

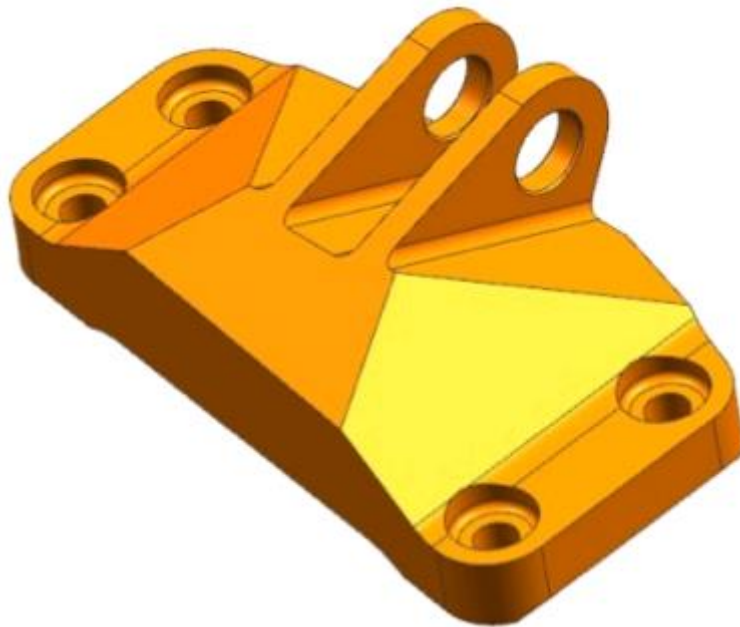
# GE Jet Engine Bracket

Initial CAD geometry source: <https://grabcad.com>

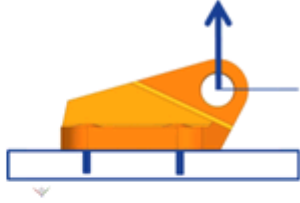
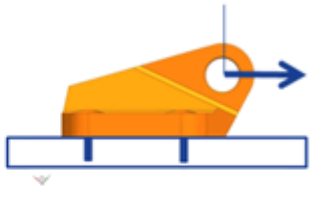
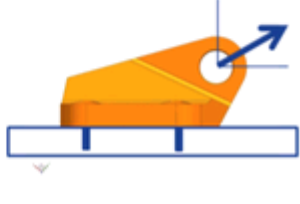

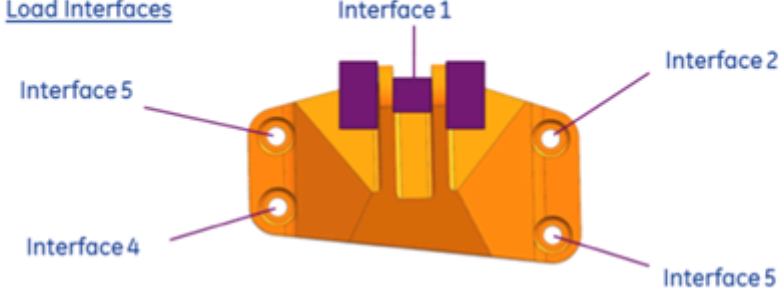
## Problem description

The goal is to determine the optimal design of a jet engine bracket. The basic requirements are as follows:

- The optimized geometry must fit within the original part envelope.
- Material: Ti-6Al-4V - Assume yield strength is 131 ksi.
- Service Temperature: 75 F
- Load Conditions:
  1. Max static linear load of 8,000 lbs vertical up.
  2. Max static linear load of 8,500 lbs horizontal out.
  3. Max static linear load of 9,500 lbs 42 degrees from vertical.
  4. Max static torsional load of 5,000 lb-in horizontal at intersection of centerline of pin and midpoint between clevis arms.

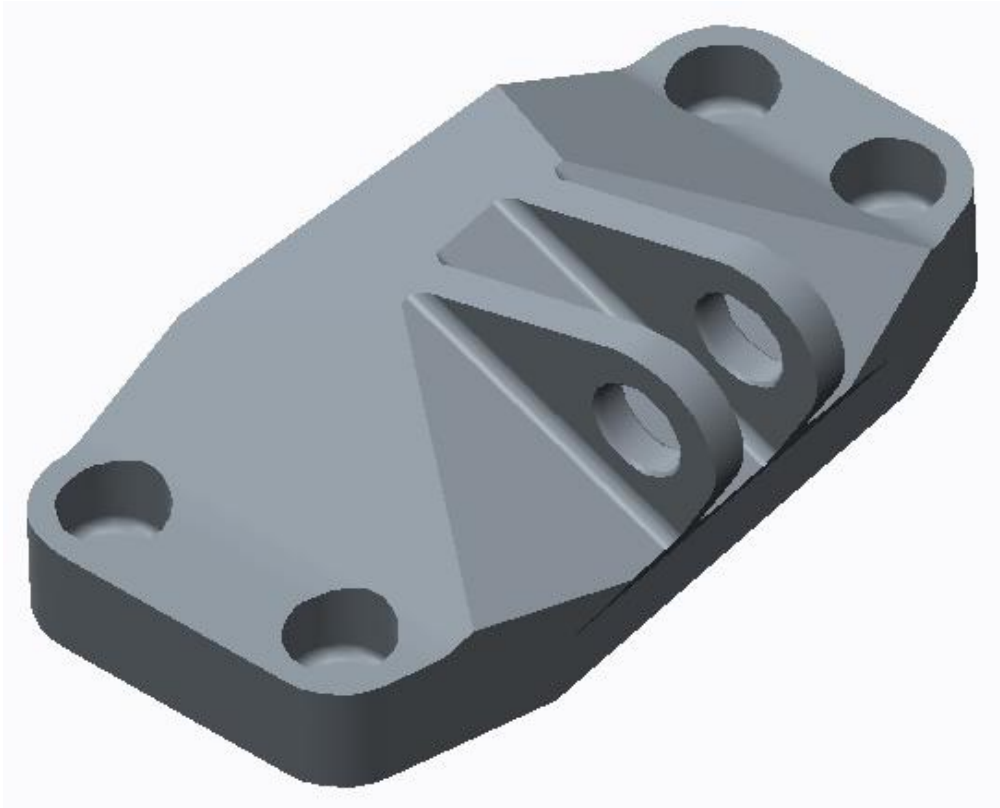


# Case Study

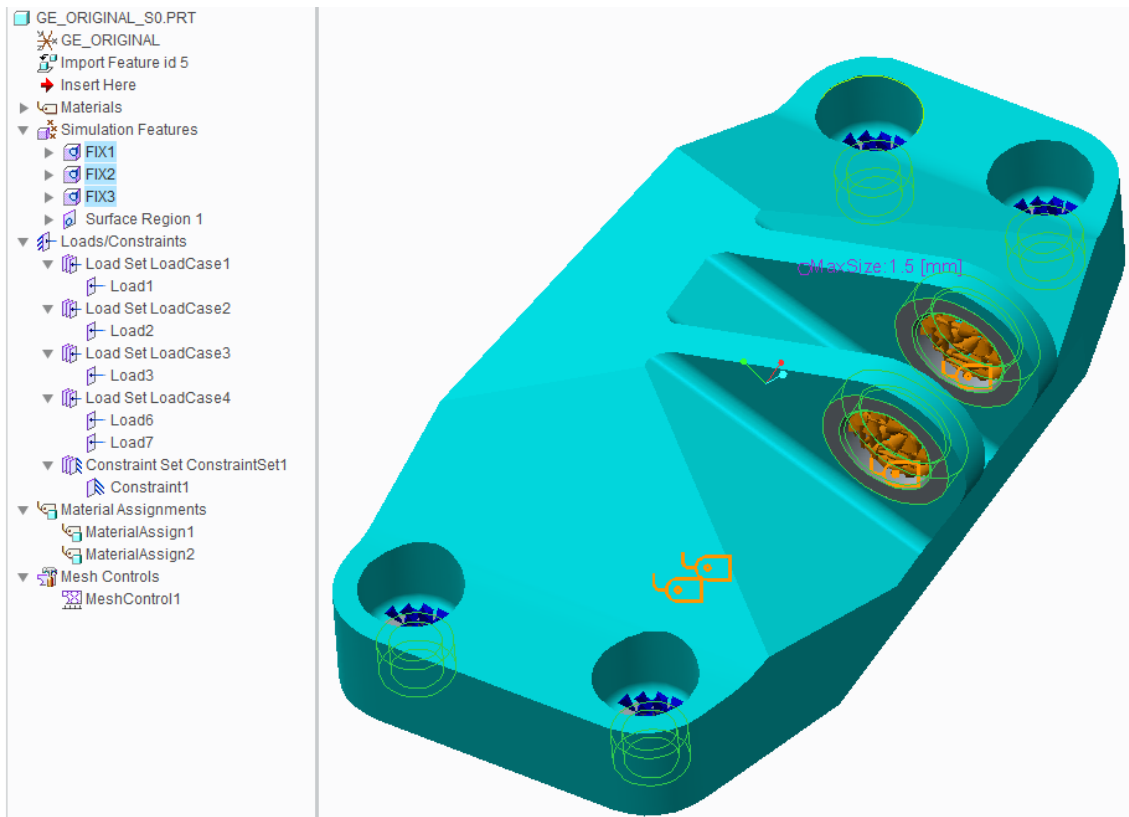
<p>Load Conditions 1</p> <p>Static</p> <p>Vertical</p> <p>8000 lbs up</p> 	<p>Load Conditions 2</p> <p>Static</p> <p>Horizontal</p> <p>8500 lbs out</p> 
<p>Load Condition 3</p> <p>Static</p> <p>42 degrees from Vertical.</p> <p>9500 lbs out</p> 	<p>Load Condition 4</p> <p>Static Torsional</p> <p>Horizontal plane at centerline of clevis.</p> <p>5000 lb-in</p> 
<p><u>Load Interfaces</u></p> 	

