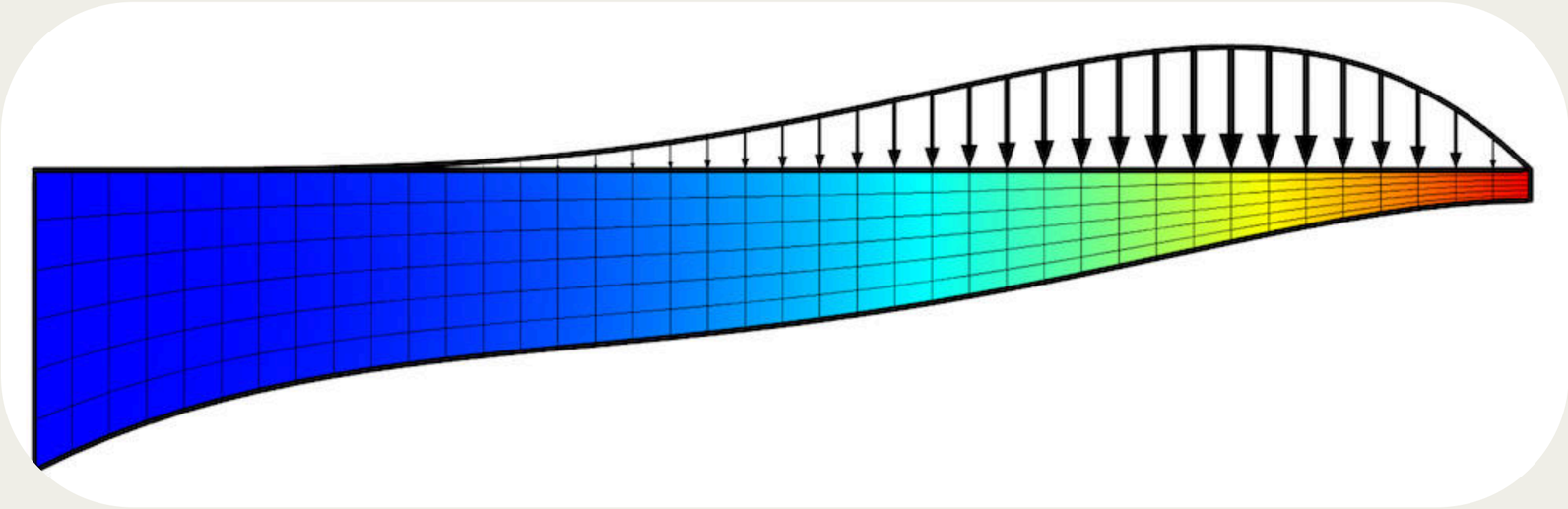
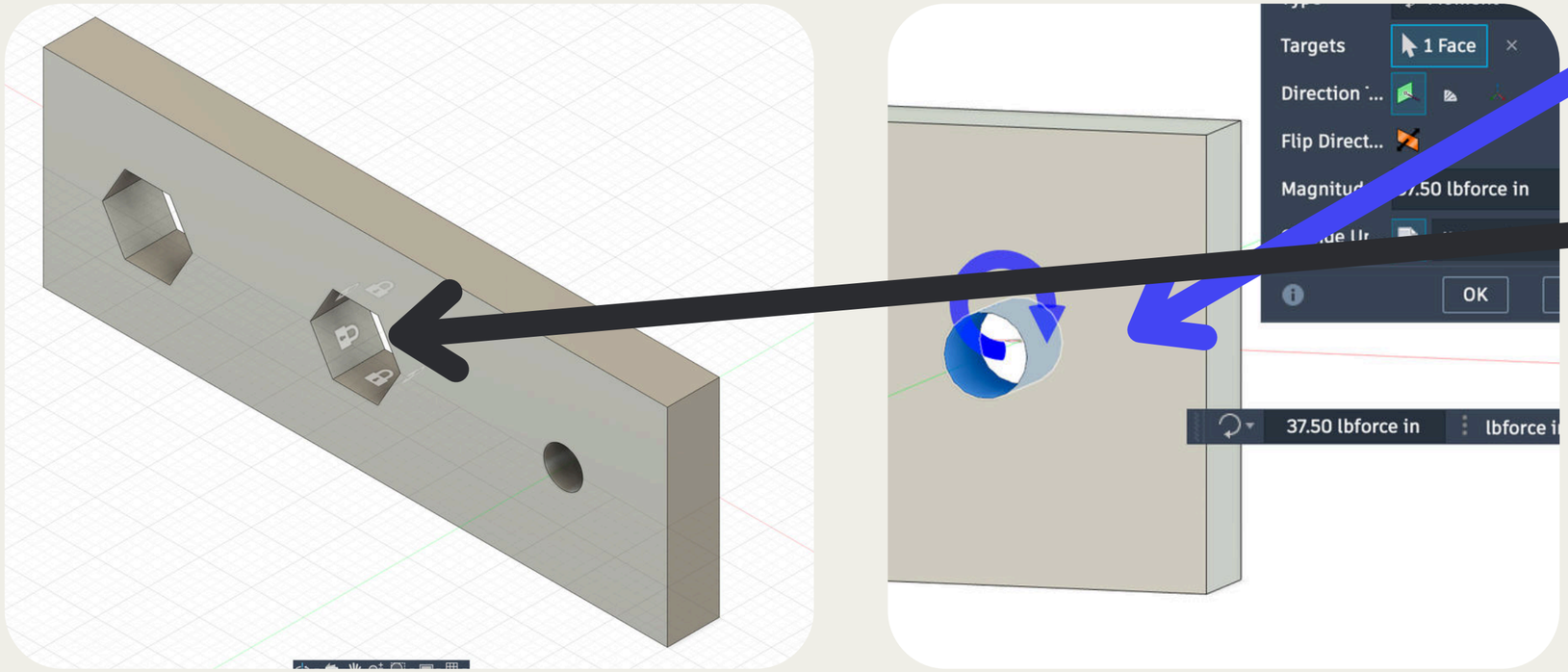
Sebastian Esteva

