CB400F Stress Analysis

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1. Introduction

Summarize the FEM analysis on Stock CB400 FEA

The goal of this analysis was to:

1. Establish a baseline stiffness by analysing a stock CB400F frame

2. Determine the most efficient manner to stiffen a stock frame

3. Look at some alternate designs;
a) My Existing "Egli" style large backbone frame
b) A new perimeter tube frame using formed sheet spar panels
c) A perimeter tube frame using triangulated tube spars

Note:

Do not base your design decisions solely on the data presented in this report. Use this information in conjunction with experimental data and practical experience. Field testing is mandatory to validate your final design. COSMOSWorks helps you reduce your time-to-market by reducing but not eliminating field tests.

2. Description

Loads and Restraints - See Appendix for load calculations

Braking

Restraints - The two swingarm pivot faces were considered fixed.

Loads - 1. A normal force of 8400 lbs pushing rearward on the bottom steering head bearing race.
2. A normal force of 8400 lbs pushing forward on the top steering head bearing race.
3. A normal force of 1200 lbs pushing upward on the bottom steering head bearing race.

Torsion

Restraints - The two swingarm pivot faces were considered fixed.

Loads - 1. A normal force of 5000 lbs pushing sideways on the bottom steering head bearing race.
2. A normal force of 5000 lbs pushing sideways (opposite to load 1) on the top steering head bearing race.
3. A normal force of 1200 lbs pushing upward on the bottom steering head bearing race.

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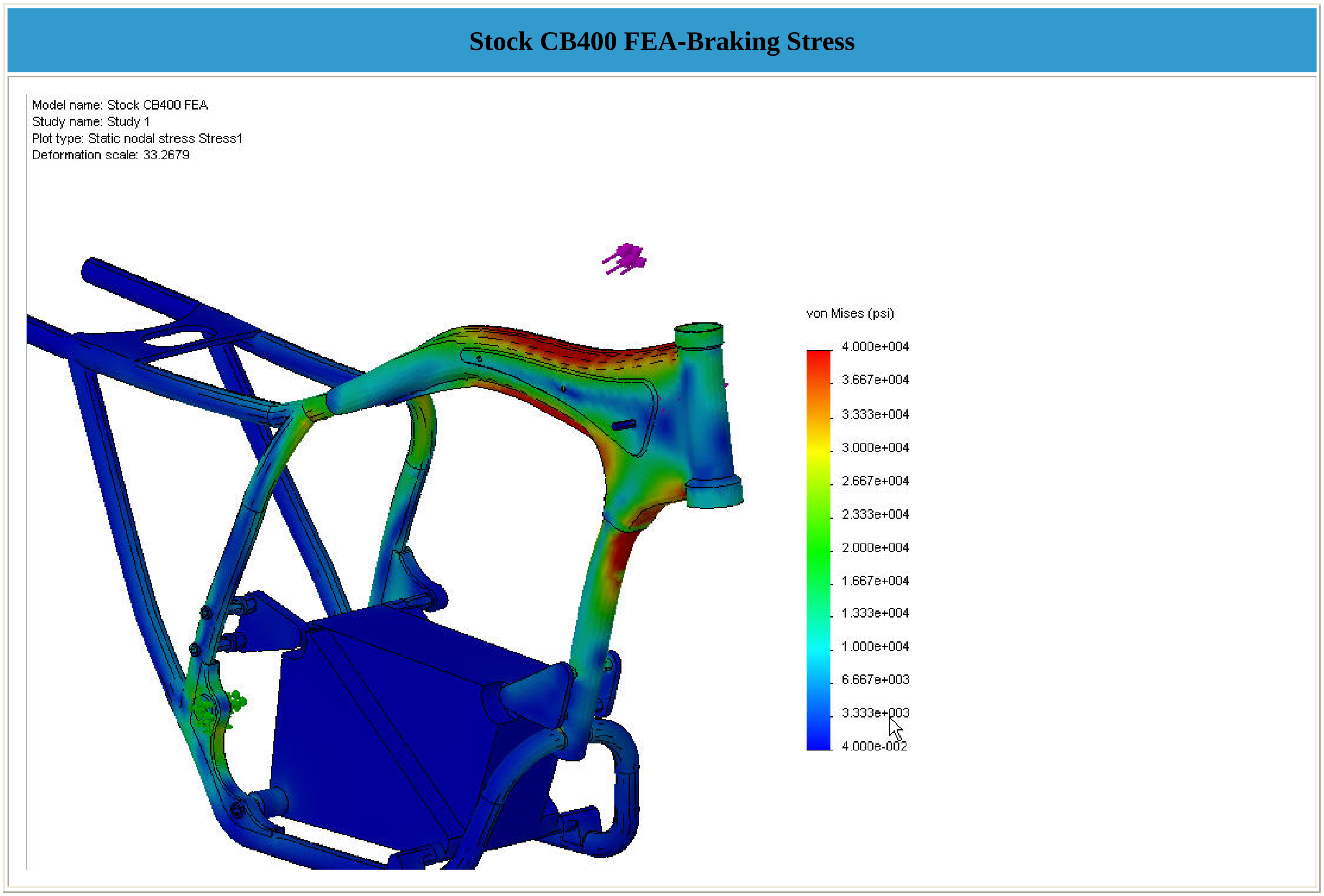
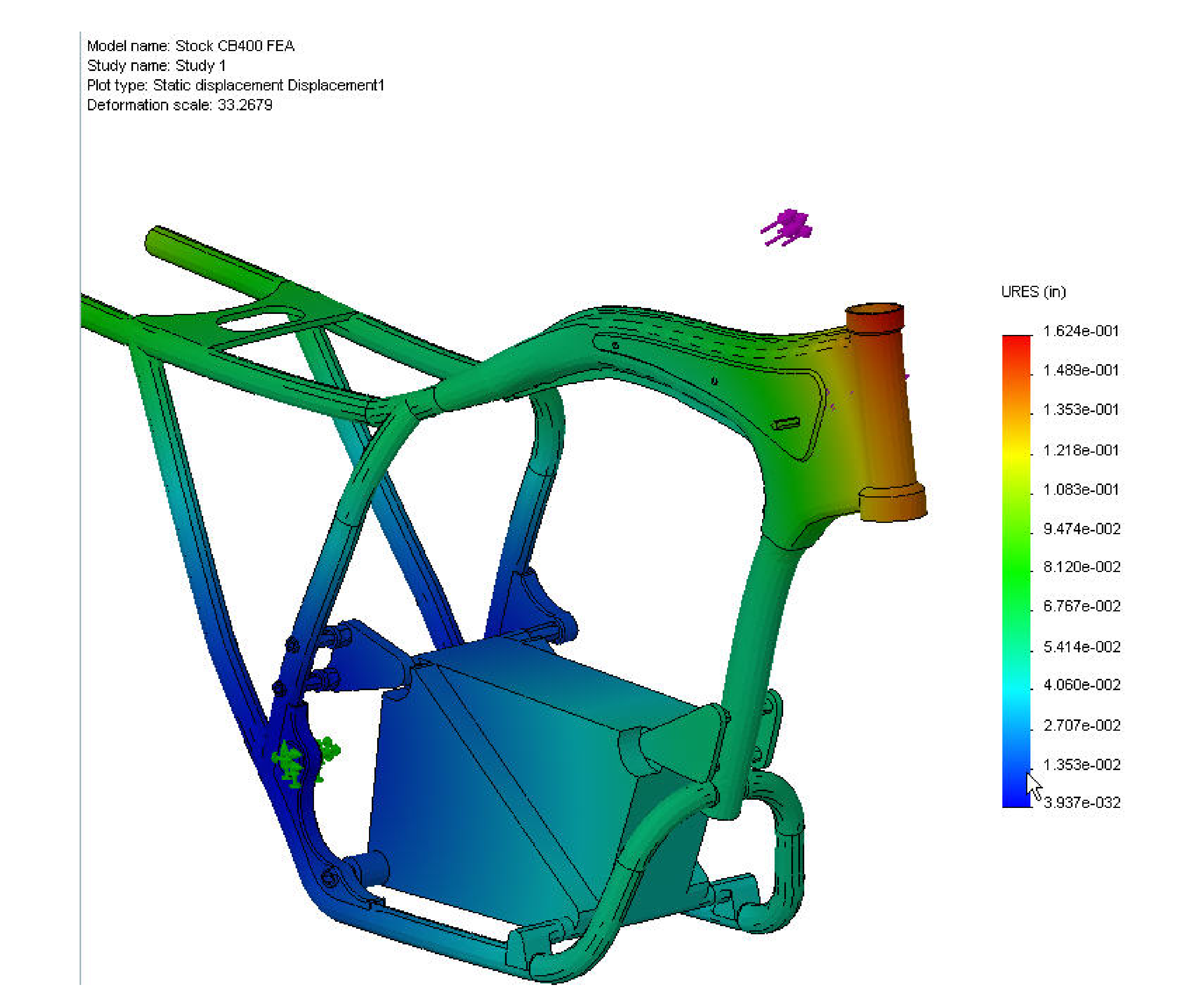
3. Materials

All steel material set to AISI 1020 Mild Steel. All aluminum material set to 6061-T6

