Satellite Testbed for Attitude Response

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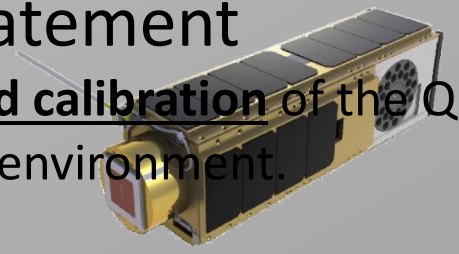
Introduction

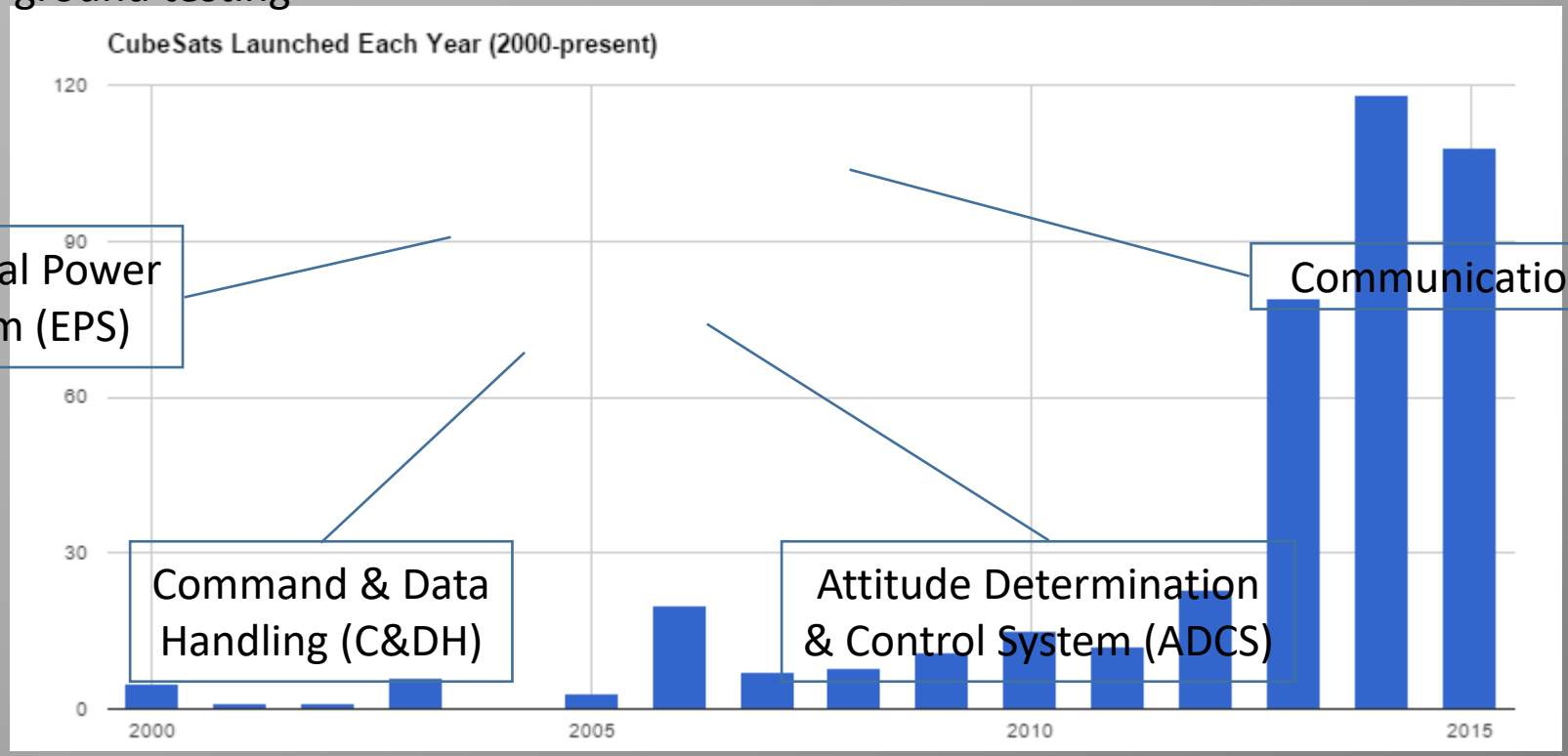
CubeSat

- Small scale satellites used for space research
- Feasibility of scientific research
- Low budget missions
- Significance of ground testing



