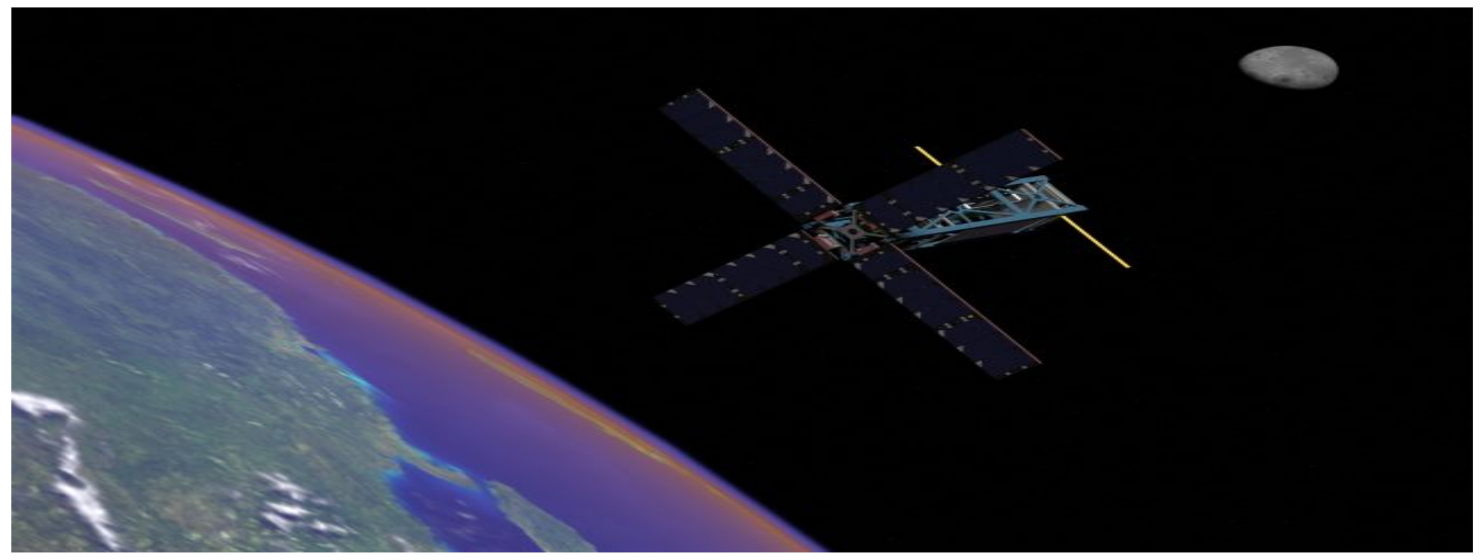
Attitude Control System testing SPACE HAUC

Andrew Burns, Eric Webb, Roarke Myers, Mitchell Ryan, Sim Dy
University of Massachusetts Lowell