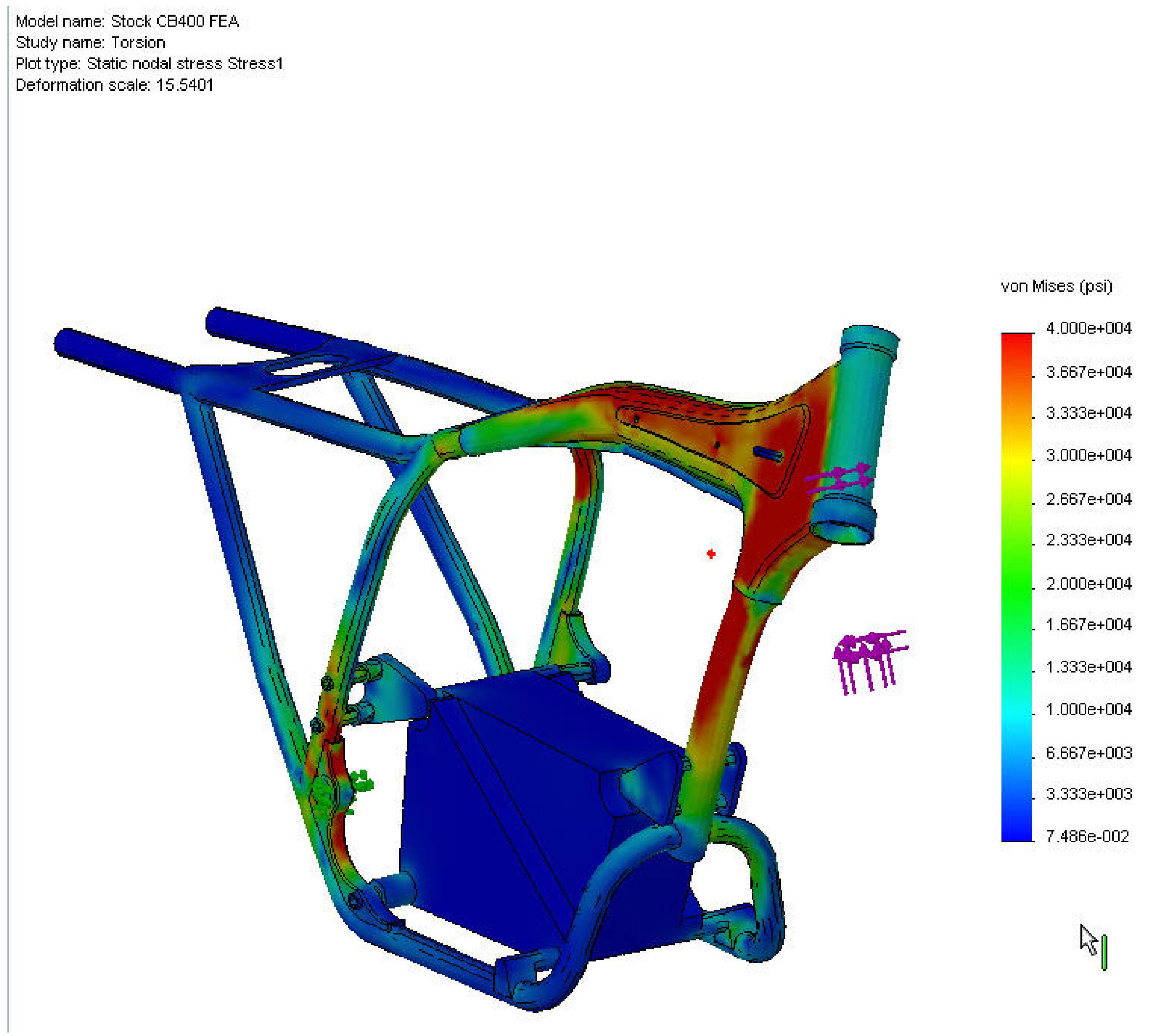
4-A. Results – Stock CB400F Frame



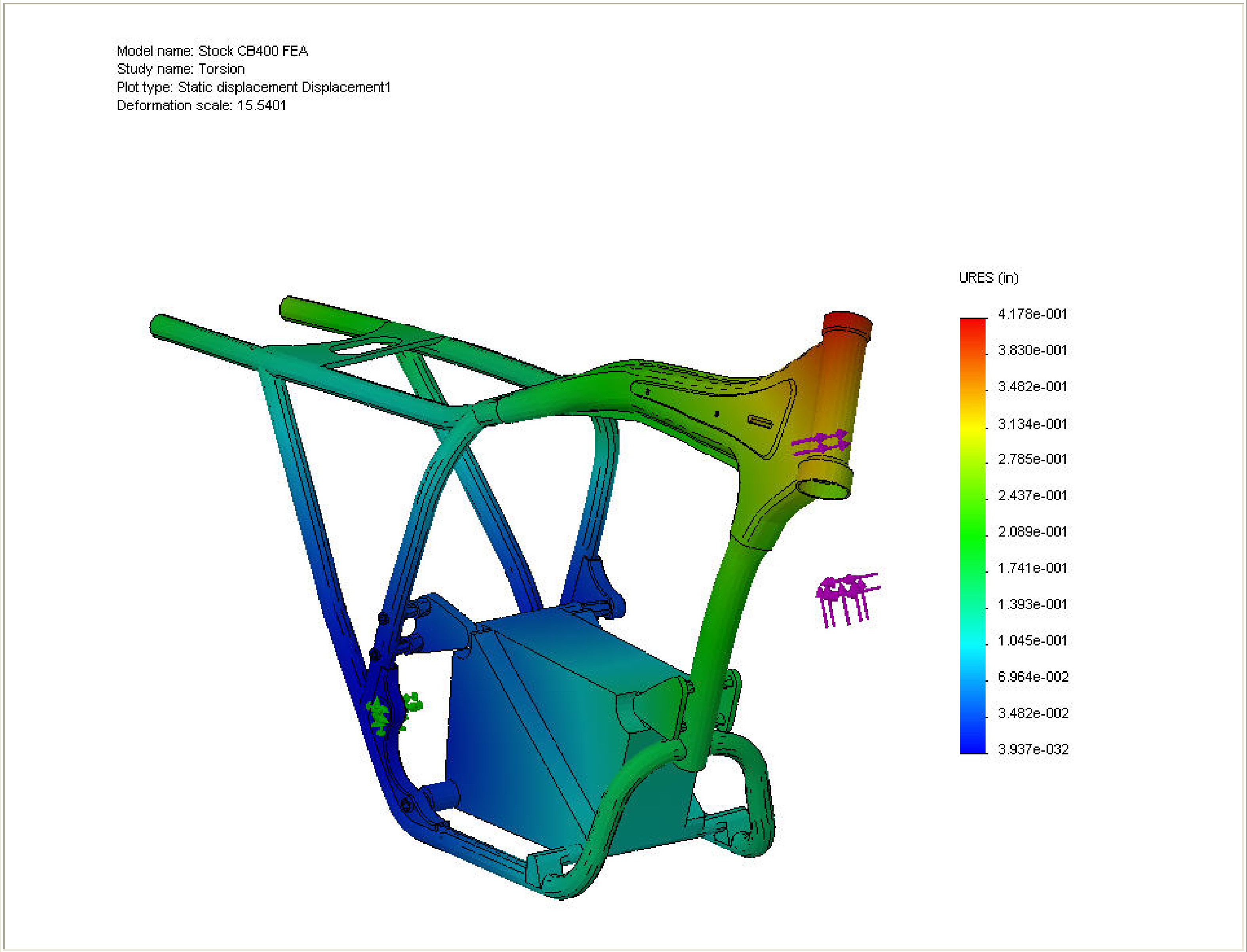
Stock CB400 FEA-Braking-Displacement



Stock CB400 FEA-Torsion Stress



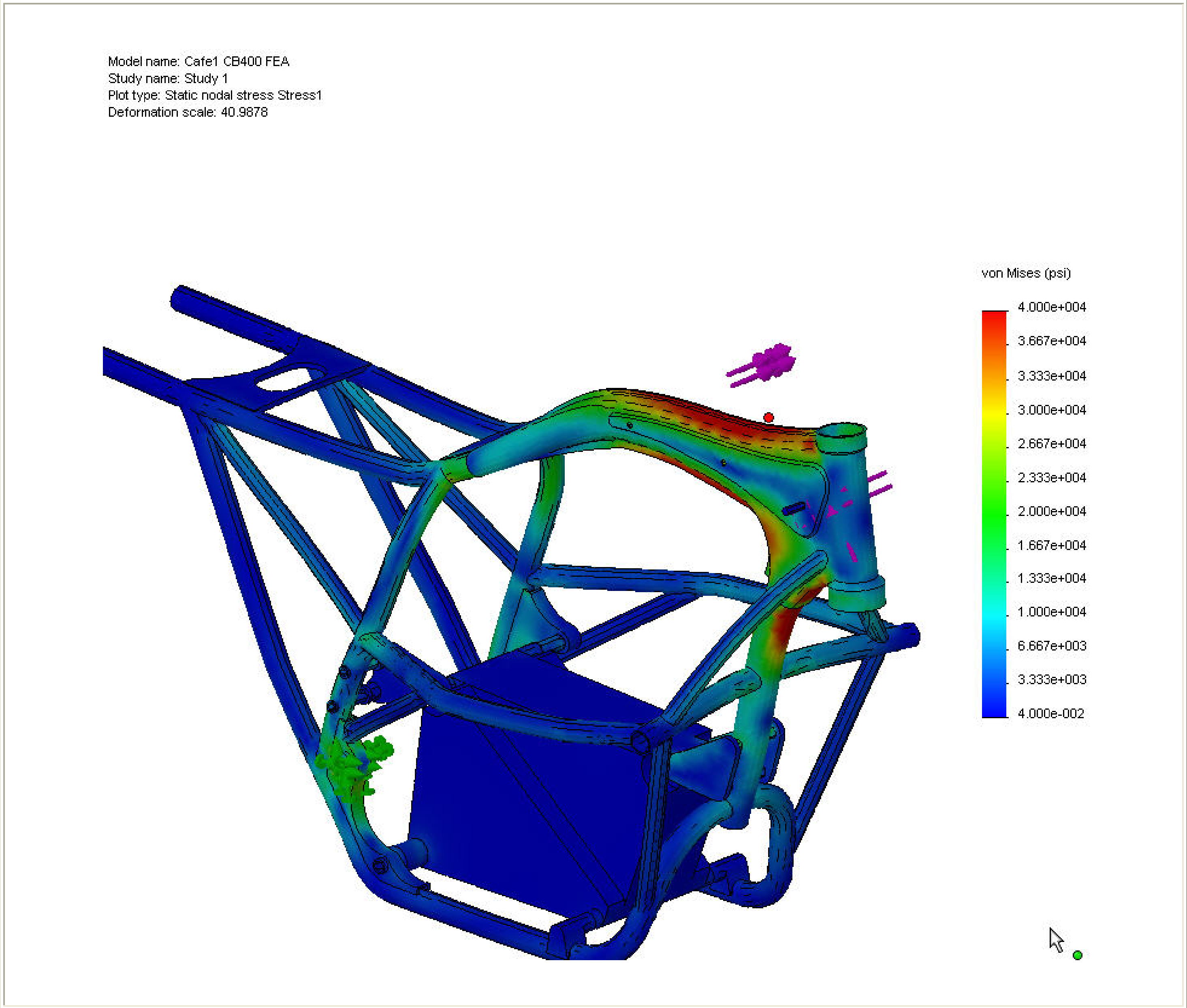
Stock CB400 FEA-Torsion-Displacement



The initial test indicated that the stock frame was relatively stiff in braking, but not so good in torsion. Step 1 was to have a look at stiffening the stock frame.

