

# DESIGN FOR ADDITIVE MANUFACTURING

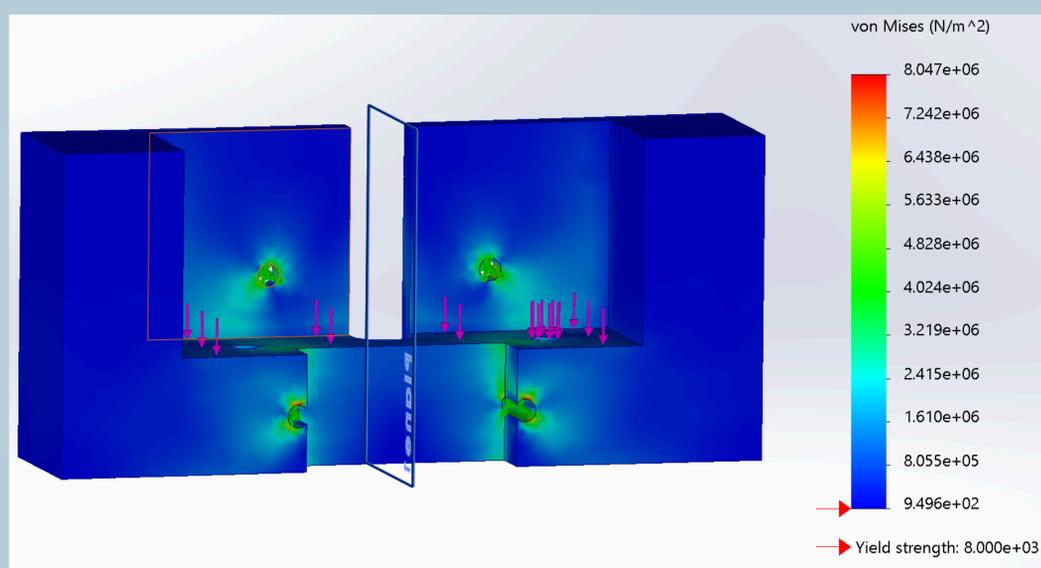
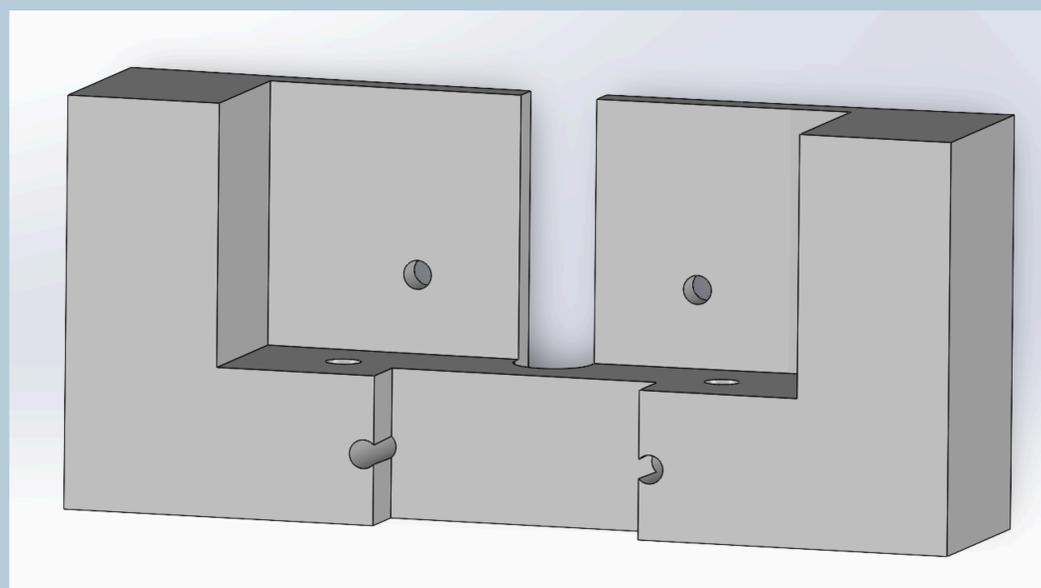
## Topology Optimization

