Small Satellite Mechanical Structure Design and Analysis: Structural Analysis in Transition from 3U to 6U

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DESIGN AND RESEARCH OVERVIEW

Over the past year, the MOCI (Multi-view Onboard Computational Imager) team of the SSRL has been undergoing a design shift from a 3U formfactor to a 6U form factor for the MOCI satellite. The goal of this research was to design and analyze the mechanical frame of the satellite, used to protect essential satellite subsystems during flight. It was determined that the 3U formfactor, a vertical satellite of three cubic units was not suitable for the payload, and so permission was requested, and we were allowed to move forward with a 6U frame, which was double the size of the previous SSRL satellite, SPOC. The 6U (226.3mm x 353.0mm) frame is built of Aluminum 6061, which is ideal in structural rigidity and thermal dissipation. The main design elements consist of an internal frame along the Z-axis, Y+/- and X+/- panels, a structural bridge, and various structural ribs that surround the avionics stack and batteries to prevent warping along standoffs. Full system simulations were run in ANSYS with Modal Excitation, Random Vibration, Inertial Loading, and Thermal Expansion testing. To be concise, this report will focus on Inertial Loading.

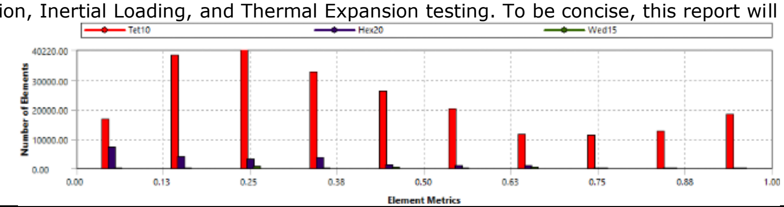
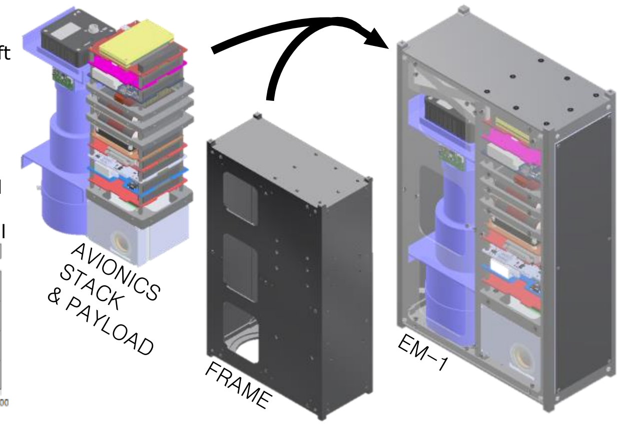
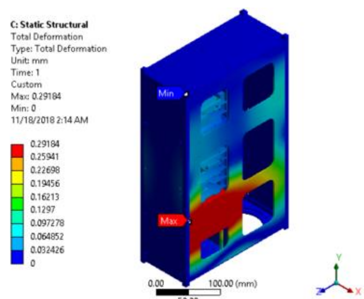


TABLE 1: MESH SKEW FOR ANALYSIS



STRUCTURAL SIMULATIONS SETUP AND RESULTS

A simulation was run assuming an 12kg load as recommended by the UNP User's Guide for CubeSats 6U or smaller. The resultant acceleration is approximately 28Gs, or 274.59 m/s-2. Considering the location of the maximum equivalent stress for each launch orientation, a factor of safety (FOS) can be computed for each given a 12 kg mass. The FOS is calculated by dividing the tensile or yield strength of the material divided by the resultant experimental value. The maximum deformation at +X is 1.4157mm on the standoff supporting the ADCS (Attitude Determination and Control System).

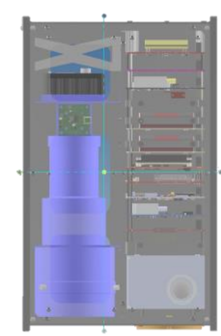


ORIENTATION	PART	MAT. UNDER STRESS	TENSILE YIELD STRENGTH	ULTIMATE TENSILE STRENGRTH	YIELD FACTOR OF SAFETY	ULTIMATE FACTOR OF SAFETY
+X	STANDOFF	STAINLESS STEEL A2	450	700	1.7432	2.7117

TABLE 2: INERTIAL LOADING RESULTS AT GREATEST DEFORMATION

CONCLUSIONS AND IMPROVEMENTS

The FOS of 1.7432 and 2.7117 were well below the design requirements of ~5.0, which was expected in this phase of the design process. The main problem faced was in the mass of the ADCS which was supported by four long steel standoffs, acting more like a spring which would oscillate back and fourth during Inertial Loading and Random Vibration simulations. We lowered the ADCS, designed a support rib to fix the part in place, and added additional structural ribs which were fixed to the internal Z-axis frame and X+/- panels. In addition, when the optical payload was fixed to the frame, a structural "bridge" was design to fill the space above the payload and prevent warping of the internal Z-axis frame which could be caused by the asymmetrical force the avionics stack applies on it. This also fixed the center of gravity which was causing for asymmetrical force distribution on the satellite.



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