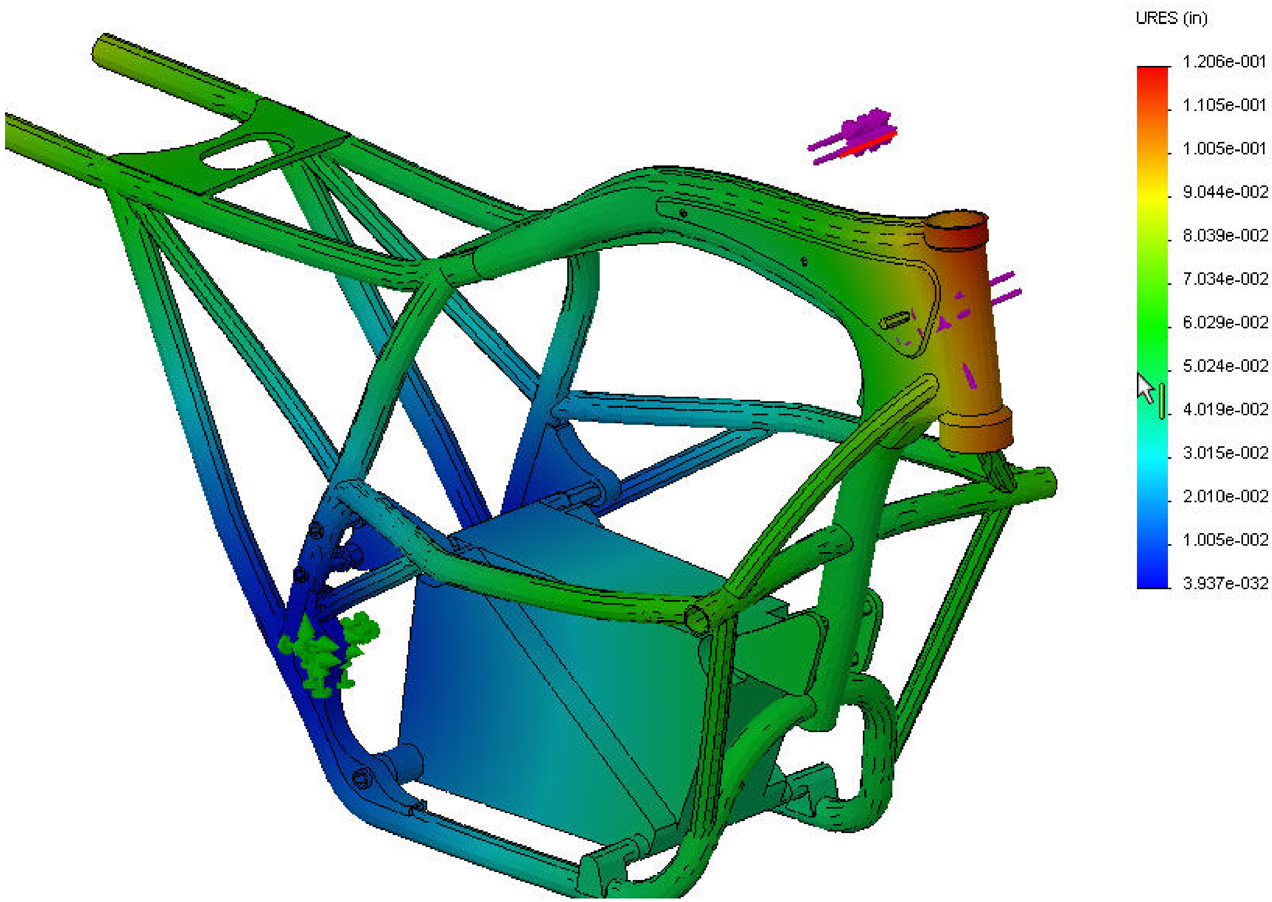
4-B. Results – Cafe1 – Stiffened Frame

Cafe1 FEA-Braking-Stress

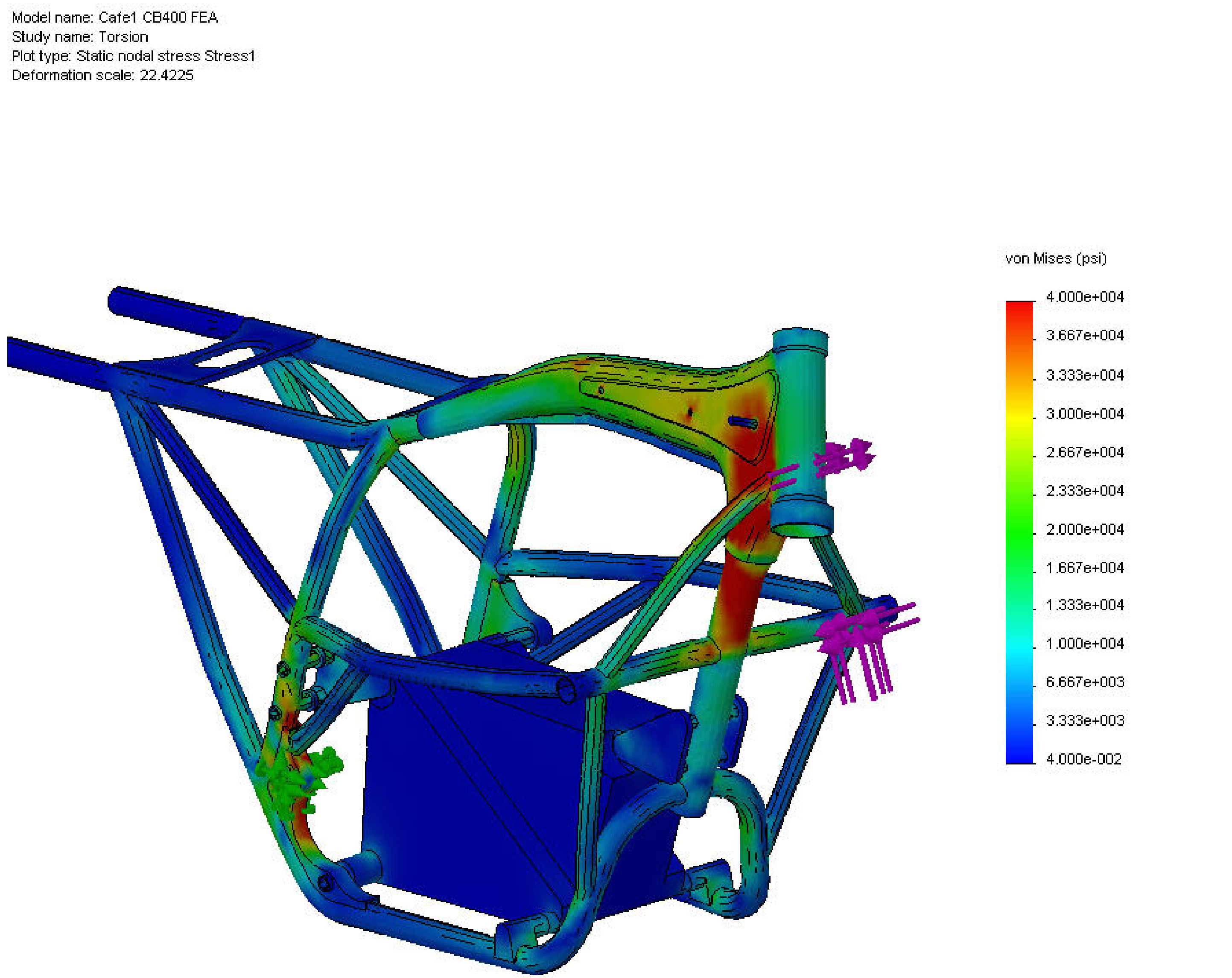


Cafe1 FEA-Braking-Displacement

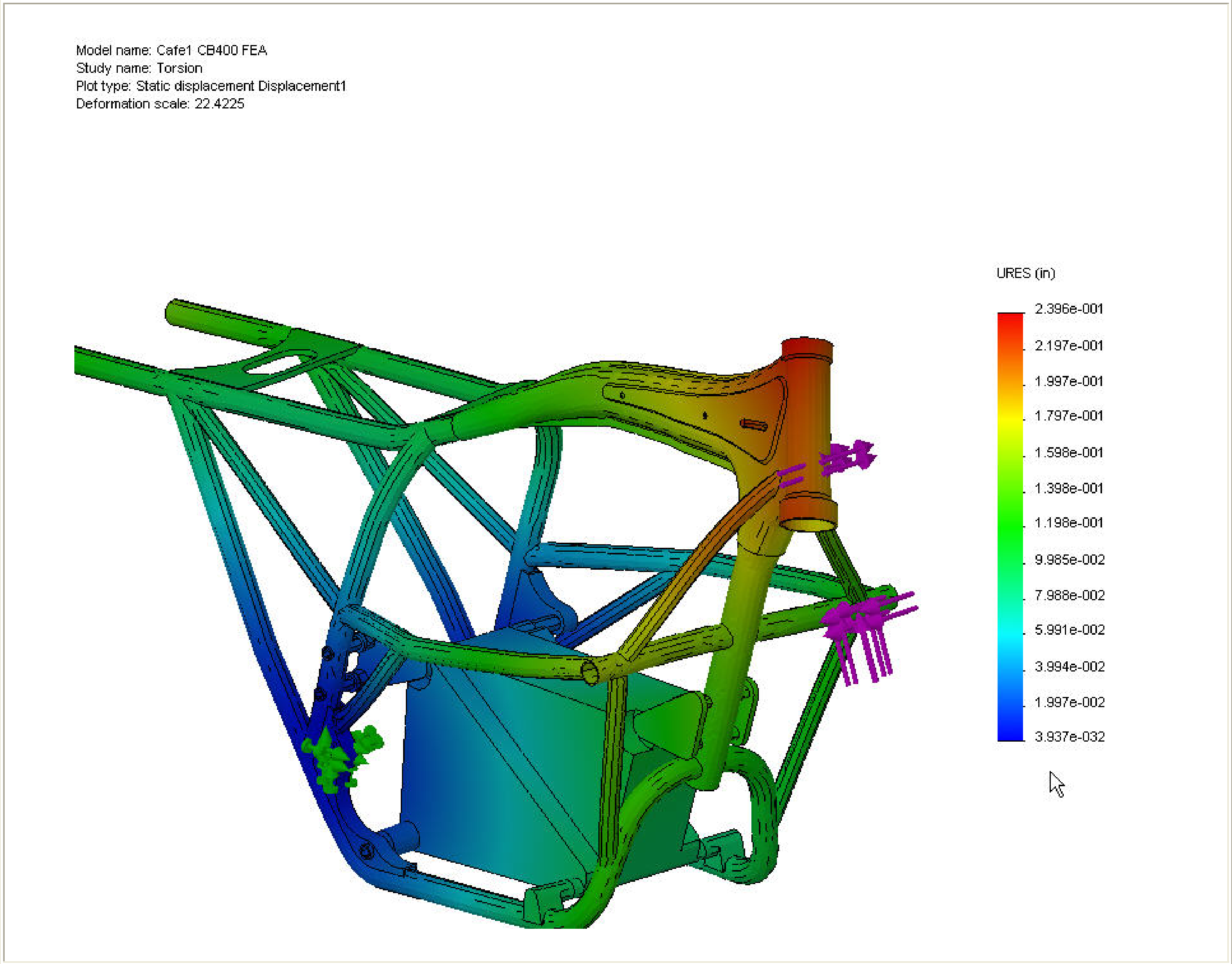
Model name: Cafe1 CB400 FEA
Study name: Study 1
Plot type: Static displacement Displacement1
Deformation scale: 40.9878



Cafe1 FEA-Torsion Stress



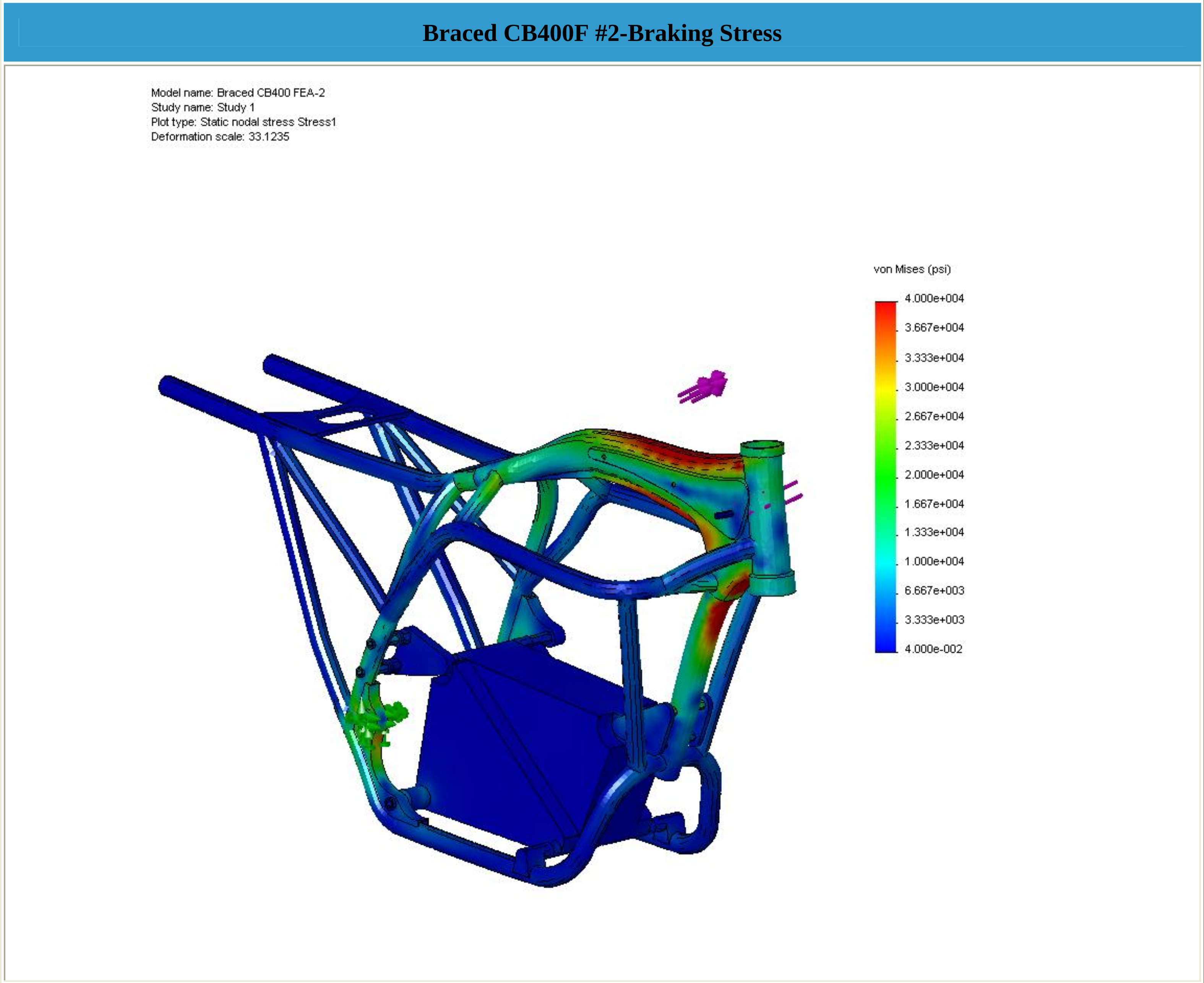
Cafe1 FEA-Torsion Displacement



The braking displacement was cut from 0.16” to 0.12”, and the torsion displacement was decreased from 0.41” to 0.24”. I think that to drastically improve the frame stiffness would require diagonal bracing from just above the swingarm pivot to the steering head. This would not work with the stock gas tank.

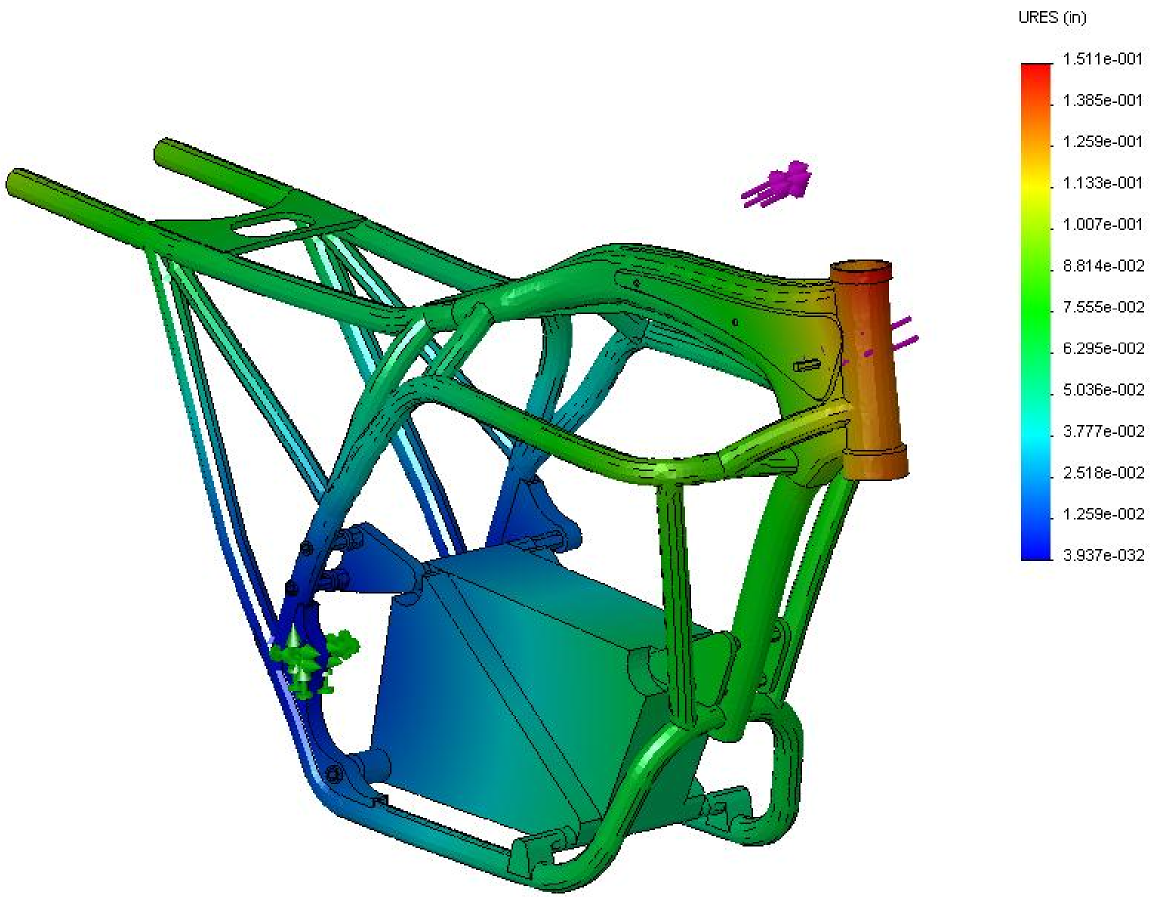
4-C. Results – Café Bracing #2

I had a look at the braced framed that Team Hansen was running on their Hailwood replicas and modeled a variant of that.