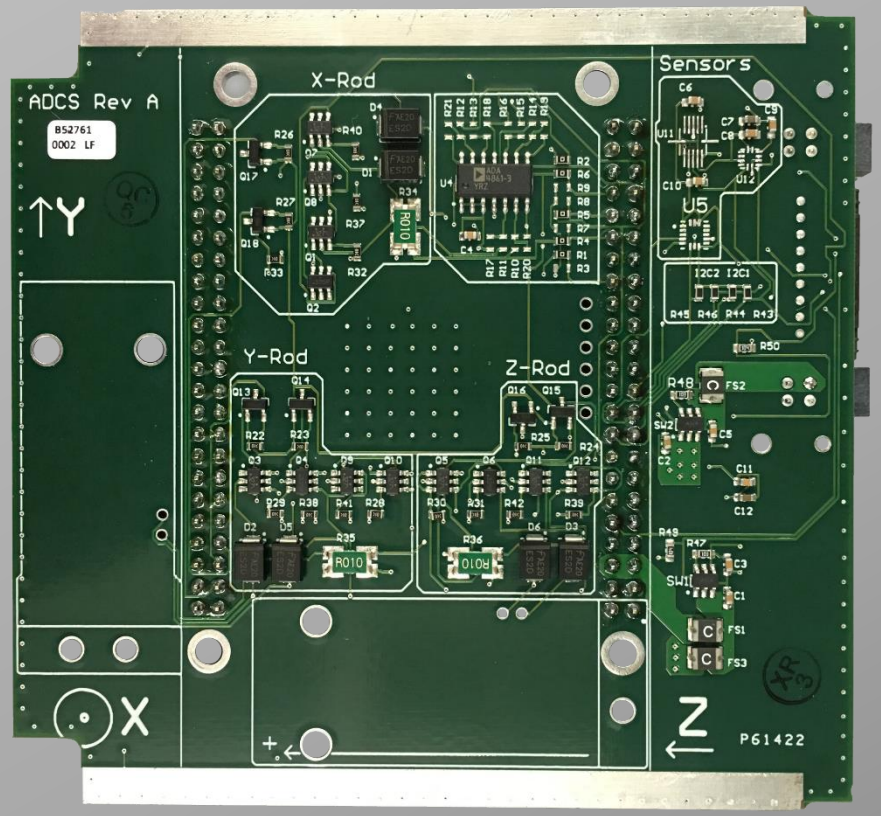
Problem Statement

Develop a **test suite** that will allow for the **validation and calibration** of the QB50 Attitude Determination and Control System based (**ADCS**) on simulated mission environment.



Attitude Determination and Control

Sensors are used to measure vehicle orientation and **actuators** to re-orient to desired attitude



<u>QB50 CubeSat Attitude Determination:</u>

- 15 Sun sensors
- 3 Magnetometers
- 2 Rate Gyroscopes
- Global Positioning System (GPS)

<u>QB50 CubeSat Attitude Control:</u>

- 3 Magnetorquers

Project Overview

- Develop an ***interface board*** that will allow for a hardware-in-the-loop simulation by running a simulation on the ADCS board.
- Develop a ***turntable*** apparatus for Sun sensor calibration.
- Develop ***test apparatus*** to test functionality of magnetorquers.

