1U CubeSat Structure

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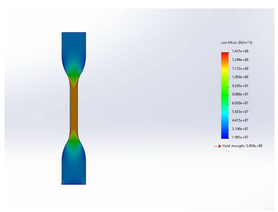
3D Print a 1U CubeSat Structure

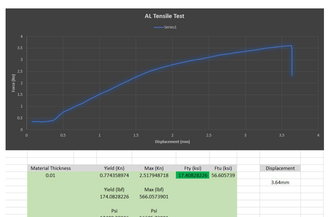
- Design and create a 1U CubeSat Structure ensuring compatibility with internal components and space conditions created using a metal 3D printer
- Perform tensile tests on material used for printing
- Perform a vibrational analysis on the structure with simulated weights for internal electronics

Research

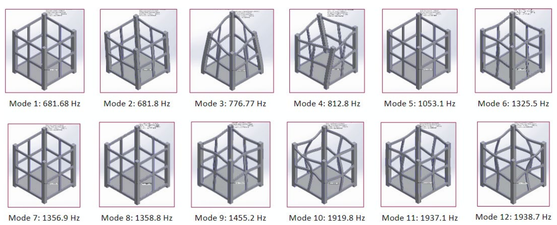
- Aluminum "dog bones" were printed at various thicknesses and stress tested to determine its ductility
- Simulated vibration testing was conducted to help understand how the structure would act when experiencing 12 different modes of vibrations
- A model was printed on the SLS printer to simulate the printing style of the metal printer
- Specification requirements

Maximum Weight	1 kg
Size	10x10x10 cm
Maximum Volume	200 cm^3
Operational Temperature	-150C - 150C
Vibration Profile Frequencies	20 to 2,000 hz
Minimum Natural Frequency	400 Hz
Shock Profile Excitation Levels	10^{-5} to 10^{-7} V^2/Hz
Maximum Loading Force	1,200 N
Minimum Strength Limit	385.6 MPa
Minimum Structural Limit	265.1 MPa
Minimum Axial Factor of Safety	1.6
Minimum Tensile Factor of Safety	1.6
Radiation Resistance	1321 to 1412 W/m²

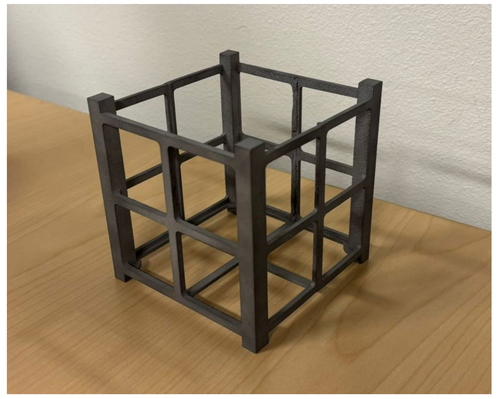


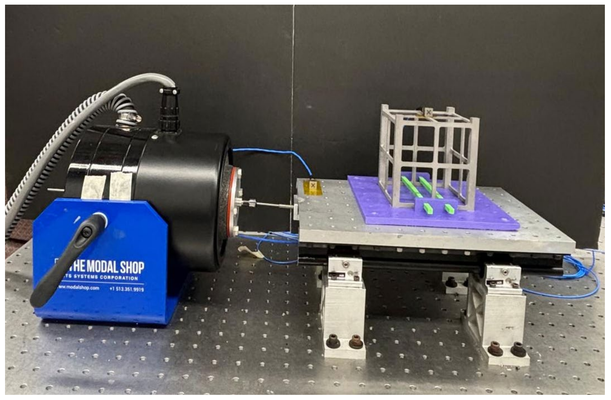


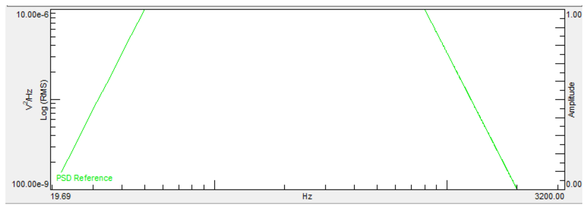
Material Thickness	Yield (Kn)	Max (Kn)	Fty (ksi)	Ftu (ksi)	Displacement
0.01	0.774358974	2.517948718	11.60676	56.605739	3.64mm
	Yield (lbf)	Max (lbf)			
	174.0828226	566.0573901			
	Psi	Psi			
	17408.28226	56605.73901			

