Fox CubeSat Mechanical Design

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Abstract

Fox 1 will be AMSAT's first 1U CubeSat, 100x100x100 mm (about 4x4x4 inches) with a weight of up to 1.33 kg (about 2.9 pounds) with 113.5 mm long rails. The bent aluminum sheet metal exterior structure will contain a ten stack of PCBs with the top four reserved for experiments. Each of the six faces of the cubesat will have a solar panel affixed. Two whip antennas will now be stowed on side panels, but after launch still extend parallel to +/- Z axis. Fox 1 mechanical design is expected to be fully designed and prototyped by the end of 2012. This paper describes the changes made in the mechanical design since last year.

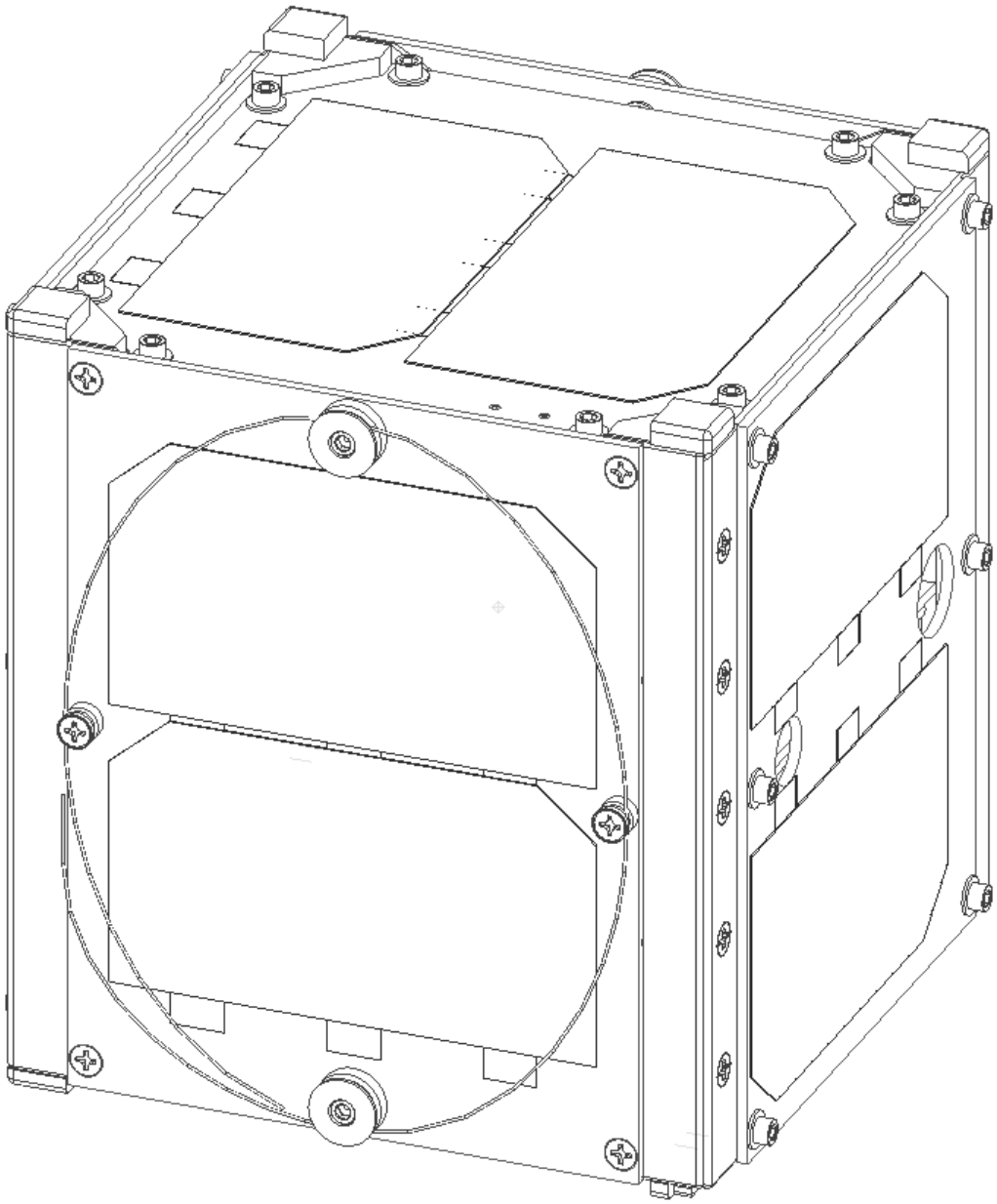

Figure 1 Fox1 stowed

Structure

The cubesat structure is bent aluminum sheet metal in order to offer greater volume for internal PCBs and to eliminate a number of fastener joints. Since last year, the two identical sheetmetal pieces are extended from 100mm tall to 108mm tall. After recessed fasteners and recessed sides of the Rail Ends are considered, the sheetmetal alone meets the 75% rail contact area requirement. The added length still fits within the allowable volume by reducing the heights of the Rails Ends on top and bottom.