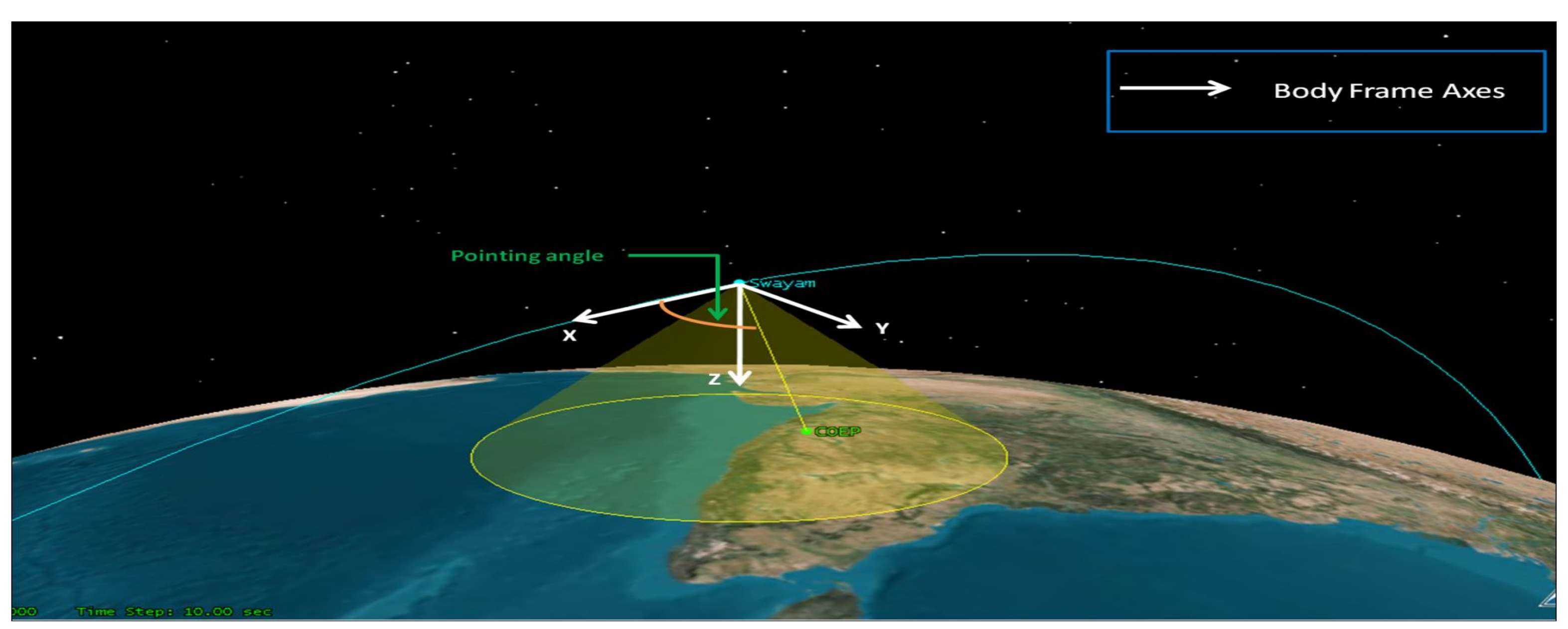
What is Attitude Control?

- SPACE HAUC is a 3U CubeSat mission funded by NASA, designed and tested entirely by undergraduates at UMass Lowell.
- The SPACE HAUC satellite's purpose is to transmit high frequency data using an X Band Phased Array antenna.