ME 127 HW 2 (ALGORITHMIC MODELING), WINTER 2026

Shape Optimzation



Middle + Outer Hex Simulation: **Setup**



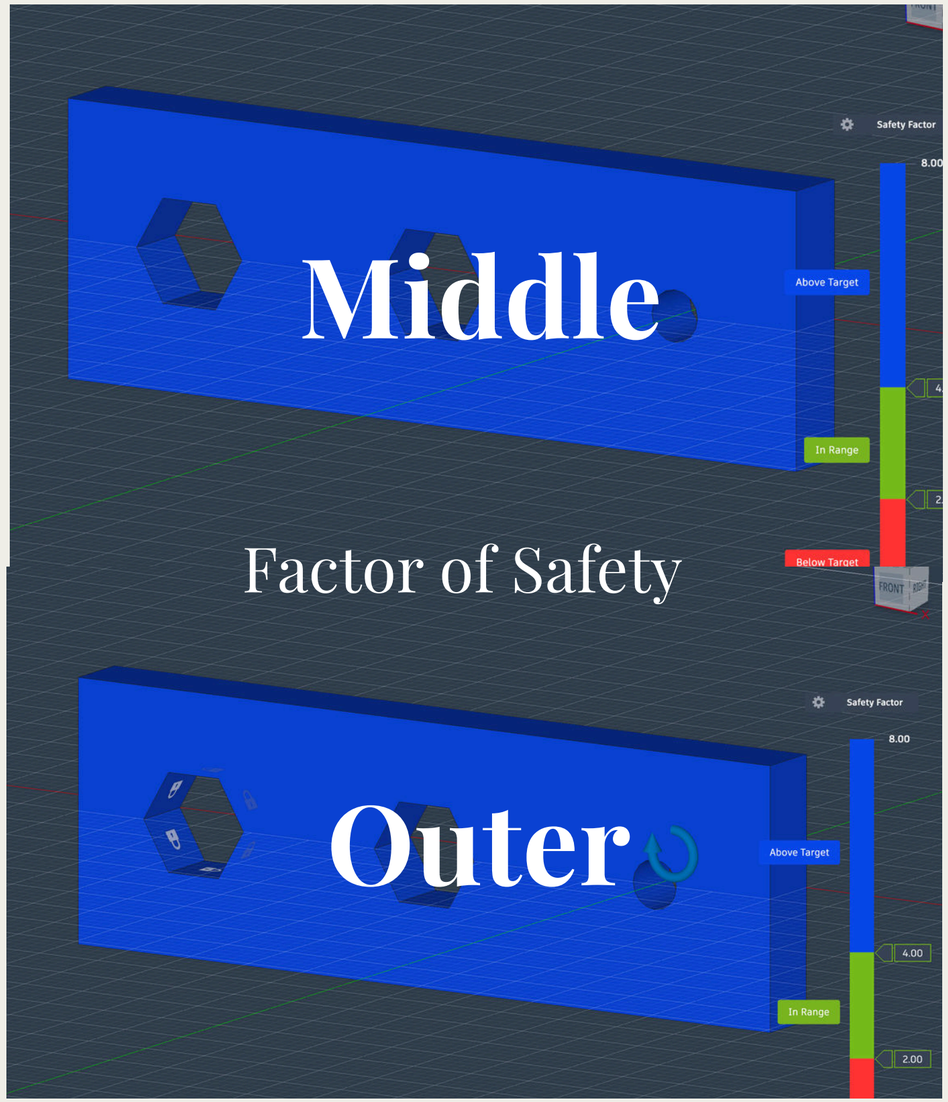
Middle: Force of 25lb 1.5" produces a **Moment** of 37.5 lb*in

