Choose Your Own Simulation Adventure

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- CP322055

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About the speaker

Aaron Magnin

Aaron attended the University of Nevada, Reno, where he obtained a degree in Mechanical Engineering. In industry he had a focus on safety products, recreational sports equipment, and computer peripherals. He then found his way to application engineering where he focused on simulation products, training, & technical presentations. At Autodesk --and for Fusion 360 specifically-- he creates QUICK TIPS, “What’s New Videos”, along with a wide array of other marketing content.

Description

Sometimes design changes can produce counterintuitive changes to the performance of a design. In this interactive session, we'll explore different design changes, all the while using simulation to determine the right direction to take a design. In the end, we'll explore how generative design can provide a shortcut in this sometimes-arduous task.

Agenda

8:00 – Intro

8:05 – Types of Simulation/Best Use/Cloud Benefits

8:15 – Problem introduction and first go

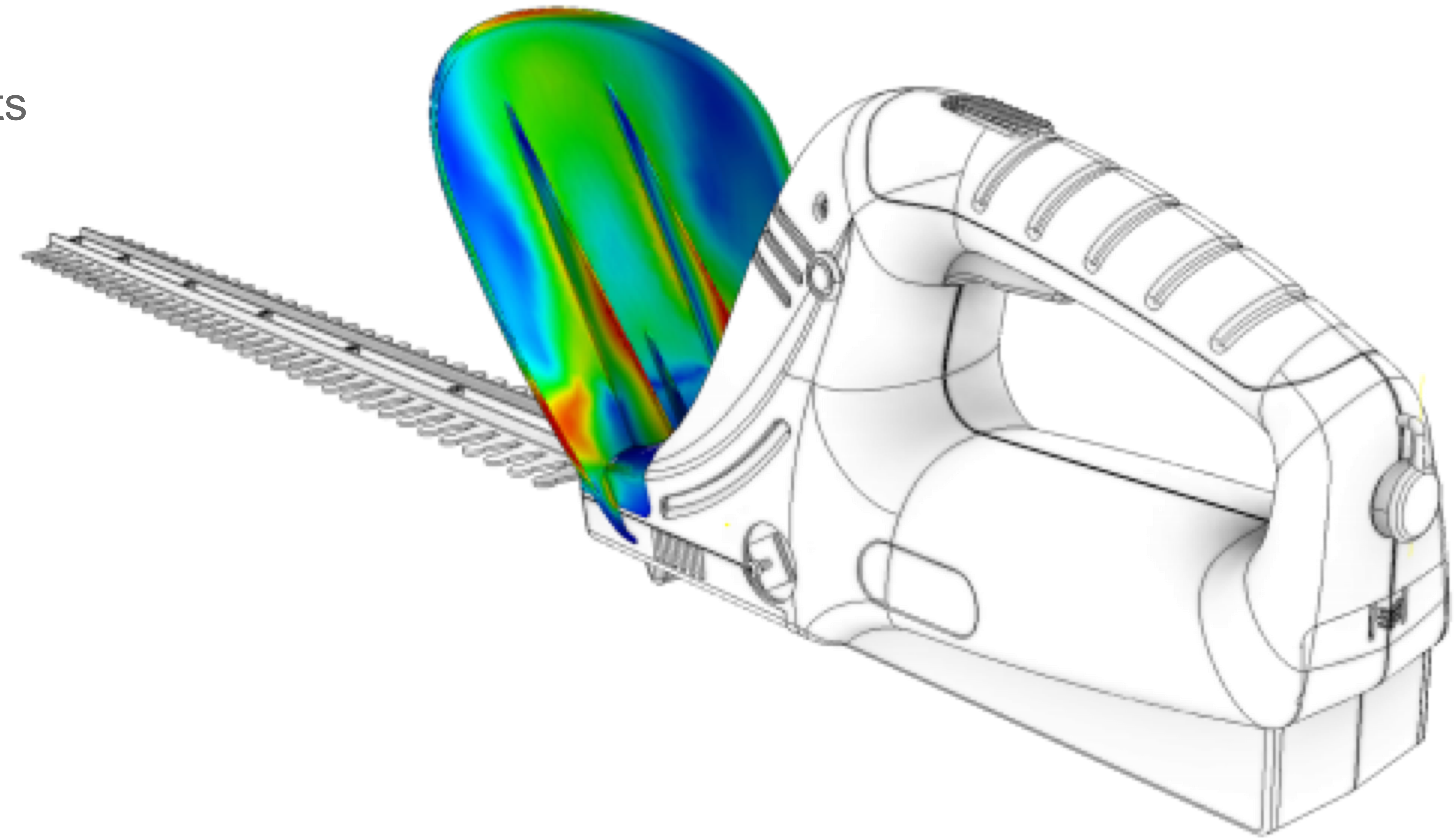
8:25 – Iterate

8:30 – Iterate

8:45 – Iterate

8:46 – Iterate

8:50 – Generate



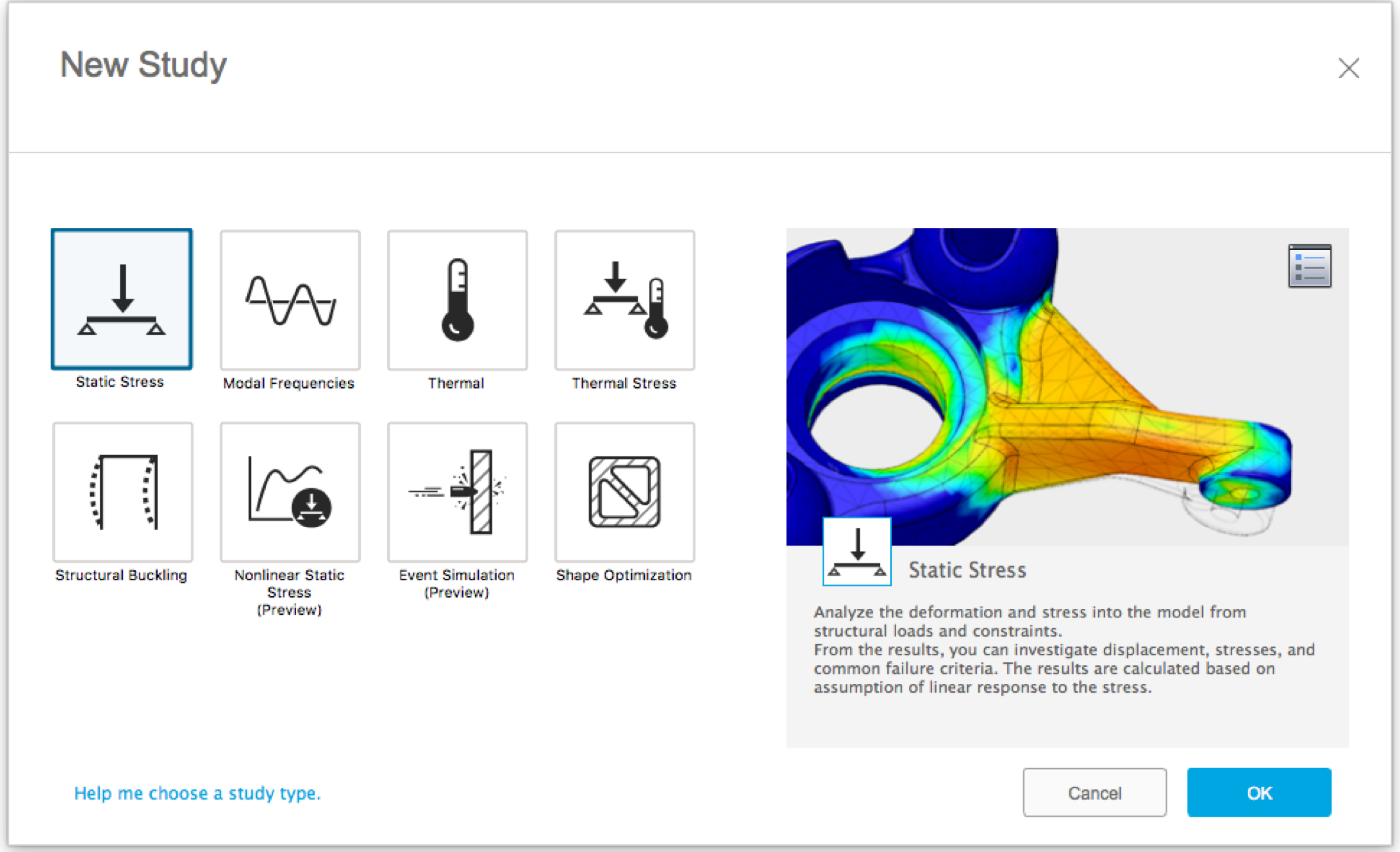
Analyses/Best Use/Cloud Benefits

What is FEA?

Finite element analysis *(**FEA**) is a computerized method for predicting how a product reacts to real-world forces, vibration, heat, fluid flow, and other physical effects.* ***Finite element analysis*** *shows whether a product will break, wear out, or work the way it was designed.*

Types of Analyses

- Static Stress - Will it break?
- Modal Frequency - Will it vibrate?
- Thermal - Will it overheat?
- Thermal Stress – Will it break due to overheating?
- Buckling – Will it buckle due to instability?
- Nonlinear Static – Will it break?*
- Event Simulation – Will it break?**
- Shape Optimization – Can it be lighter?