## CAD and FEA model

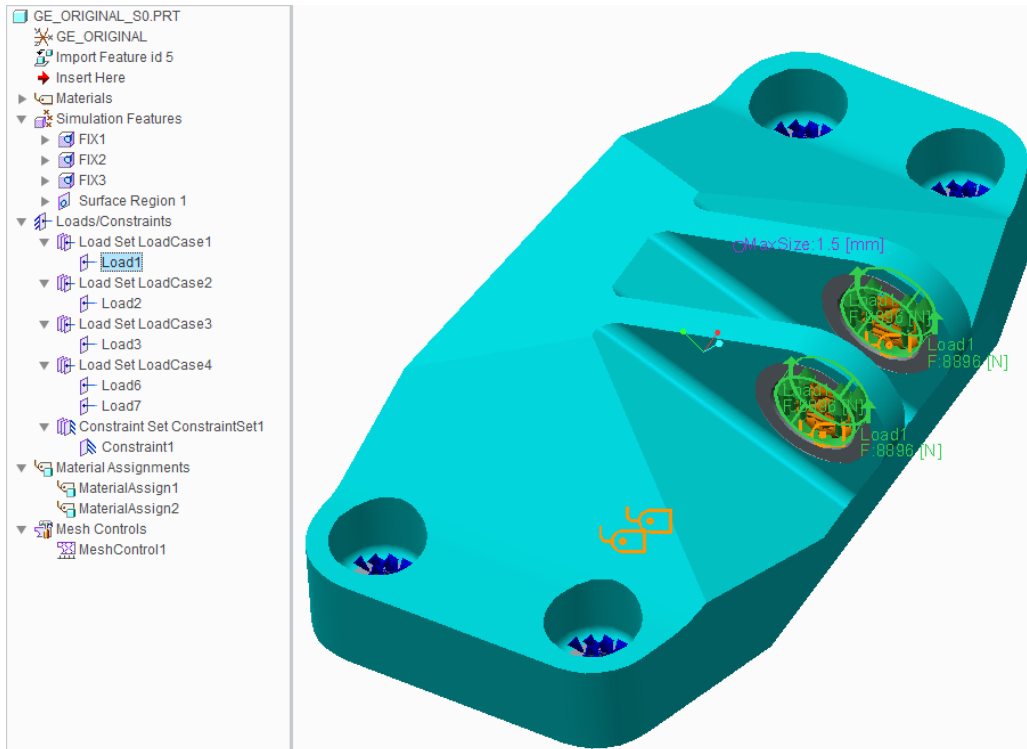
GE Jet engine bracket optimization initial model in PTC Creo.



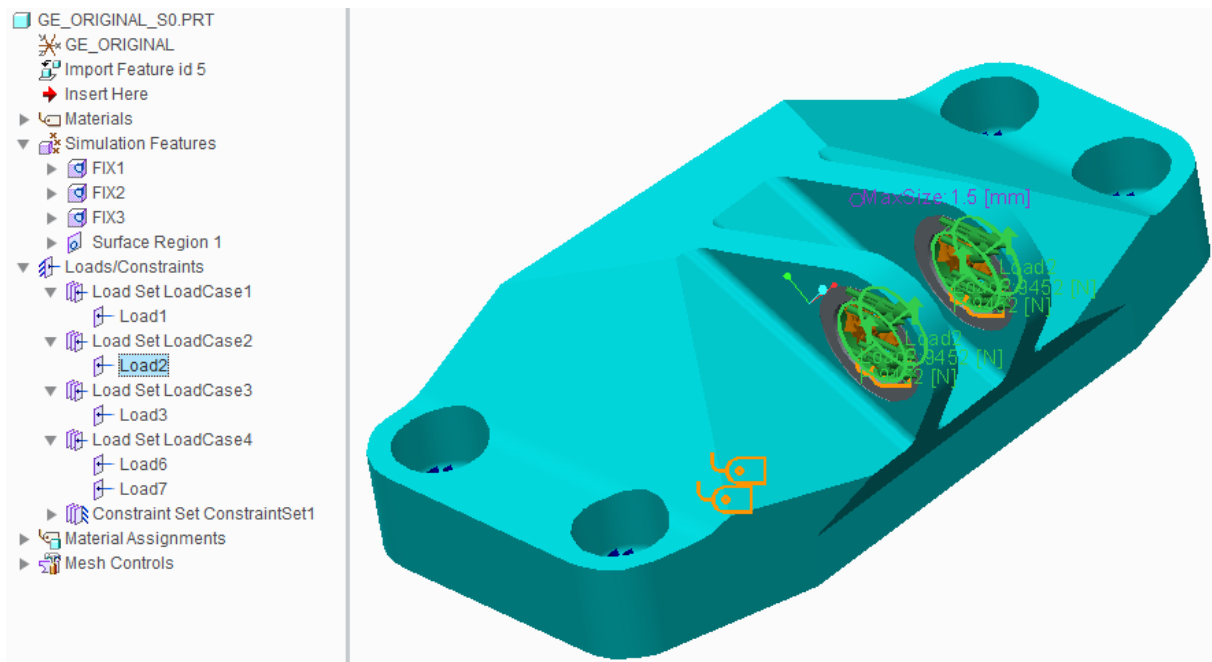
Fixed volume regions around interfaces



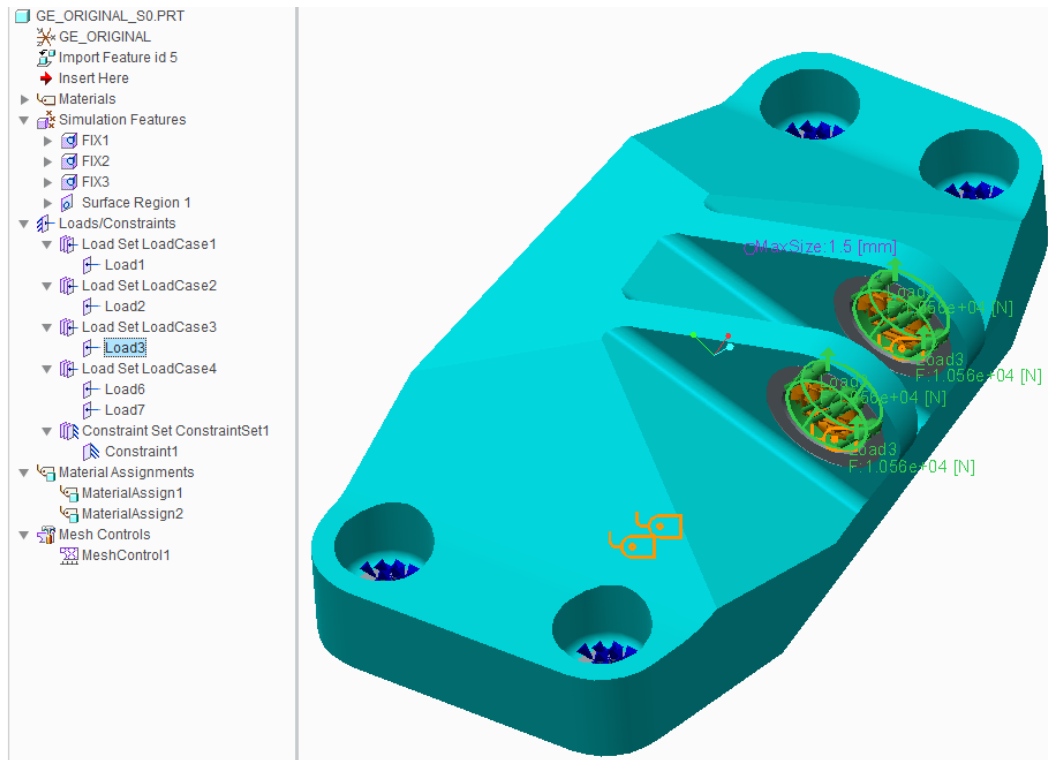
## Load case 1: Load Set 1, Vertical load



