Engineering Department and Prof. Adam Barnes of the UVA Electrical and Computer Engineering Department in guiding the group through the many obstacles that were encountered and providing this opportunity to develop hypersonic electronic systems. I would also like to thank all of those in the Spacecraft Design class and Prof. Michael Mcpherson for welcoming the contributions of the Capstone group and integrating the electronics into the larger CubeSat system. I must also thank Prof. Richard Jacques for serving as a wonderful STS advisor and providing useful feedback throughout the Prospectus/Thesis writing process.

Forward

The majority of the "Literature Review" section of the STS paper was taken from my Capstone project's final report. I was the author of this section, but it deserves a note, as it was still taken from another source. The report is unpublished and its title is "Capstone Final Project Report". I received permission from both my STS and technical advisors to reuse this portion of work. This section was re-framed from a strictly patent-ability context to a technological relevance context.

The majority of the "External Considerations" section of this paper was taken from my Capstone project's final report. I was the author of this section, but it deserves a note, as it was still taken from another source. The report is unpublished and its title is "Capstone Final Project Report". I received permission from both my STS and technical advisors to reuse this portion of work. This section was re-framed from a strictly external technological considerations context to a functional relevance context.