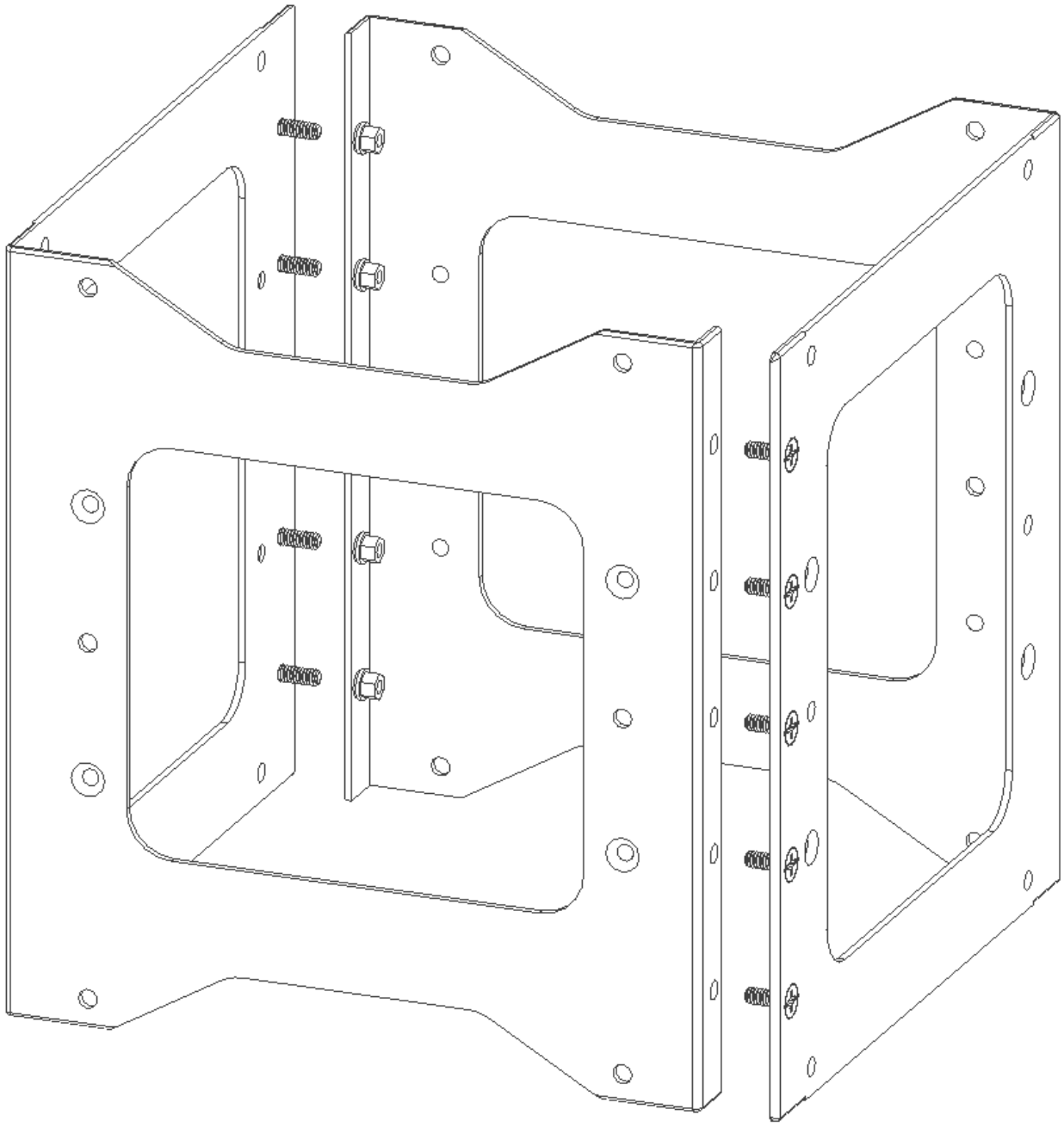

Figure 2 Bent Walls (exploded)

Two of the –Z Rail Ends hold spring plungers, specifically the part number specified by the CubeSat Design Specification. The other two –Z Rail Ends can accommodate contact switches, though only one of the two is baselined to fly.