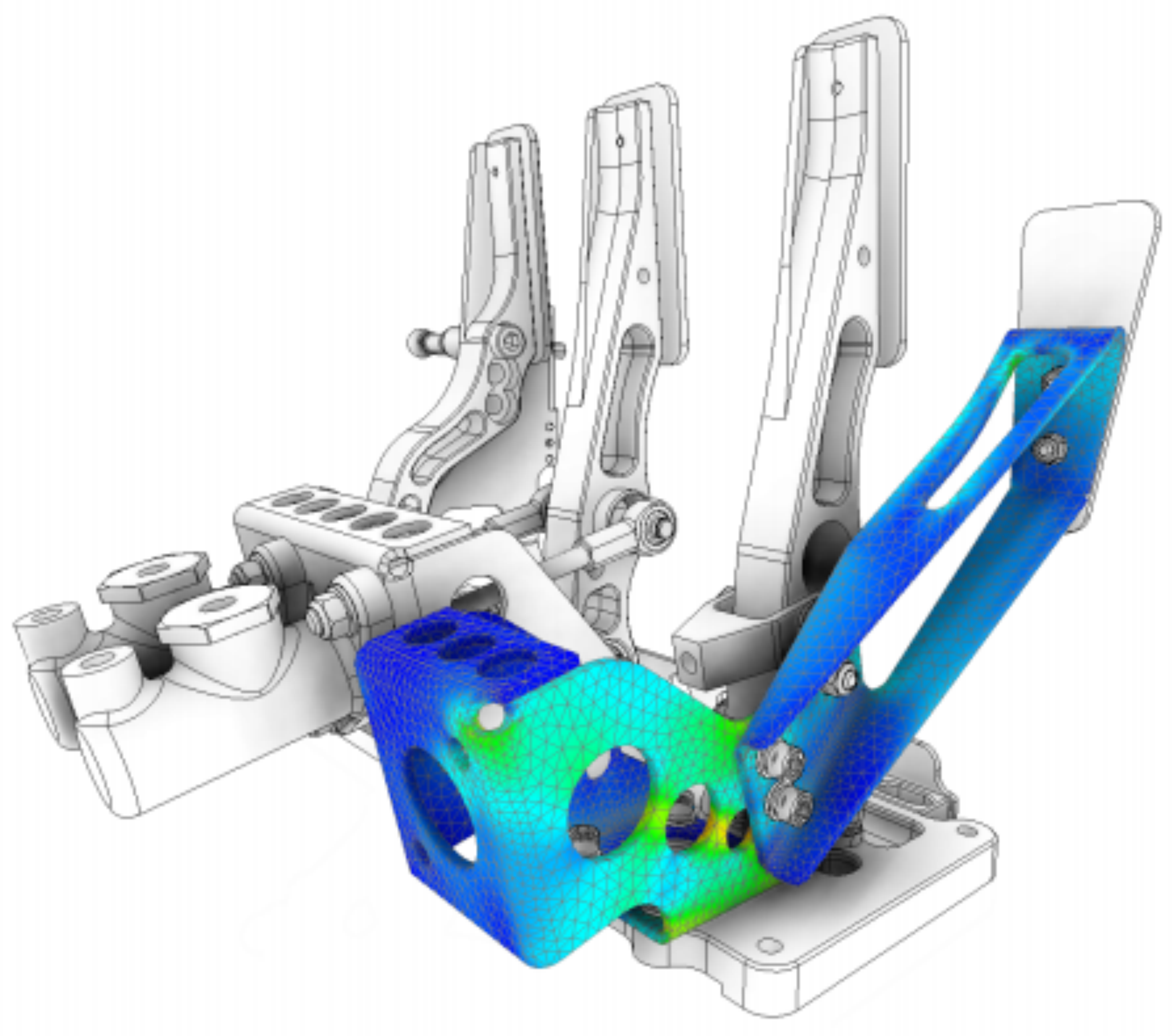
*by adding support for large deformations, changes in contact, changes in loads, nonlinear material behavior.

**This simulation type expands capabilities beyond nonlinear static stress analysis by adding support for inertial effects.

Where Simulation is Typically Used

- **Validation**
  - Is my design strong enough?
  - Does it fail?
  - Does it overheat?
  - Is it prone to resonance?

- **Optimization**
  - Does it use too much material?
  - Can I substitute a different material?
  - Can I minimize deformation?
  - Am I on the right track?



Optimization Goals

EVALUATING DESIGN ALTERNATIVES

Early in the design process, you can quickly evaluate the performance characteristics of many different design possibilities to identify those that show the most promise. You can also assess different loading or constraint options to identify how it will perform in a variety of use cases.

OPTIMIZING STRENGTH

Knowing where the highest concentrations of stresses and displacements in the part will be, you can modify the geometry or add structural reinforcements in these areas to increase strength and improve performance.

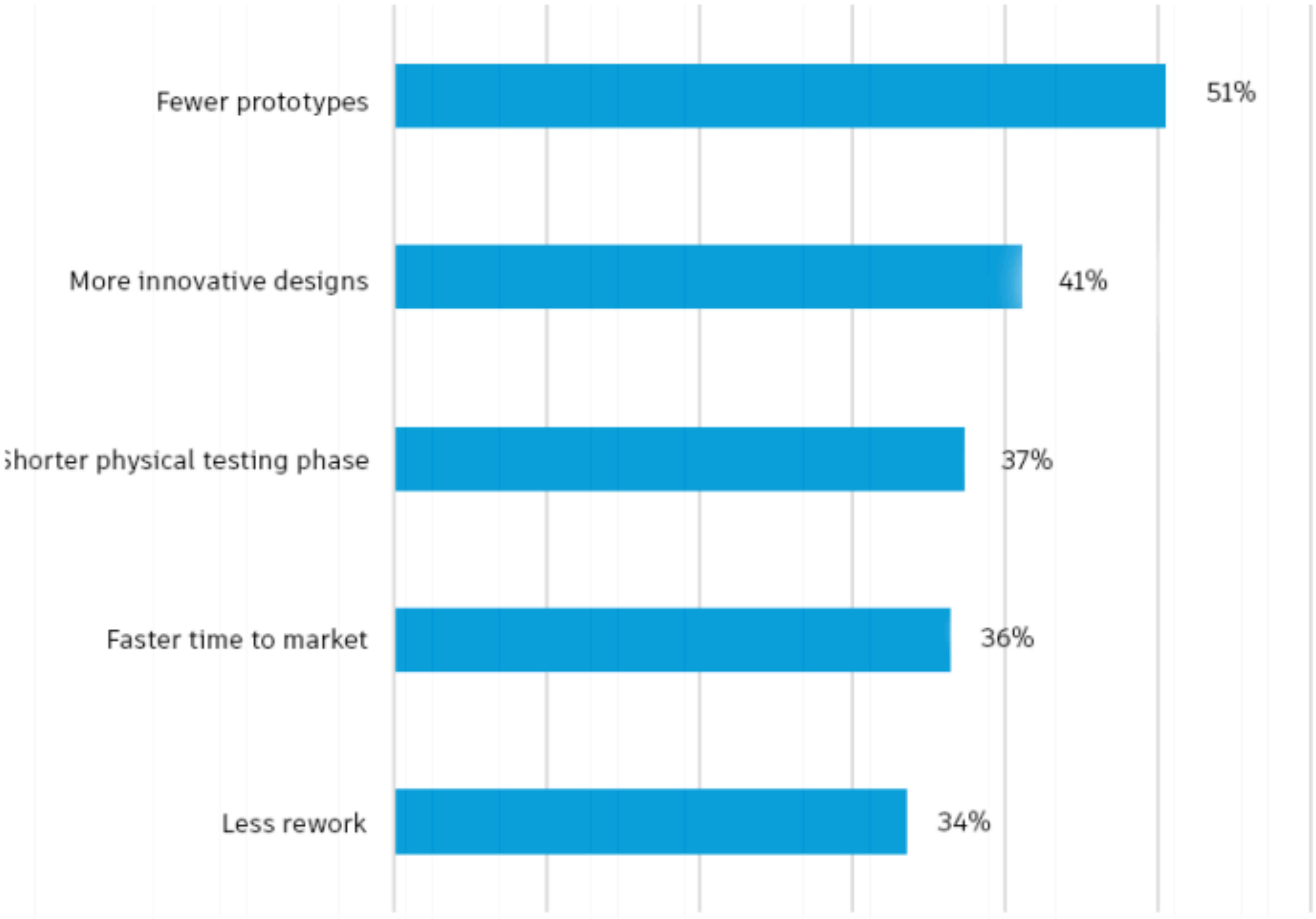
LIGHTWEIGHTING

Locations of the part that do not contribute to the strength or stiffness of the design can also be identified. In these areas, material can potentially be eliminated to reduce costs and avoid over-engineering while still maintaining the appropriate factor of safety.

MATERIAL SELECTION

You can also look at how the product will perform with different materials. With guidance on material performance, you can select the best option for your design, giving consideration to both quality and cost.