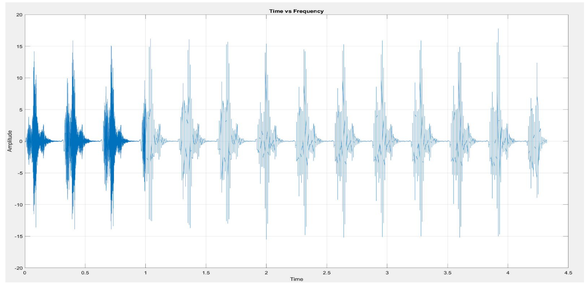


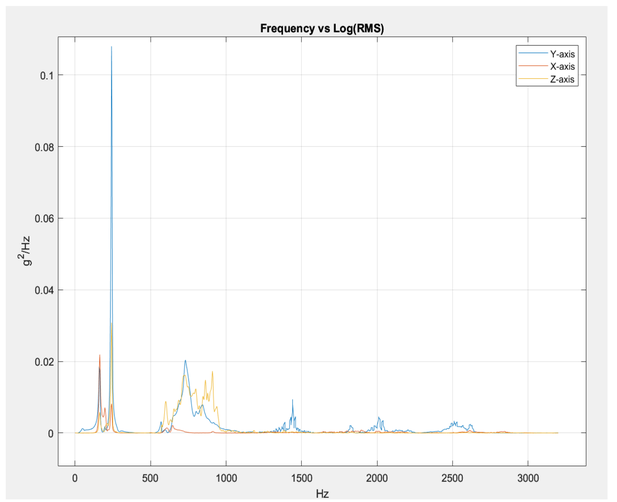
Final Design











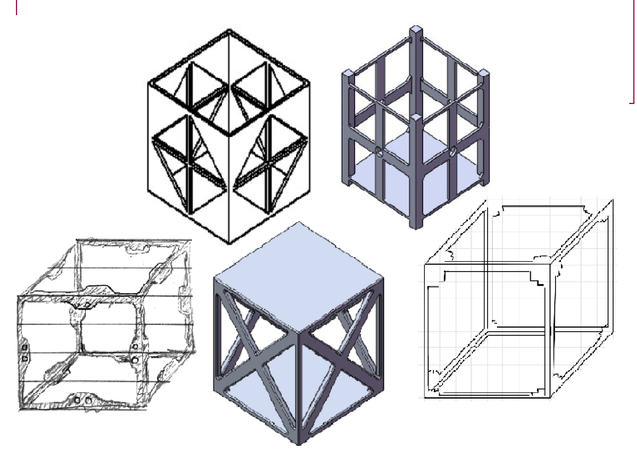
- Final design will be printed as one single piece to maintain the structures strength.
- The sides of the CubeSat are open allowing for the placement of solar panel to draw in light for power.
- Simulated weights are not included in this model but are used for vibration testing.
- Consulting with the vibration test lab a model was made from PLA to use as something to mount onto their test stand.
- The CubeSat then undergoes 14 vibration tests on a timeframe of 4.5 seconds in three-axis directions and a range of 20 to 2000 Hz following a vibration profile.
- The test results largely aligned with expectations, demonstrating the CubeSat's ability to maintain structural integrity during the simulated launch environment.
- A resonance peak was identified at approximately 241 Hz, leading to amplified frequency and generating minimal stresses.
- This resonance peak did not compromise the CubeSats integrity as post-test inspections revealed no visible damage or structural failures.

Concept Development

Around 10 concepts were developed to explore a wide range of design possibilities. The main concepts were assessed based on ease on manufacturing and fit with target specifications, a vote was conducted to select the most promising design. Two leading approaches were considered during prototyping:

- A single piece structure designed to be printed as a cohesive unit
- A multi piece structure designed to be printed in separate components and assembled in post-production

After careful analysis, the team decided to focus on a single piece printing approach due to its benefits. Some benefits are enhancing structural integrity, reducing potential weak points , and making it easy to manufacture to reduce resources required in production. This concept was refined to ensure it could meet all performance and production goals.



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