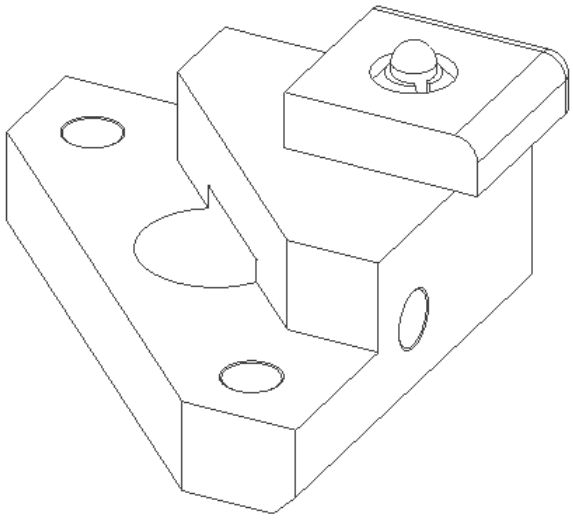

Figure 3 -Z Rail End with Spring Plunger

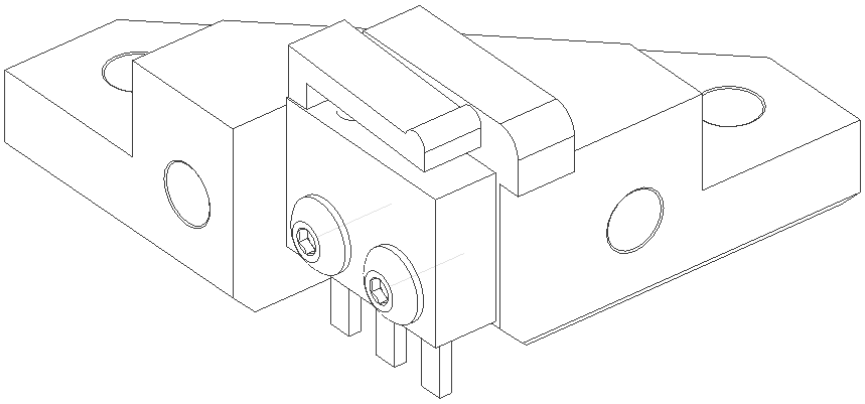

Figure 4 -Z Rail End with Contact Switch

Batteries
The four “C” sized batteries were changed to six Sanyo “A” KR-1700AUT batteries based on convenience to package. The six “A” cells have less capacity, but eliminate the need to deeply machine the battery circuit board. The battery board is in the middle of the PCB stack so that the combined center of gravity is inside the requirement set in the CubeSat Design Specification. The individual batteries are pushed to the perimeter of the circuit board to encourage spin stability around the Z axis.

Hysteresis Rods and Magnet
Similar to AO-51, the Fox 1 cubesat will spin about a permanent magnet. The magnet is a standard size, about ¼” diameter and 1” long. See Figure 6 and Figure 7. Two hysteresis rods are added to dampen oscillations. The hysteresis rods are also a standard 1/8” diameter, and cut to about 3” long. They are mounted under the battery board, orthogonal to each other, and orthogonal to the magnet. See Figure 5.