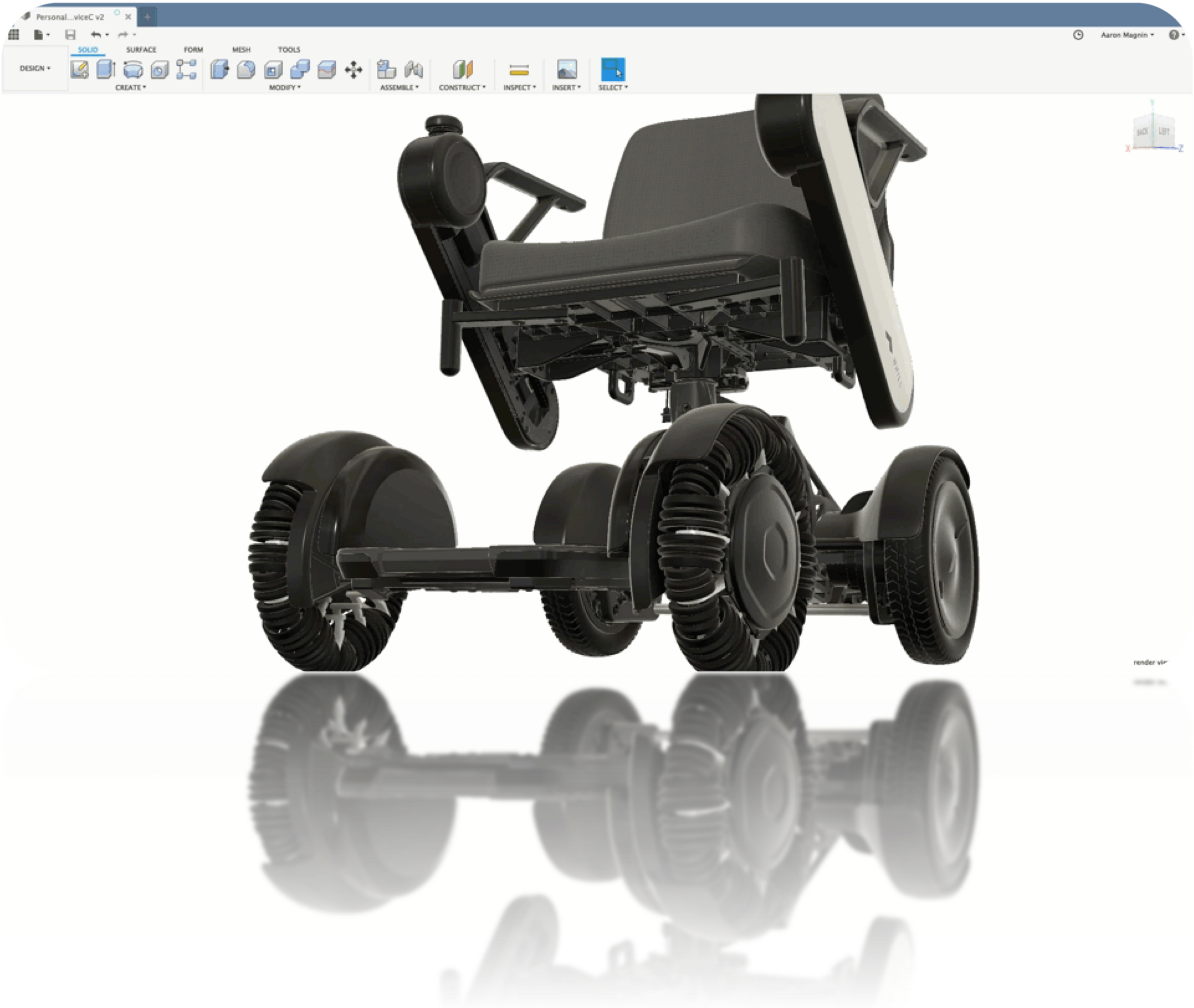
Biggest Benefits of Simulation



Cloud Advantages

Major benefits

- Overcome hardware limitations -- by using the the cloud can still have access to top quality, advanced simulation results.
- Unburden of the local solve -- When you solve a simulation locally, there’s not much else you can do...
- Simultaneous solve – combine both benefits above, then multiply it. Solve 10’s or 100’s of simulations at the same time.



Cloud Collaboration

Whether your want to share results, or the optimized geometry you come to, there's no easier tool than Fusion 360.

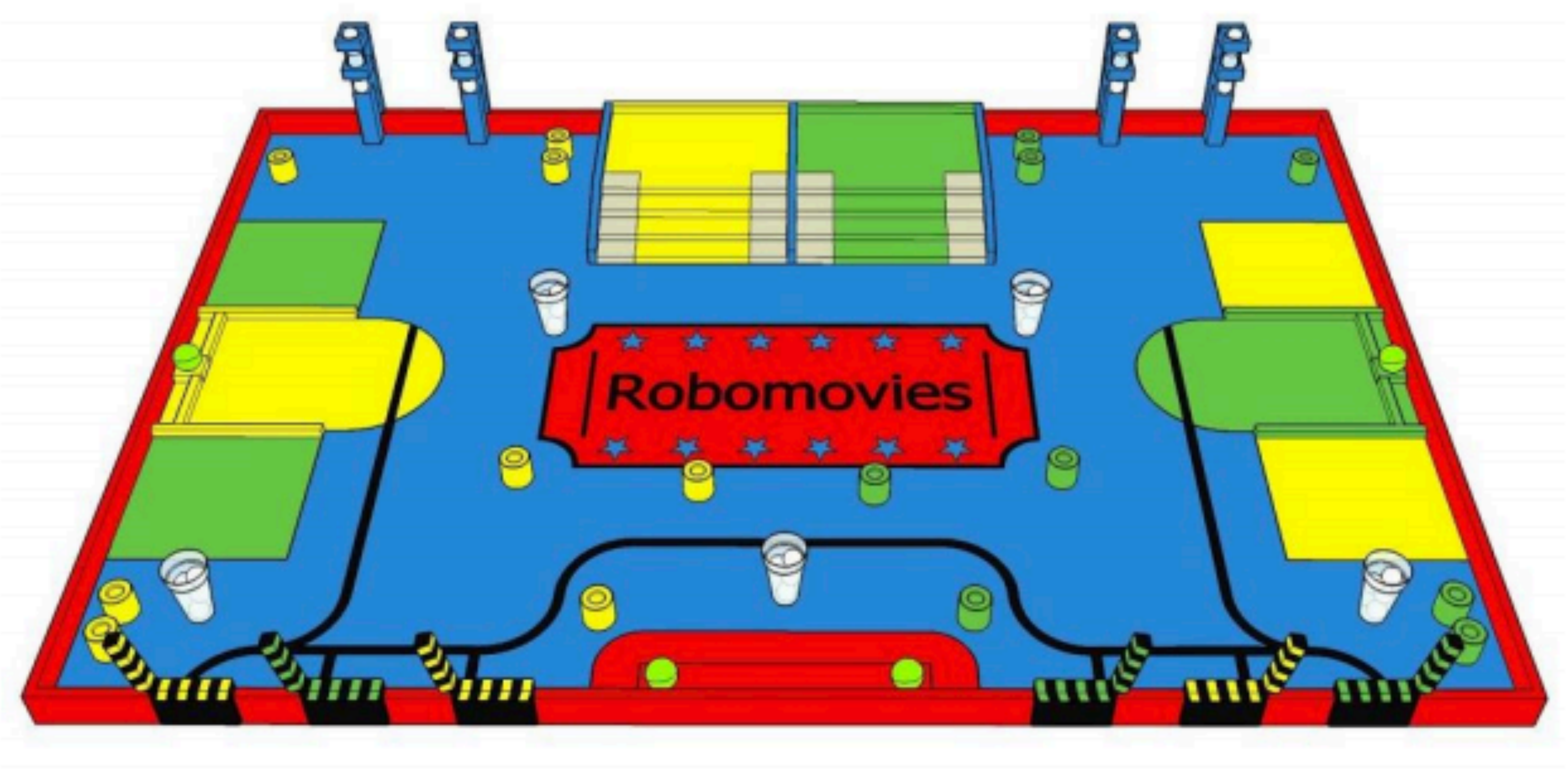
- Share Links (https://a360.co/2CXI4RK)
  - From anywhere, with any device*
- Mobile Apps
- Add Collaborators to Project...

*provided there's internet.

Problem Introduction

Eurobot

Created in 1998, Eurobot is an international amateur robotics contest open to teams of young people. One such club, CVRA (Club Vaudois de Robotique Autonome- https://www.cvra.ch/) is a group of students and engineers passionate about robotics based in Switzerland. They shared a part of one of their robots, Debra 5, on GrabCAD.

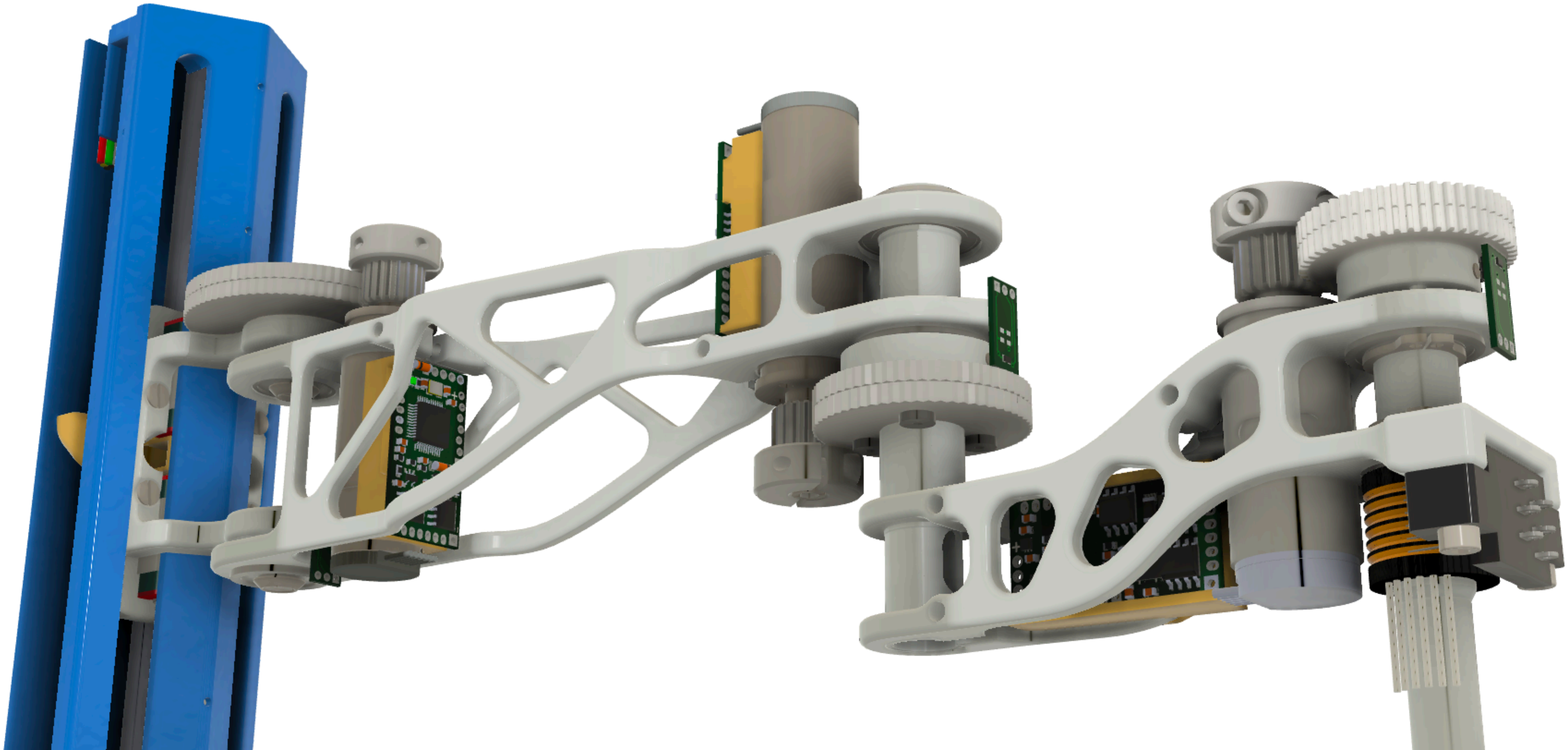


Becoming a movie star isn't easy: acting isn't enough! The robots will experience it this year, and will have to show us their multiple talents in an extraordinary shoot.