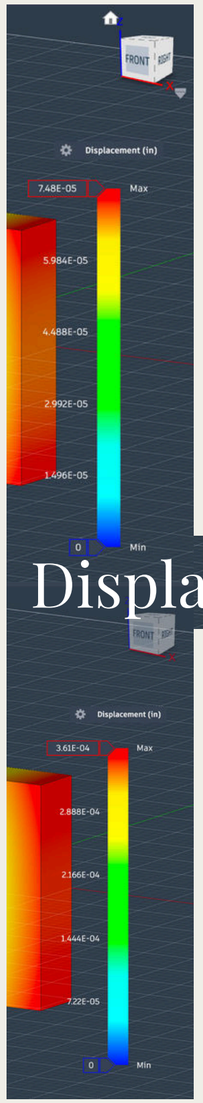
Locked Hex inner heads

Out: Same as middle, but moment is 75lb*in, and the locked faces are in the far hole.

With symmetry assumed, a moment in either direction is identical for both situations. Just need to choose the "beefier" side from the shape optimization simulation to reflect across the xy plane.

Middle + Outer Hex Simulation: **Results**

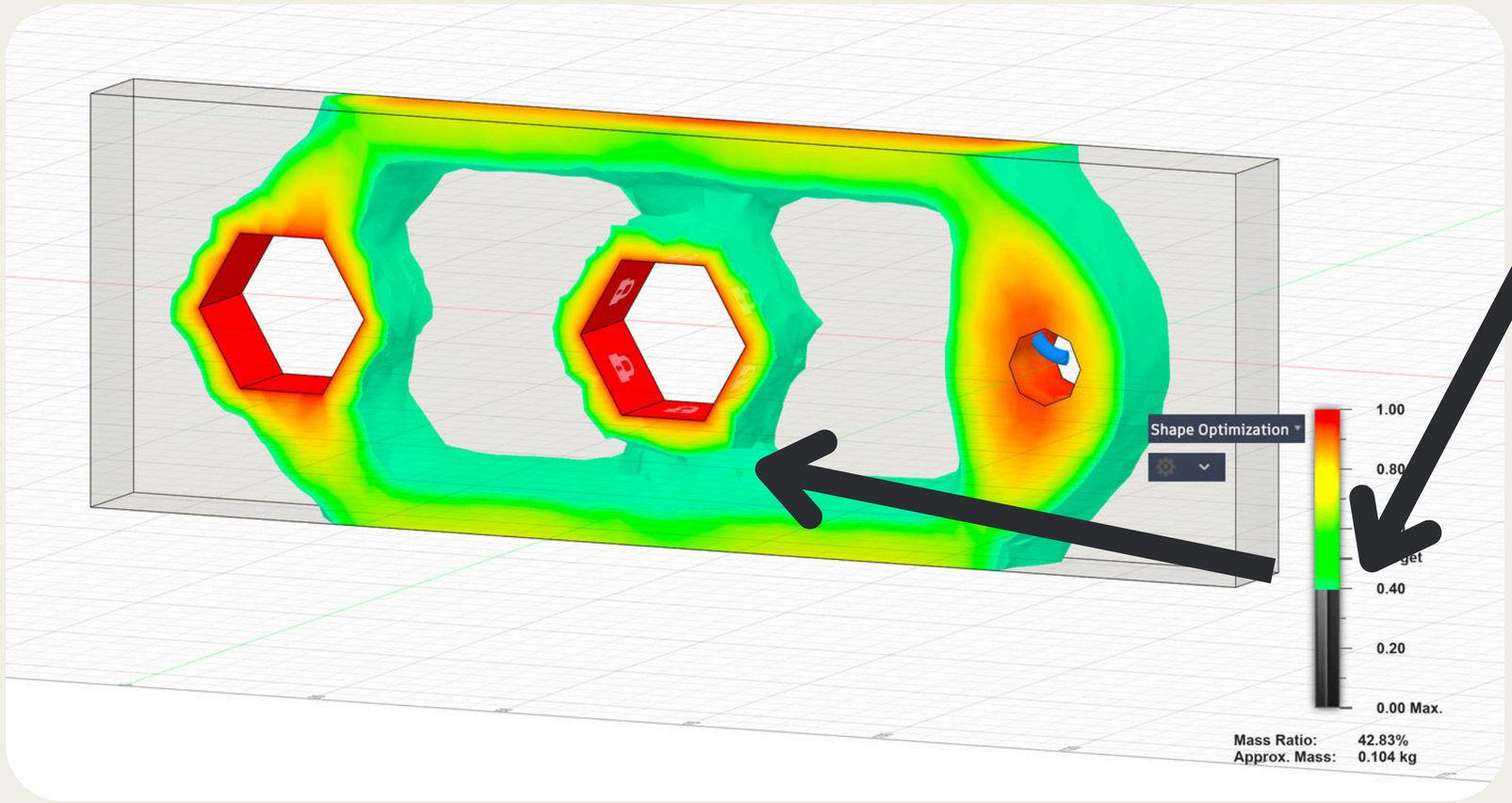