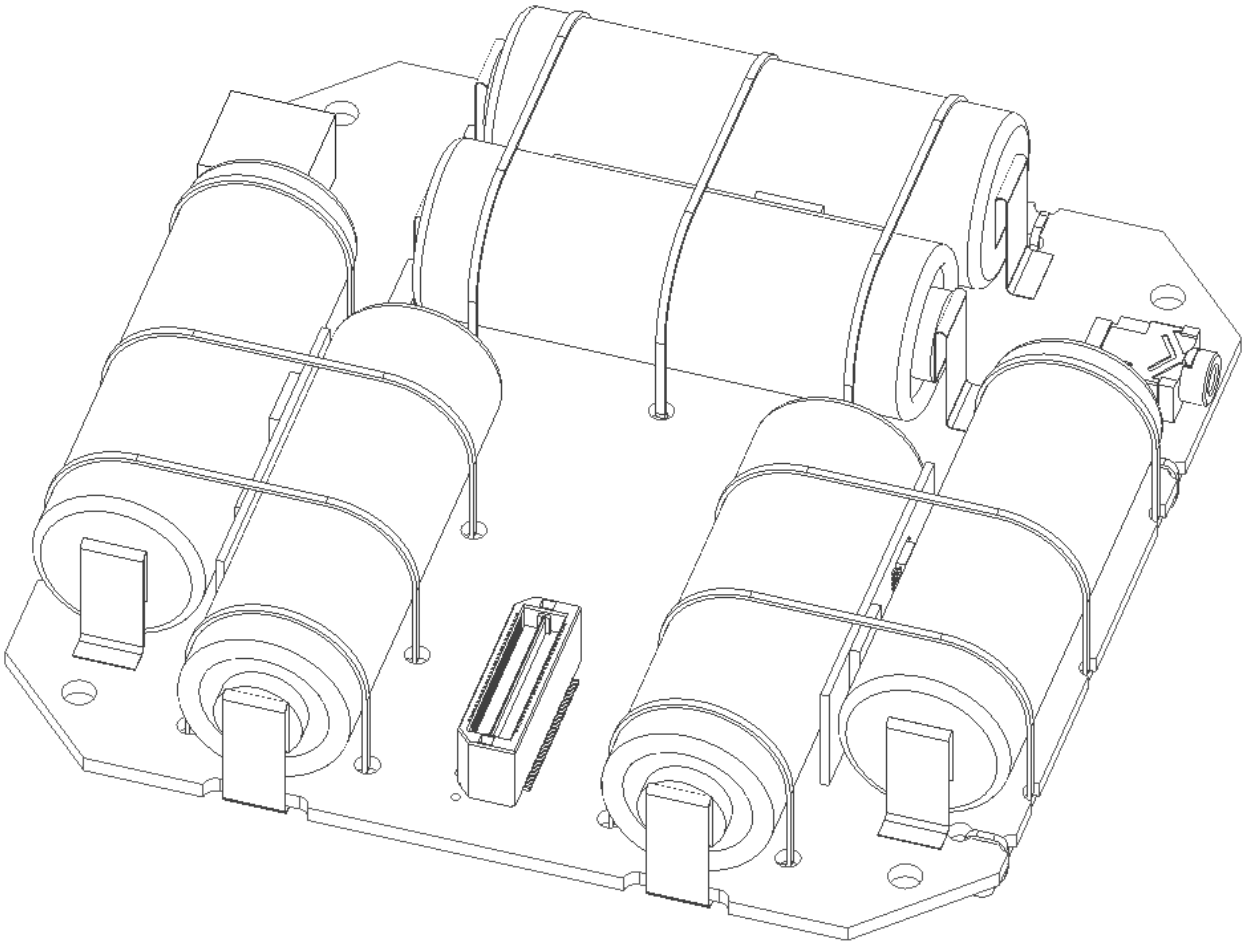

Figure 5 Battery Assembly

PCBs

The PCBs are a single stack of ten with the batteries centered and the top four reserved for experiments. The PCBs are stacked with long corner screws and spaced with aluminum spacers for electrical and thermal conduction. The gaps between all PCBs is 8mm To prevent heat leakage from the PCB stack to the colder structure and solar panels, Delrin blocks mount the PCB stack to structure. To keep the Delrin small, those aluminum spacers were swapped with copper so the diameter could be reduced. To accommodate potential tolerance buildup of the PCB stack height, The Delrin mounts can be adjusted slightly higher or lower by moving shim washers above and below.