Rendering of the SPACE HAUC ONE satellite

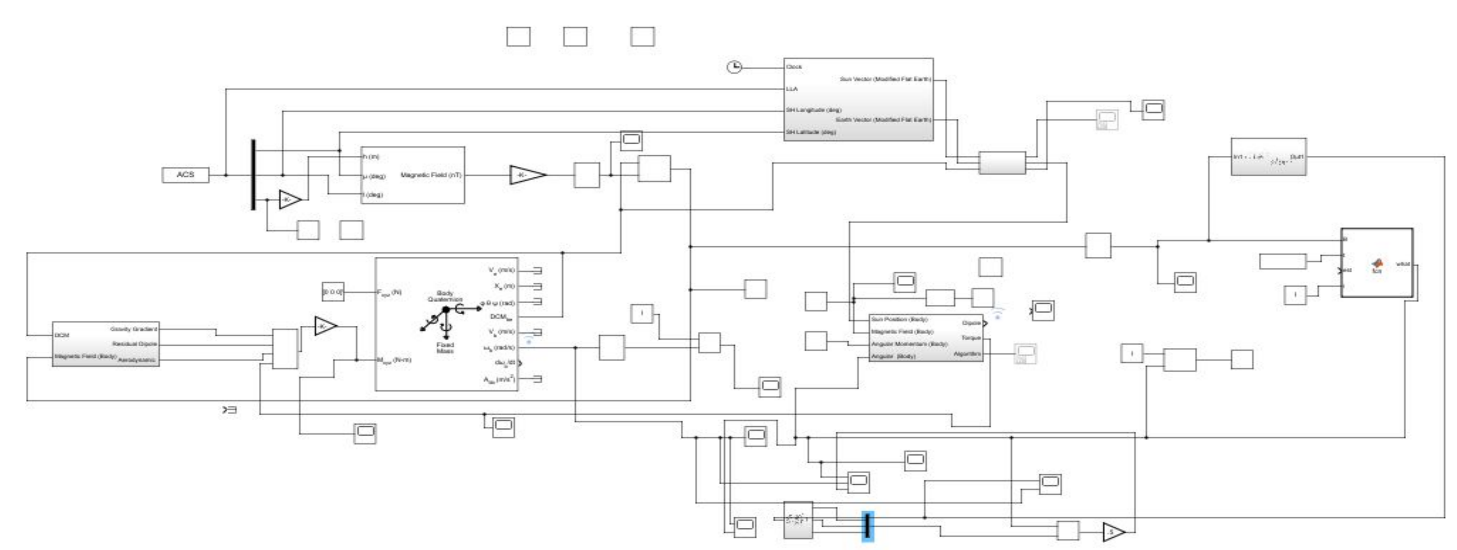
- Satellites that rely on transmitting information down to earth have the be pointed at the ground. SPACE HAUC uses solar panels, and has to be pointed at the sun.
- Attitude is the orientation of the satellite, thus attitude control is crucial for the utility and lifetime of a satellite, and often involves attitude determination, or the tracking of the satellite's current orientation.
- Attitude control is needed to correct disturbance torques from the atmosphere, the gravity gradient, the structure's magnetic dipole, and solar radiation.
- We control spin the spacecraft for stability and control using magnetic torquers.



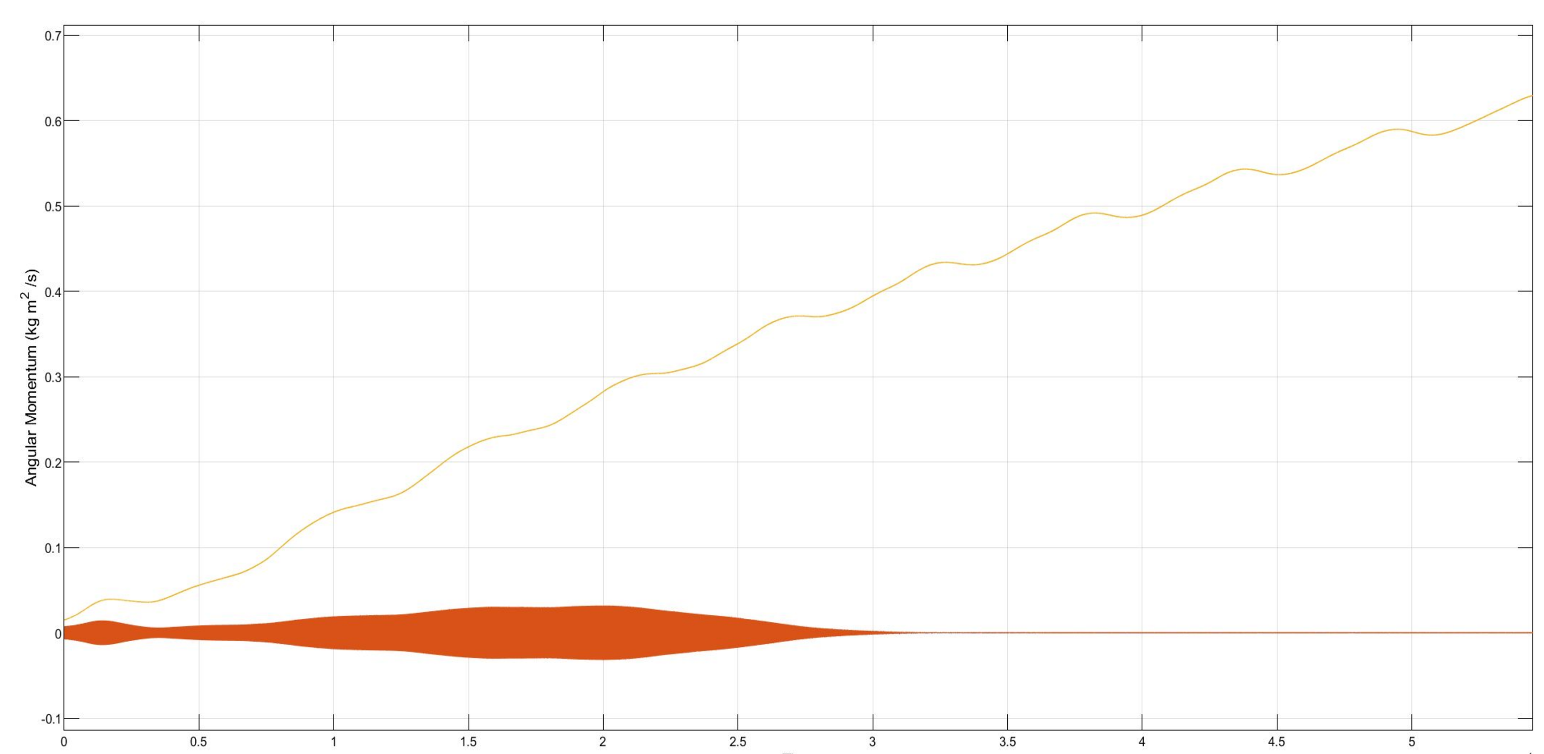
Visual representation of attitude, satellite orbit, body frame, and range of signals.