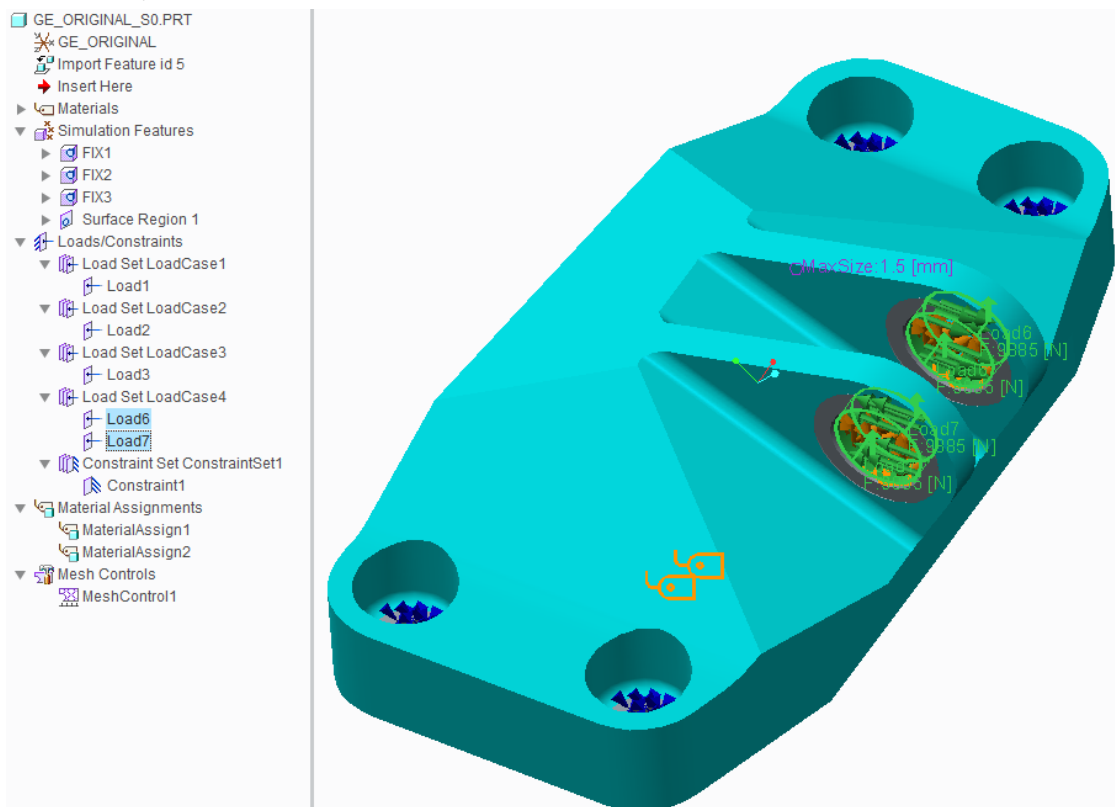
## Load case 2: Load Set 2, Horizontal load



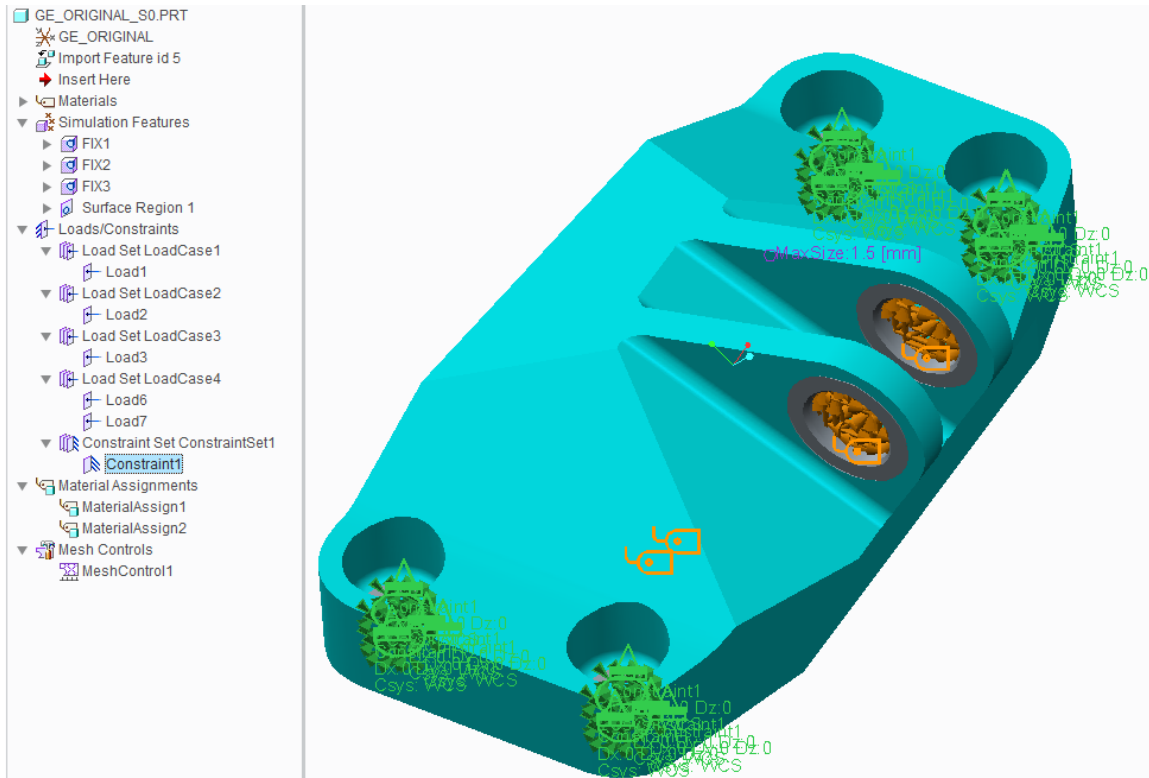
Load case 3: Load Set 3, Load direction under 42° from the vertical line



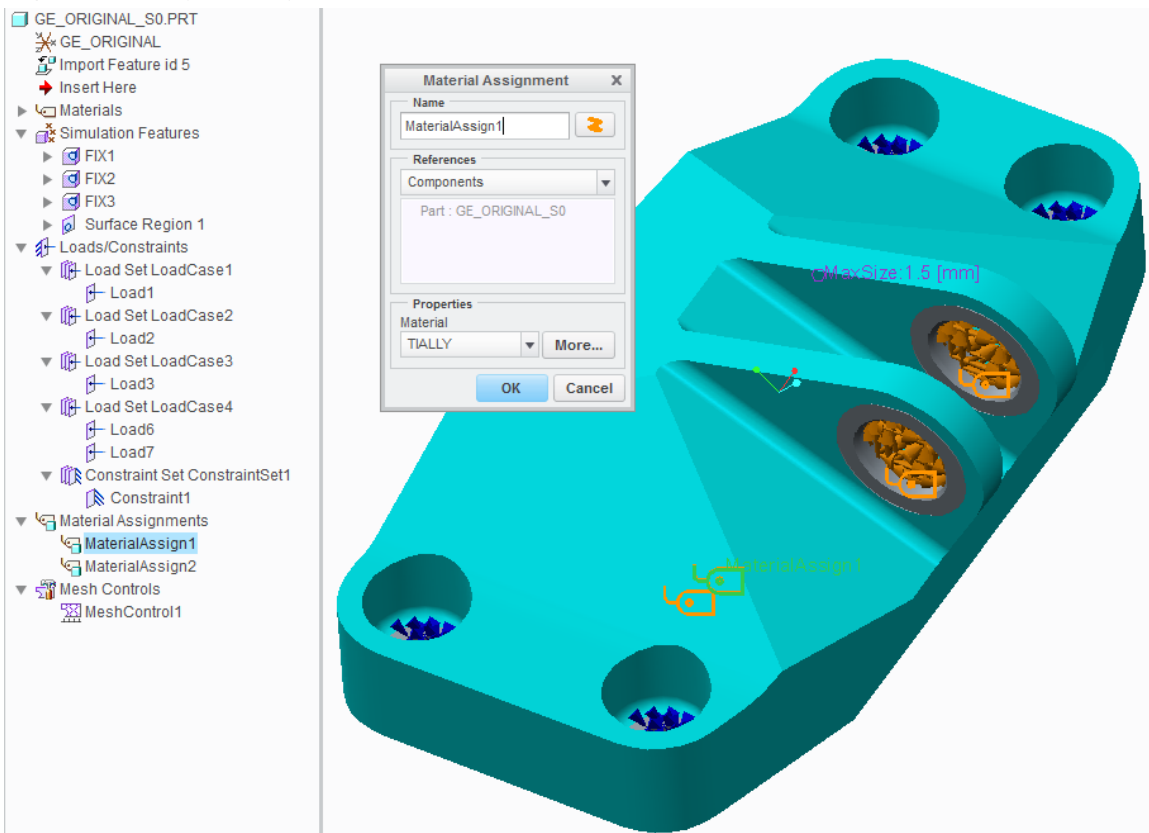
Load case 4: Load Set 4, Torsion around vertical axis