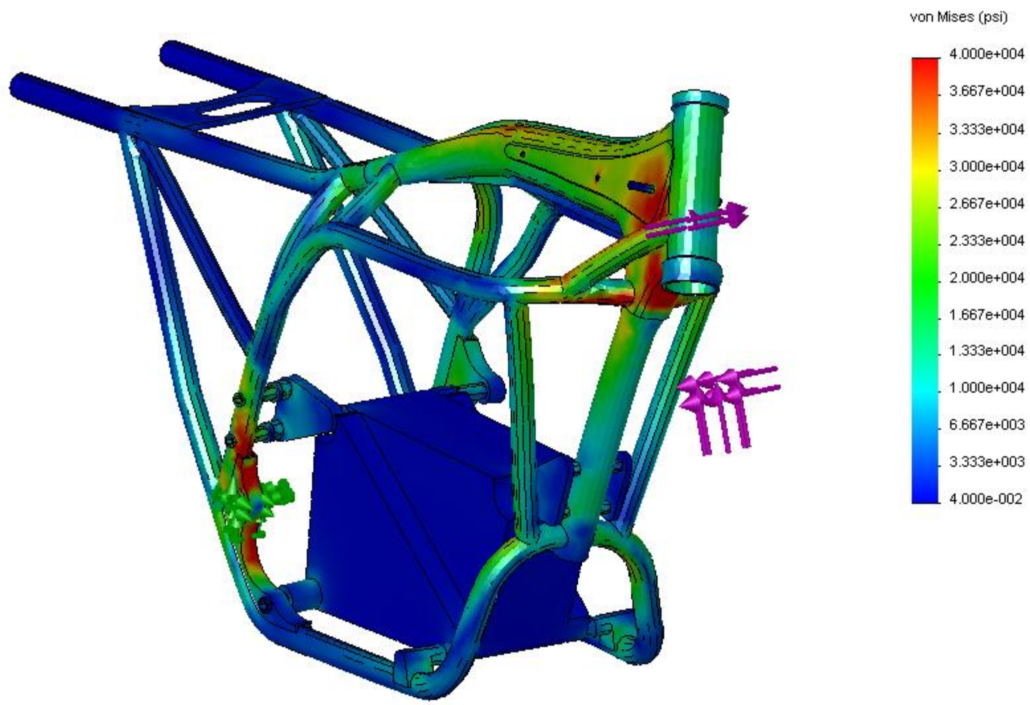
Braced CB400F #2-Braking Disp

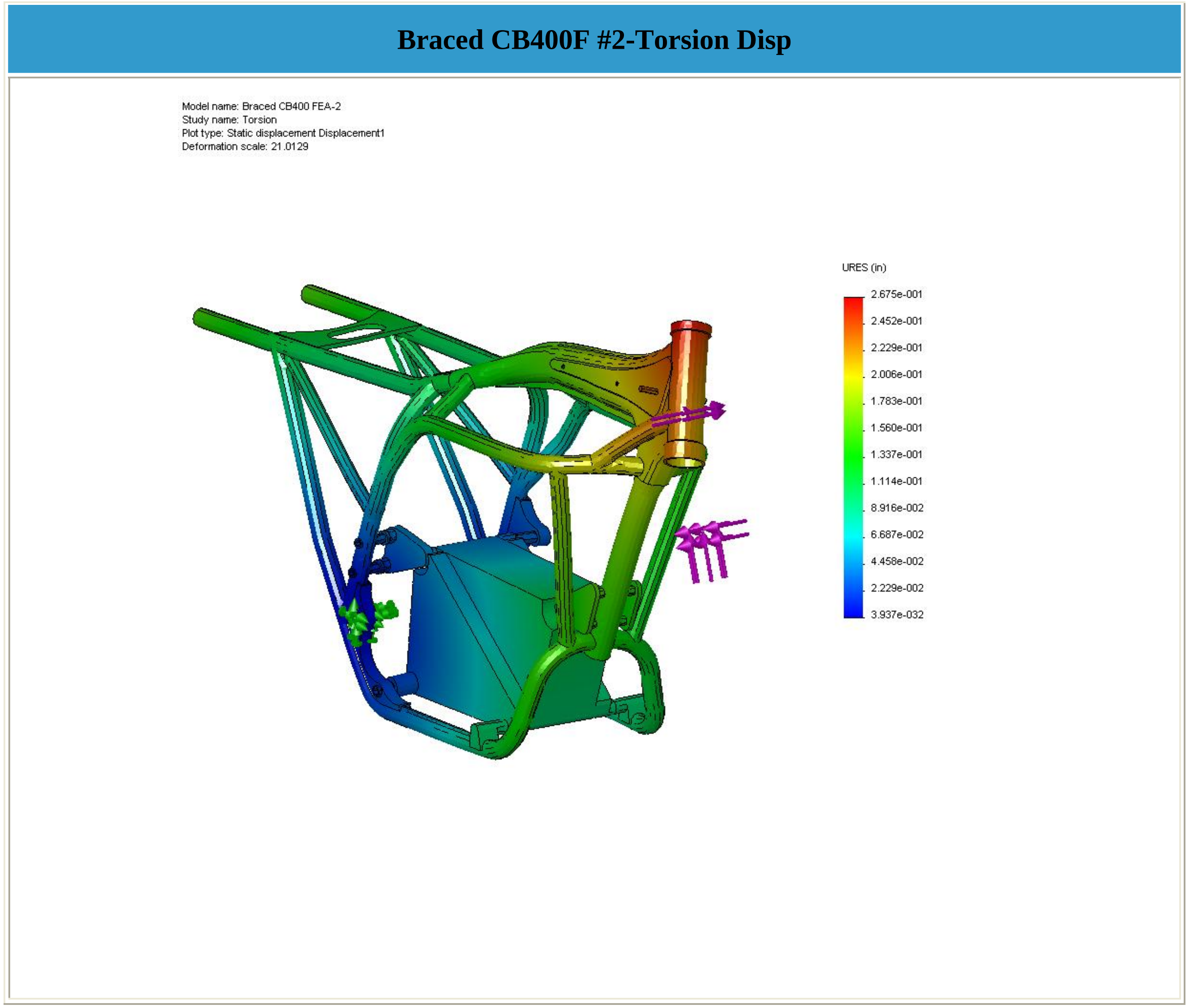
Model name: Braced CB400 FEA-2
Study name: Study 1
Plot type: Static displacement Displacement1
Deformation scale: 33.1235



Braced CB400F #2-Torsion Stress

Model name: Braced CB400 FEA-2
Study name: Torsion
Plot type: Static nodal stress Stress1
Deformation scale: 21.0129





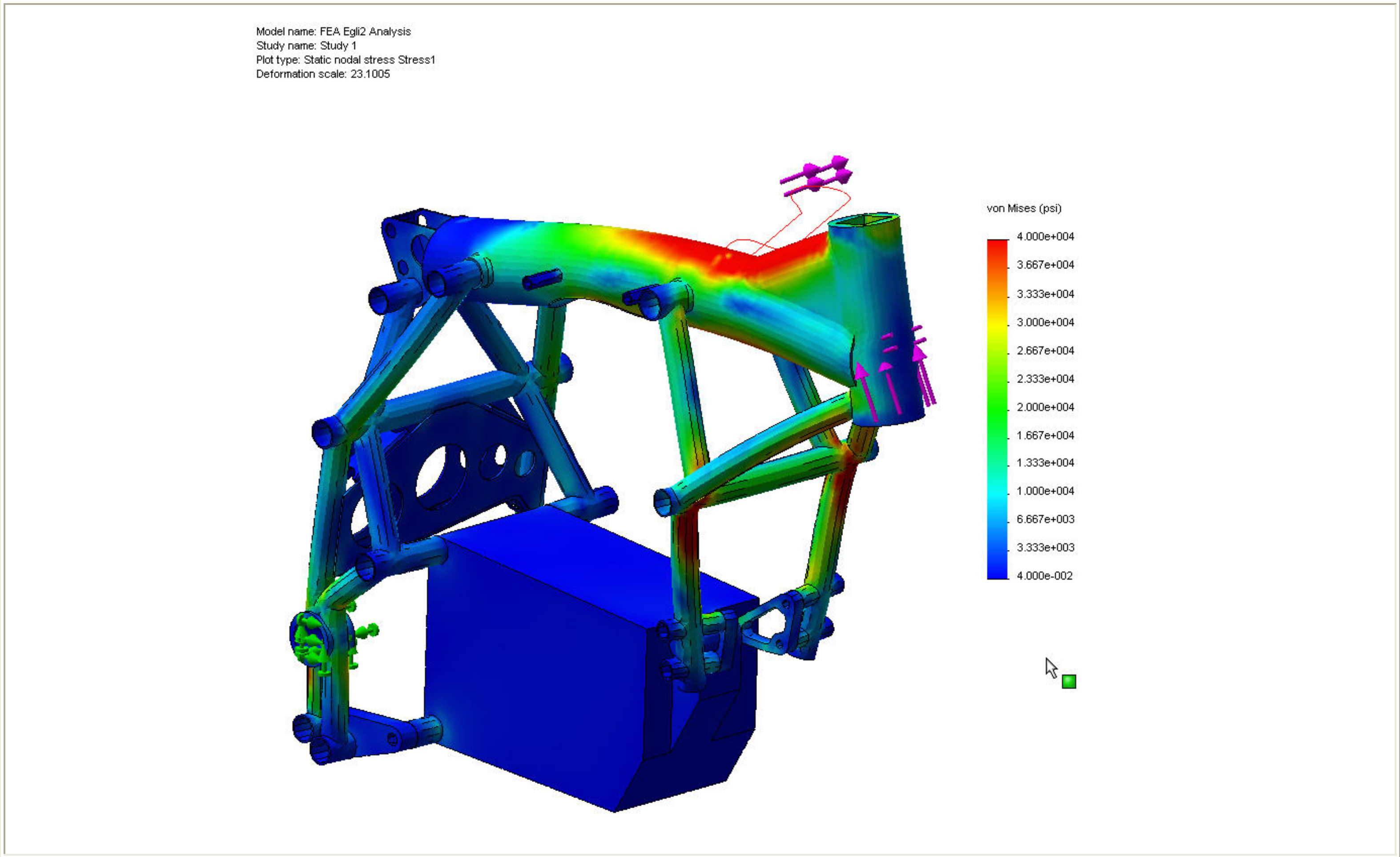
My conclusion from the studies of bracing the stock frame are;

1. It is difficult if not impossible to do a good job of bracing when limited by the stock gas tank.

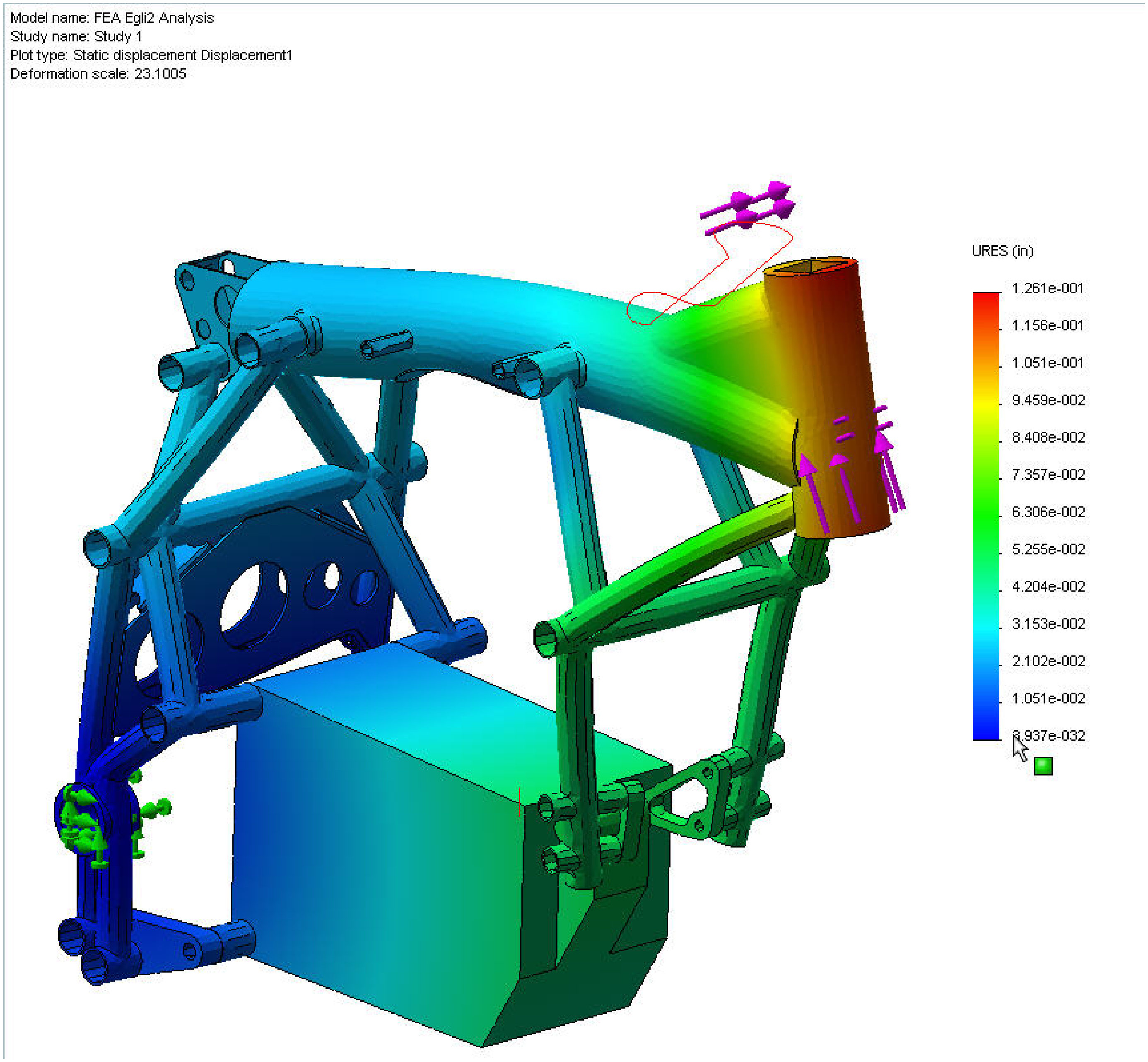
2. I ideally you would run another set of tubes from the horizontal perimeter brace up to the top of the steering head, and possibly another set from the same location on the perimeter brace back toward the middle of the main backbone. Both of these *tubes would interfere with the gas tank, so you would have to gut a stock tank to use the outer skin as a cover, and build a custom tank underneath the cover*