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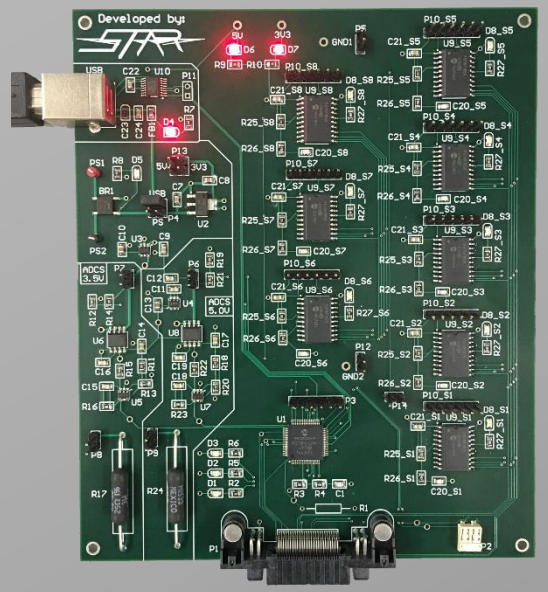

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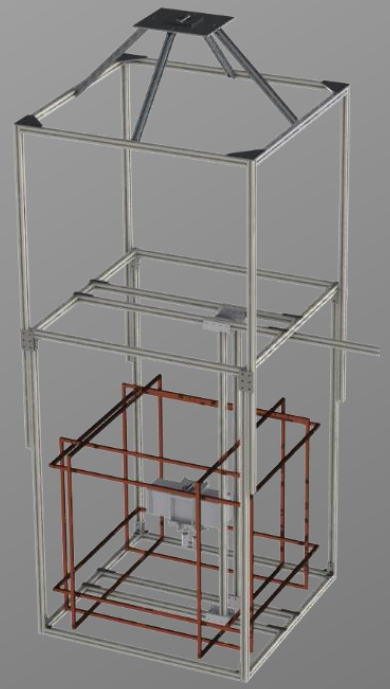
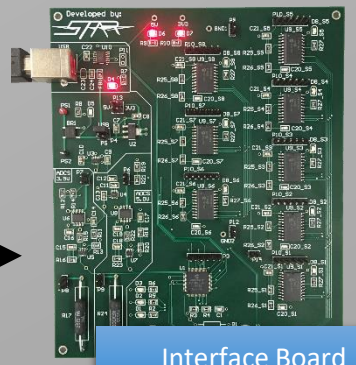


Interface Board

Purpose: Test the response from the ADCS board based on simulated mission environment