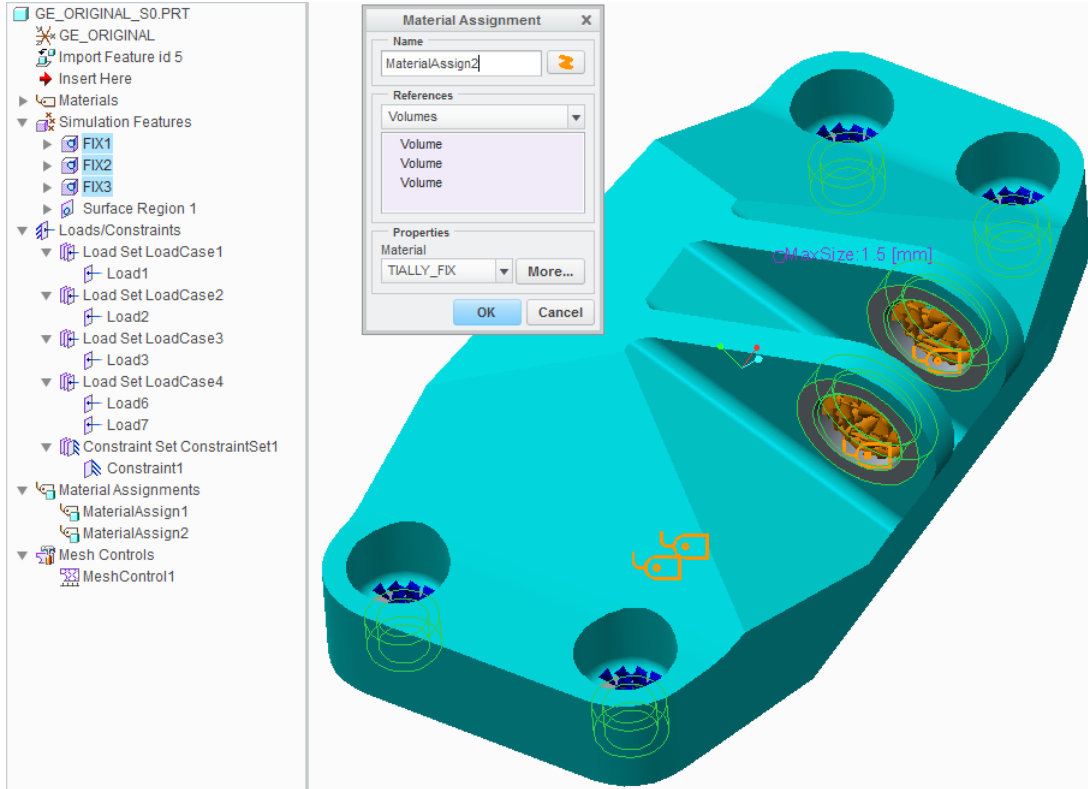
## Boundary conditions



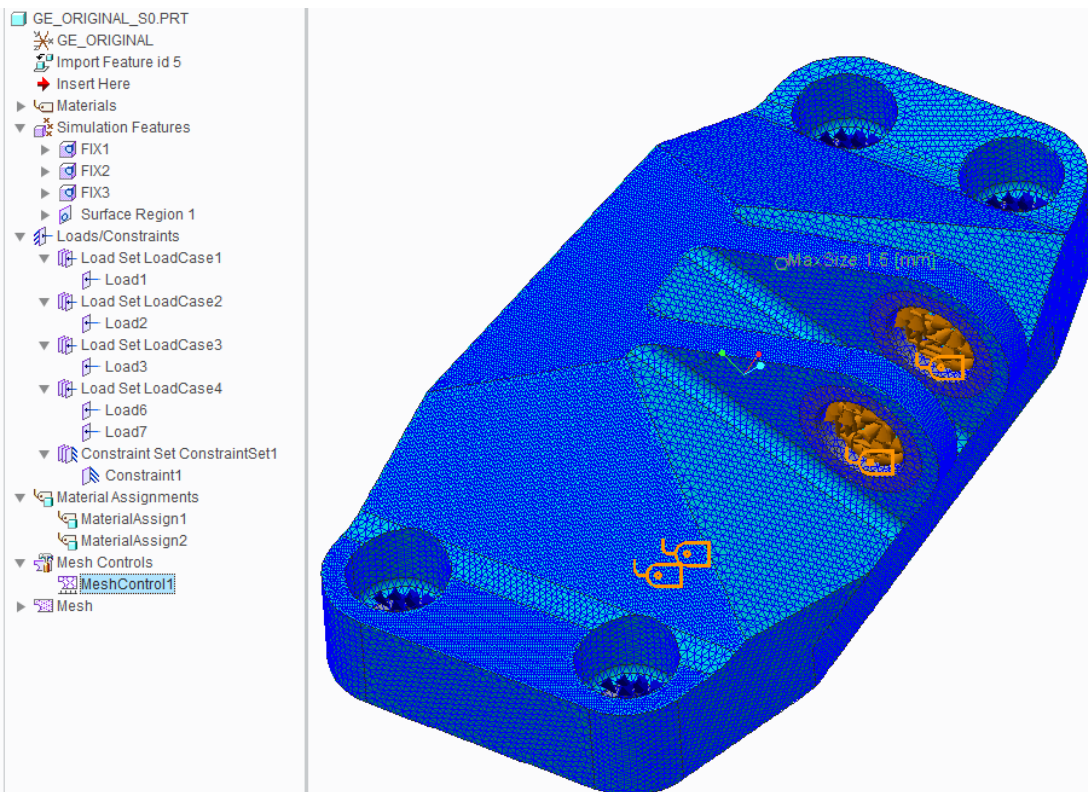
## Material assignment: Tially to component



Material assignment: Tially\_FIX to created volume regions



FEA model in PTC Creo



## Optimization by CAESS ProTOP

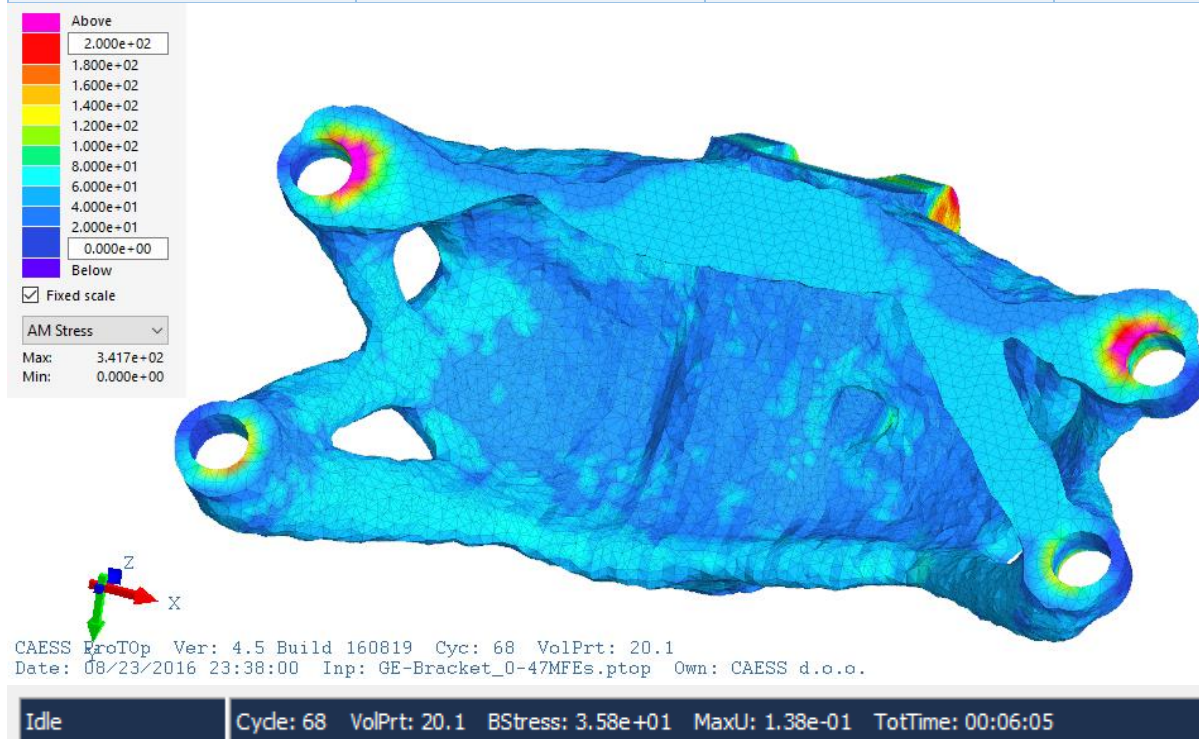
Optimization targets:

- optimization domain volume reduction by 80%
- lowest possible stress levels
- no stress concentrations within the optimized domain