4-D. Results – Egli Style Frame

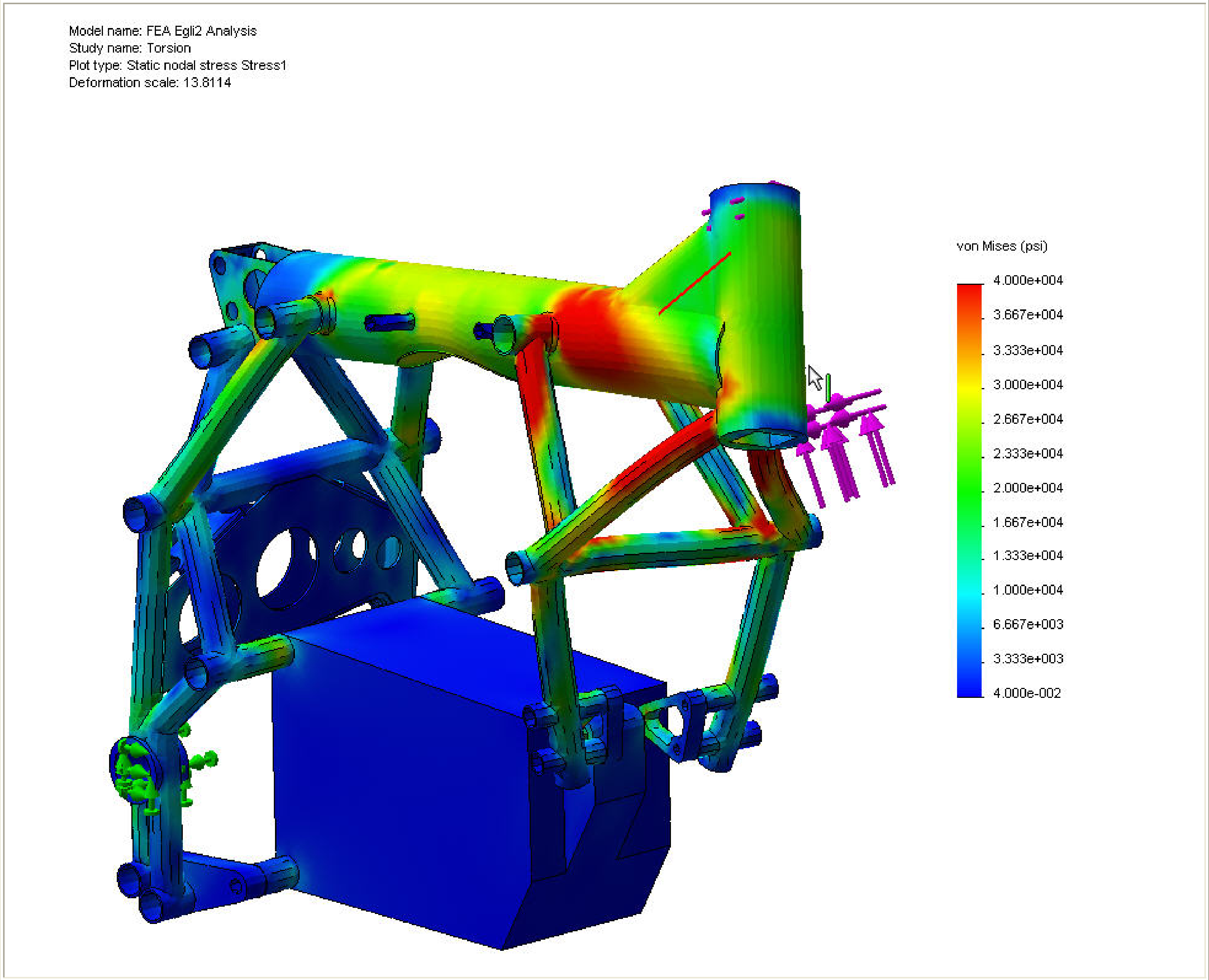
Egl1 FEA-Braking Stress



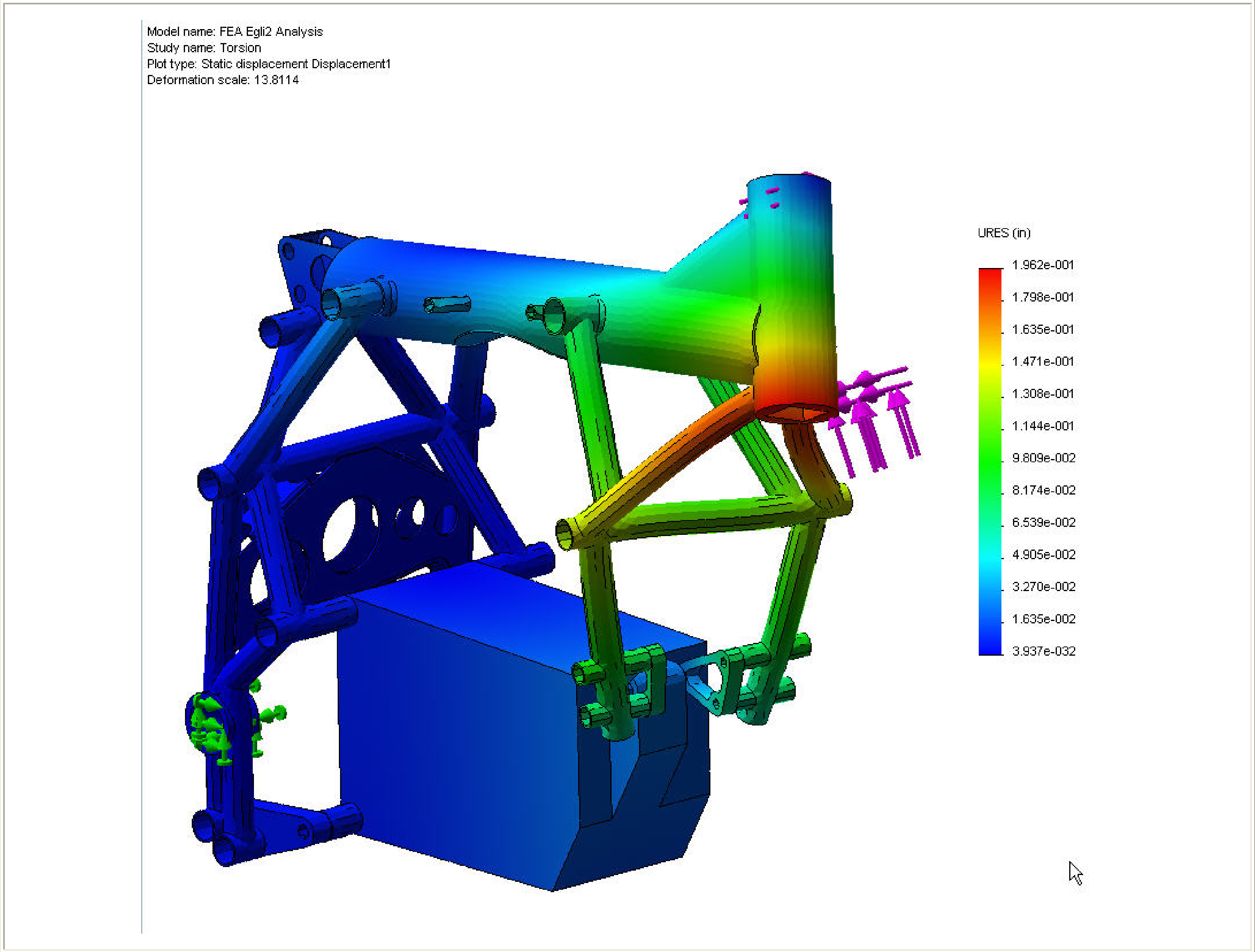
Egli FEA-Braking Displacement



Egli FEA-Torsion Stress



Egli FEA-Torsion Displacement

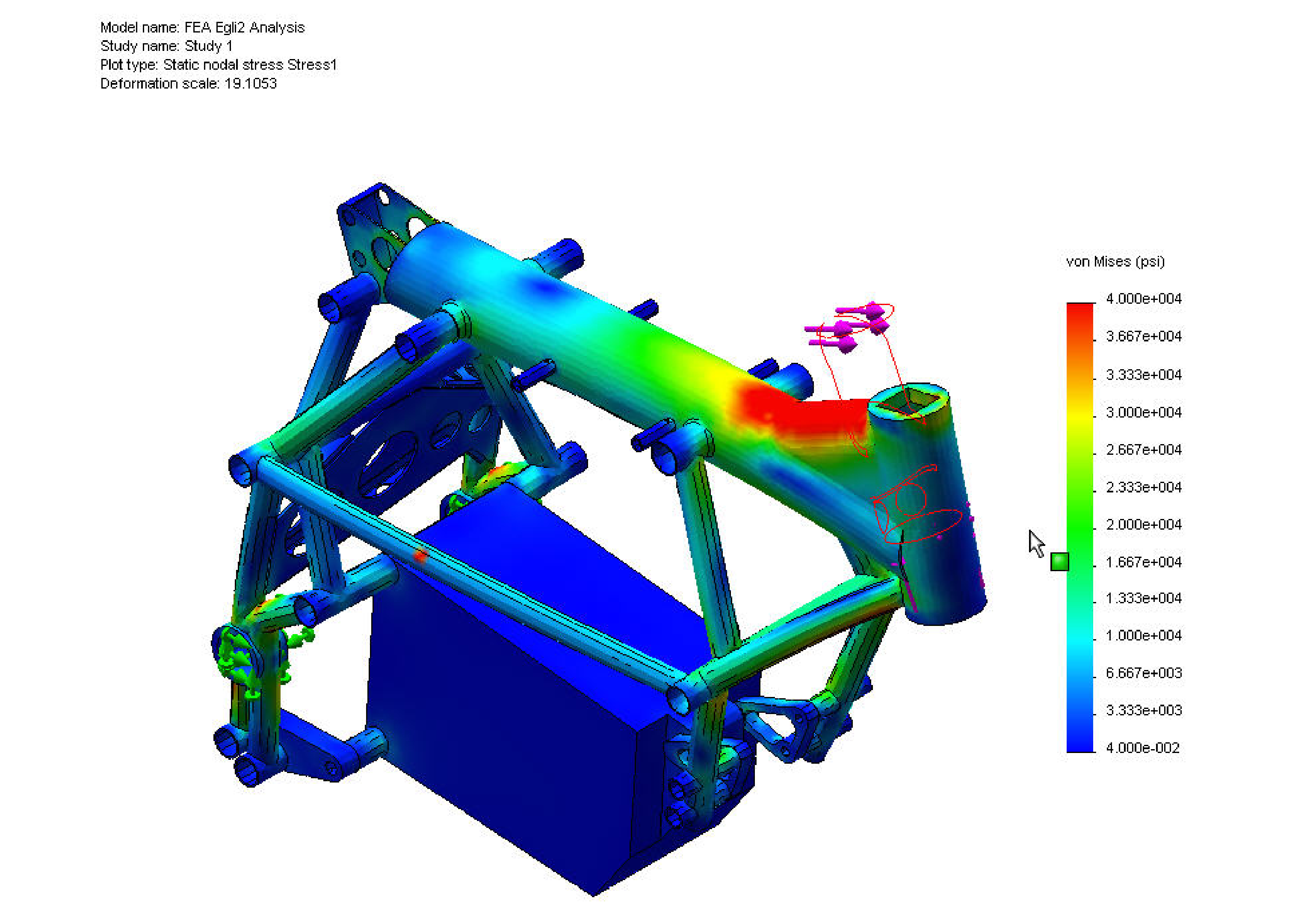


This was the frame that I actually built for my CB400F. At the time I did not do an FEA study. After reviewing the study, I had a look at how I could have improved that frame with a few more tubes.