### CHALLENGE SPECIFICATIONS

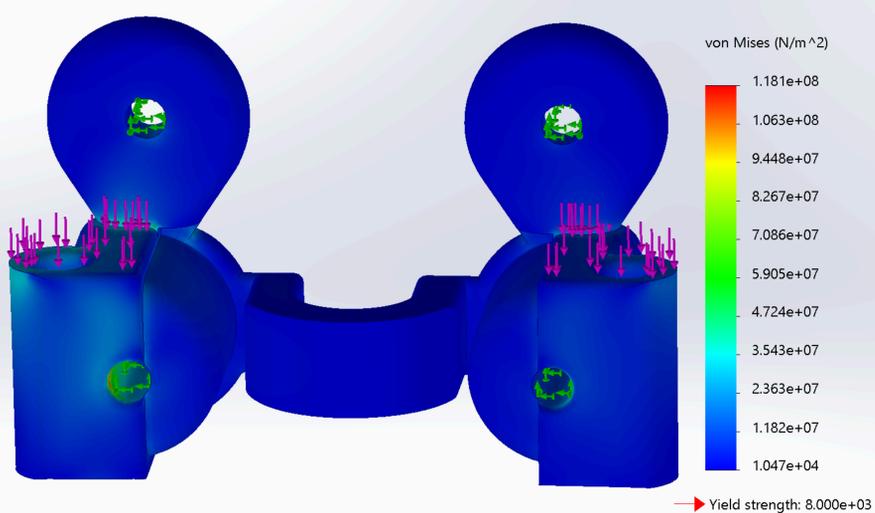
This challenge ULA was given to the GrabCAD community where participants were tasked to design a launch support attachment bracket for ULA's current Atlas V rocket. Some design constraints that were set are:

- The part will be mounted to the vehicle interface at datum A using four bolts
- A uniform load from the work platform was to be applied where the part will be fastened with two bolts
- The minimum edge distance surrounding all bolt holes must be at least 2× the diameter of the respective hole.
- The maximum allowable part weight is 0.1 lb.
- The minimum wall thickness throughout the part is 0.040 inches.

The required material for this part is Ultem 9085 with a 4500PSI allowable strength, 1.34 specific gravity, 325 KSI Young's Modulus and 0.41 Poisson's Ratio as material properties.



### INTUITIVE DESIGN



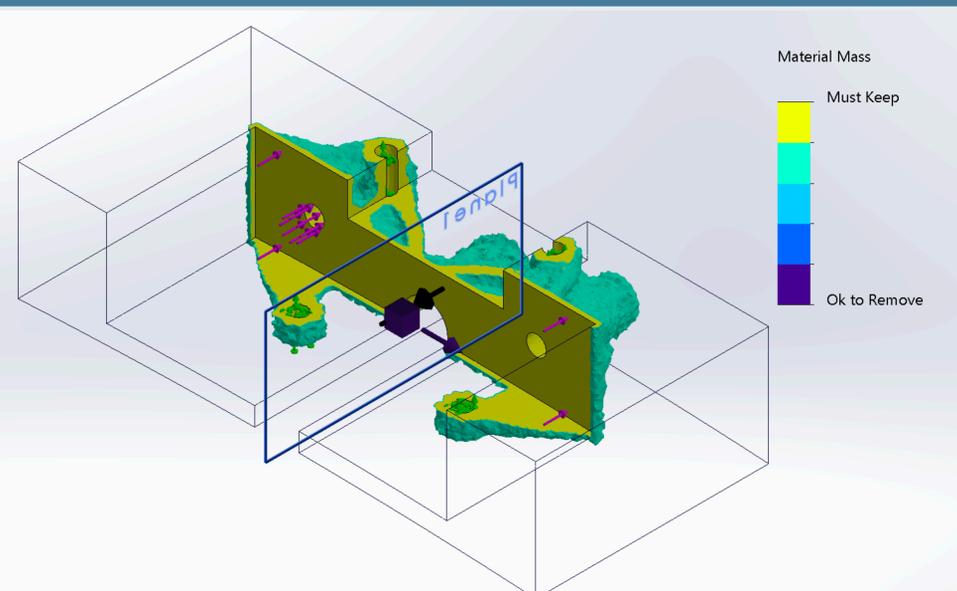
With all design specifications and constraints in mind, a finite element analysis (FEA) was conducted on the original part to analyze weak/failure points.