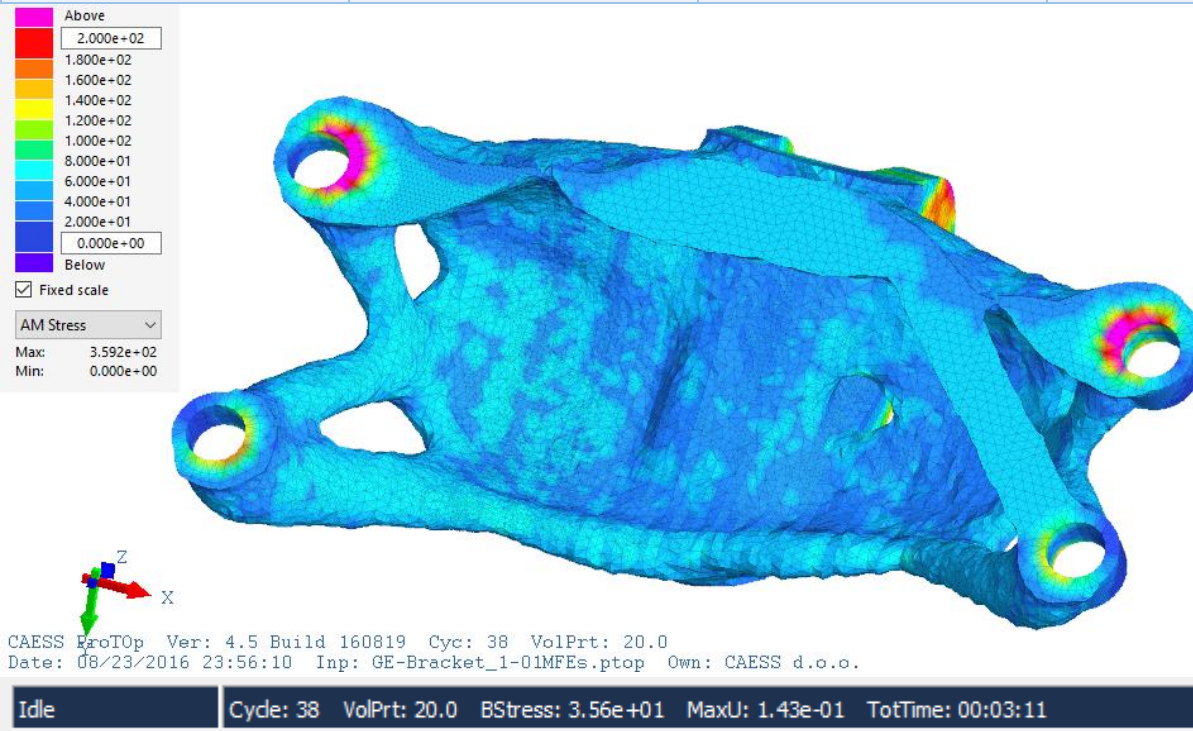
Finite elements: special linear tetrahedrons for topology optimization

Optimization strategy: using Start-From functionality to reduce CPU and RAM consumption

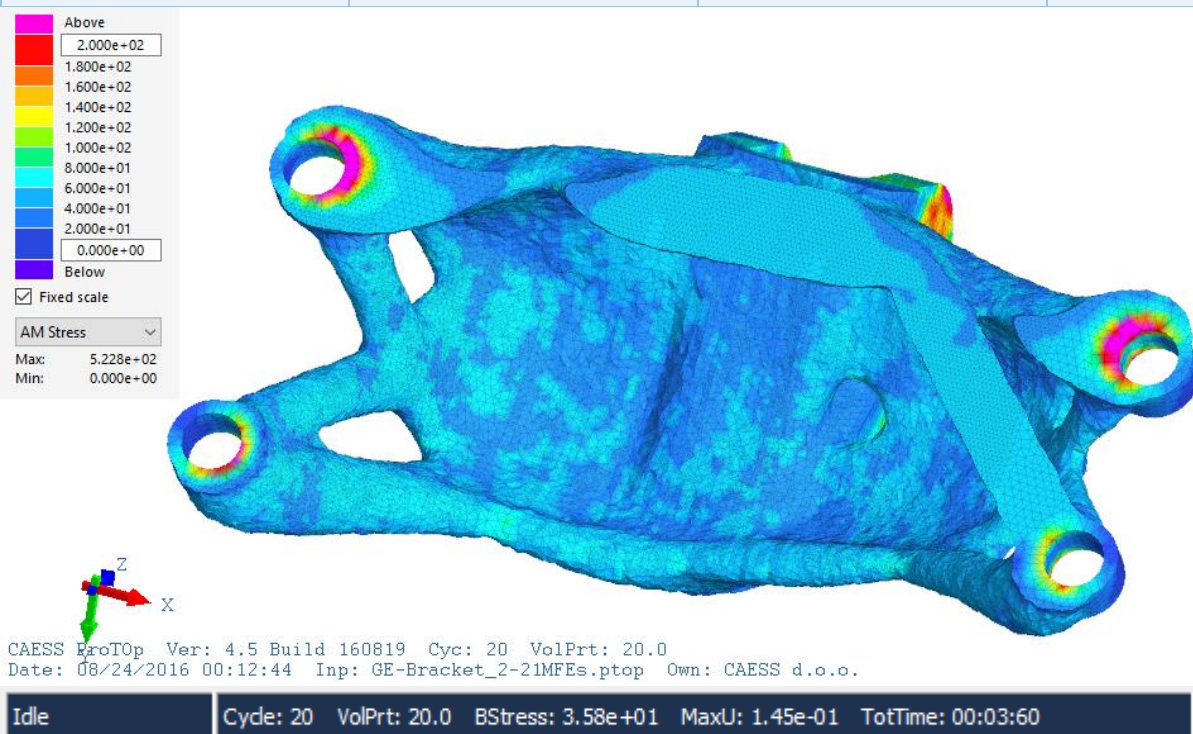
<b>Stage A</b>		Starting from: initial full-material design	
Elements: 0.468 million	DOF: 0.259 million	CPU time: 00:06:05	Max RAM: 1.3 GB



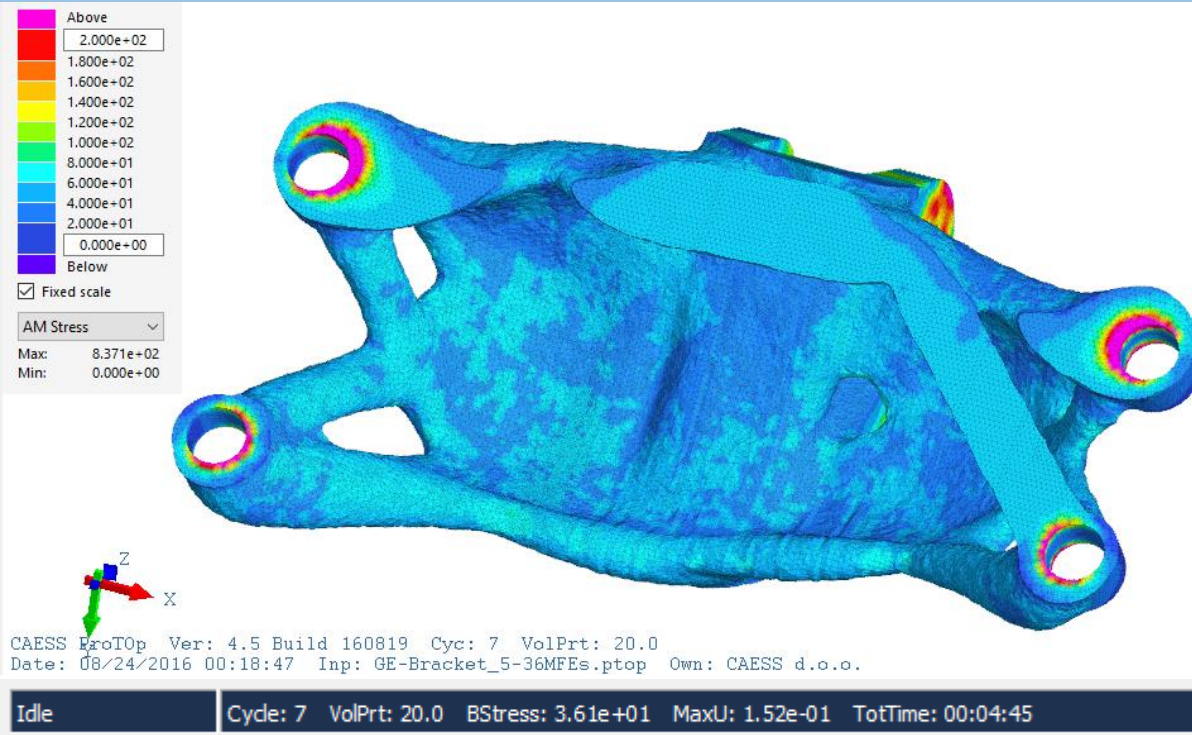
<b>Stage B</b>		Starting from: stage A result	
Elements: 1.0 million	DOF: 0.535 million	CPU time: 00:03:11	Max RAM: 0.6 GB