The minimum **safety factor** of **15** for the worst-case scenario (outer hex), with **maximum displacement** in the sub-**thousandths-of-an-inch** range.

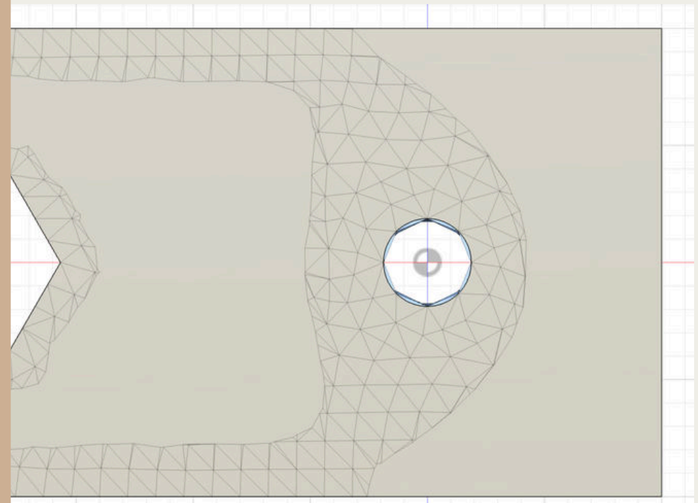
There is **significant potential** for **optimization** while ensuring safe usage in all aspects.

Middle + Outer Hex Simulation: **Shape Opimization**

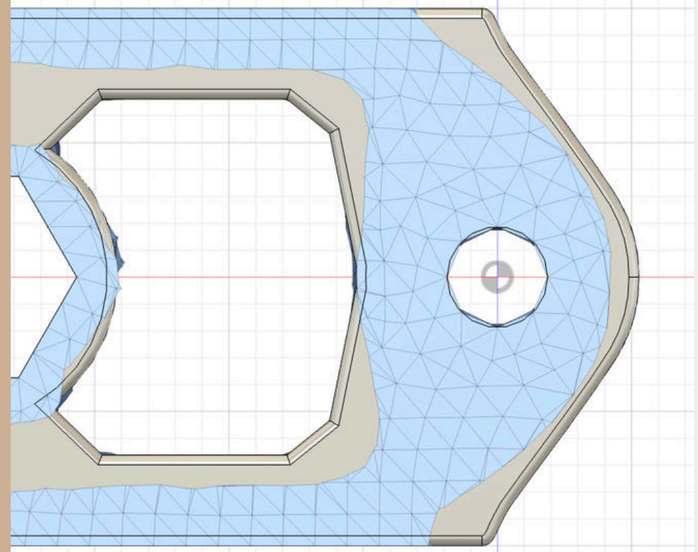


Choose to **promote** a shape with a **higher safety margin** than the target optimization to avoid concerns about over-cutting during final product crafting.