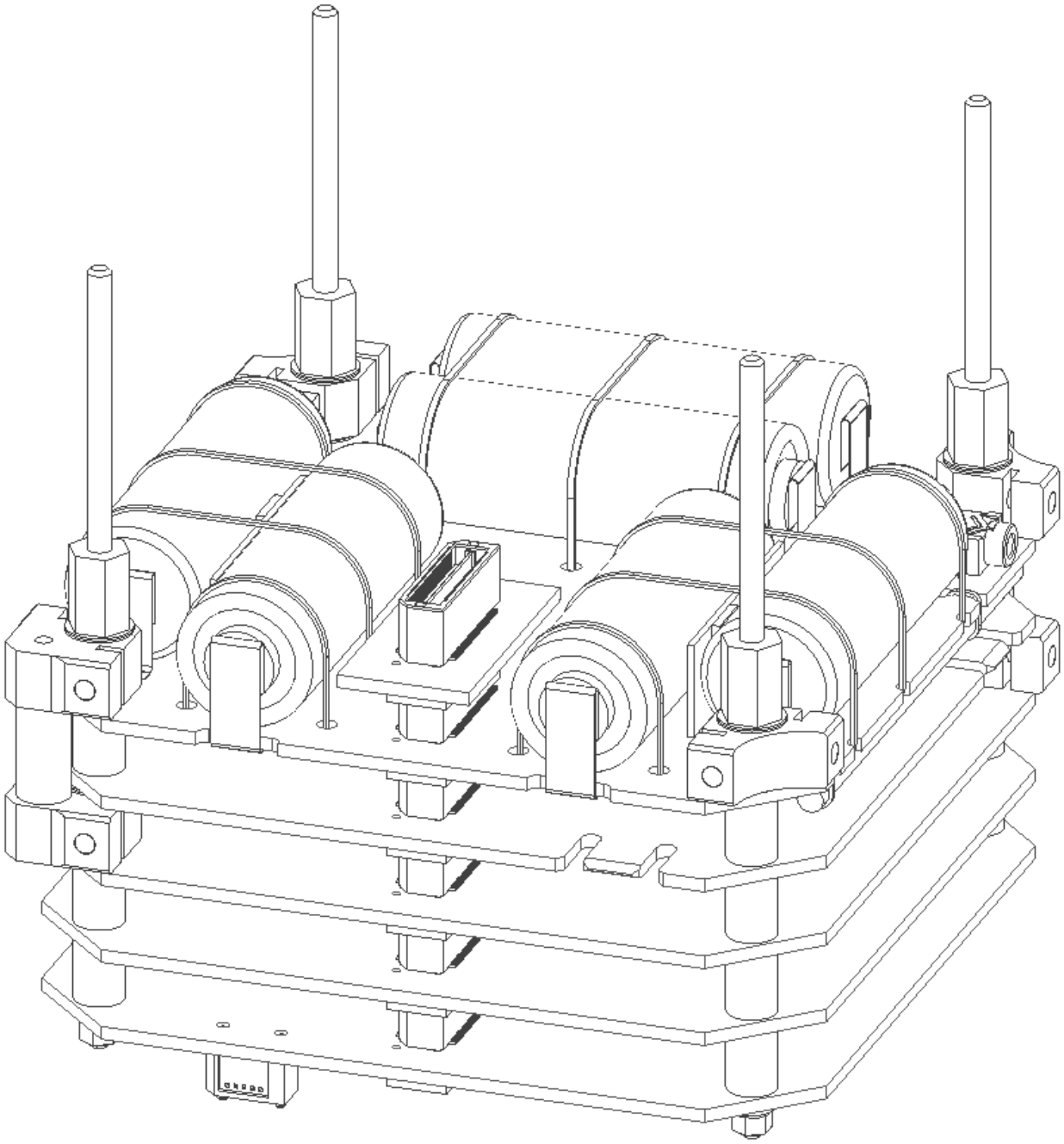

Figure 6 PCB Stack of Avionics

The PCB stack height happens to be about 88 mm. This makes it convenient to use 6mm tall connectors from the top and bottom of the PCB stack to the +Z and –Z Solar panels. To limit heat loss here, the pin count is kept to a minimum and the solar panels do not share the standoffs and corner screws.
The side solar panels have a one-piece connector that allows each edge of the PSU card to attach as if it were an edge card. Again, to limit heat loss here, the pin count is kept to a minimum.