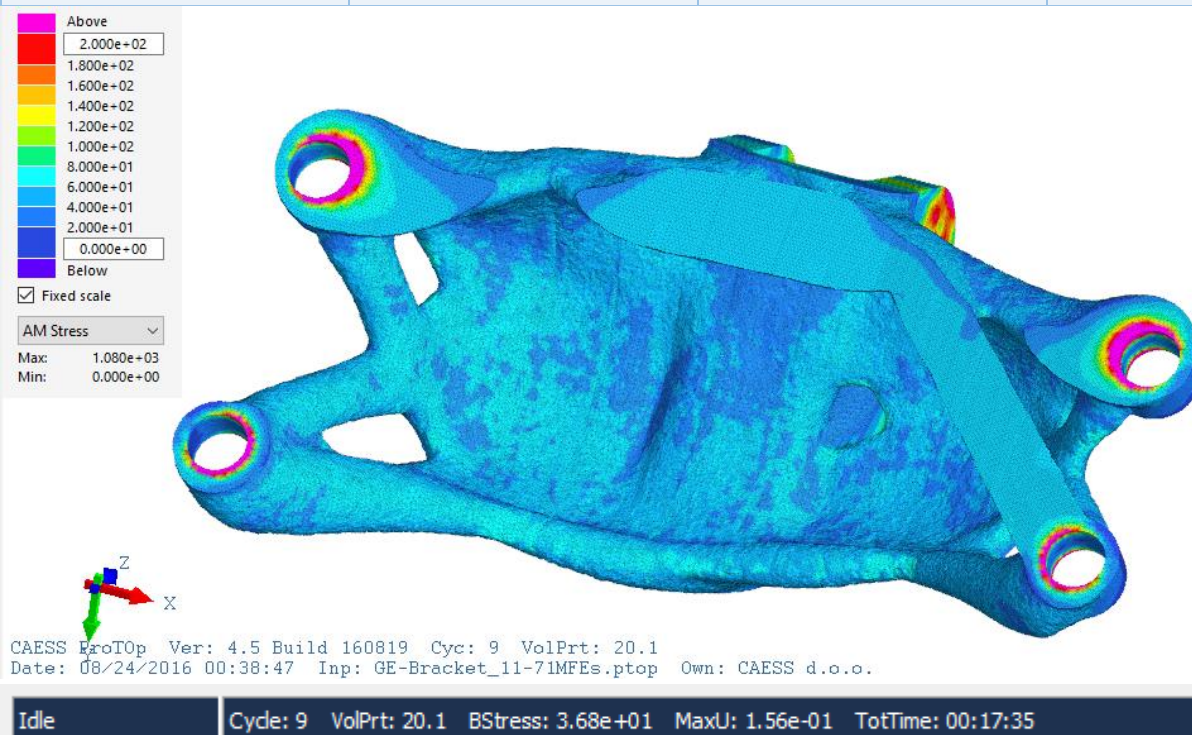
<b>Stage C</b>		Starting from: stage B result	
Elements: 2.2 million	DOF: 1.2 million	CPU time: 00:03:60	Max RAM: 1.4 GB



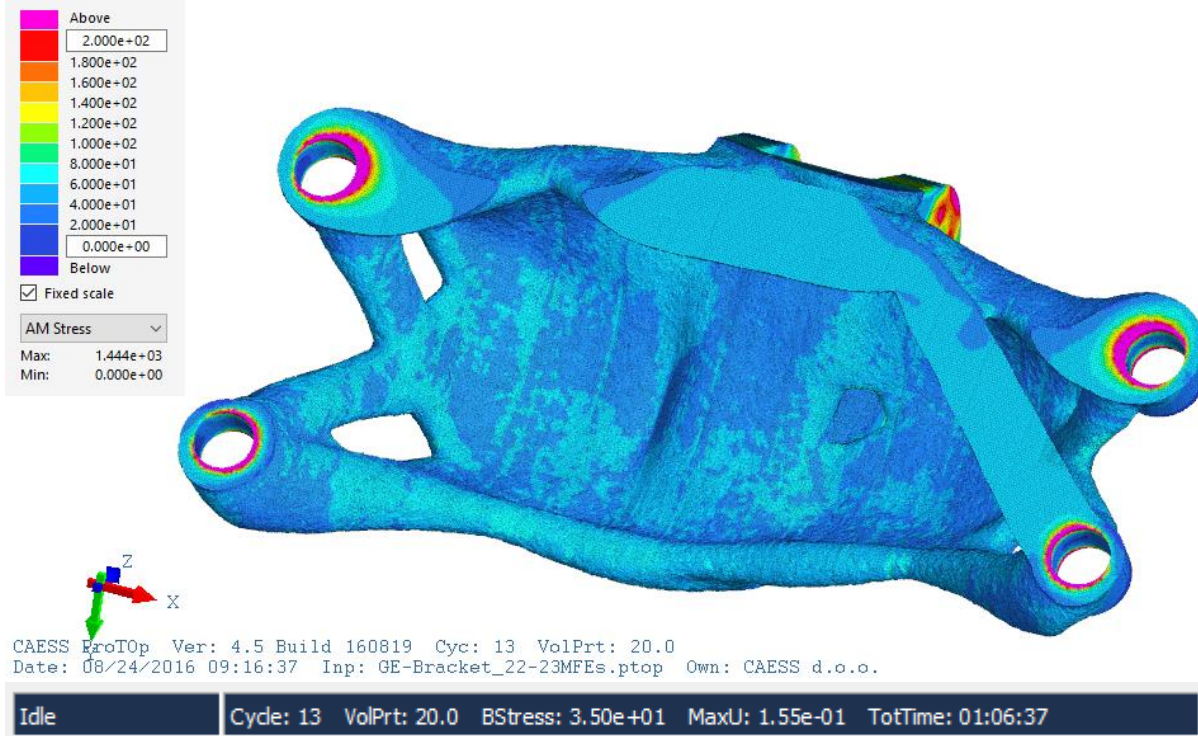
<b>Stage D</b>		Starting from: stage C result	
Elements: 5.4 million	DOF: 2.8 million	CPU time: 00:04:45	Max RAM: 3.7 GB



<b>Stage E</b>		Starting from: stage D result	
Elements: 11.7 million	DOF: 6.1 million	CPU time: 00:17:35	Max RAM: 9.4 GB



<b>Stage F</b>		Starting from: stage E result	
Elements: 22.2 million	DOF: 11.5 million	CPU time: 01:06:37	Max RAM: 20.0 GB



## Stage F results:

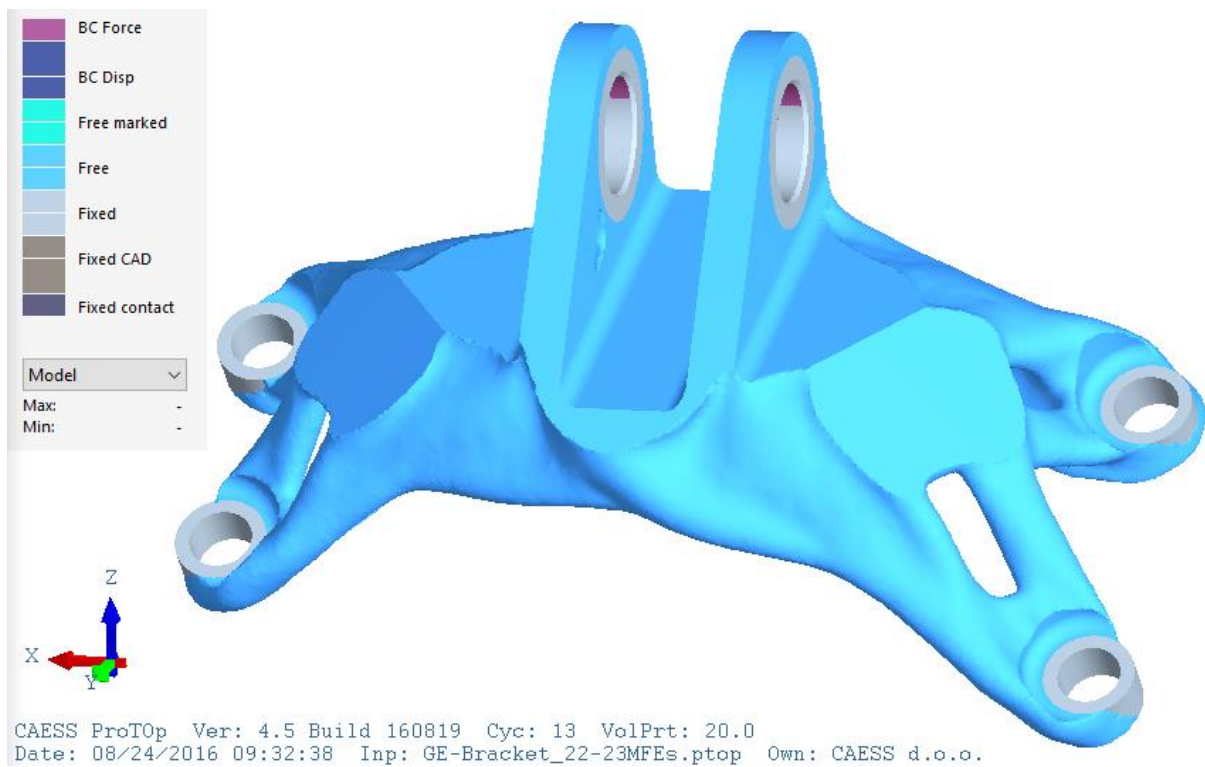
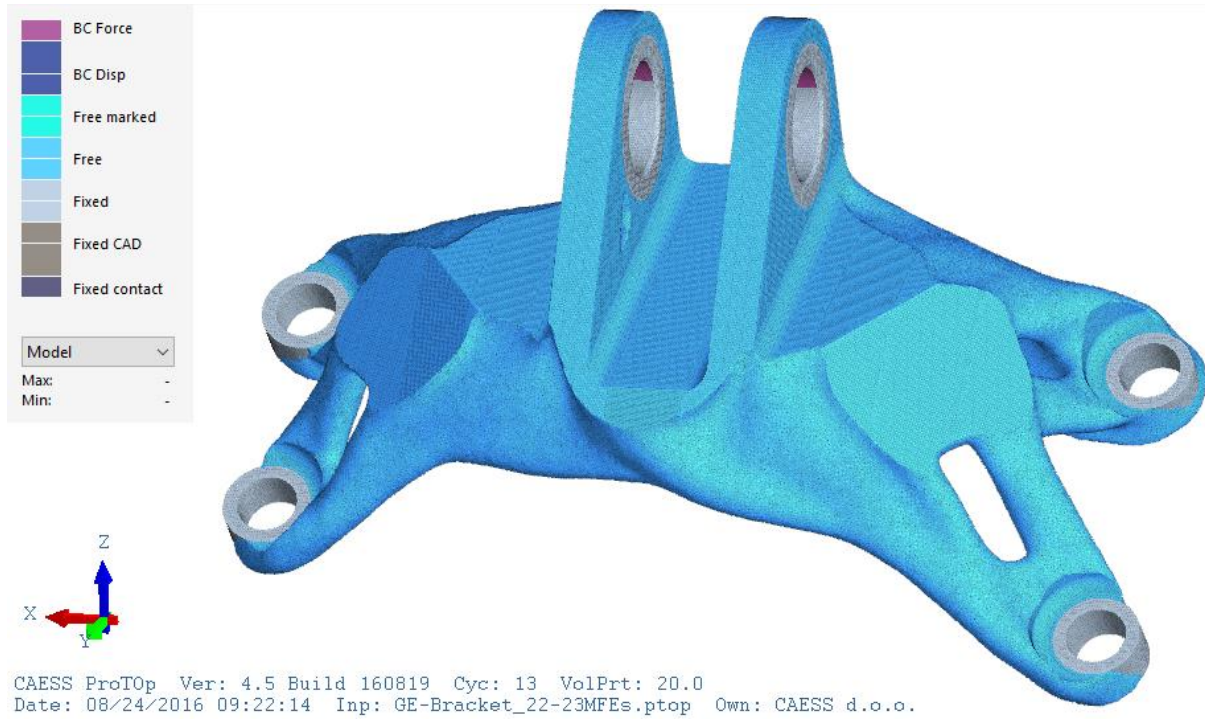
- strain energies (SEner)
- boundary (cut) surface stress measures (BStress)
- max displacements (MaxU)