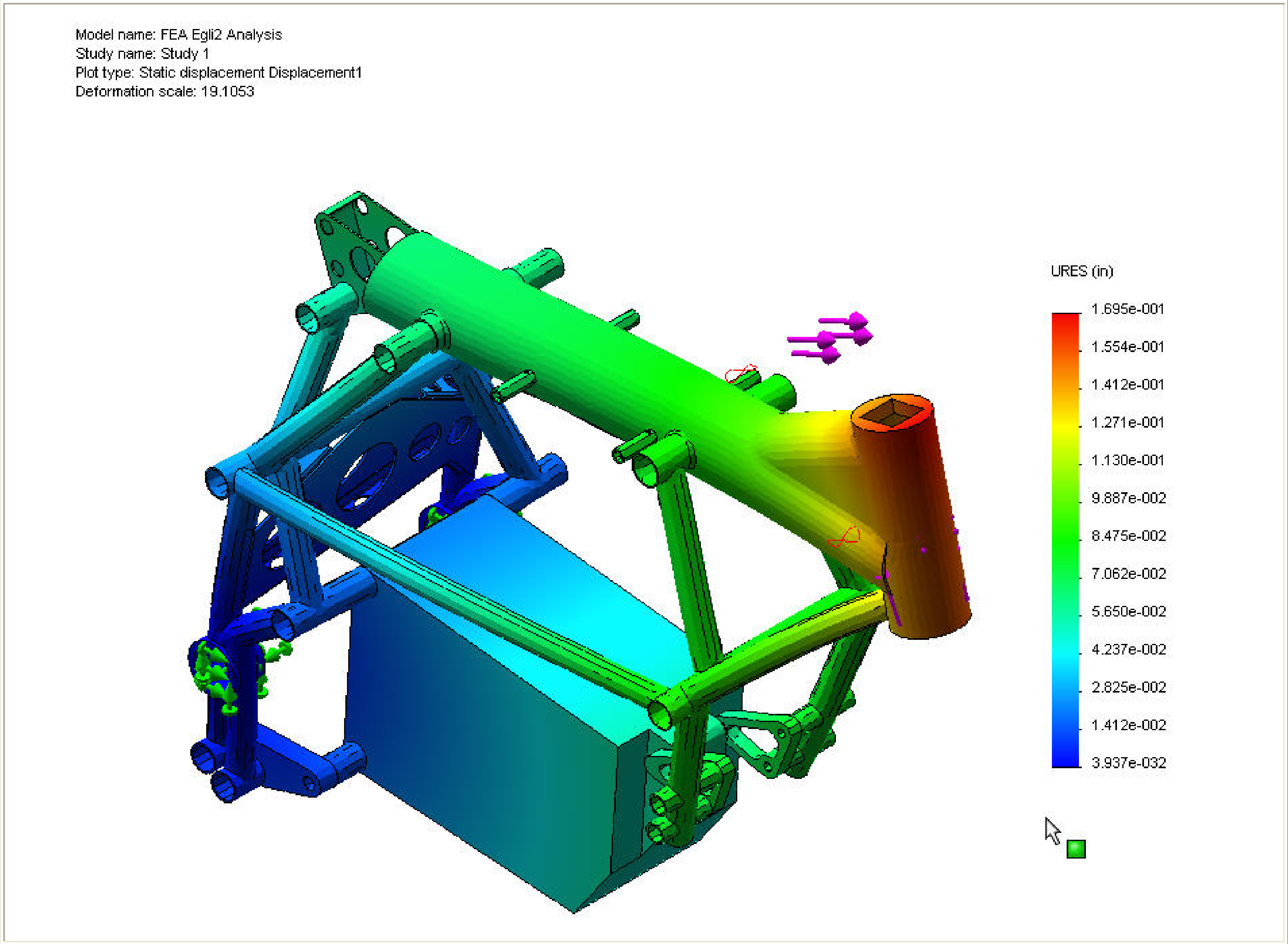
4-E. Results – Egli Braced Frame

Egli Braced FEA-Braking Stress

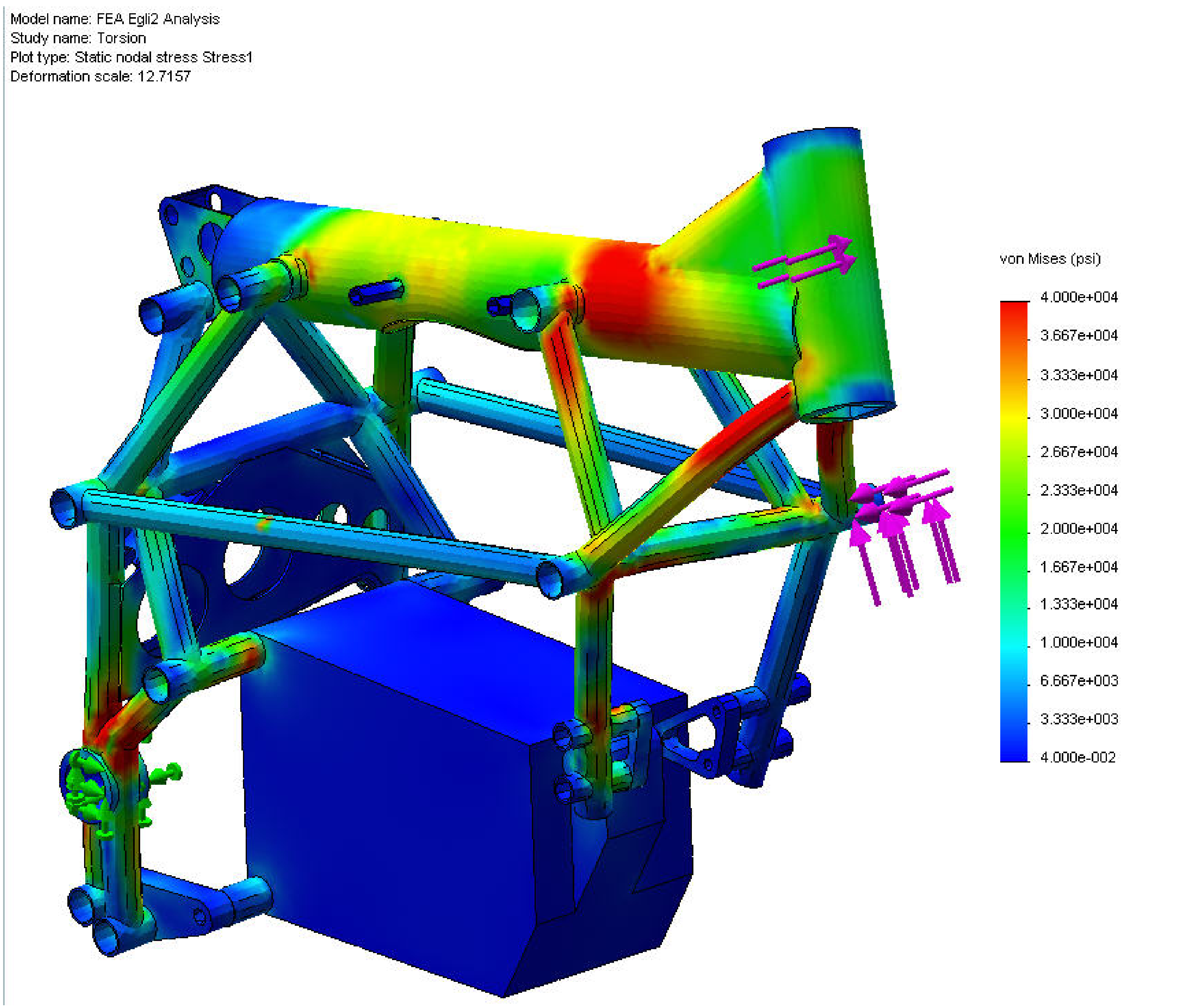
JPEG



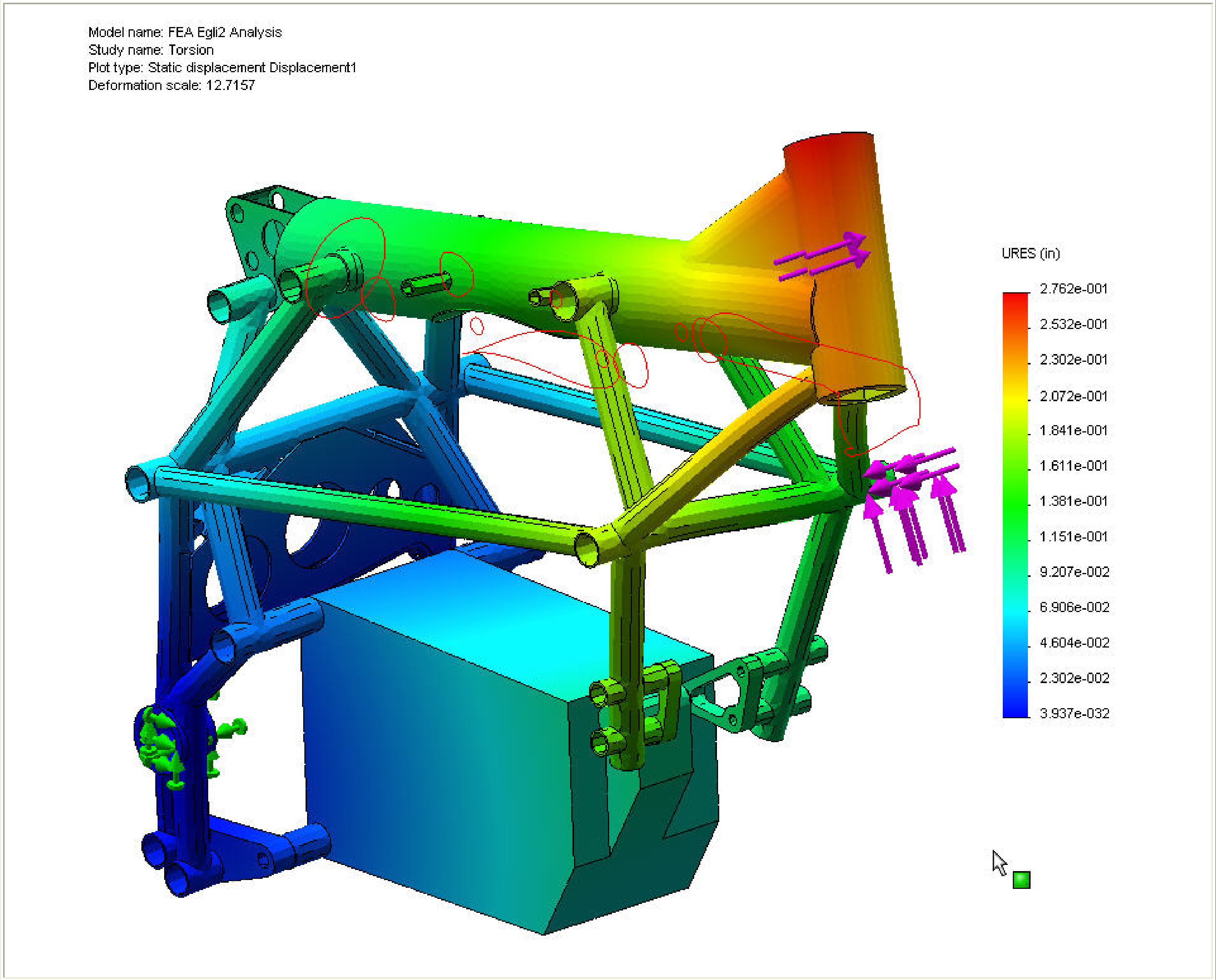
Egli Braced FEA-Braking Displacement



Egli Braced FEA-Torsion Stress



Egli Braced FEA-Torsion Displacement

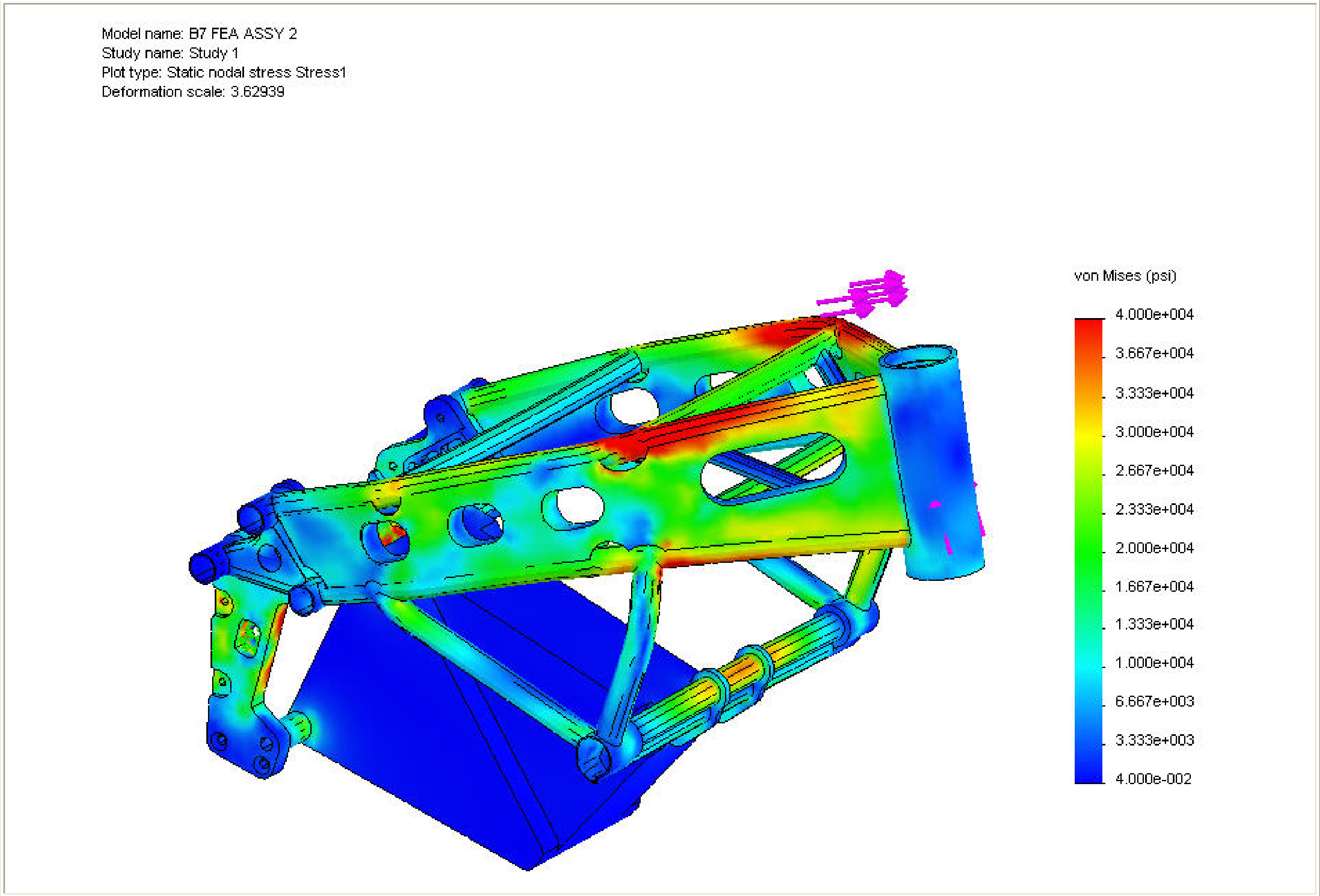


An interesting side effect to notice here is that the extra tubes have stiffened the bottom of the steering head, transferring more force into the upper part of the steering head and actually increased the displacement at the top compared to the frame without the extra bracing.