They have several tasks to do:

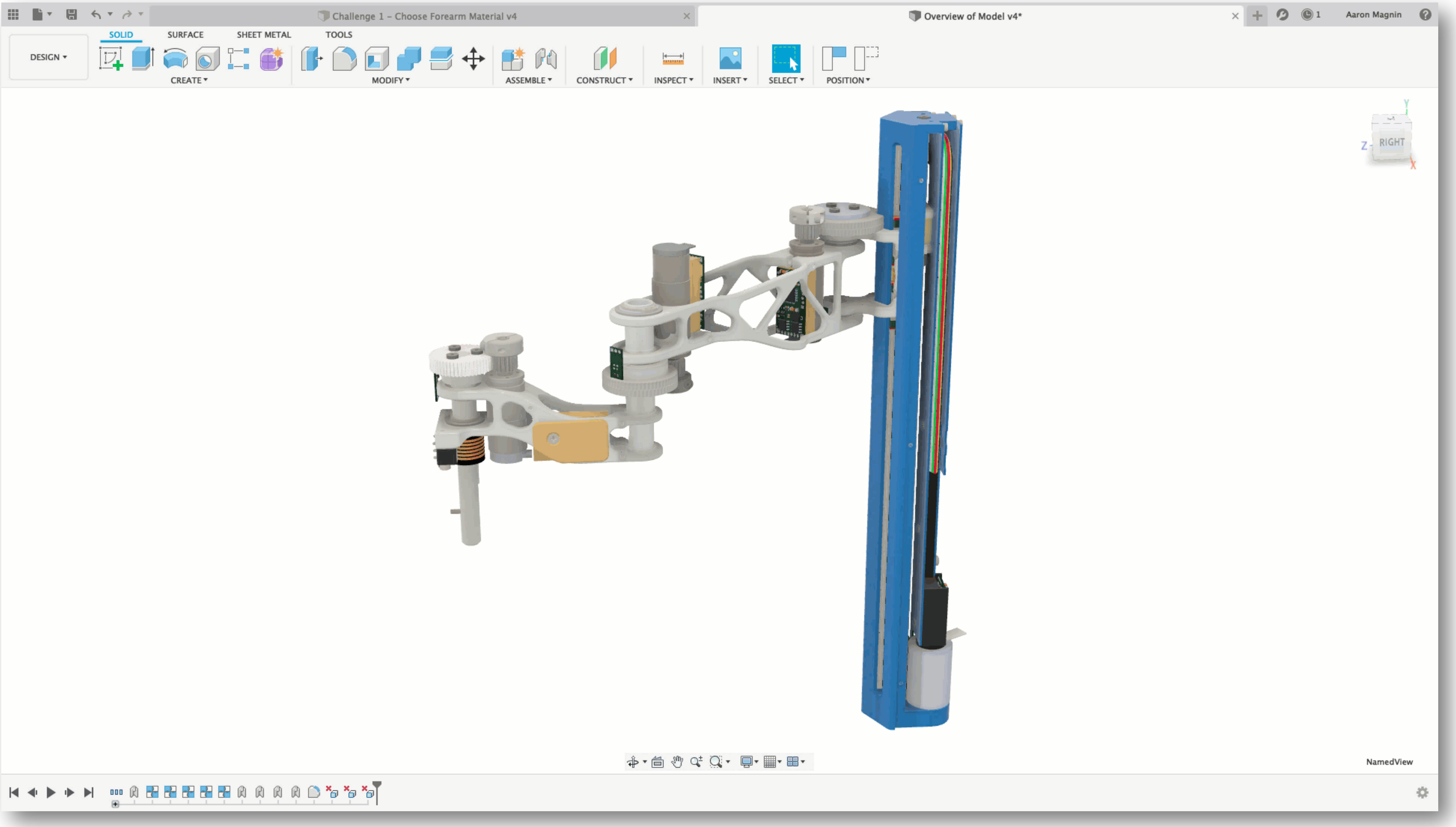
- *The spotlight: The robots will have to install them as high as possible in order to illuminate the movie actors.*
- *The clapperboard: The robots will have to close their clapperboards.*
- *The popcorn: The robots will have to gather popcorn and put it in their popcorn basket.*
- *The red carpet: The robots will have to roll out the carpet on the steps in order to welcome the artists.*
- *Climbing the red carpet steps: The robots will have to go the top of the steps before the end of the match.*

4 Axis Robotic Arm



Challenge 1 – Choose Material Forearm

Without running a simulation, it can *usually* be accurately assumed that one material will be stronger than another, or one will displace more, but to what extent?



Challenge 1 –Material Considerations

Strength, cost, manufacturing, availability are just some parameters we'll want to keep in mind as we consider materials. So how do you pick materials…

Google

best materials for robots?

Materials we're considering after researching this:

-Al-7075

-Al-6061

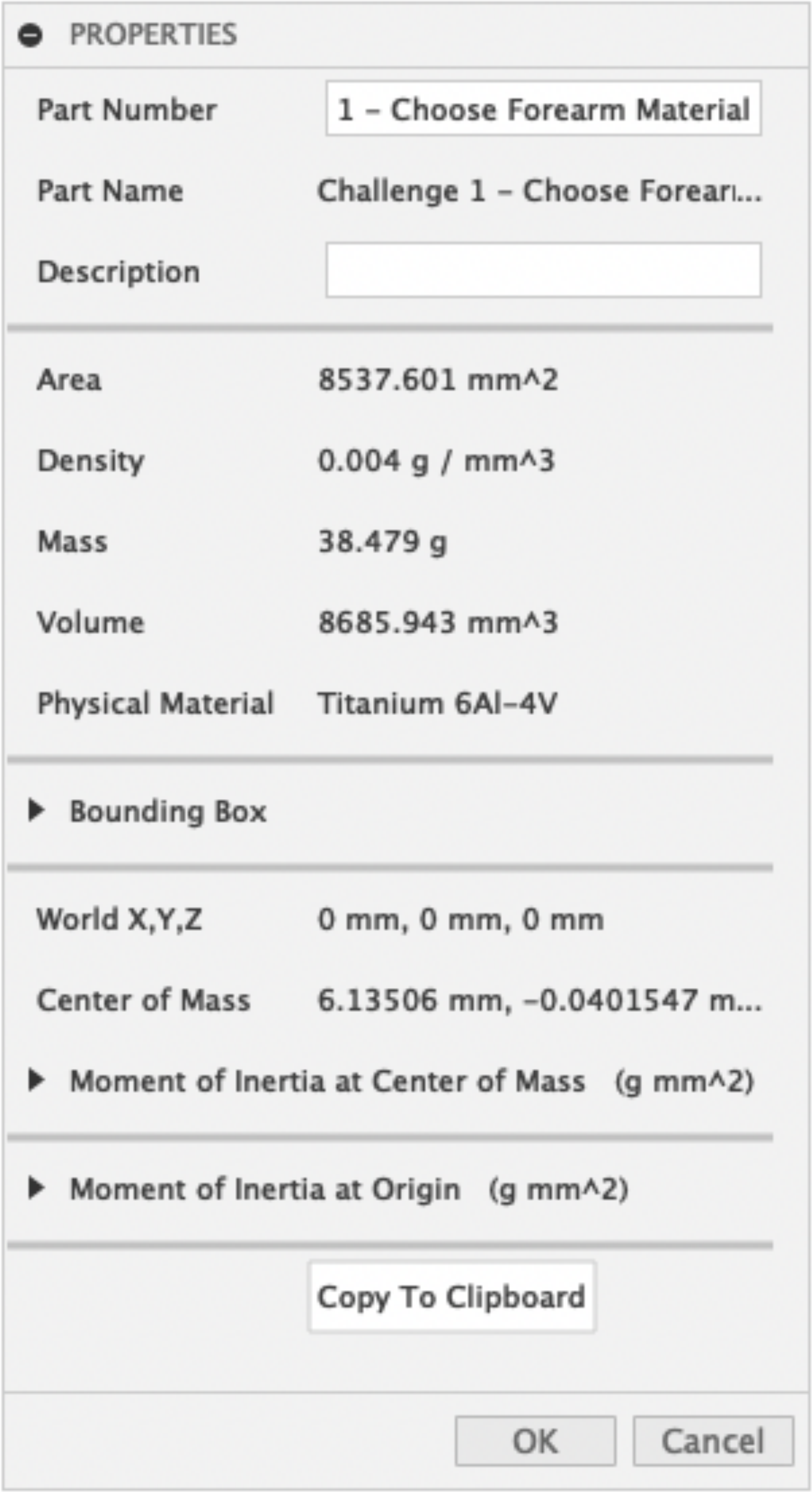
-Ti 6-4

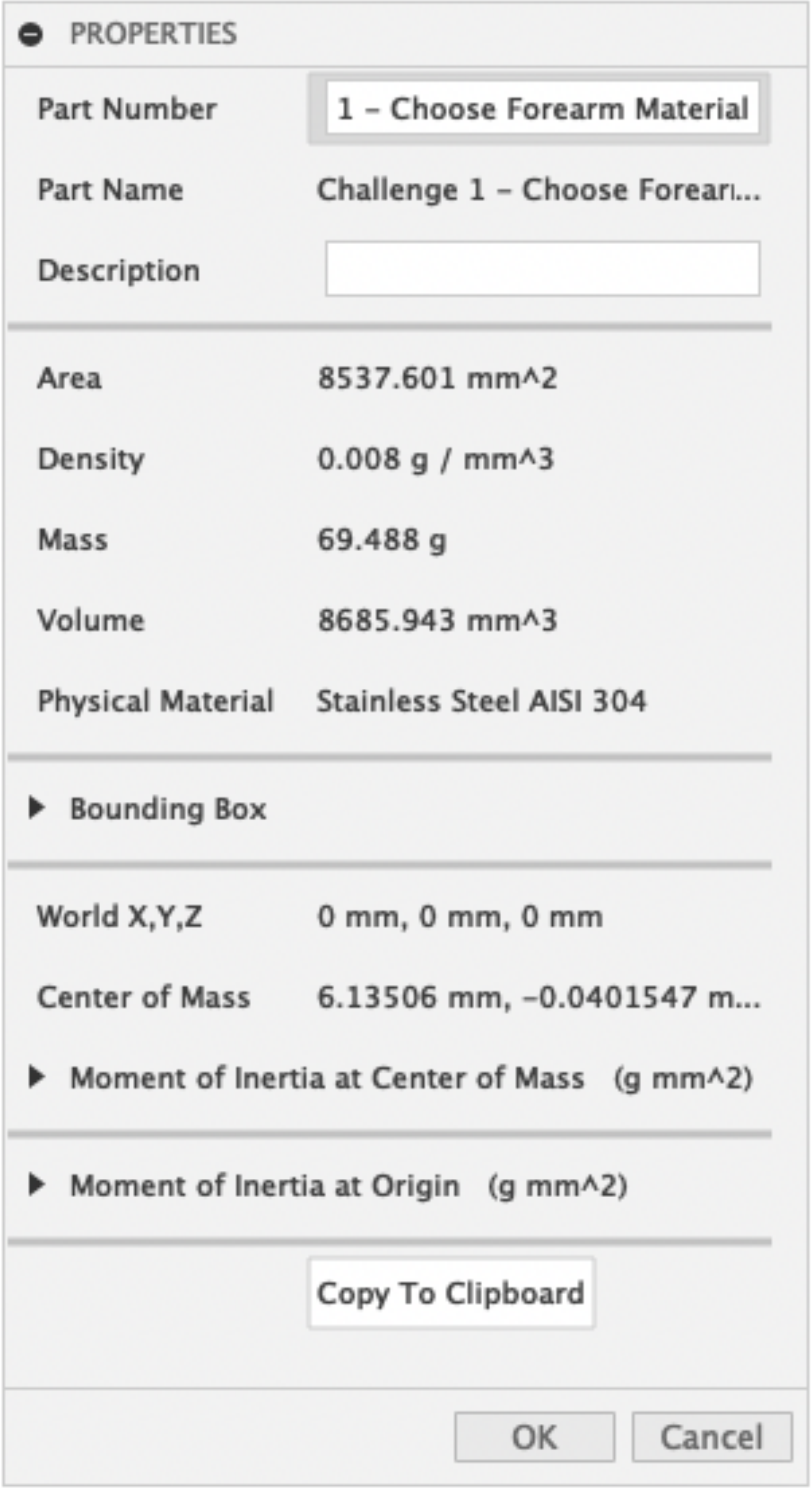
-304 Stainless

Mass Comparison

	(mass in g)
Al-7075	24.4
Al-6061	23.5
Ti 6-4	38.5
304 SS	69.5

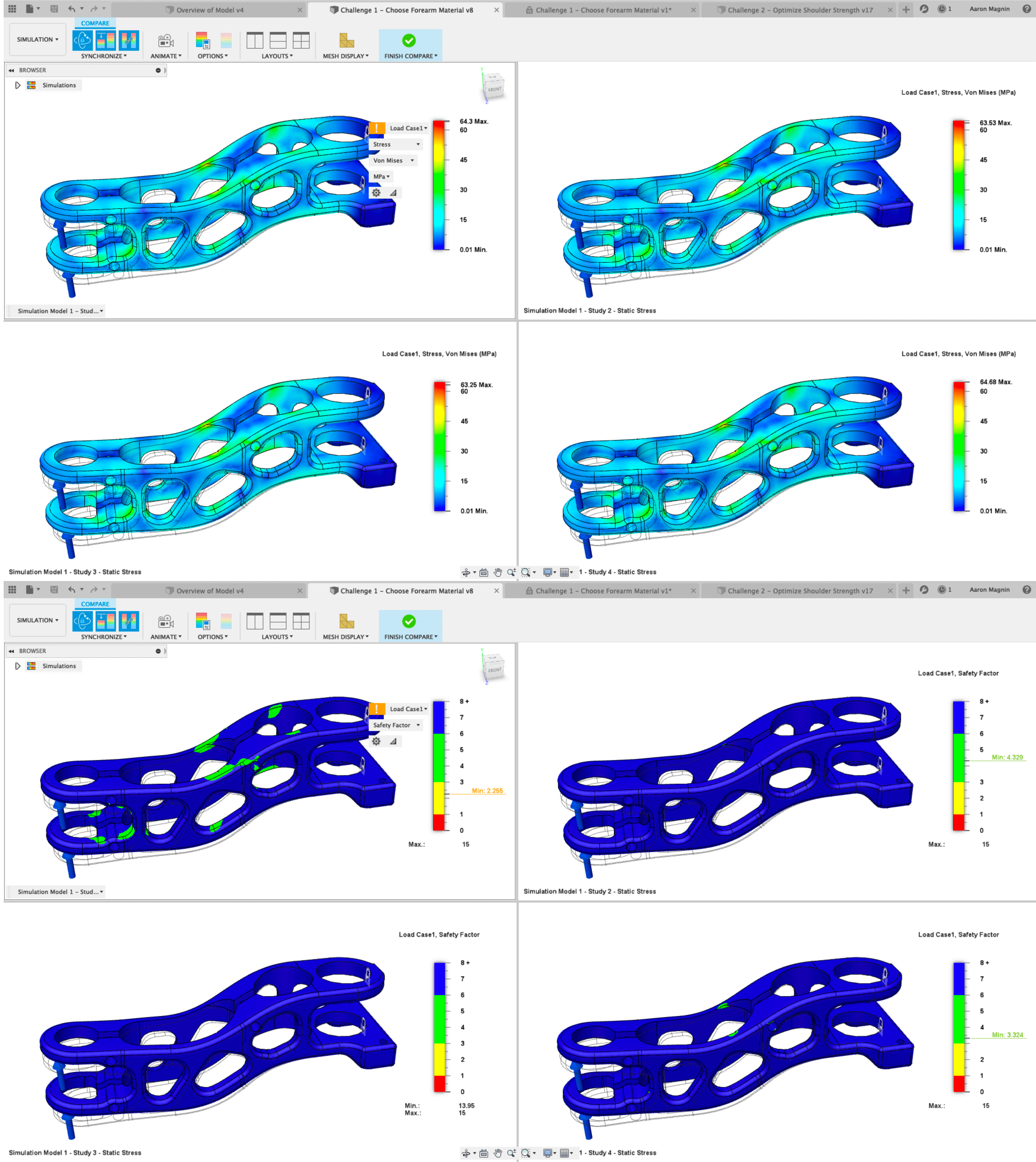
The world's first mass production usage of the 7075-aluminum alloy was for the Mitsubishi A6M Zero fighter. The aircraft was known for its excellent maneuverability which was facilitated by the higher strength of 7075 compared to former aluminum alloys.





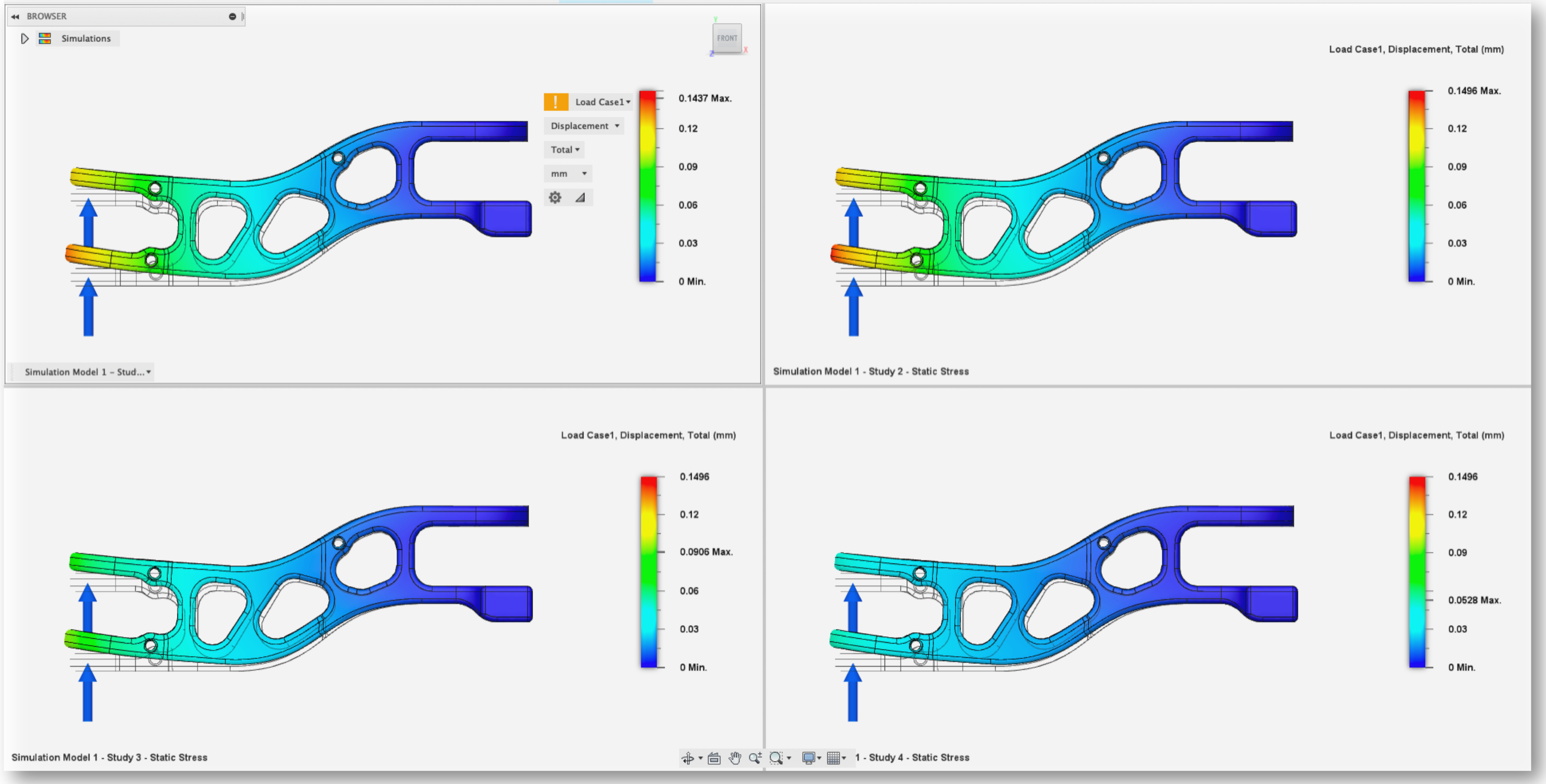
Stress FOS Comparison

	Min FOS
Al-7075	2.26
Al-6061	4.33
Ti 6-4	13.95
304 SS	3.32



Displacement Comparison

	Max Displacement (mm)
Al-7075	0.1437
AL-6061	0.1496
Ti 6-4	0.0906
304 SS	0.0528



Decision Time

	Mass Δ	Disp Δ	Material Price	Price Δ*
Al-7075	-	-	$ 0.08	-
Al-6061	-4%	-4%	$ 0.06	-19%
Ti 6-4	58%	37%	$ 2.24	2716%
304 SS	185%	63%	$ 0.25	215%