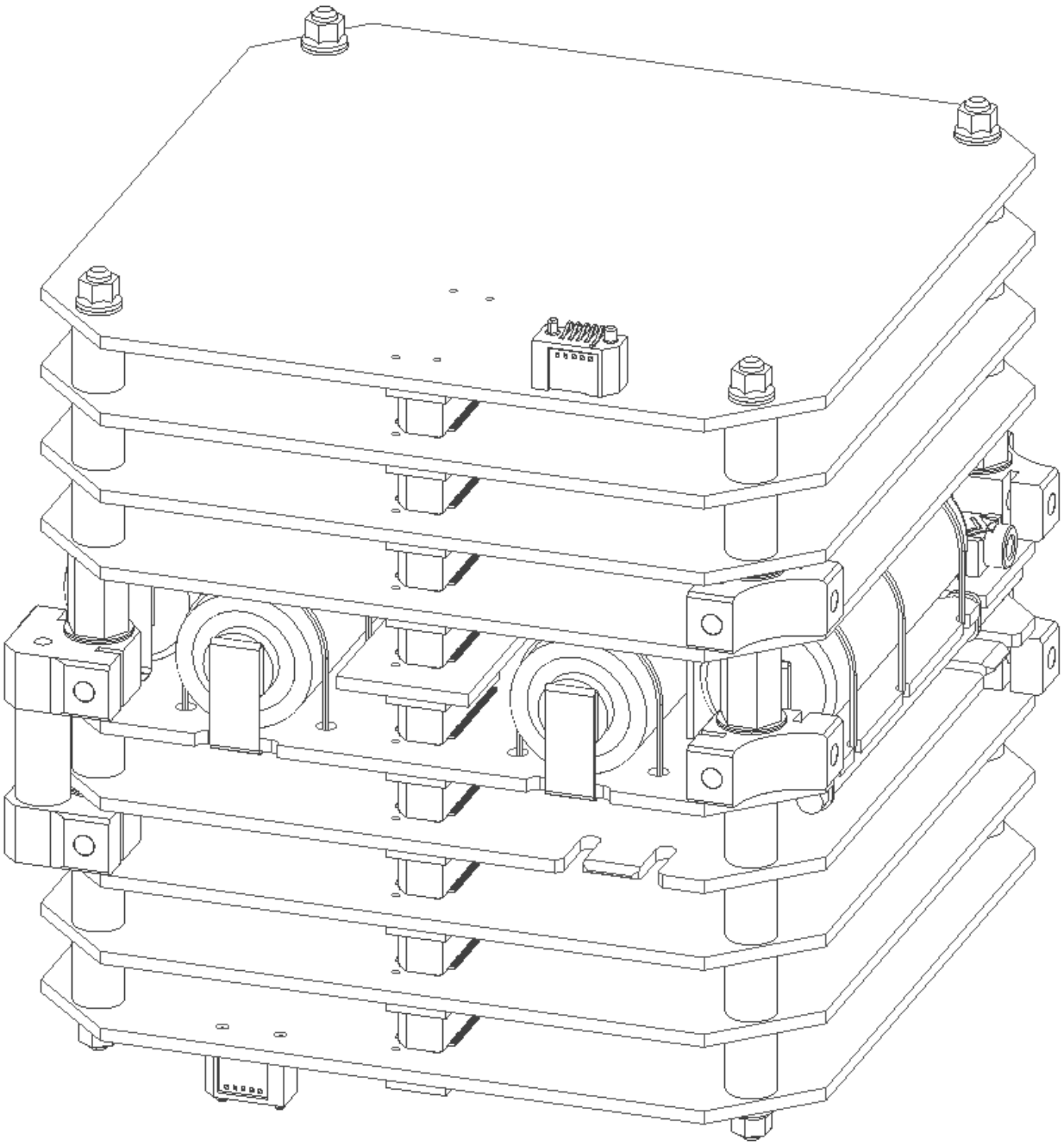

Figure 7 PCB Stack of Avionics and Experiments

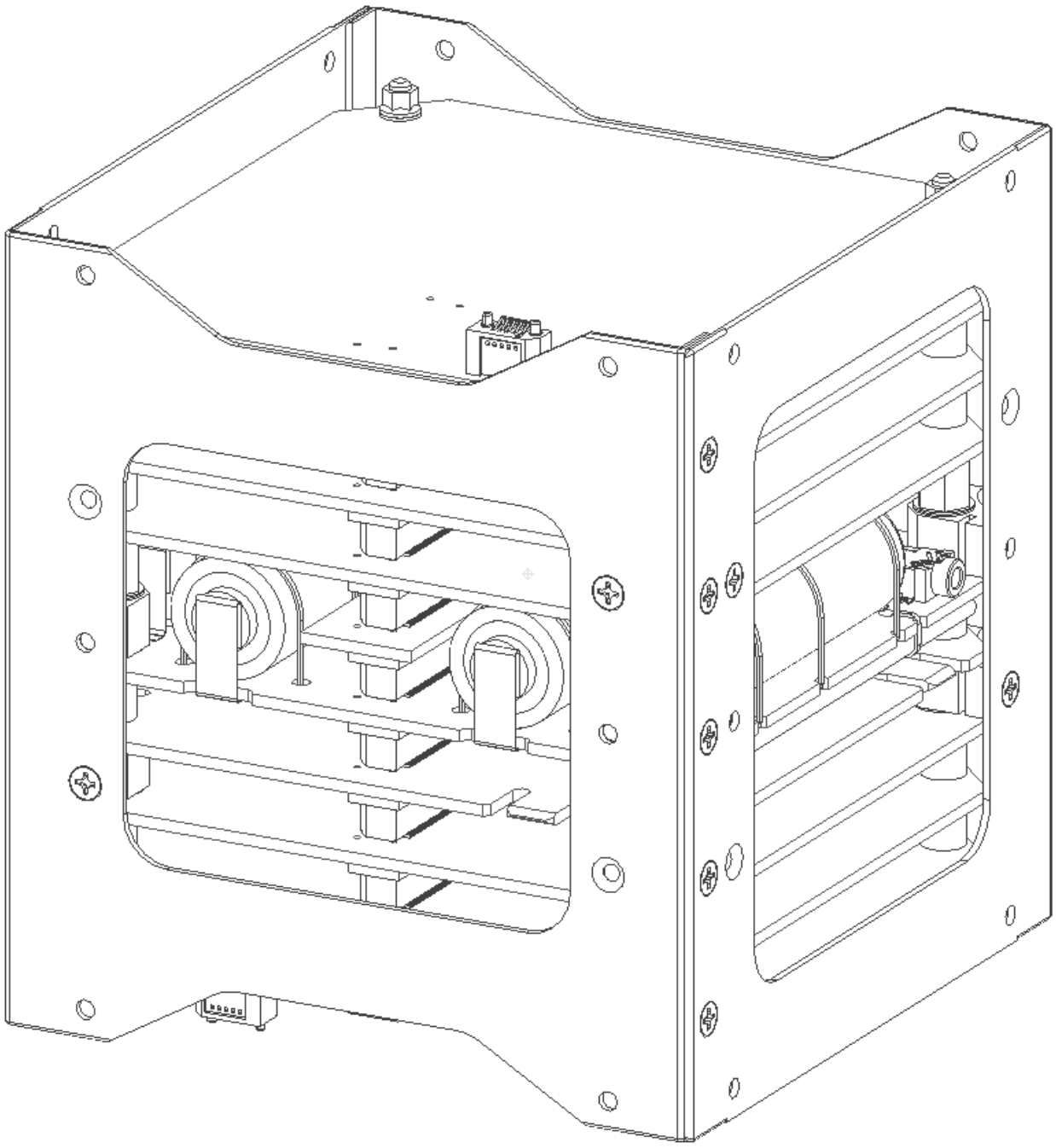

Figure 8 PCB Stack slides into Walls

Solar Panels

The six sides of the cube will be covered with fixed, Cell-Interconnect-Coverglass (CIC) solar cells. The side solar panels will be 82 mm wide and 108 mm long and the top and bottom solar panels just under 100x100 mm. The solar panel substrates will be standard thickness (.062 inch) PCBs.