Concept of Operations

Matlab Simulation



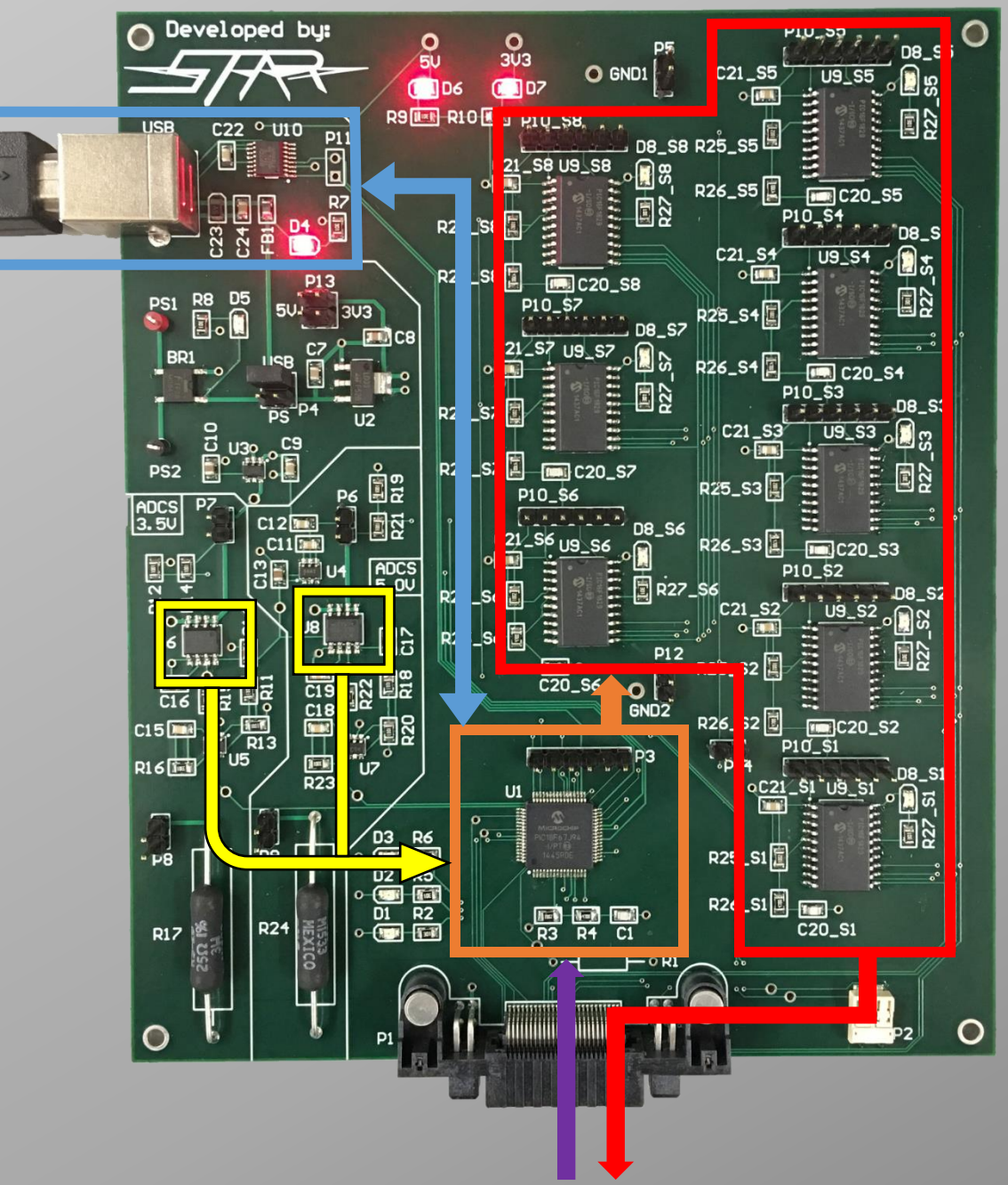
Interface Board

Customer ADCS

3. Log necessary data for analysis

1. Send Simulation data to Interface Board

2. Emulate sensor readings to ADCS Board



Interface Board Data Flow

- Incoming sensor data from simulation
- FTDI chip converts USB to *USART

- Master microcontroller receives sensor data from FTDI chip

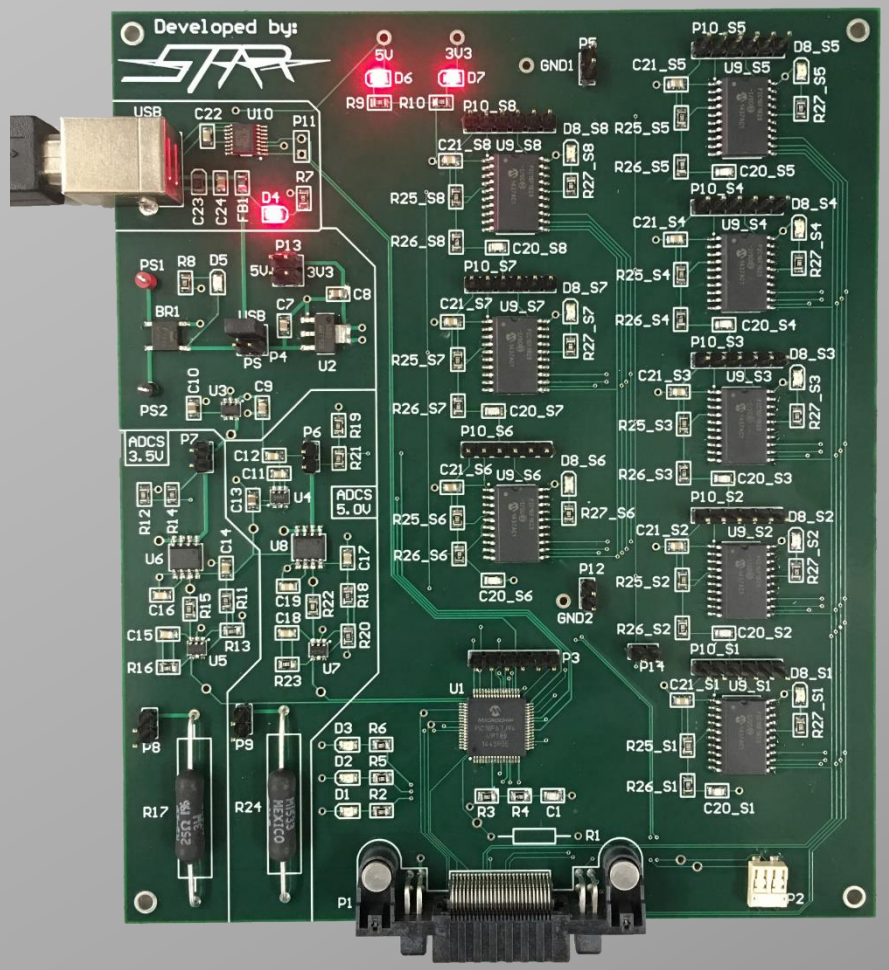
- Array of 8 slave microcontrollers receives sensor data from master microcontroller
- These microcontrollers emulate the CubeSat sensors and transmit the data to the ADCS over *I2C
- Can emulate 16 sensors (2 per microcontroller)