A redesign of the bracket was done, which was expected to perform just as the original model. The main idea was to redesign the bracket and preserve the functional parts under continuous deformations, such as the 600lb introduced.

### TOPOLOGY OPTIMIZED DESIGN

The main goal was to maximize performance just as the original part and minimize material usage by finding the most efficient material layout within a given design space under some boundary conditions with the help of a software package. Solidworks software was used to run the topology optimization study.

The main boundary conditions used here were identifying and setting the fixed points, a 600lbs force on the platform identifying and using a plane of symmetry and preserving required thickness.

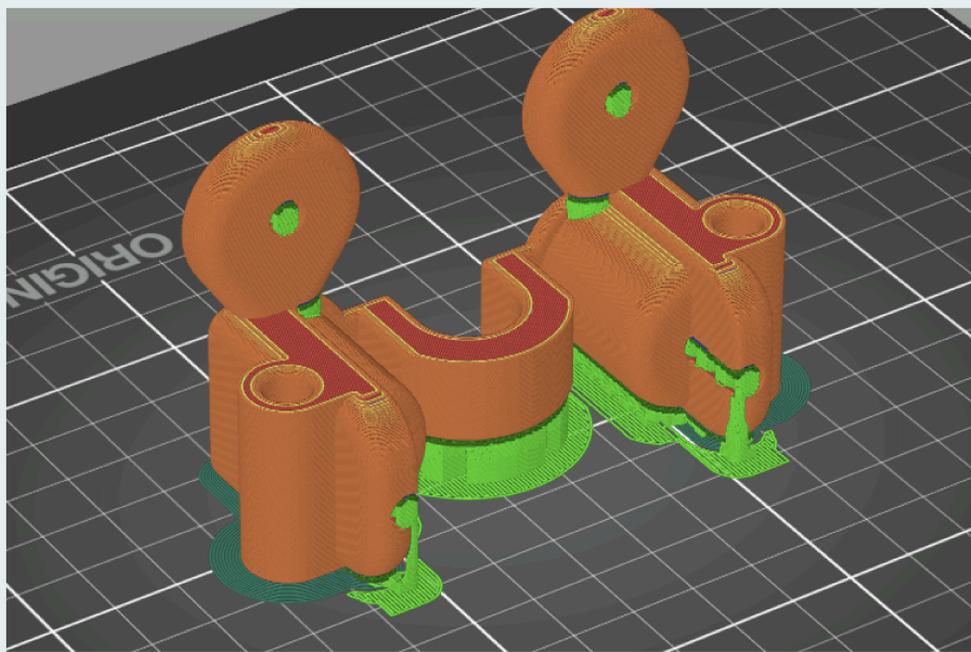


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## Topology Optimization

### COMPARISON WITH SAMPLE DESIGN GIVEN

If manufacturing of these parts were done with some traditional form of manufacturing, it would be way easier to do with the part that was intuitively optimized rather than the software-optimised one, mainly due to the many different contours that would have to be dealt with and the lack of conventional shapes seen in the design. However, if this is 3D printed as defined by the material and challenge, it would still be fine to print just that a lot of material is being used as support. Also for both parts, printing in the orientations shown uses way less support material and also preserves most of the circular holes needed. From the information shown below, the software-optimised part uses more build time as a result of more material usage whereas the intuitively designed part uses less material and build time.

