ADVANCED CONCEPTS FOR SMALL SATELLITES: MATERIALS, EJECTORS AND FORMATIONS.

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I. **INTRODUCTION:** Small satellites have a total mass of 500kg or less. Of many classifications of small satellites, picosatellites have become an area of interest to many in the last eleven years. In 1999, California Polytechnic University (CalPoly) and Stanford University formed a partnership to create the first program dedicated to the creation and advancement of small picosatellites called CubeSats.[1] Since then, many other universities have participated in this program to take advantage of the low fabrication cost and abilities that CubeSats offer. Unlike normal-sized satellites, CubeSats measure 10x10x10cm, normally weigh about 1kg and only cost between forty and sixty thousand dollars. [5]

Figure 1: Basic 1U CubeSat [3]

Making their way into space by hitching a ride on a launch vehicle, usually a rocket, CubeSats require a deployment mechanism to be placed into the desired orbit once in space. Although there has been much advancement with CubeSats themselves, a deployment mechanism which could offer higher deployment velocities is currently not available. One propulsion system, The Poly Picosatellite Orbital Deployer (P-POD), also developed by CalPoly, is currently one of the few standard deployment mechanisms for CubeSats. The P-POD can contain up to three 1U (one unit) CubeSats and has proven many times to be a successful secondary payload [2].

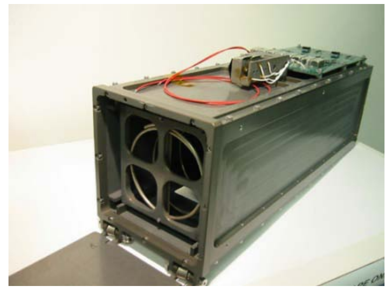

Figure 2: CalPoly P-POD Mk.I[4]

Currently, research is being done for a 3U (30x10x10cm) CubeSat named RAMPART. For RAMPART, "3D Burst Cube" test and "3D Tensile" test were carried out in order to test the amount of stress, pressure, and temperature that the RAMPART material could sustain.

II. **RESEARCH/EXPERIMENT:** The materials tested were Windform XT (carbon fiber filler) and Windform LX-2 (glass fiber filler). Of the materials, eight different 1in. and four different 1.5in. hollow cubes were made for the burst experiment. Made of either the XT or LX material, the cubes either had 0.125in. or 0.0625in. walls and were either filleted or non-filleted. For this particular experiment the test cubes were attached to a stem inside a MCBH Temperature Chamber and enclosed in a container. The stem made a path to the outside of the chamber connecting to a tank of compressed nitrogen, a pressure transducer, and control, bleed, and restrictor valves.

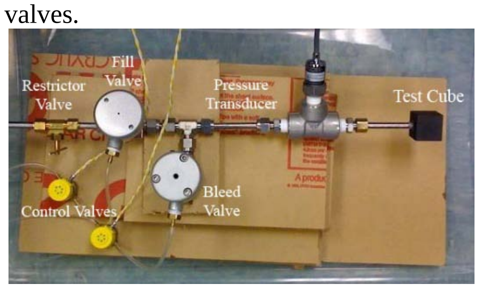

Figure 3: 3D Burst Test Set Up

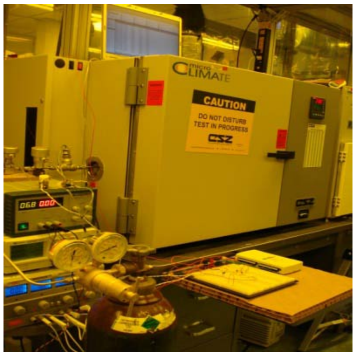

Figure 4: 3D Burst Test Set Up

To run the experiment, chamber was set at temperatures ranging between -70°C to 80°C then the pressure tank was opened to send pressure to the test cube, depending upon sustainability. For the “3D Tensile” test, the two different materials were molded into ISO 527-Flat “Dog-bone” and underwent different amounts of pressure and forced on a Tinius Olsen H50K-S UTM.

Figure 5: 3D Tensile Test Set Up

Along with the testing of materials, research for the deployment mechanism was also conducted. Because CubeSats are often secondary payloads or non-primary payloads, they are sometimes restricted to the orbit of their primary payload. Research shows that by making the deployment mechanism pneumatic, non-primary payloads and so on will have a higher deployment velocity which could enable them to reach different orbits than their primary payloads. Because there is no way to practice launching payloads into space, STK (Satellite Tool Kit) along with basic orbital mechanic equations were used as an aid in different mission simulations [7]. STK is a software program that allows one to set up a mission in real time and project the outcome depending on input variables.

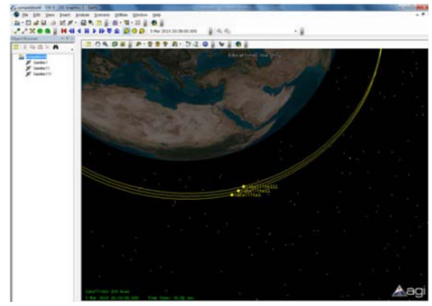

Figure 6: 3 Satellite Orbit in STK[7]

III. **CONCLUSION:** The “3D Burst” proved that the 1.5in XT hollow cubes with 0.0625in. walls could sustain a larger temperature range and higher pressures. All of the cubes survived temperatures up to 80°C; however, the non-filleted cubes could only sustain a maximum pressure of $\leq$ 400 psi while the filleted cubes could sustain up to 500 $\leq$ psi. The test also concluded that of the eight 1in. teshet cubes, the XT with 0.125in. walls also could survive temperatures up to 80°C and of 1000 $\leq$ psi. The “3D Tensile” test showed that the XT Principle X bone could sustain larger stress(psi) and force(lb); however, the Vert ZY bone had less strain. The same went for the LX materials.

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