Attitude Control of SPACE HAUC

- SPACE HAUC's Attitude Control System is comprised of multiple physical components: a magnetometer, several "coarse sun sensors", a "fine" sun sensor, three magnetorquers.
- We only set voltage through magnetorquers at certain values (-5 V, 0 V, 5V).
- Detumbling: Reduce spinning around X,Y axes. Spin satellite around Z (perpendicular to camera, panels).
- Due to time and budget constraints, we do not calculate absolute attitude.
- Sun Pointing: Determine where the sun is using sensors, torque to that attitude..
- Gyroscopes are not able to be tested in the lab, so we use the magnetic field values from the magnetometer to determine angular velocity. We use a Kalman filter to do this.
- We use Simulink to calculate the orbit, rotation, magnetic field values, and sun and earth vectors.



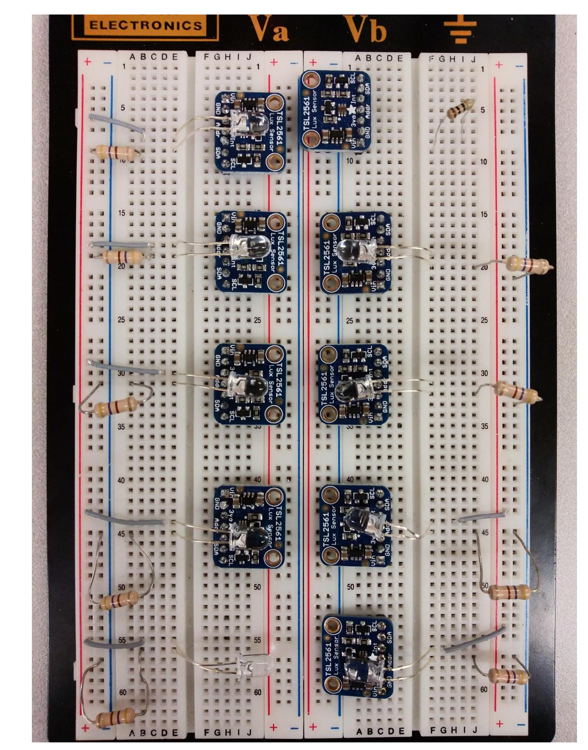
Our Simulink model. Simulink is a graphical programming language made by Mathworks (MATLAB).