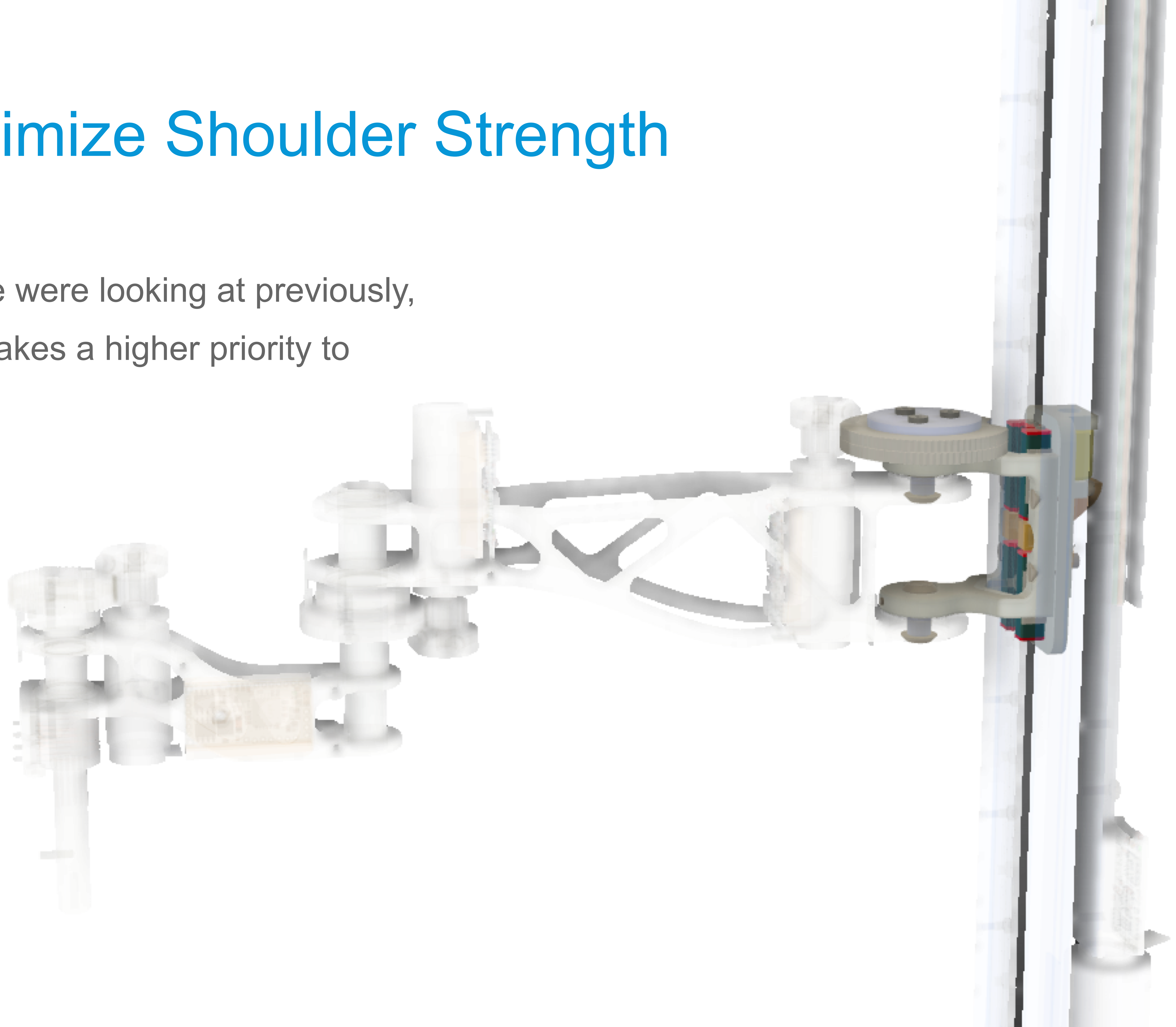
*ignores stock body & machine time.

Challenge 2 – Optimize Shoulder Strength

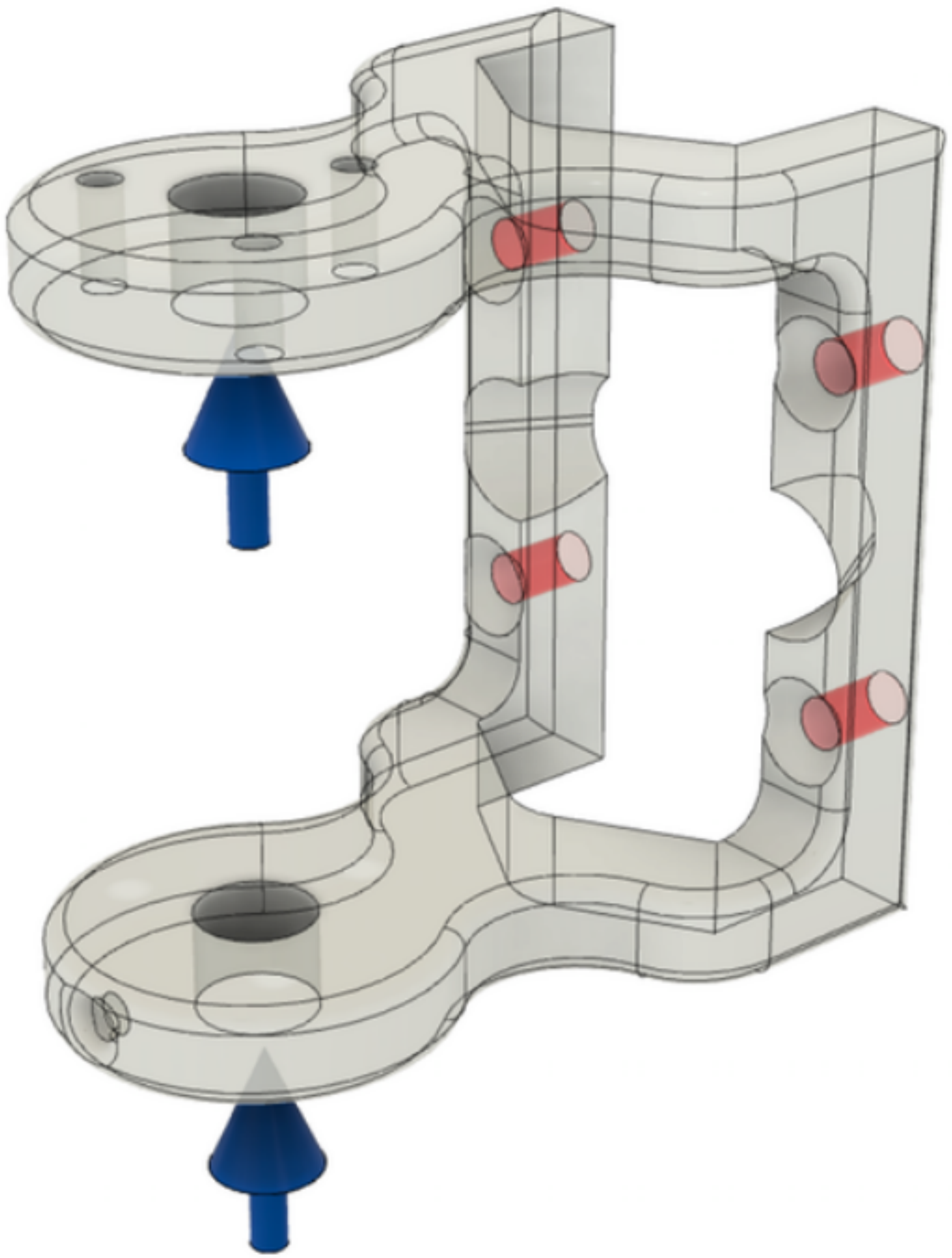
As opposed to the end of arm we were looking at previously, for the “shoulder” part, strength takes a higher priority to weight savings.

OPTIMIZING STRENGTH

Knowing where the highest concentrations of stresses and displacements in the part will be, you can modify the geometry or add structural reinforcements in these areas to increase strength and improve performance.



