CougSat Simulation Software

Project Description and Clarification

Sponsors

Team Viking
Courtney Snyder
Angie Park
Solomon Egwuonwu

I. Introduction

The goal of our senior design project is to develop a simulation software for our client, Cougs in Space, to successfully launch a cubesat into Low Earth Orbit. This software will model the cubesat from launch to orbit and take into account project requirements from all stakeholders, make sure all systems are integrated, and support the engineering processes outlined by the engineering sub-teams for the cubesat.

II. Background and Related Work

Cougs in Space needs some kind of modeling software to help them get a better idea of what they are building, integrate the separate systems, see how the satellite will behave from launch to orbit, and keep NASA's requirements in mind in order to promote and develop the skills necessary for designing, manufacturing, and testing. Software and hardware developers in various engineering sub-teams in Cougs in Space are going to use the modeling software in the development and design of CougSat I. We have explored various tools such as NASA's General Mission Analytics Tool (GMAT), AGI's System Tool Kit (STK), Robot Operating System (ROS), the state machine (smach) library for ROS, and MATLAB. When we attended the Canadian Satellite Design Competition on September 18 and 19, we saw four different schools present their satellite designs to a panel of experienced industry professionals. These students also shared some of their technologies that they used for testing, which included STK and GMAT for orbital simulation, STK for ground control, LTSpice for circuits, SolidWorks and MATLAB for the cubesat itself, MATLAB for static analytics, and MATLAB and LTSpice for thermal analysis. None of the schools mentioned which software they used for building their state machines, but there is a club at WSU called the RoboSub Club of the Palouse that successfully uses ROS and a library called smach for their state machines.

We have decided to use ROS and smach to construct our state machine. Then, we will most likely be using MATLAB to model the satellite. Next, we will need to run static, thermal, and circuit analysis. We will most likely use MATLAB for the static and thermal analyses, and LT Spice for circuit analysis. Finally, we must decide on an orbit simulator. GMAT has a very clunky, intimidating user interface and does not seem to allow custom satellite imports, while STK is more user-friendly and customizable. Since STK will allow us to import our own model of CougSat I and will help us model the interaction with the ground control station, we are leaning more toward using STK as our orbit simulator, though we will test the accuracy of both simulators using existing cubesat data.

To complete this project, we will need to learn how to use ROS, smach, MATLAB, LT Spice, and STK. We will also need to learn how to combine these technologies; how to use import our MATLAB model to STK, how to get outputs from STK to use in LT Spice, and how to use MATLAB with ROS.

III. Project Overview

In order to build the modeling software for CougSat I, we will be breaking up this process into two steps: alpha and beta prototypes.

First, our alpha prototype will be a state machine outlining CougSat I's software and hardware behavior from launch to orbit. We will base most of this state machine off of NASA's cubesat requirements, while taking into account the current designs of the engineering sub-teams of Cougs in Space. This state machine is important to building the modeling software, as it will help us to get a better understanding of what Cougs in Space wants from our software and it will be influential in CougSat I's system designs, as it will help engineering sub-teams of Cougs in Space conform to NASA's requirements.

