Objective
To develop an open source toolkit that will optimize the design and performance of small satellites. For the VISORS project, specifically, the toolkit will help design CubeSats that will monitor coronal heating.

Introduction
While the Sun’s temperature appears to increase near the core, recent observations find that there is a sharp increase in temperature at the corona, the outermost part of the Sun [1]. Scientists have yet to fully comprehend this phenomena, especially due to the technological limitations preventing them from accurately modeling the corona’s environment.

Methodology
OMTools

- Environment Setup
- Coding & Debugging
- Testing
- Codes work as expected
- Push Changes

Figure 3. A flow chart of the steps for modeling each discipline

1. Obtain necessary operating systems, tools, and packages
2. Create Python scripts within Visual Studio Code
3. Use OMTools to declare components and model equations
4. Produce an N2 diagram to visually check the relationships established and use to debug
5. Push to remote repository on Github

Surrogate Modeling Toolbox

Battery
- Battery models will be made to represent the behavior of the battery cells as a function of state of charge (SOC) and temperature.

Thermal
- Surrogate modeling toolbox will be utilized to generate equations from physical data
- Existing thermal equations will be implemented into an open source python package to generate thermal models to represent physical limitations in spacecraft

Results
Attitude
- A model that could compute the external torques due to reaction wheels and thruster misalignment was successfully built
- The model correctly calculated external torques and integrated aspects of a satellite’s attitude dynamics
- The model produced the correct values for its partial derivatives given power

Battery
- An equivalent circuit model for the battery cell in use was created in order to approximate the transient effects and behavior of the battery cell as a circuit.

Thermal
- A thermal model for the heat conduction for the solar panels is created from existing thermal equations as well as surrogate models
- In addition, the model contains additional information on the effect of temperature on solar panel efficiency and constraints to enforce safe temperature ranges

Figure 5. A sample of the code worked on for the reaction wheels.

Discussion

- The simplest equivalent circuit is an RC circuit and since the battery cell is not an RC circuit, surrogate models were used to model the outcome of interest experimentally which would otherwise be very difficult to measure directly
- The battery models will help the VISORS team determine efficient power and current draw for the different hardware components on board the Cubesat such as the communication system, actuators, and valves

- Using surrogate models and existing heat transfer equations, we created a thermal model for the cubesats in the VISOR project
- The model allows us to determine heat distribution throughout the entire cubesat and therefore, determine limiting temperatures
  - Implements several important subsystems in the project
  - Thermal interactions between subsystems like batteries and solar panels dictate the crucial component of the missions that could result in failures if otherwise not properly modeled

- The open-source toolkit will set precedence for the design and optimization of future small satellites
- Coded models for satellite attitude, battery, and thermal disciplines in Python using existing OpenMDAO framework and incorporating it into a new framework called OMTools
- Models for the attitude, battery, and thermal(?) disciplines were successfully created and tested
- Next step in the research are to expand the toolkit to include models for other satellite disciplines (e.g. propulsion, orbital mechanics, communication, etc.)

Conclusion/Future Work

- The open-source toolbox will set precedence for the design and optimization of future small satellites

Acknowledgements

- Guided Engineering Apprenticeship in Research (GEAR)
- P.I. John Hwang
- Large Scale Design Optimization Lab (LSDO Lab)
- Graduate Student Victor Gandarillas

References