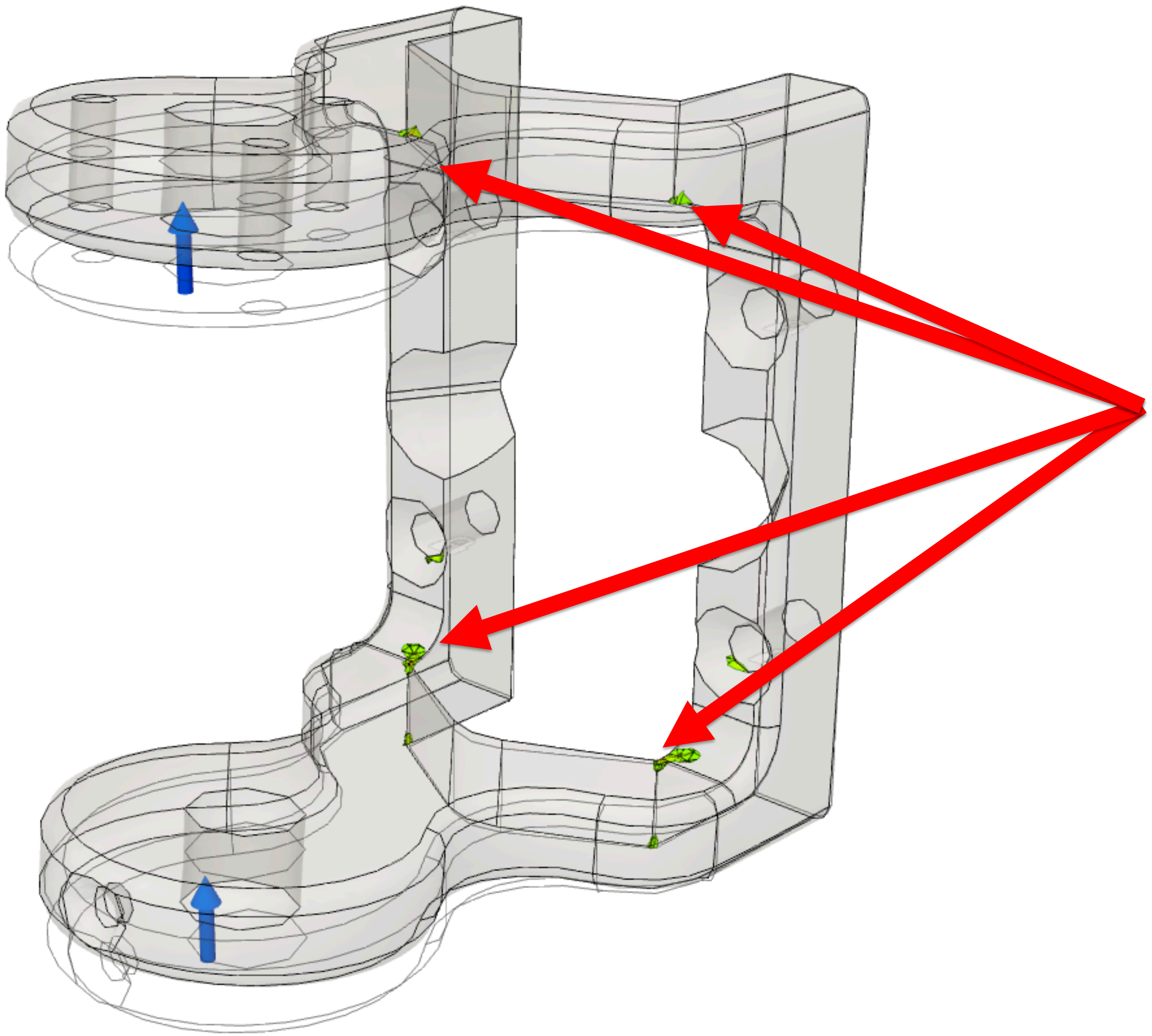
Where do you expect the highest stress?