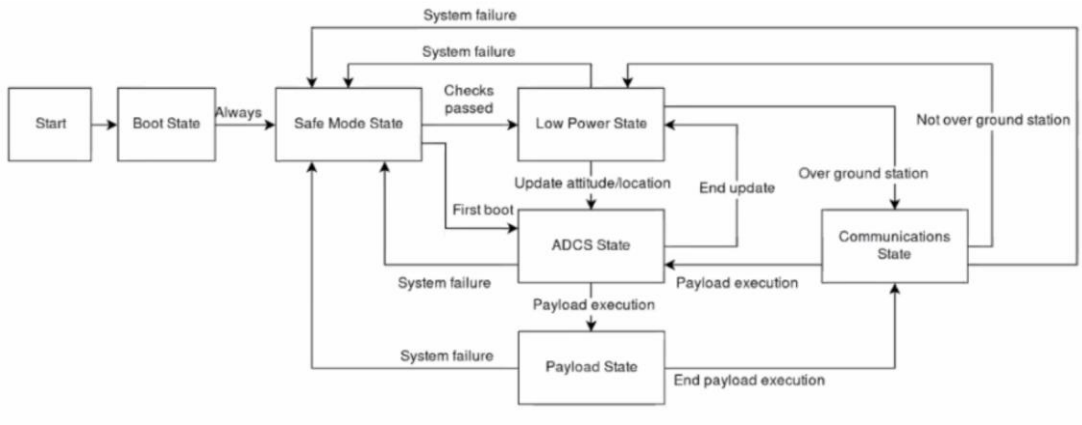

Figure 1. Sample State Machine used for University of Victoria CubeSat

Finally, our beta prototype will simulate all of CougSat I's states and behaviors from launch to orbit, including communication and control systems and resource management. Having the simulation model will help us and the members of Cougs in Space discover errors and confront problems that might happen in order to improve the satellite and prevent failure in space. This simulation software is crucial to the launch of CougSat I, as it will help the systems conform to NASA's requirements and integrate all the different systems. In addition, it will inspire Cougs in Space to push forward in their engineering processes by making the satellite feel more "real" to them.

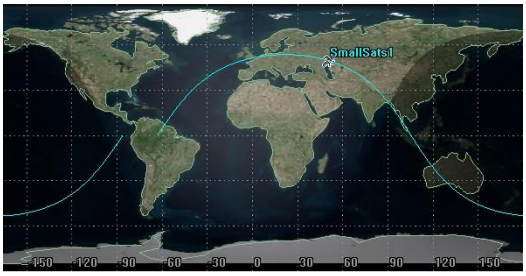

Figure 2. Ground Track using STK

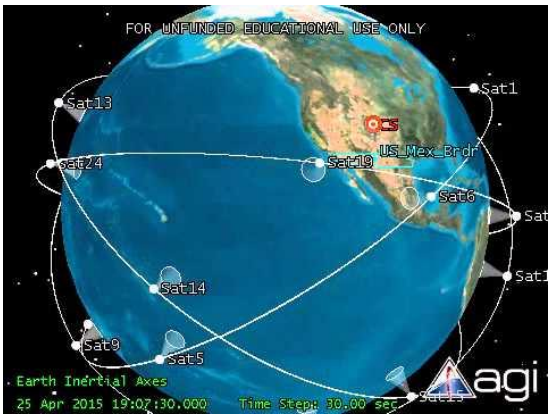

Figure 3. Satellites Simulation using STK

IV. Client and Stakeholder Identification and Preferences

Our client and main stakeholder is a student club of Washington State University (WSU), Cougs in Space. Cougs in Space began last November after being accepted as a part of NASA's cubesat initiative. The club's primary goals are to educate students about aerospace engineering, give students hand-on experience building a cubesat, and to connect students with professionals in the aerospace industry. CougSat I is a cubesat that will be built in-house by undergraduate students at WSU, and is the first cubesat to ever be built in the school's history. Since Cougs in Space is building CougSat I as a part of the NASA cubesat initiative, NASA is a stakeholder. As they are providing the launch for CougSat I, if CougSat I fails to meet NASA's cubesat requirements, NASA will not allow it to launch using their rocket, and then everyone's efforts will be for naught. But if the satellite passes all of their tests, CougSat I will be launched by NASA in 2019 or early 2020. Because of this, Cougs in Space must build CougSat I in accordance with NASA's cubesat requirements and specifications. Our software will help CougSat I meet NASA's requirements and pass their tests.
Since Cougs in Space is a student club at WSU, the university is a stakeholder as well. If CougSat I successfully launches, it will provoke more student aerospace interest at the school and from aerospace industry to the school. Not only that, but the launch of CougSat I may inspire engineering students to pursue aerospace engineering.

V. Glossary

Cubesat: A cube-shaped satellite commonly used by researchers to collect data. Cubesats comes in various size; 1 U, 2 U, 3 U, and 6 U. Each U is 10 cubic centimeters.
State machine: A set of states the satellite can be in and what actions cause the satellite to switch states.
Low Earth orbit: An orbit around Earth that is relatively low, about 2,000 kilometers.

VI. References

[1] National Aeronautics and Space Administration (2014). Launch Services Program Program Level Dispenser and CubeSat Requirements Document (Revision B) [Online]. Available https://www.nasa.gov/pdf/627972main_LSP-REQ-317_01A.pdf

[2] University of Victoria. Canadian Satellite Design Competition Critical Design Review at University of British Columbia on September 19, 2017.