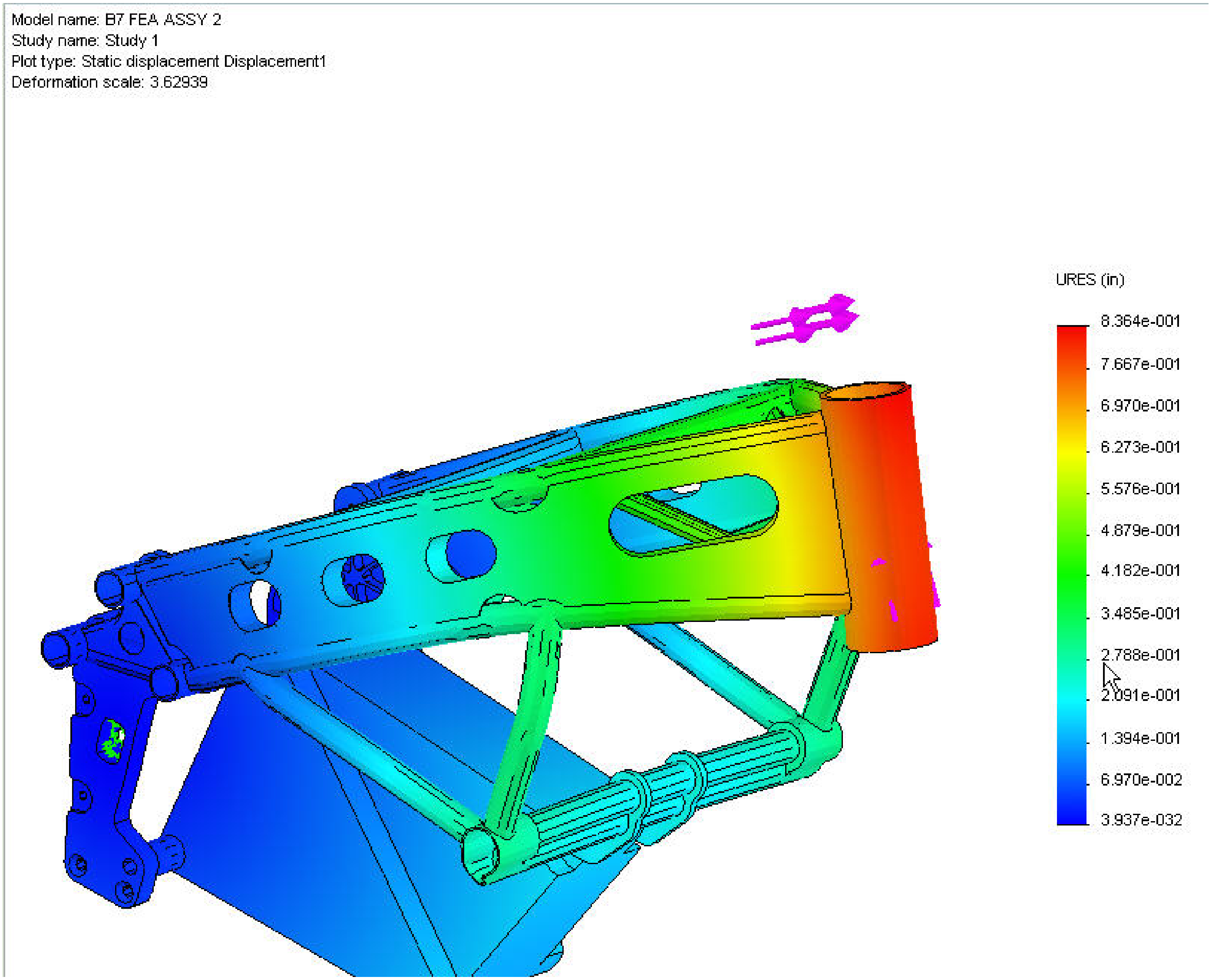
4-F. Results – Bimota

I called this a Bimota style frame because of the aluminum sandwich plates connecting the swingarm pivot to the engine and steel frame structure. This was a kind of combo tubular/beam style frame with a top and lower tube connected with gusseting panels