- Incoming magnetorquer control signals to master microcontroller

- Current sensors measure current to ADCS

*USART (Universal Synchronous/Asynchronous Receiver Transmitter
*I2C (Inter-Integrated Circuit

Data Transmission



Transmitted Data:

- 15 Sun sensors (I^2C)
- 3 Magnetometers (I^2C)
- 2 Rate Gyroscopes (I^2C)

Received Data

- 3 Magnetorquers (Pulse Width Modulation)
- Calculate power
  - Measure voltage
  - Measure current

Sun Sensor Turntable

Purpose: Test and calibrate the accuracy of sun sensors

Test:

- Angle measured by table
- Angle calculated from sun sensor data
- Compare results for calibration

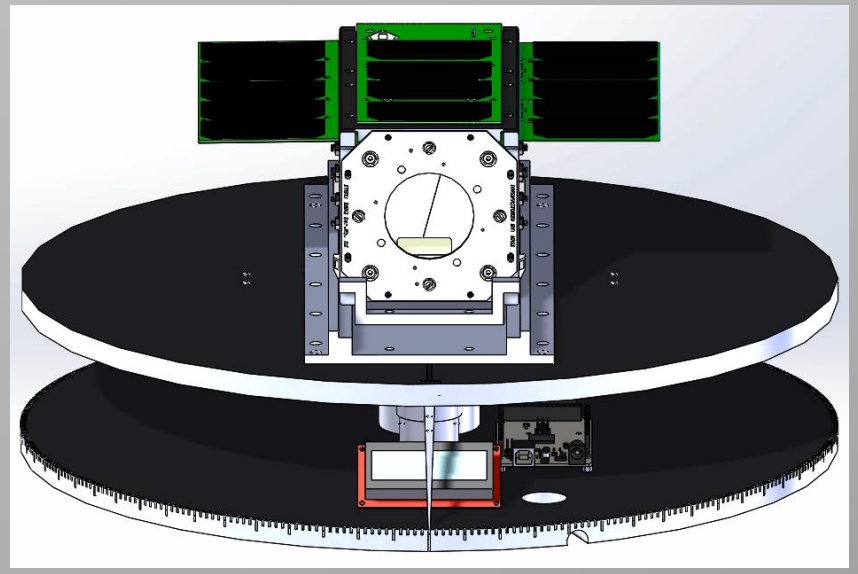
Functionality:

- Manual Rotation
- Automated 360° sweep
- Automated Point

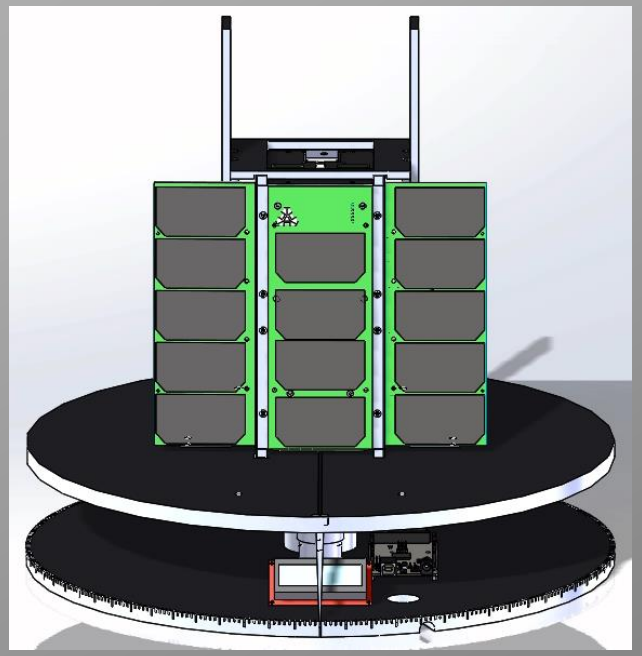
Orientation:

- Horizontal
- Vertical

Sun Sensor Turntable

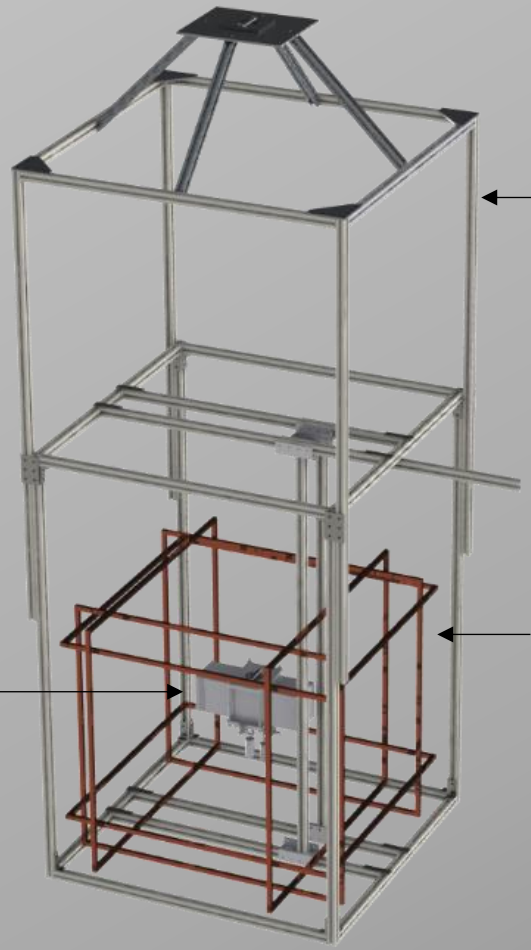


Horizontal Orientation in Sweep Mode



Vertical Orientation in Point Mode

Magnetorquer Testing System



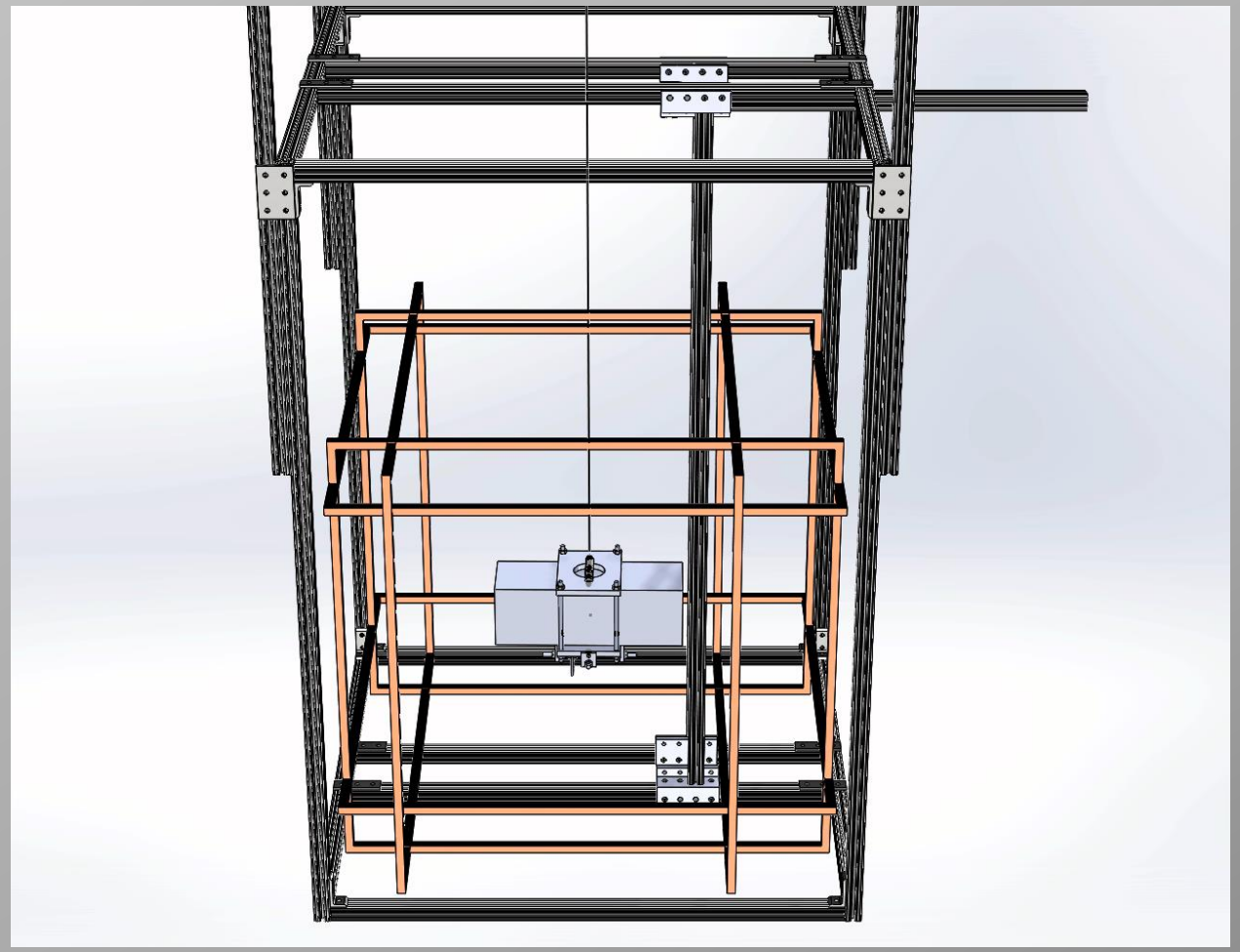
Purpose: Verify functionality of magnetorquers

Helmholtz Cage: Series of wires that induces a magnetic field

Design challenge:

- Magnetorquers produce very small magnetic torque
- Testing system must have low resistance to see effects

Magnetorquer Testing System



Test:

1. Rotate satellite clockwise 360° by hand with magnetorquers disabled
2. Measure time to rotate back to 0°
3. Repeat steps 1 and 2 rotating counterclockwise

4. Rotate satellite clockwise 360° by hand with magnetorquers enabled
5. Measure time to rotate back to 0°
6. Repeat steps 4 and 5 rotating counterclockwise

Summary

- Hardware-in-the-loop simulation to test response of ADCS board
- Sun sensor calibration
- Testing functionality of magnetorquers

Acknowledgements

- Professor Nabity
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