**CubeSat Electronic Boards Design**

By:

A. Wong

J. Sands

K. Mody

P. Zwinkels

Faculty Advisor: Dr. Jayshri Sabariathan

ECE 4416 Electrical/Computer Engineering Project

**Technical Project Proposal**

Department of Electrical and Computer Engineering

Western University

London, Ontario, Canada

**Proposal Summary**

This proposal will highlight all aspects of our capstone project, including what we expect to be involved, to what we hope to accomplish. With the help of our faculty advisor, Dr. Jayshri Sabarianthan, we hope to make a positive and important contribution to the CubeSat project. Our design will be based on some work that has already been completed for the project, as well as further research into areas we are less familiar with in order to meet the project standards.

# **1. Problem Statement**

The circuit boards within the CubeSat must contain all of the necessary components and integrate properly with the existing hardware, while meeting the safety requirements set out by the Canadian Space Agency in order to be safely used in space.

# **2. Background Information**

The University of Western Ontario, in collaboration with Nunavut Arctic College, has received a grant among several other post-secondary institutions from the Canadian Space Agency, to build a satellite as part of their CubeSat Program. This satellite is 10cm x 10cm x 10cm in total volume, weighing about 1kg in a square shape (roughly the size of a rubix cube). [1] The Canadian CubeSat Project (CCP) was announced in April 2017 and has already begun. [2] It will be completed with the launch of the satellite in 2021. The payload of the satellite will be two 180 degree cameras on either ends, to be able to take full 360 degree photographs as the satellite orbits. This is expected to last for about 6 months. [3] We will not only be working alongside our faculty advisor, Dr. Jayshri Sabariathan, but also other graduate students and capstone groups who are working on other components of the project. There is a significant amount of work that has already been completed, which we will have to review and base our design around in order for it to integrate properly into the project or make proper adjustments and initiate some new ideas. [4]

# 

# **3. Project Objectives**

We wish to design, build and test two custom electronic boards to be used in the CubeSat satellite. These boards will contain three magnetorquers that will control the satellite's orientation, as well as detumble it after it is launched from the International Space Station. The end goal of this is to produce a 360 degree photos from the orbiting satellite using two 180 degree cameras mounted on both ends. [5]

# **4. Methodology**

As we are joining an existing project, our first step will be reviewing all of the documentation from work that has been previously completed. Our main focus will be documents related to the structural work that has been done, as well as the established electrical components and systems. From there, we will then have to look into the safety requirements and protocols set out by the Canadian Space Agency, to ensure that our boards do not violate them. The may also include some form of safety training with our faculty advisor and other related parties. We will then begin the planning and external research for our design. Using the information we obtained from the past documentation and safety training, we will plan the layout and designs for our boards. External research will be mandatory for this project, as it will make use of components we have not encountered previously. This includes looking at the effects of weightlessness, space rated parts, wire bending constraints, amongst other variables. From there, our design will have to be refined to be both practical and effective. This includes making sure the tasks are performed without error, and ensuring it properly integrates with the existing structure and components of the project. The final step will be testing our designs, and correcting it if necessary based on the results. Since we will not be able to make adjustments after the satellite is launched, it is imperative that our design produces positive results from the testing. Once again, as we lack experience working with space rated technology, we will request the assistance of external parties for testing purposes. [6]

The board design can be broken up into three main components. These are the magnetorquers, GPS system, and control system. A magnetorquer is a satellite torque rod system built out of electromagnetic coils. It creates a magnetic dipole that interfaces with the ambient magnetic field of Earth. The counter-forces produced by this provide torque deemed useful. [7] The GPS (Global Positioning System) is a navigation system comprised of 31 satellites in orbit. They run 24 hours a day to pinpoint both time as well as geolocation, if at least 4 satellites have pinpointed the unobstructed view of the receiver. [8] A control system commands devices or systems that use control loops. The control system for the CubeSat is there to manage and regulate the satellite, based on the varying info it receives. The boards also each have a PC104 stack. [9] This stack acts as the CPU, power supply and will connect to and receive data from the other components on the boards. This stack is advantageous to our design because it allows one board to connect directly to the one underneath it. This will minimise the amount of space used by the boards.

Another fundamental aspect of this project is the extensive documentation that must be written. As we select components and make design choices, we will be creating documentation using the research we collected. These documents will be used for future users to understand each piece of the CubeSat, what components were used, and how it operates.

**5. Project Tasks and Responsibilities of the Team Members**

The project will consist of three stages: designing, prototyping, and testing. Patrick will be the project lead for the designing stage. This role includes reviewing the documentation, creating a PCB layout for the two boards, communicating with other teams, and deciding which space rated components will be chosen. Andrew will be the project lead for the prototyping stage. This role includes creating an assembly and integration plan, gathering the appropriate materials, and soldering the components together. James and Keith will be the project leads for the testing stage. These roles will include creating the testing plans (i.e. who, when, where, what equipment), verifying compliance guidelines, and testing the overall functionality of the boards.

Due to the large amount of documentation, the parts research will be split amongst the group members. Andrew will be researching the GPS, Keith will study the magnetorquers, James will focus on the gyroscope, and Patrick will find information on the PC104 Stack. Managerial titles will also be assigned as follows:

*Lead Programmer* - Keith

*Component Sourcer* - James

*Board Layout Designer* - Patrick

*Outreach Coordinator* - Andrew

Our goal is to have each member contribute to each aspect of the project but by having a designated leader for each facet of the project, that person can more effectively collect our research and document it in order for the other members to reference it later on.