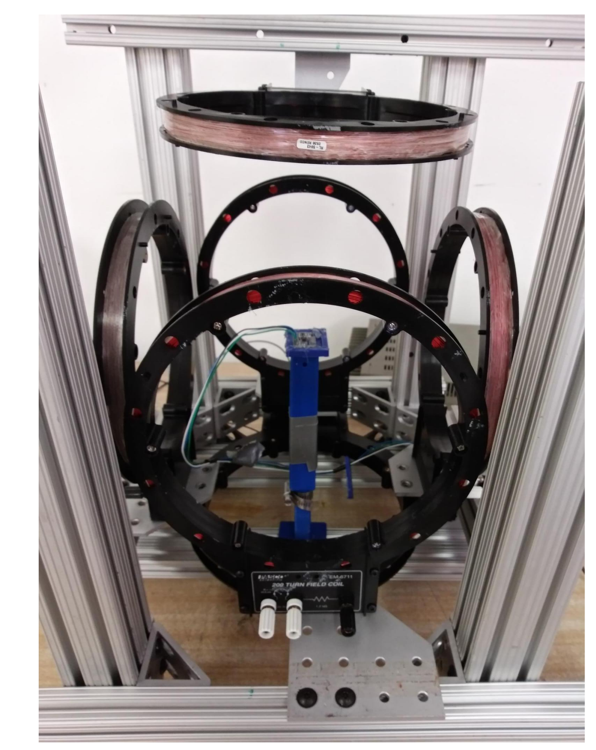
This graph shows the detumbling stage of attitude control. This shows the angular momentum components of the satellite over the course of about 15 hours using magnetic field values to calculate the angular velocity, as well as using 3 voltage settings to run current through the magnetorquers so that the resulting dipole torques the satellite with the external magnetic field.

Physical Testing of ACS

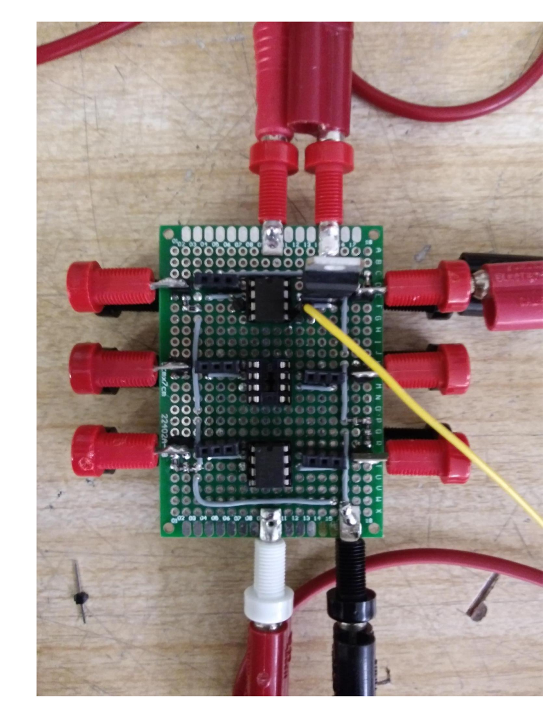
- In order to accurately test our system, we have to give our sensors the same or similar input in the lab, in real time.
- We surround our magnetometer with three mutually perpendicular helmholtz coils.
- The coarse sun sensors are placed near LEDs with brightness control and covered from the environment.
- We are currently in construction of a setup to control a laser diode point to move across the surface of our fine sun sensor.
- Our Simulink code is converted to C++, so that our flight computer can calculate the appropriate voltages to run through the magnetorquers.
- Hardware in the Loop: final test that calculates values in Simulink, changes environment around sensors, flight computer processes signals from sensors, gives out current, current is detected, and goes back into the simulation to update the orientation.



Coarse Sun Sensors next to LEDs.



Helmholtz Coils around Magnetometer.



Amplifier for Signals out of Analog discovery 2, connected to Simulink.