Visual comparison of **OLD** and **NEW** gripper against optimized *mesh*



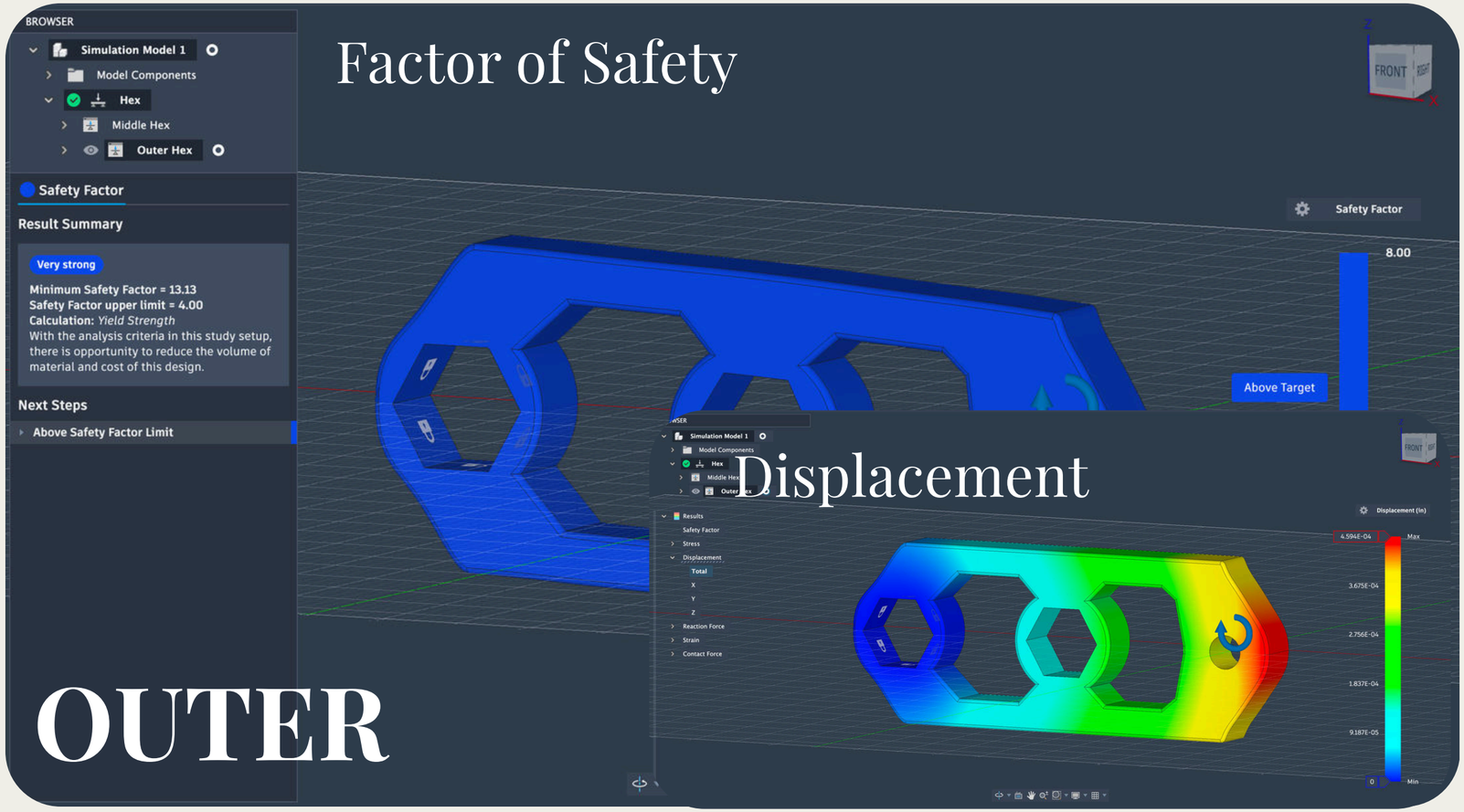
***Mesh* of optimized shape inside OLD gripper**



***Mesh* of optimized shape inside NEW gripper**

***Deviations** from the mesh were made to enhance design for function, manufacturability, and aesthetics. I **prioritized** caution by cutting away less material to **ensure safety**.*

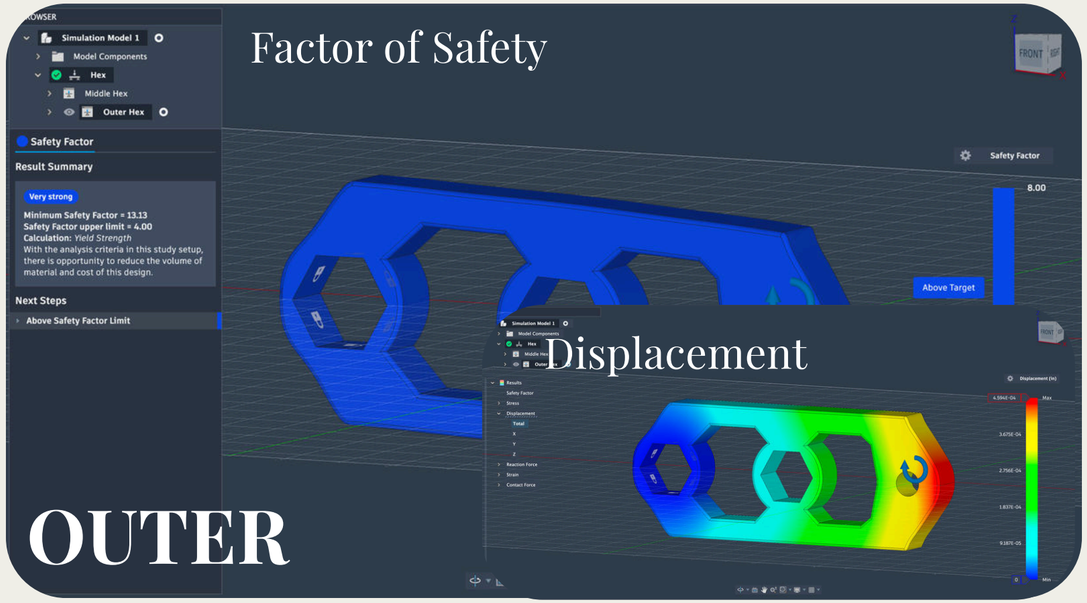
NEW gripper Simulation Results



Minimum **safety factor** of **13** for the worst-case scenario (outer hex), with **maximum displacement** once again sub-**thousandths-of-an-inch.**

