Rapid Prototyping

- Designed for rapid iteration
- FDM 3D printed main structure
- Inexpensive COTS components: DC Brushless hobby motors, Intel Edison microcontroller, and Sparkfun "blocks"
- Controller code written in *Python*

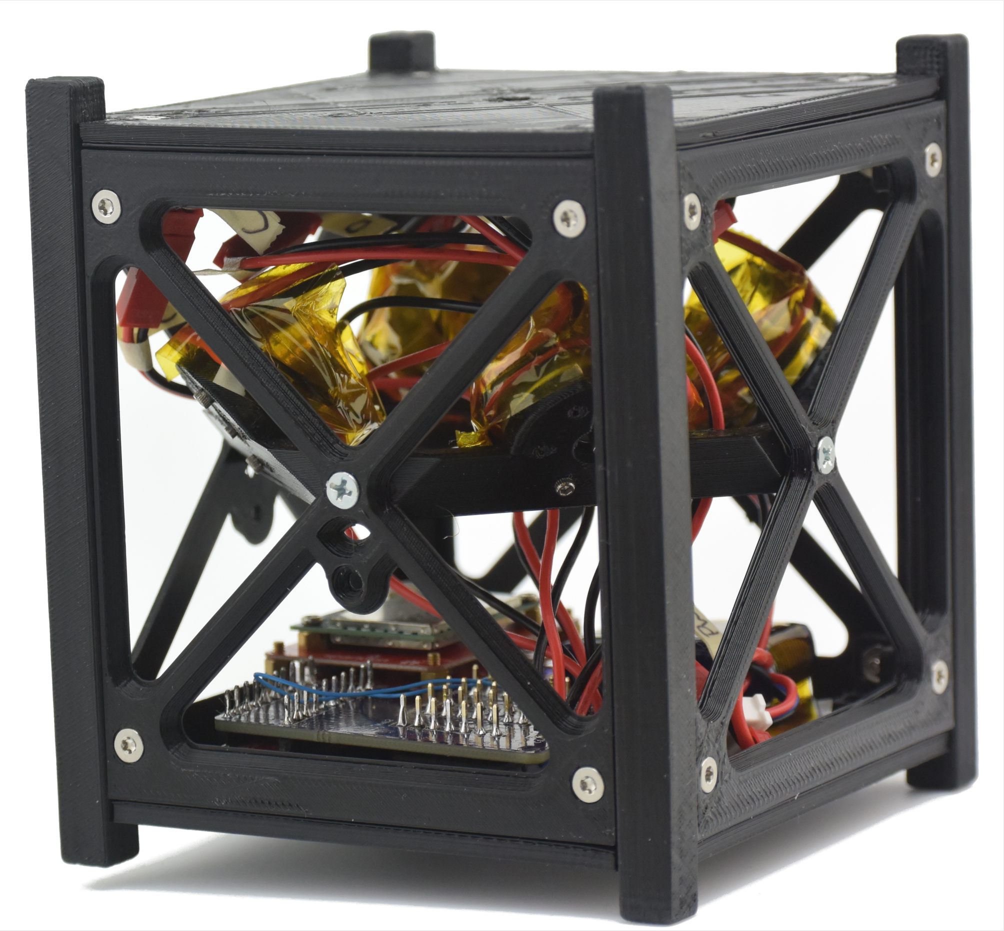

Figure: The reaction wheel subsystem test cube.

Control Development

- The controller for the reaction wheel system is a simple PID loop
- The top-level controller design procedure was as follows:
  1. Determine the transfer functions from dynamics analysis of free body diagrams of the system
  2. Create simulation in GNU Octave
  3. Design the controller using iterative testing (with comparisons to the model) and classical Bode techniques
- The forces acting on the cube are the torques created by the motors T_i^0, damping effects $b_1\dot{\theta}_{cube}$, and spring effects $G_1\theta_{cube}$. Summing the moments around the center of gravity gives the following equation (for the x-axis):

$$\sum M_0^{+\circlearrowleft} = I_{x,cube}\ddot{\theta}_{x,cube} = T_{Ax}^0 + T_{Bx}^0 - T_{Cx}^0 - T_{Dx}^0 + T_x^0 - \dot{\theta}_{x,cube} - G_x\theta_{x,cube}.$$

- By setting the system to Standard Equilibrium Position (at SEP the input perturbations are set to zero), considering only a single input, substituting the torque-inertia relation, and taking the Laplace transform we arrive at (*the incredibly simple*) transfer function of the cube:

$$G_A(s) = \frac{\theta_{x,cube}(s)}{\theta_A(s)} = \frac{s^2}{\frac{I_{x,cube}}{\sin(45^\circ)I_{rw}}s^2 + \frac{b_x}{\sin(45^\circ)I_{rw}}s + \frac{G_x}{\sin(45^\circ)I_{rw}}}.$$