**6. Preliminary Budget and Parts List/Software Tools**

Each student will receive $75.00 to spend for the entire project. [10] In addition, there is a budget listed by the Canadian Space Agency, which will be determined in the future. Below is a components list for each custom board [11] :

Custom Board 1 (10cm x 10cm):

* Magnetorquer (2) (x and y axes)
* PC104 Stack (1)
* Gyroscope (1)
* Misc Connector (3)

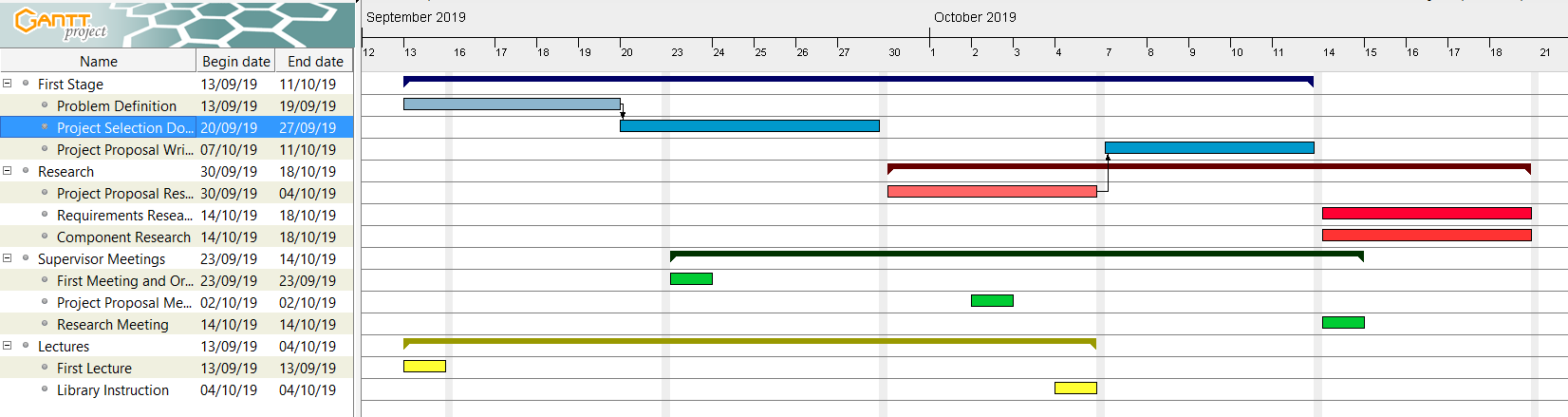
Custom Board 2 (10cm x 10cm):

* Magnetorquer (1) (z axis)
* PC104 Stack (1)
* GPS Receiver (1)
* Misc Connector (3)

All components for our design must be space rated which will lead to higher costs, making the additional CSA budget necessary. Additionally, we require parts to be as light as possible to reduce the mass of our CubeSat. We will be conducting extensive research into which parts will most efficiently meet both of these conditions.

The software we plan on using for this project includes Autodesk EAGLE to design the board layout, and Slack to keep in touch with other groups, and our supervisors. These programs are both free to use and will not cut into our budget.

**7. Gantt Chart**

****

The Gantt chart displays the work that has been completed up until this point and that has been planned for the future. Each aspect of the project is color-coded for easy viewing. Currently, we are in a research phase so in the near future our Gantt chart will mainly consist of red research blocks and green meeting blocks. We will be updating this document regularly in order to organize our work schedules and the latest version will be submitted with our completed deliverables.

##### 

##### 

##### **8. References:**

[1] “What Is a CubeSat.” *Canada.ca*, 27 Nov. 2018, [www.asc-csa.gc.ca/eng/satellites/cubesat/what-is-a-cubesat.asp](http://www.asc-csa.gc.ca/eng/satellites/cubesat/what-is-a-cubesat.asp).

[2] “What Is the Canadian CubeSat Project.” *Canada.ca*, 5 Dec. 2018, [www.asc-csa.gc.ca/eng/satellites/cubesat/what-is-the-canadian-cubesat-project.asp](http://www.asc-csa.gc.ca/eng/satellites/cubesat/what-is-the-canadian-cubesat-project.asp).

[3] Dr. Jayshri Sabariathan (private communication), 2019

[4] J. Sabariathan, M. Cross, M. Bourassa, K. Doerksen, N. Mitchell, A. Pascual, B. Southwell,

“Western University - Nunavut Arctic College Cubesat Mission - Overview,” Western

University, London, Canada, Tech. Report. “What is Cubesat”, 2019

[5] Dr. Jayshri Sabariathan and Dr. Matt Cross, “Preliminary Design Review,” Western University,

London, Canada, Tech. Rep. CCP-WAC-PRD-PPT1, 2019

[6] Nicholas Mitchell, “Electrical Capstone Definitions,” Presented at initial electrical cubesat

Design projects meeting, London, Canada, 2019

[7] Claire Lizotte, “CubeSat Design, Magnetorquer Design, and Preliminary Bill of Materials,”

Western University, London, Canada, 2019

[8] “How Does GPS Work?: Explore.” *How Does GPS Work?| Explore*, [www.physics.org/article-questions.asp?id=55](http://www.physics.org/article-questions.asp?id=55).

[9] Nicholas Mitchell, (private conversation), 2019

[10] “Introduction,” class notes for ECE 4416, Department of electrical and computer engineering,

Western University, Fall 2019

[11] Nicholas Mitchell, “Full circuit,” Western University, London, Canada, Tech. Rep. “Full

Circuit,” 2019