for individual load cases:

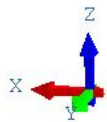
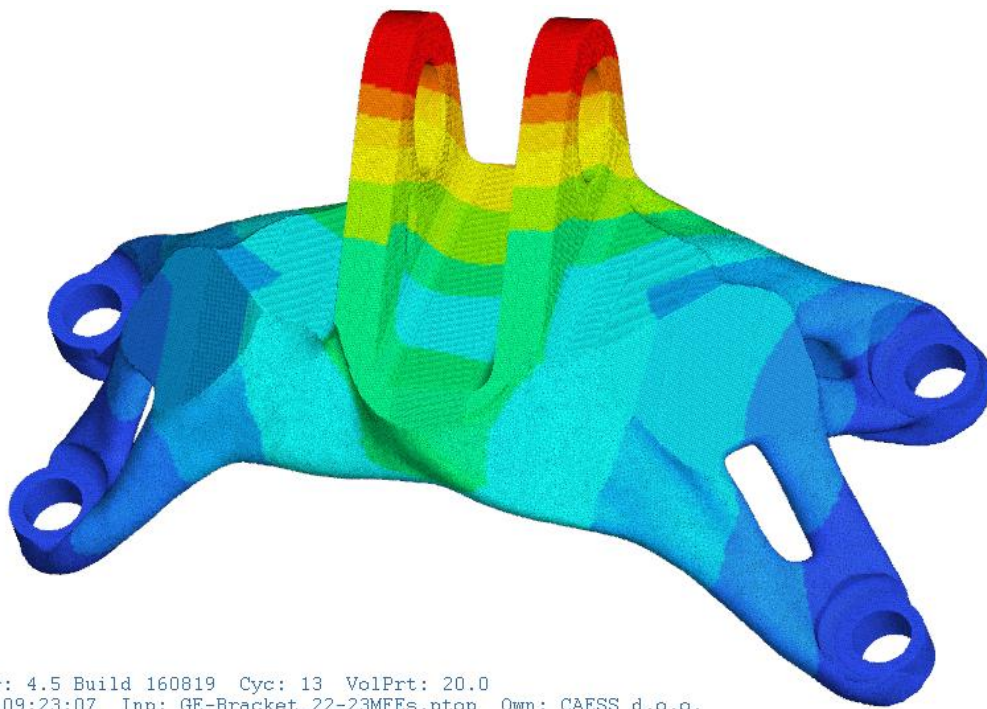
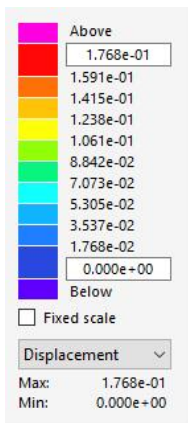
LCaseld	SEner	BStress	MaxU	EigFrq	ImpFac
1	633.6297	34.82046	0.155547		0.3211
2	508.233	35.17364	0.1350108		0.322
3	470.6956	30.95276	0.09489123		0.0994
4	681.7607	31.38695	0.110263		0.2576

## Final model

### Model view

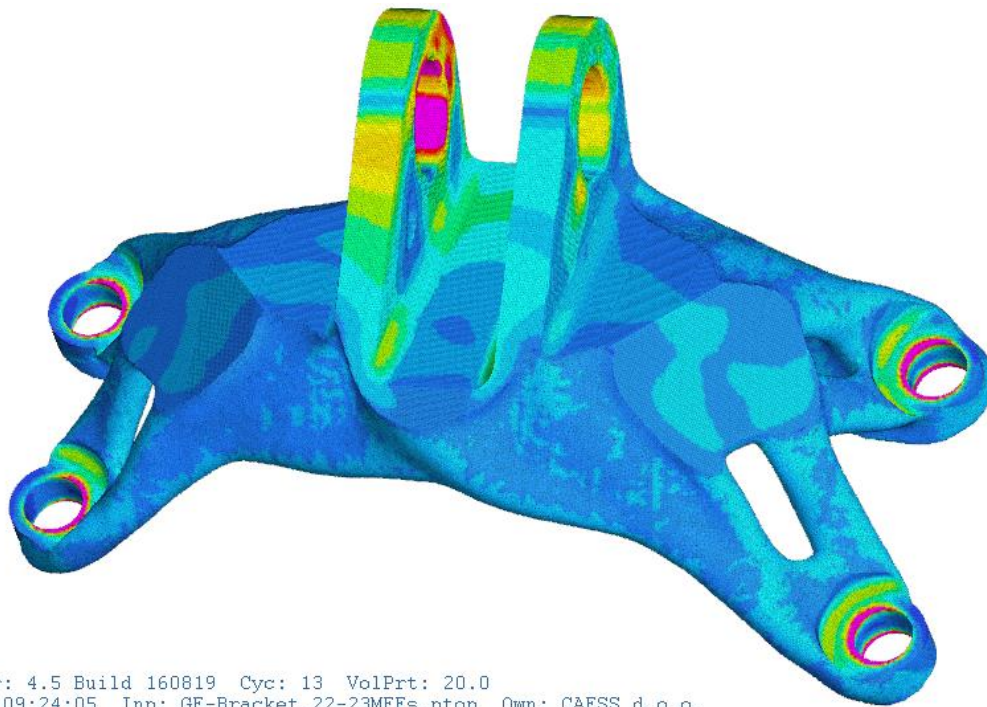
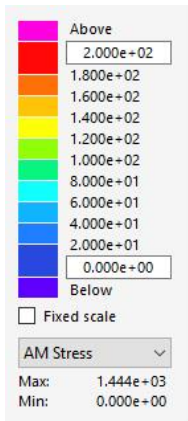


## Displacements

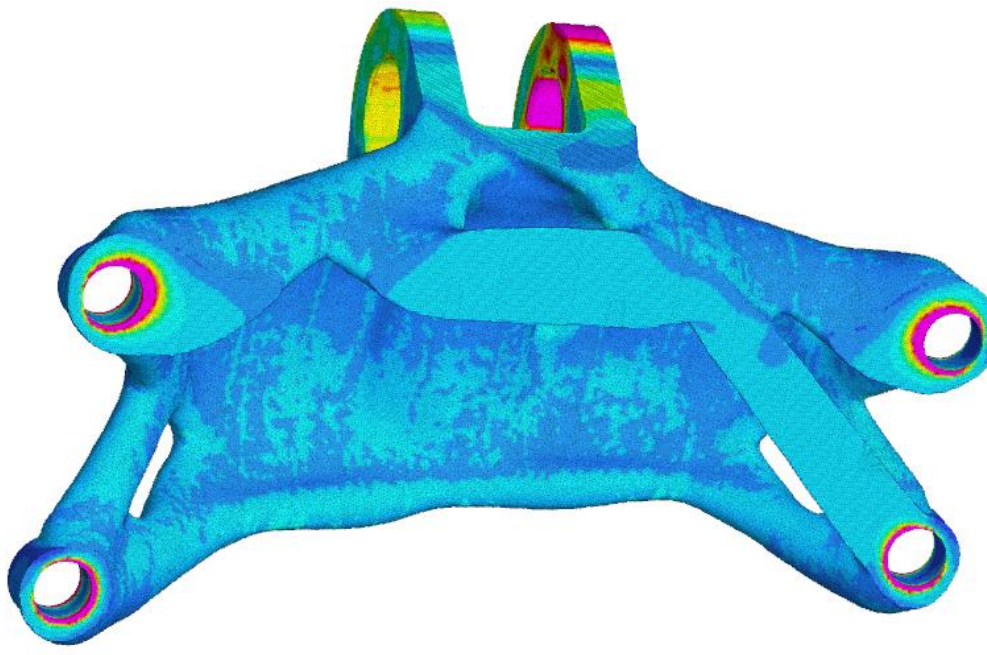
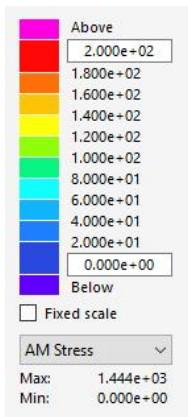