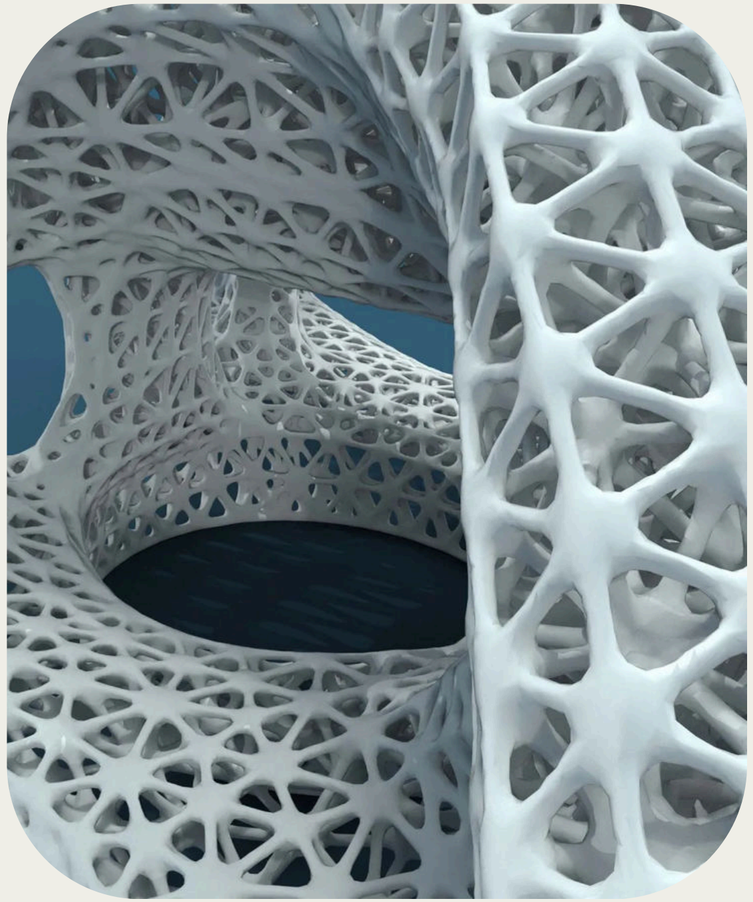
(Results are safer and show less displacement with the middle hex)

NEW gripper Simulation - Reflection



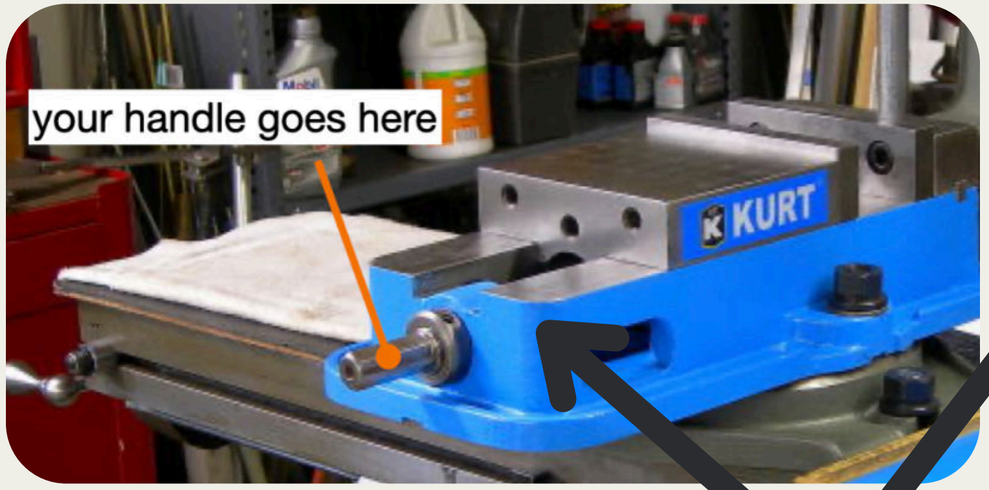
- The **factor of safety** remains very **high**, suggesting additional material could be removed while maintaining safety.
- Further analysis of **unexpected loads**, such as a moment about the z-axis, would improve confidence in the final design.