Optimize Shoulder Strength

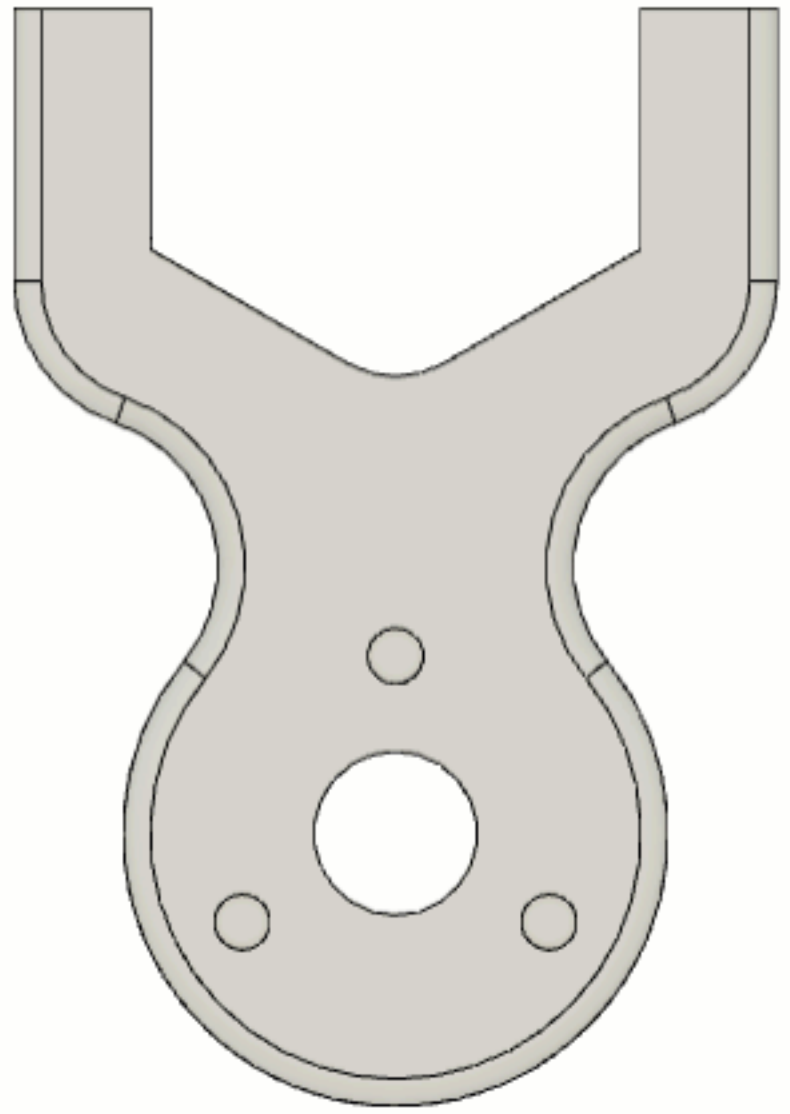
Actual results…

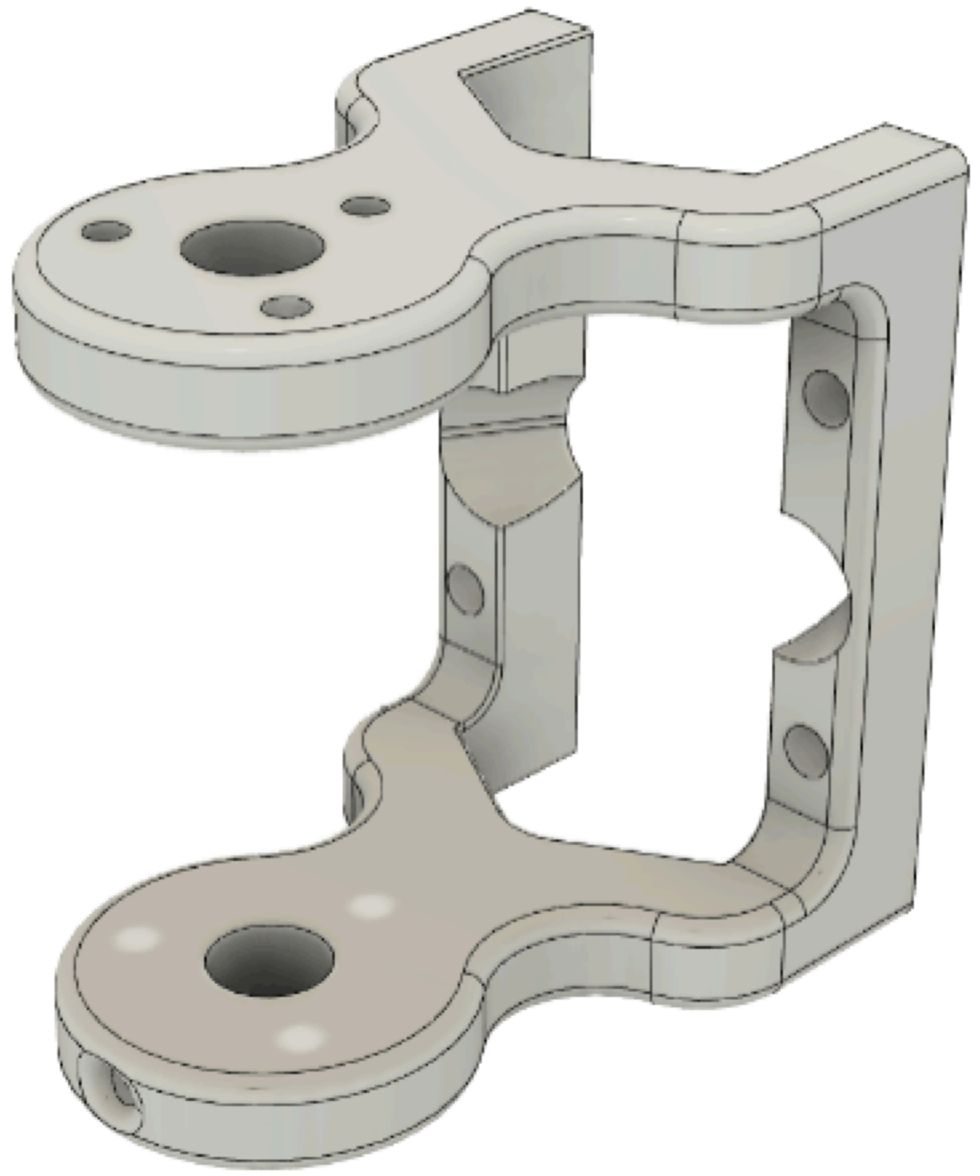
Note min FOS 1.668



Choose Your Design Change

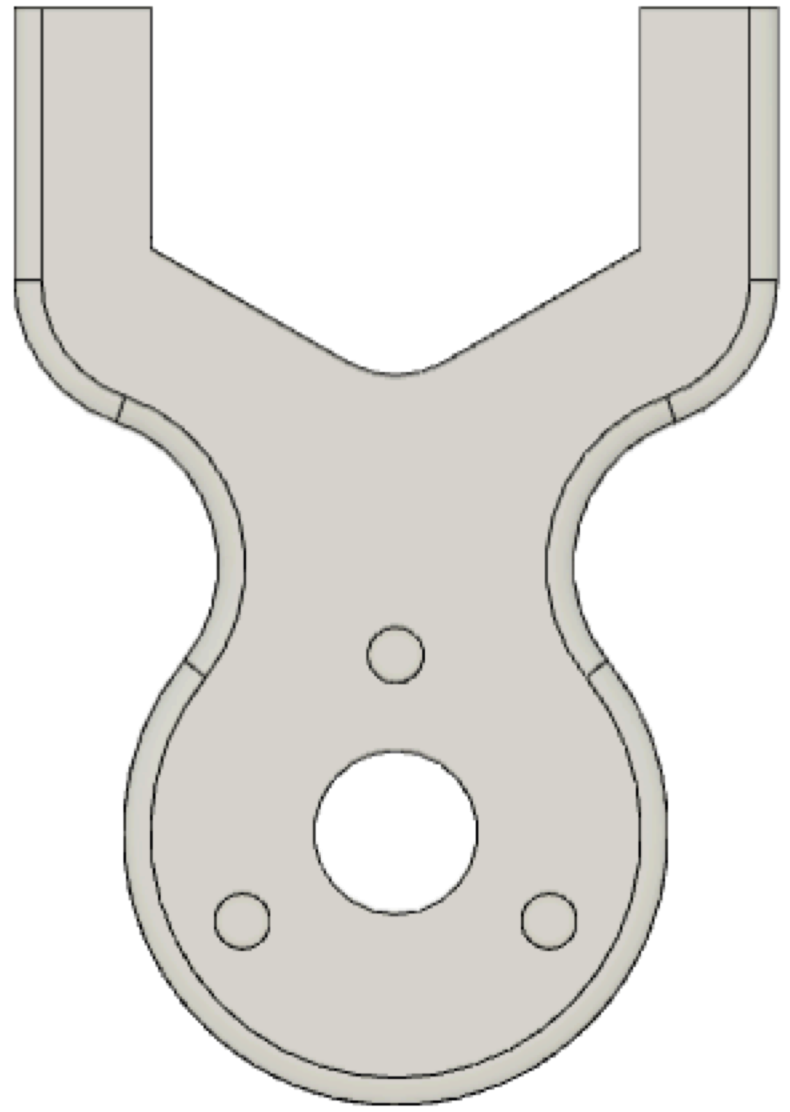
A -

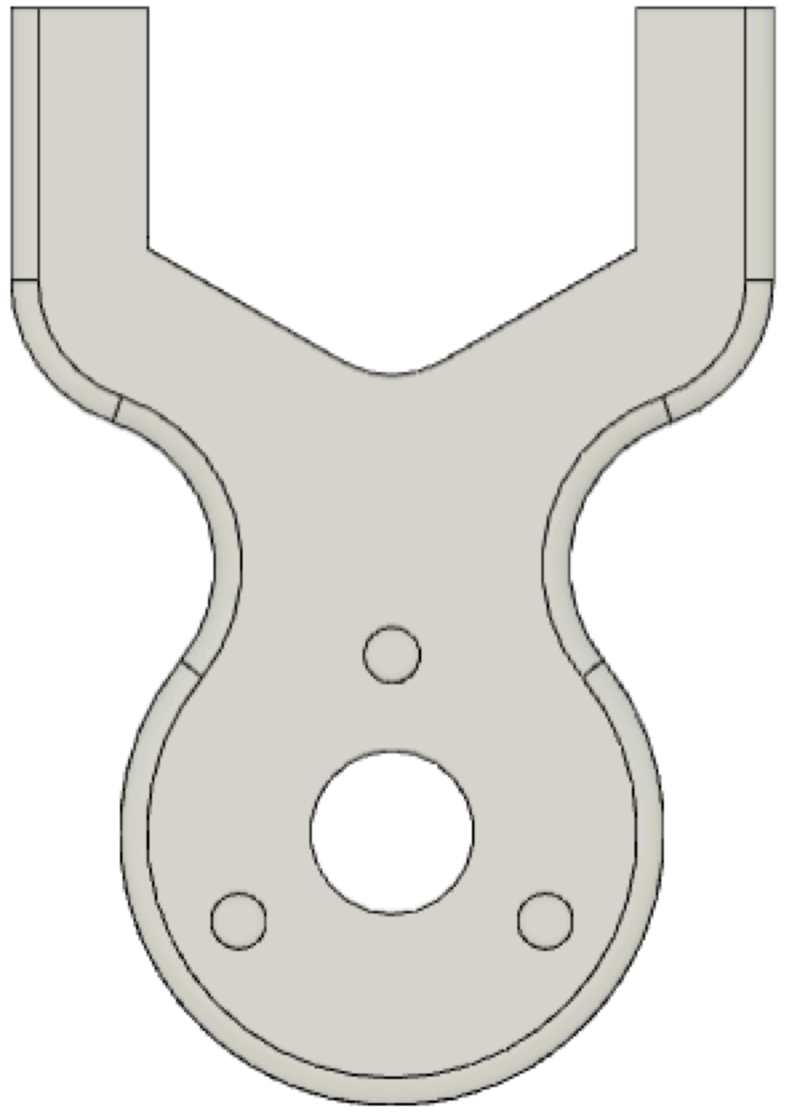




- B

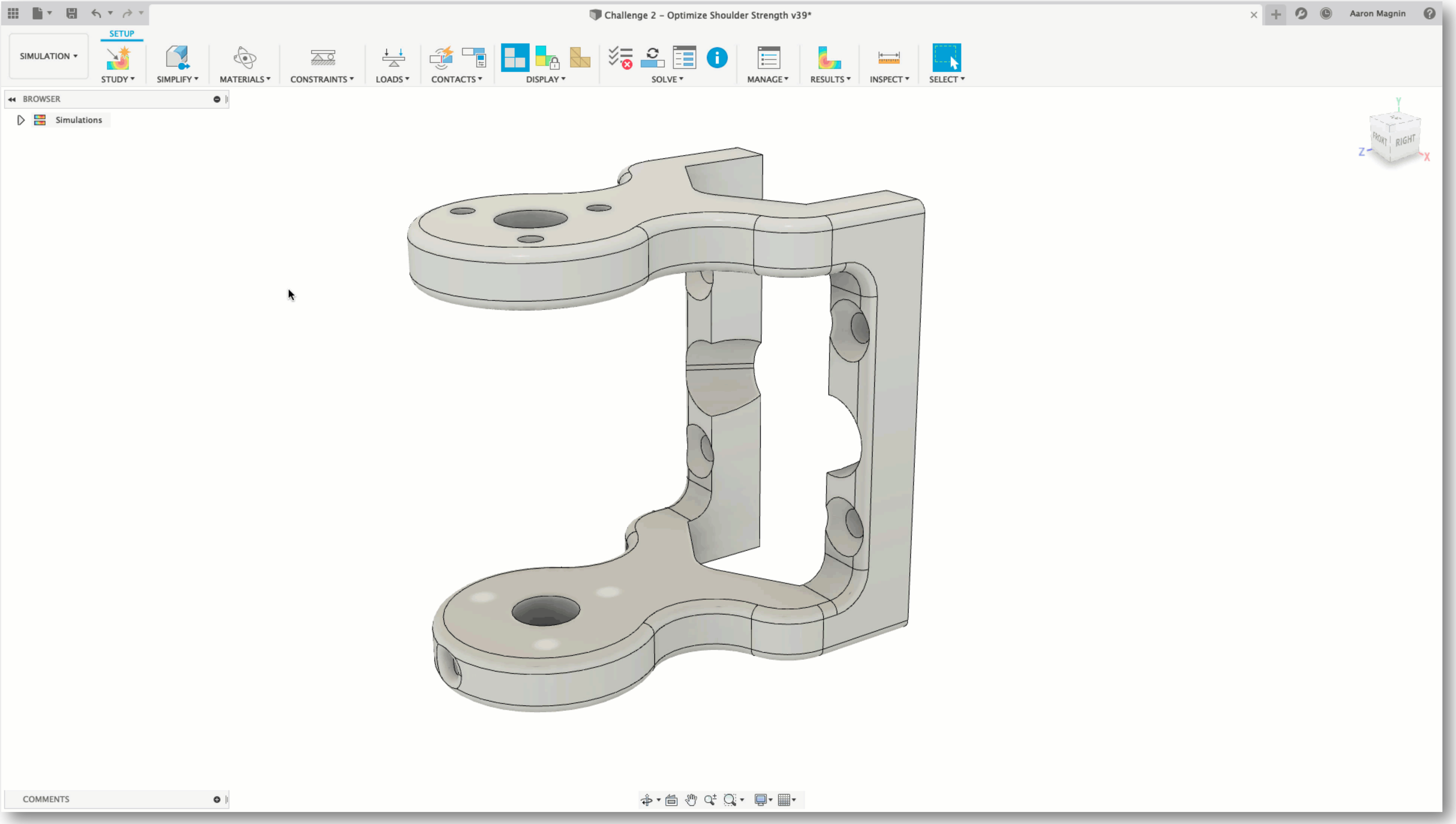
C -





- D

Design Exploration FAST!




BROWSER
Simulations
Load Case1
Safety Factor
8 +
7
6
5
4
Min: 2.701
2
1
0
Threshold: 0 - 6
Max.: 15
CASE A – Inner Fillet – Cas...
Load Case1, Safety Factor
8 +
7
6
5
4
3
2
Min: 1.598
1
0
Threshold: 0 - 6
Max.: 15
CASE B - Outer Fillet - Case B
Load Case1, Safety Factor
8 +
7
6
5
4
3
Min: 1.81
1
0
Threshold: 0 - 5.967
Max.: 15
COMMENTS
CASE C - Tangentcy - Case C
Case D, Safety Factor
8 +
7
6
5
4
Min: 3.374
2
1
0
Threshold: 0 - 6.067
Max.: 15
j Adjustment - Case D


BROWSER
Simulations
Load Case1
Displacement
Total
mm
0.09558
0.08905 Max.
0.08
0.06
0.04
0.02
0 Min.
CASE A – Inner Fillet – Cas...
Load Case1, Displacement, Total (mm)
0.09558
0.08463 Max.
0.06
0.04
0.02
0 Min.
CASE B - Outer Fillet - Case B
Load Case1, Displacement, Total (mm)
0.09558
0.07678 Max.
0.06
0.04
0.02
0 Min.
COMMENTS
CASE C - Tangentcy - Case C
Case D, Displacement, Total (mm)
0.09558 Max.
0.08
0.06
0.04
0.02
0 Min.
Adjustment - Case D

Free Generative Design Until 2020

Autodesk has teamed up with AWS and NVIDIA to offer unlimited generative design in Fusion 360 from November 18th through December 31, 2019.

Learn more

autodesk.com/free-generative-design

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