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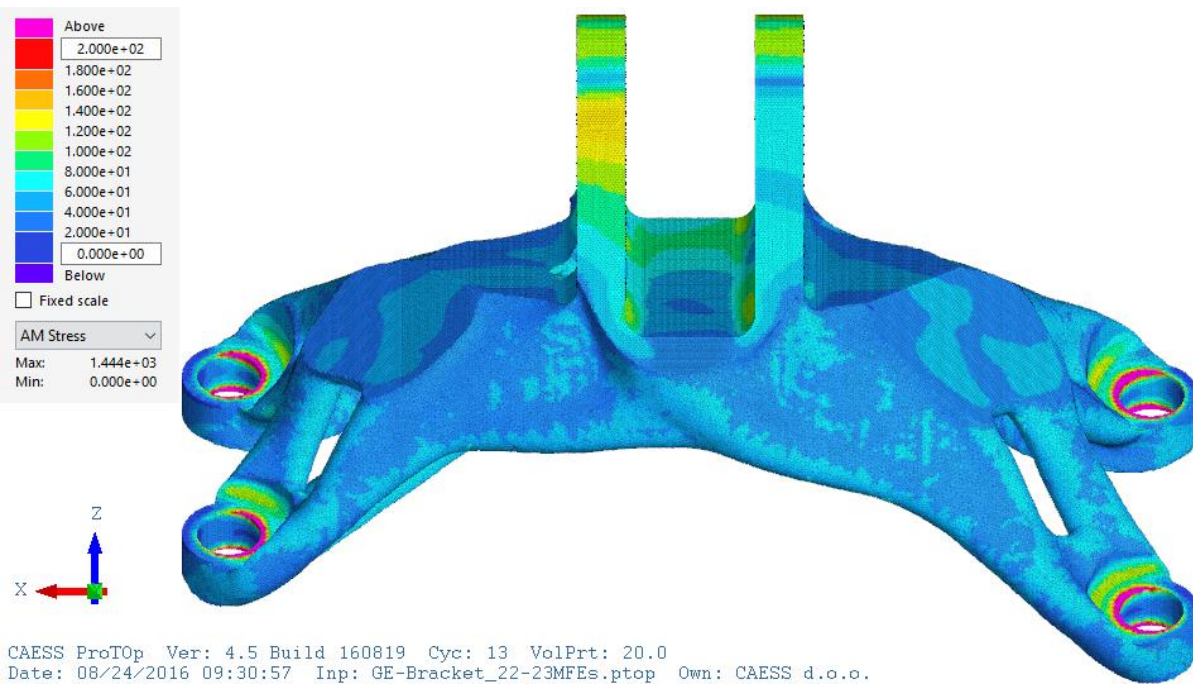
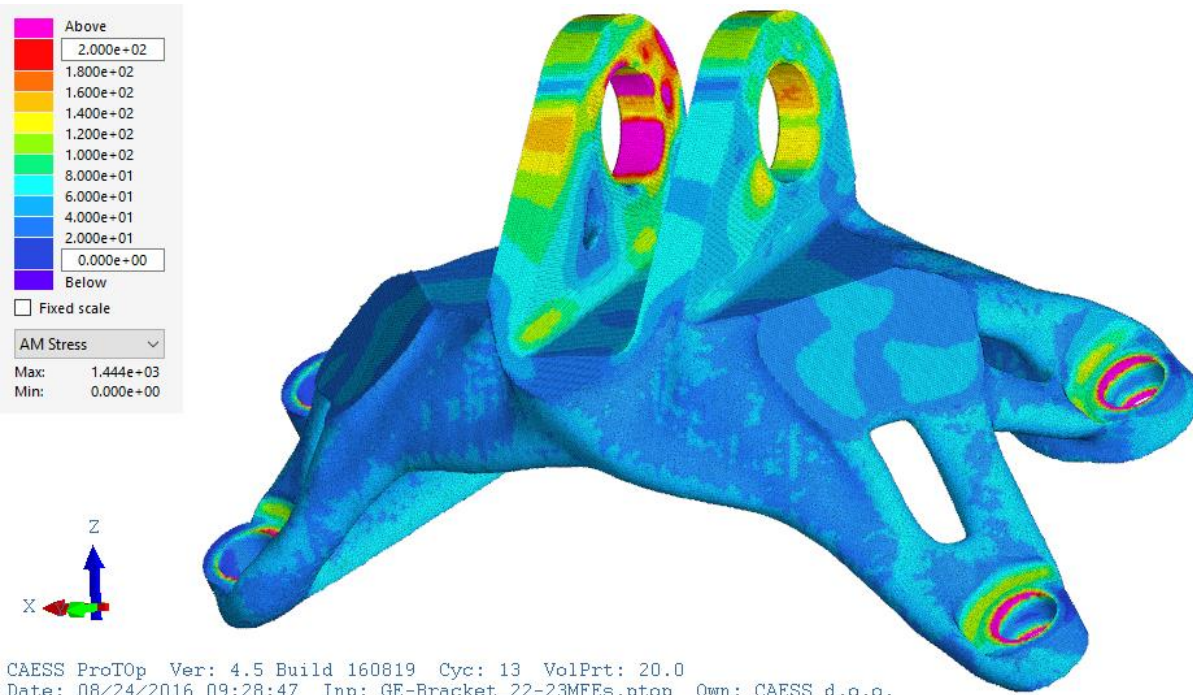
## Stress levels

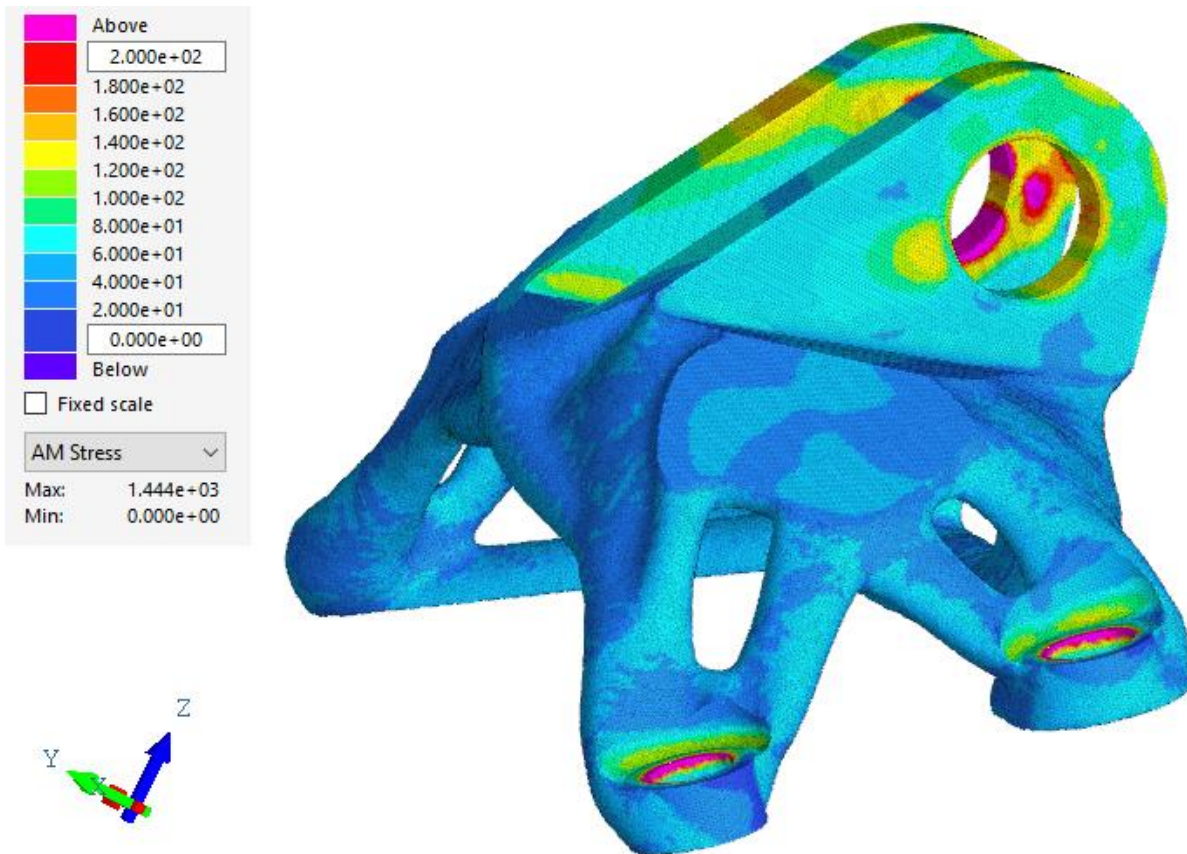


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