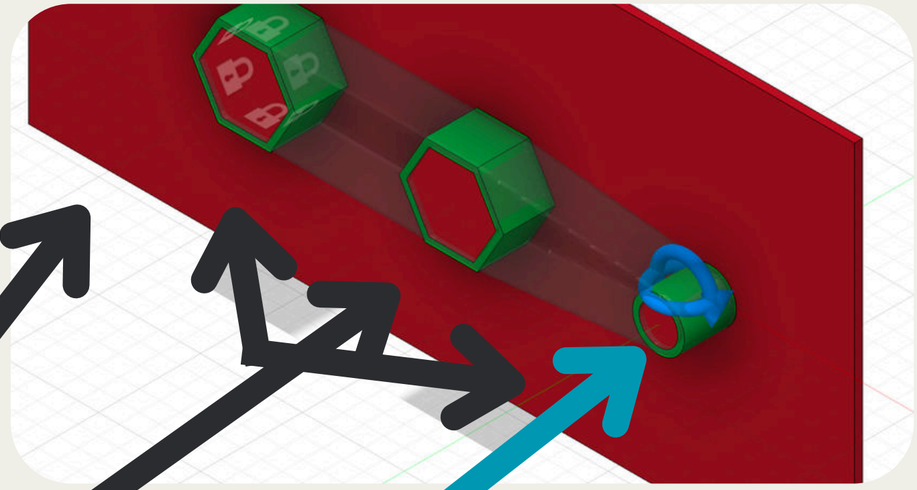
Generative Design



Setup

Note the “Preview” in the backgound





Back blocked off (to not hit tool)

Protected attachment nuts geometry and insertion

Same restraints/forces as before, **plus** an added **moment** around the z-axis equal to an average person leaning against the handle (only done in outer, because that's the worst scenario).

Also, did the negative moment of all, so the **tool works in both directions.**

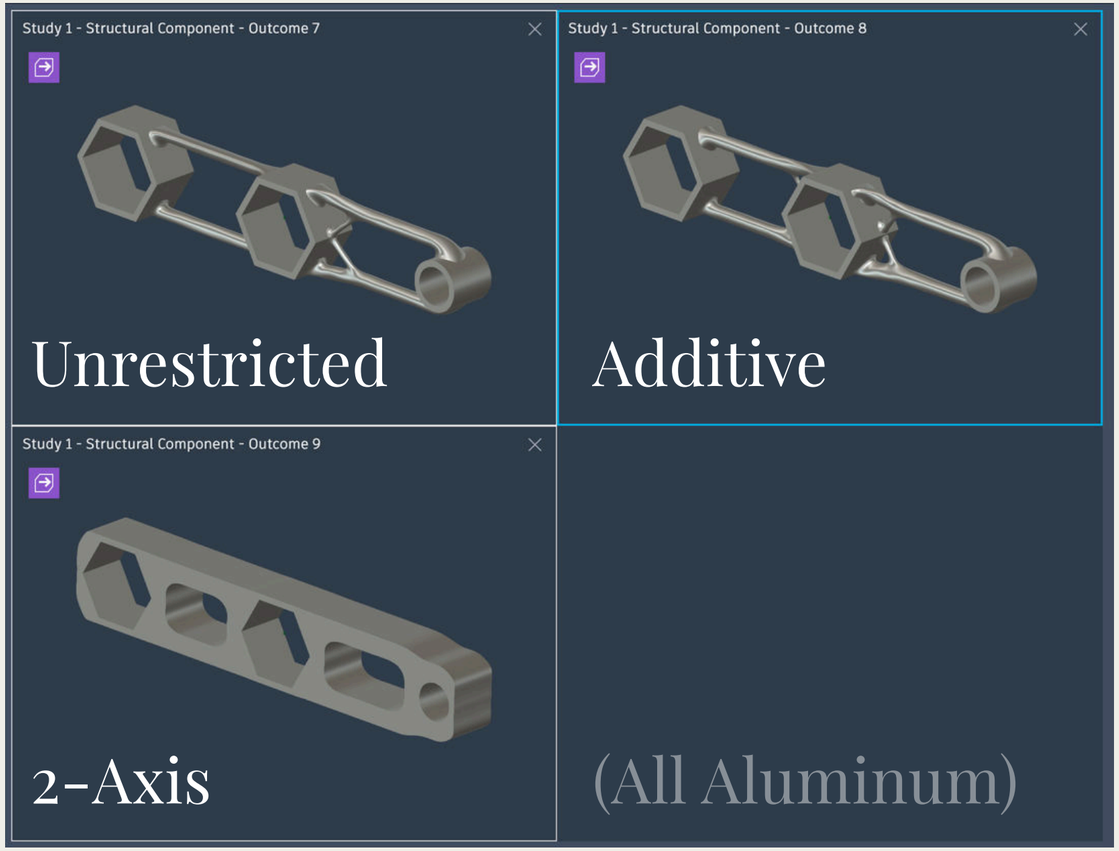
Meterials Used

Aluminum 6061 — Selected to compare against the previous shape optimization study and evaluate a lightweight, high strength-to-weight structural option.