The +X and –X Solar Panels have access holes for 2.5mm audio jack and mini-USB, which are visible thru the access holes provided by the P-POD.

The +Y and –Y Solar Panels stow the whip antennas.

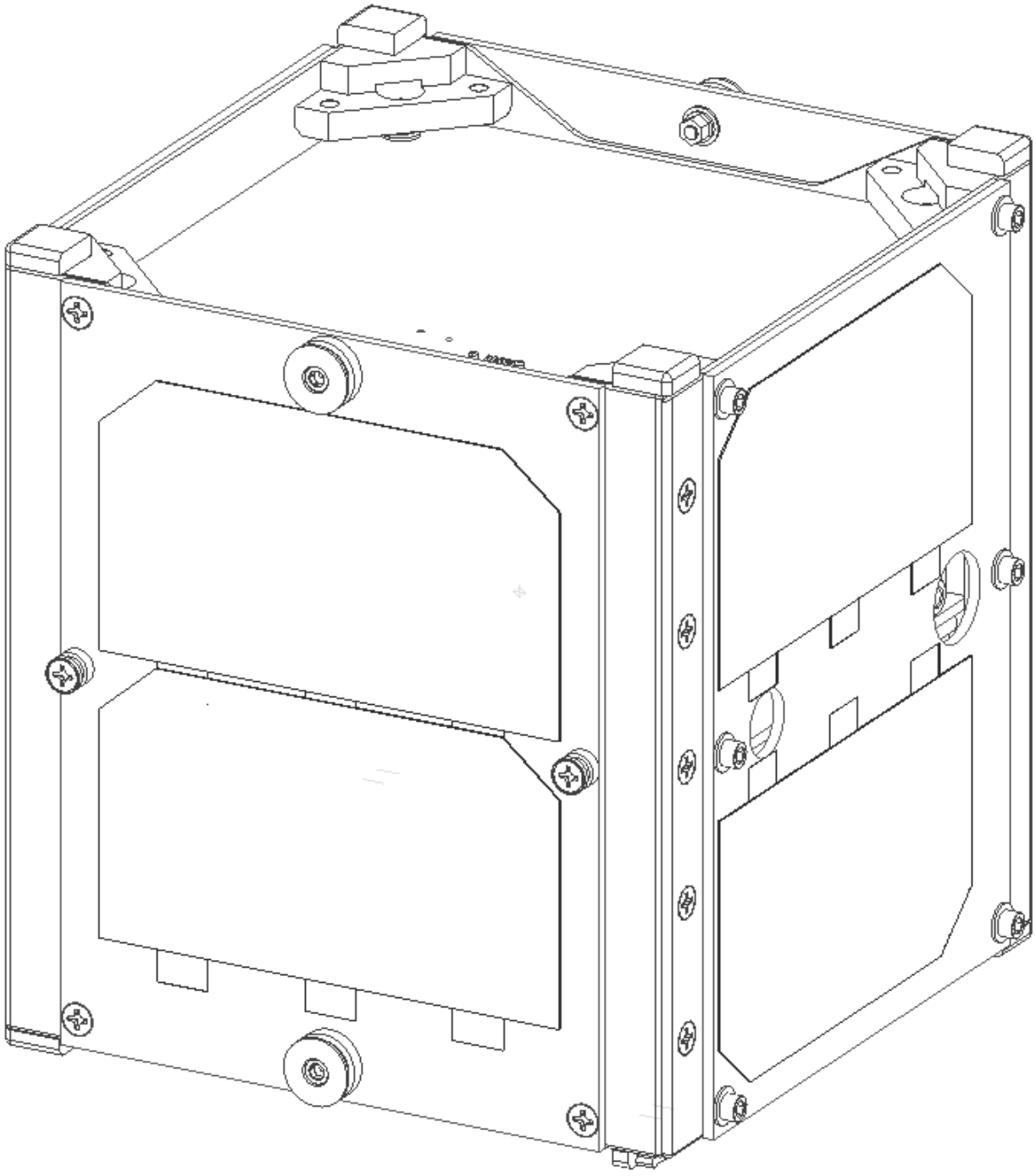

Figure 9 Install Side Solar Panels and Rail Ends

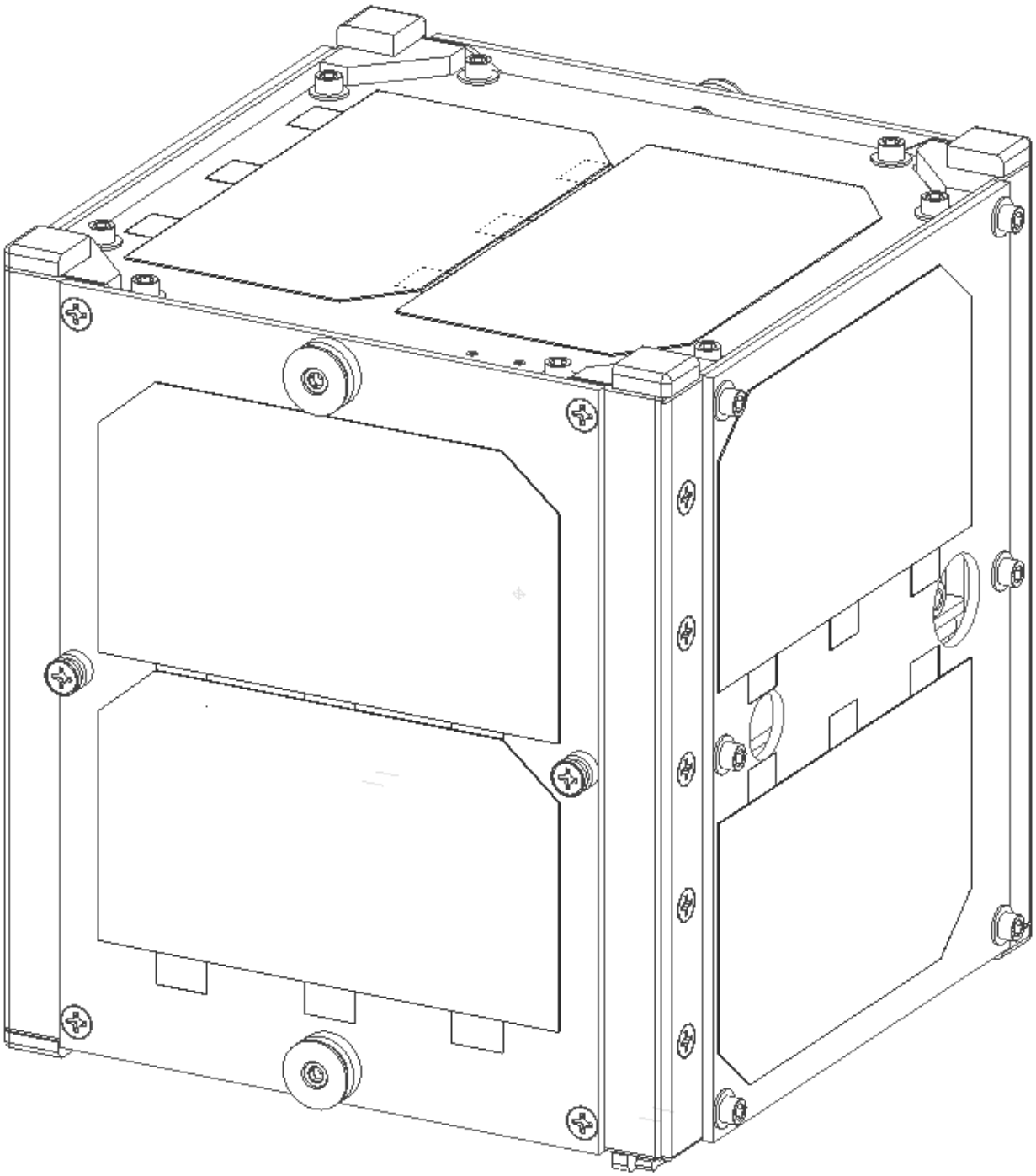

Figure 10 Install Top and Bottom Solar Panels

Antennas

The whip antennas were originally planned to wrap around the entire cubesat, and emanate from the Top & Bottom Solar Panels. Difficulties in a simple "sharp bend" around the edges of the cubesat, and concern about vibration alignment, drove a different solution.

The whip antennas are now wrapped around posts above the +Y and -Y solar panels. See Figure 1. This allows the bend radius to be larger than could have been afforded going around the edges of the cubesat, without reverting to torsion springs. The posts have a small groove to hold the wire above the panel. Two of the posts are aluminum and allow us to check electrical continuity for status of antenna stowage. The wires are stowed in their oval shapes by fishing line tied to the ends. The fishing line will be melted using a high temperature resistor.

Engineering Unit

All parts will be prototyped before the flight units are built. At the Symposium this year, we expect to have most parts, if not all, prototyped.