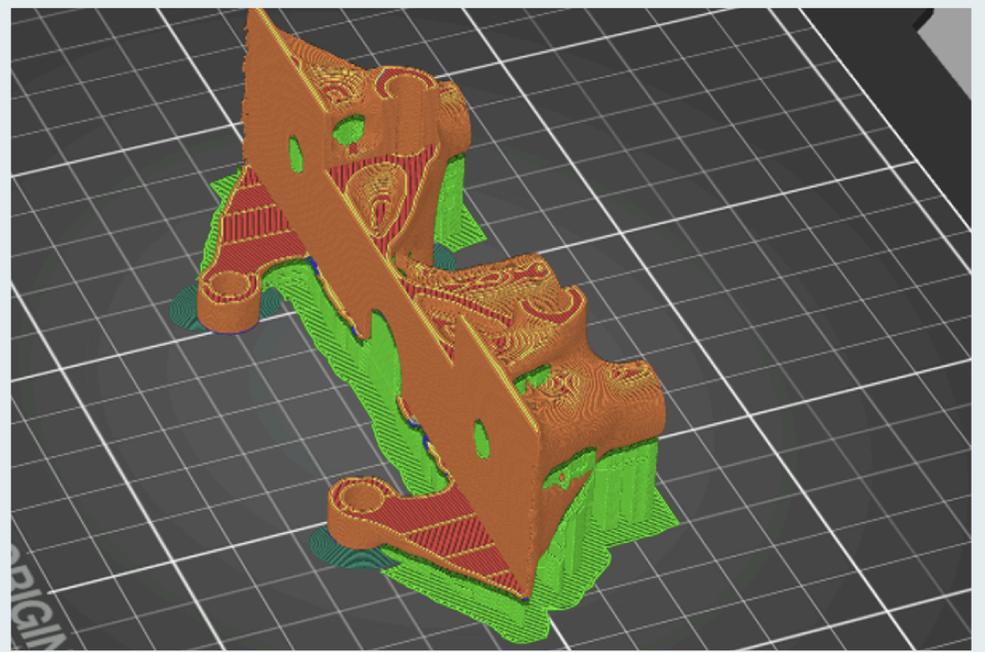


**Info**  
Size: 3.54 x 1.92 x 2.35 Volume: 2.74  
Facets: 23806 (1 shell)  
No errors detected

**Sliced Info**

Used Filament (g)	22.18
Used Filament (in)	292.81
Used Filament (in <sup>3</sup> )	1.09
Cost	0.56
Estimated printing time:	
- normal mode	1h32m
- stealth mode	1h39m

**SAMPLE DESIGN SPECIMEN**



**Info**  
Size: 4.67 x 1.51 x 1.96 Volume: 2.13 ⚠  
Facets: 71212 (3 shells)  
No errors detected

**Sliced Info**

Used Filament (g)	30.49
Used Filament (in)	402.53
Used Filament (in <sup>3</sup> )	1.50
Cost	0.77
Estimated printing time:	
- normal mode	2h16m
- stealth mode	2h27m

**REDESIGNED SPECIMEN**

### CHALLENGES AND CONCLUSION

Working through this challenge, it would be realized that planning for the intuitive optimization isn't just enough especially having to battle with the weight constraints tied to it. The designer has to constantly check in to meet the strict weight requirements while maintaining the integrity of critical parts.

For the software-optimized model, it can be a little tricky with setting the various parameters for optimization. One thing that was realized is that setting a very low minimum thickness and adding a finer mesh would result in endless hours of the software trying to perform calculations and realize the optimization. One thing that was helpful in this design was to choose either of the two. i.e. getting rid of the minimum thickness or creating a more coarse mesh.

The main advantage realized was using less material (including supports) for an intuitively designed model rather than a software optimized one. Also, it could've very helpful to use software for optimization as it can be efficient to use when fine meshes are not priority.