Stainless Steel 304 — Chosen for its higher strength and stiffness to explore a more durable but heavier metal alternative.

ABS (Similar to Tough 1000) — Included as a strong, impact-resistant 3D-printable polymer that is available in our lab, making fabrication of the optimized design feasible.

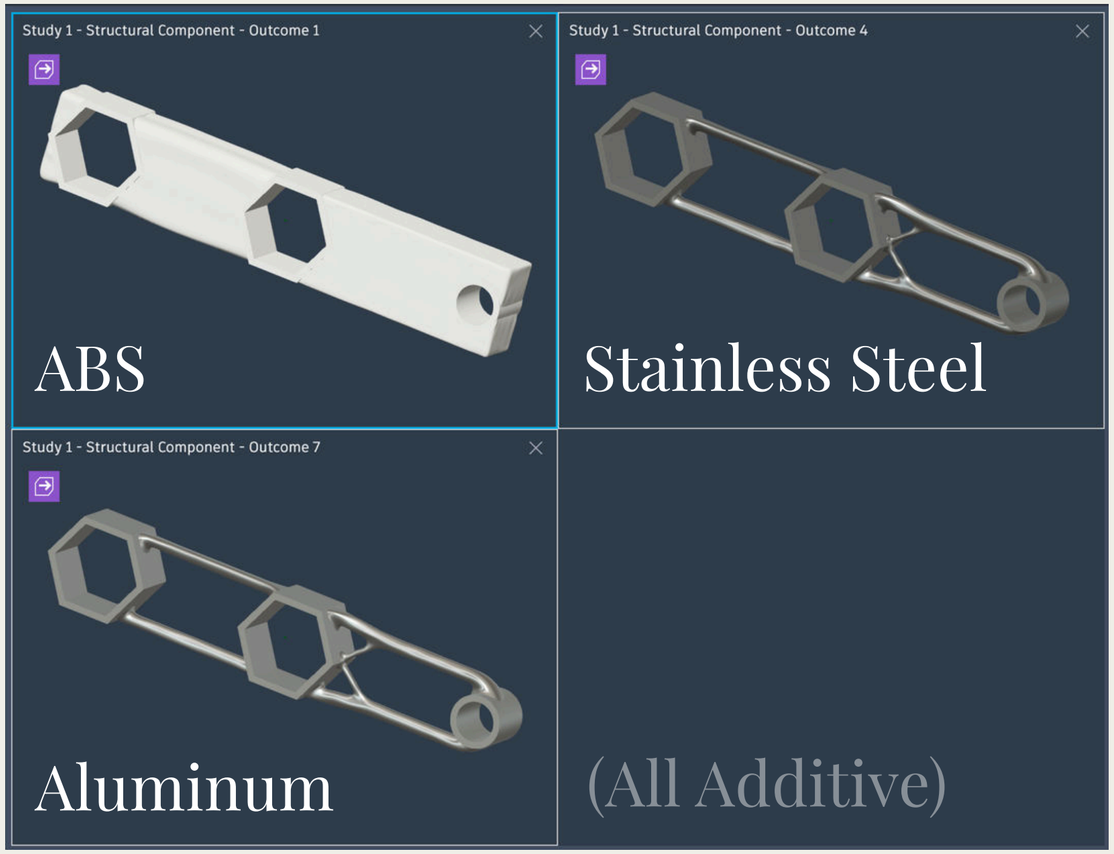
Comparison of Outcomes - Manufacturing Method



- **Unrestricted** and **Additive** designs used the least material and produced very similar, highly optimized forms.
    - Their similarity highlights how 3D printing enables near-ideal structural optimization.
- 2-Axis Cutting resulted in a bulky design with significantly more material.

All outcomes maintained a factor of safety of 2, per the design constraints.

Comparison of Outcomes - Materials



- **Stainless steel** and **aluminum** produced very similar geometries, with stainless steel requiring slightly less volume.
- Both metals used significantly less material than **ABS,** highlighting the structural **efficiency** of metals.

Final Design – ABS Additive

ABS + **Additive** design was selected because it meets the safety factor and can be manufactured in the PRL with available materials and equipment.