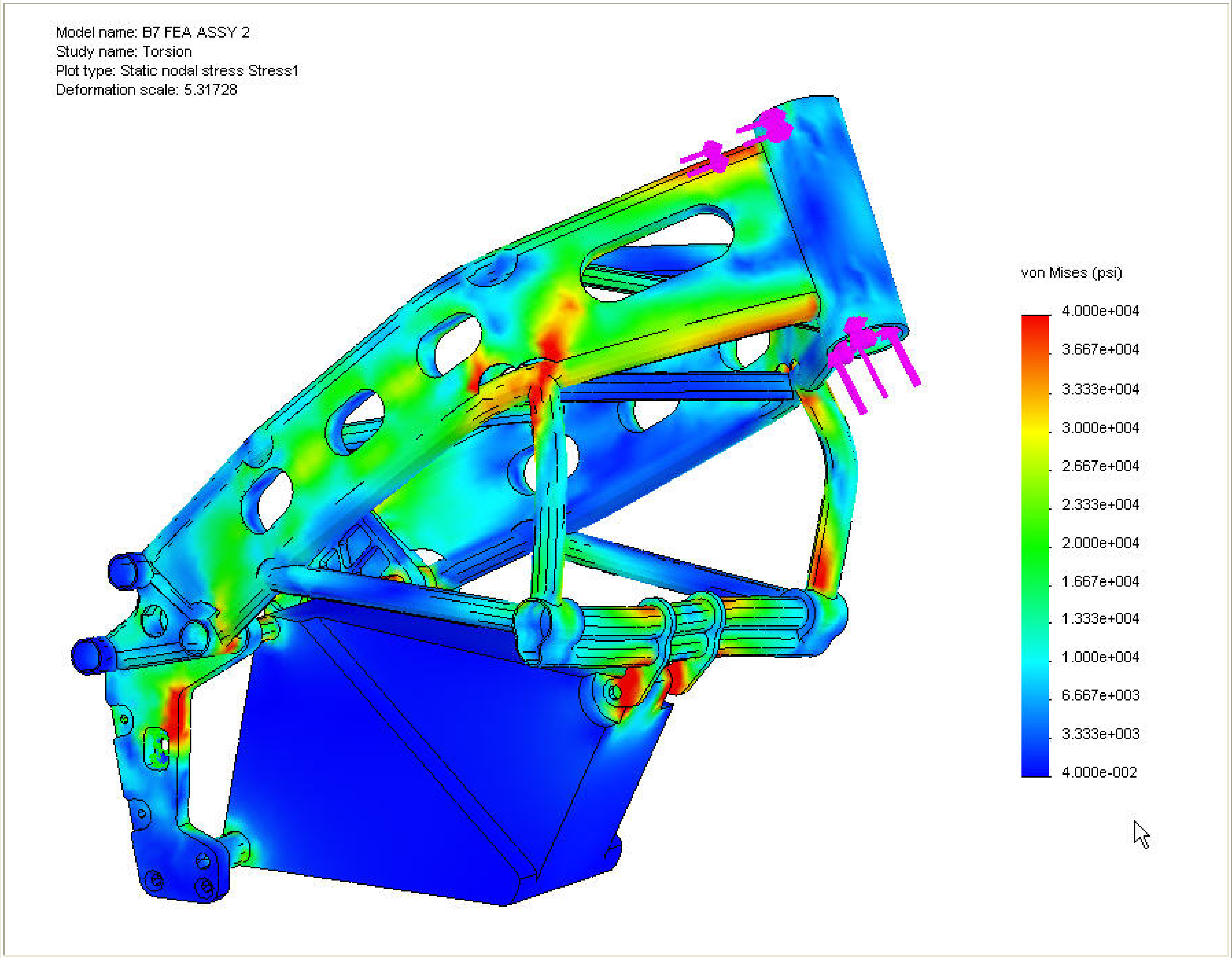
Bimota FEA-Braking Stress



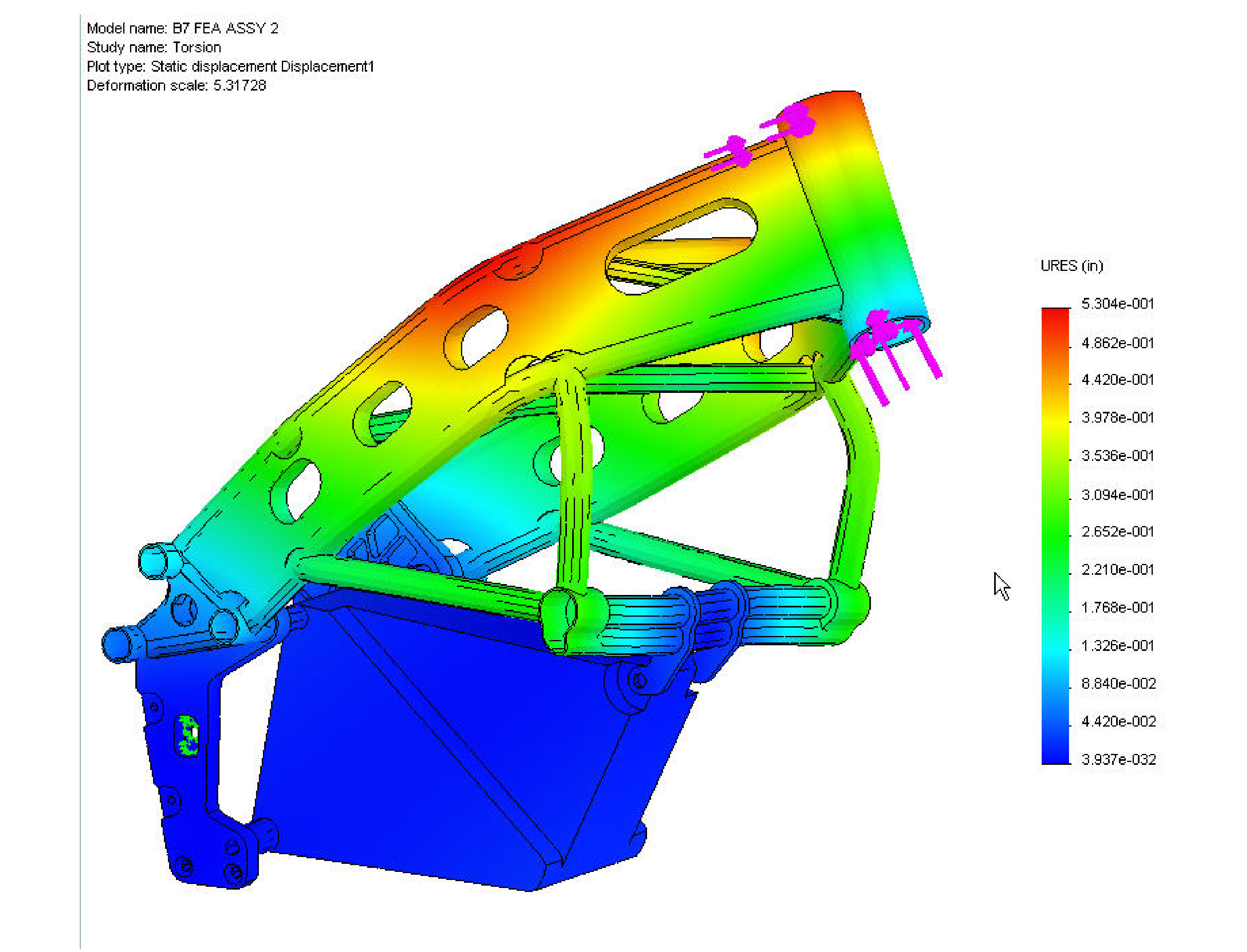
Bimota FEA-Braking Displacement



Bimota FEA-Torsion Stress



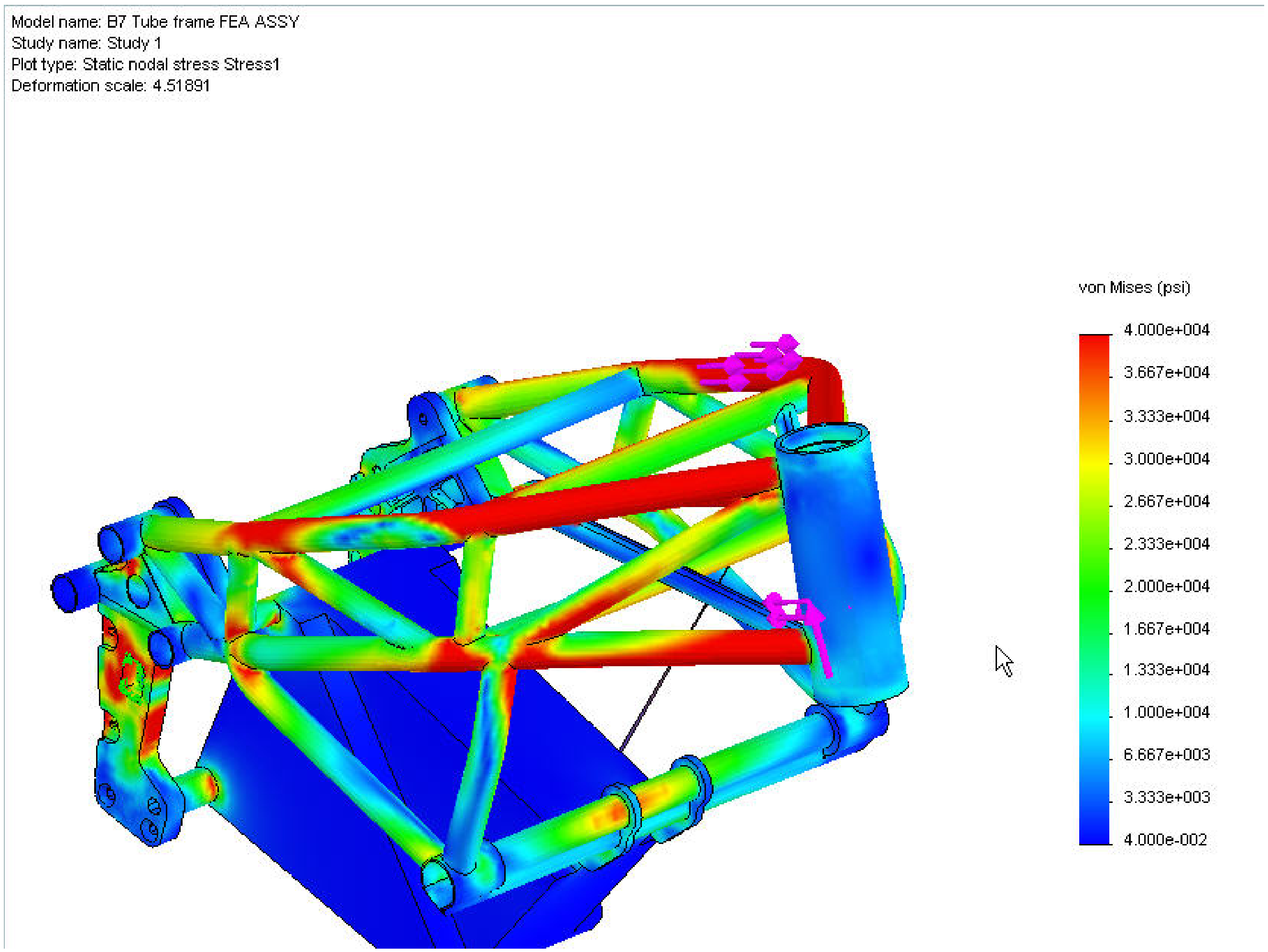
Bimota FEA-Torsion Displacement



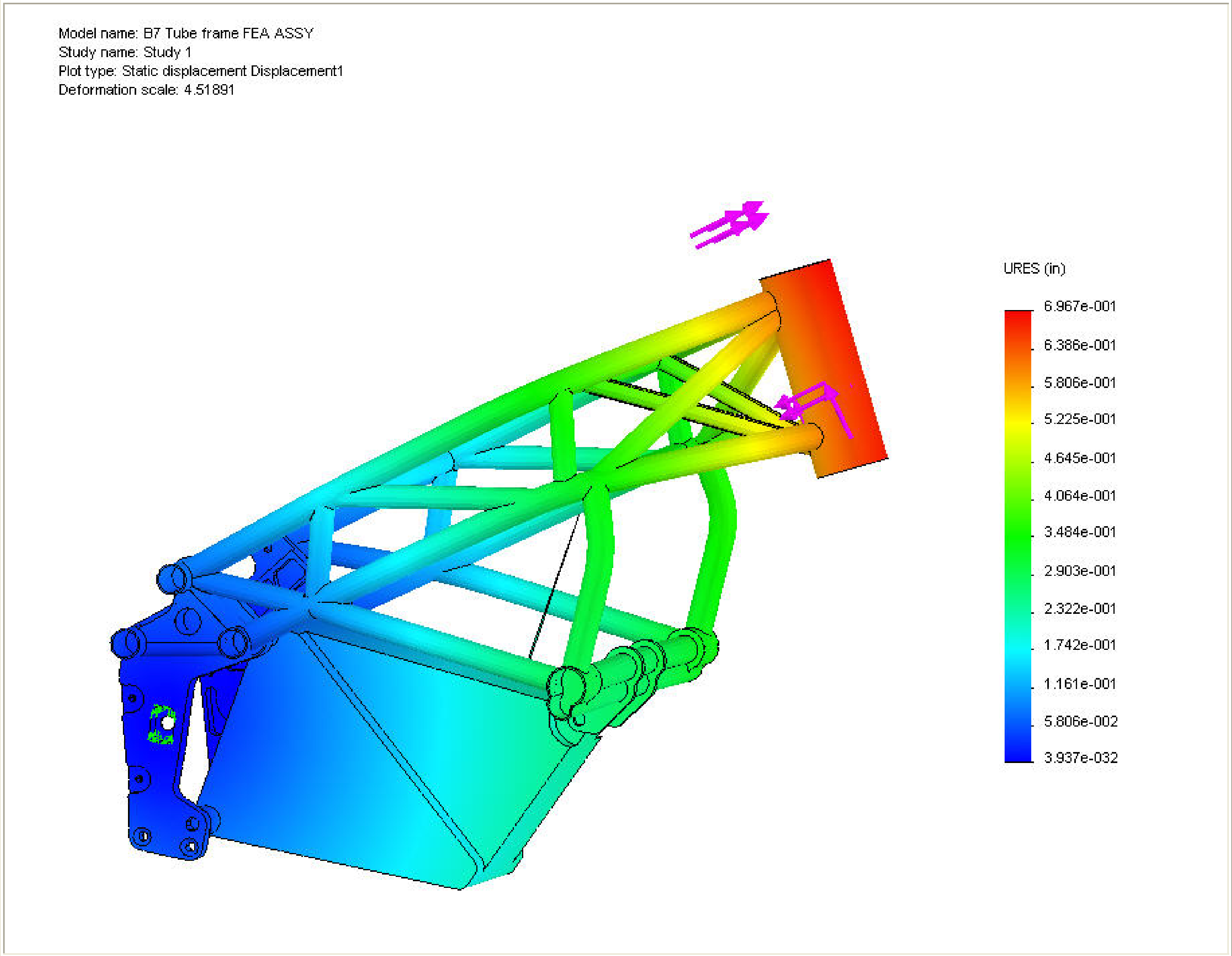
4-G. Results – Bimota Trellis

I was surprised at the amount of displacement of the Bimota style frame, and wondered if it could be improved by replacing the beam panels with tubes to make a trellis style frame.

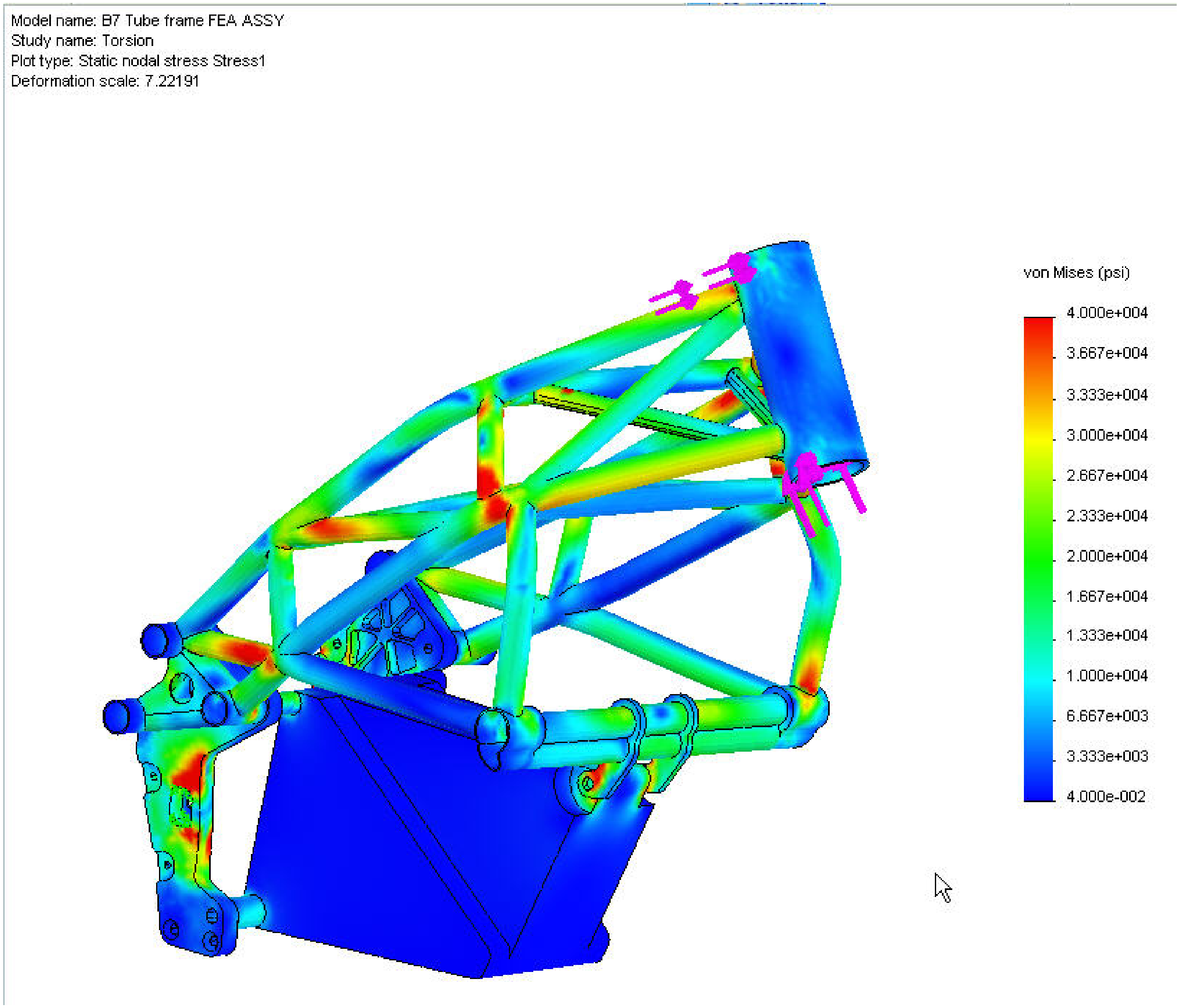
Bimota Trellis FEA-Braking Stress

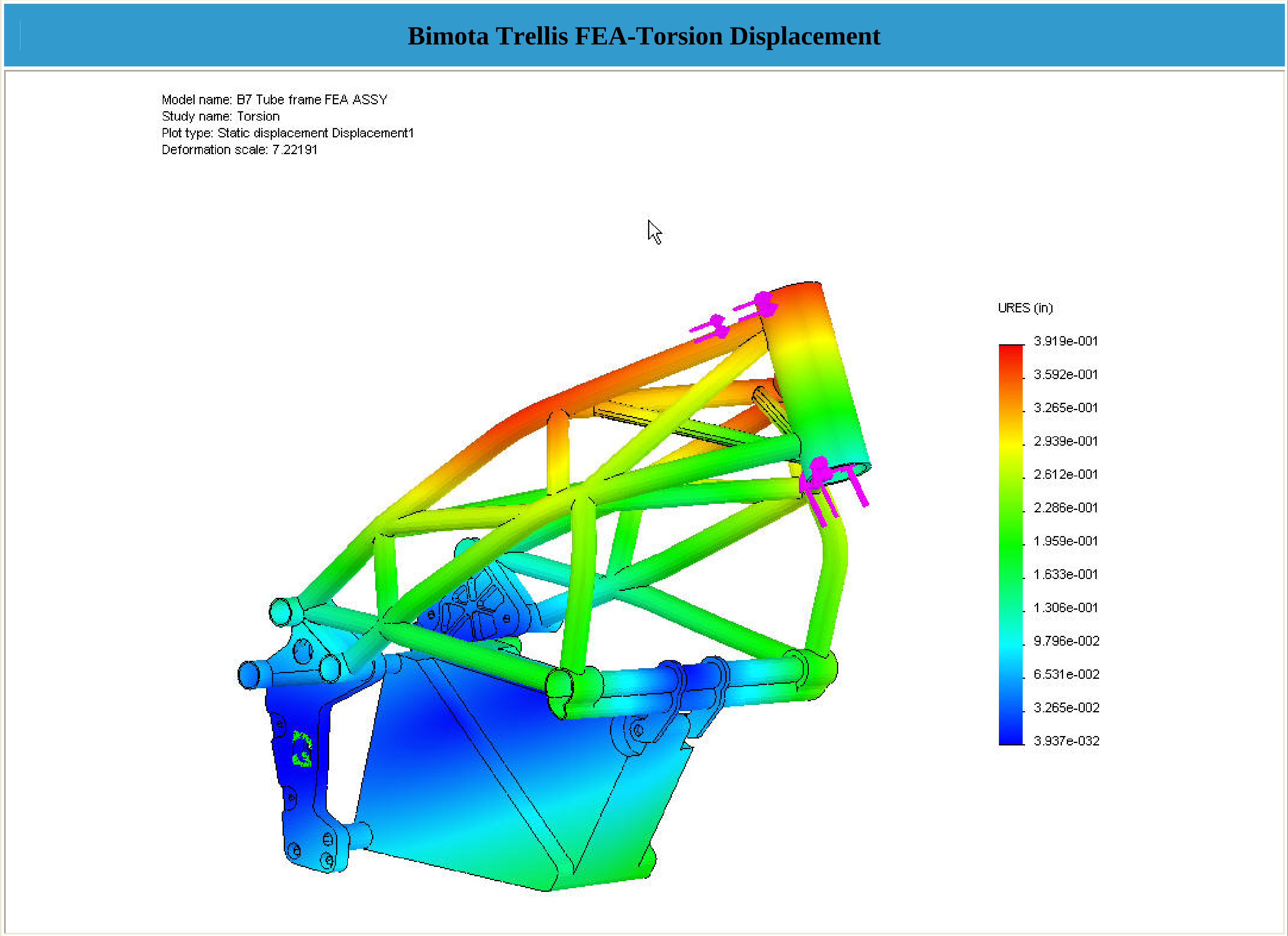


Bimota Trellis FEA-Braking Displacement



Bimota Trellis FEA-Torsion Stress

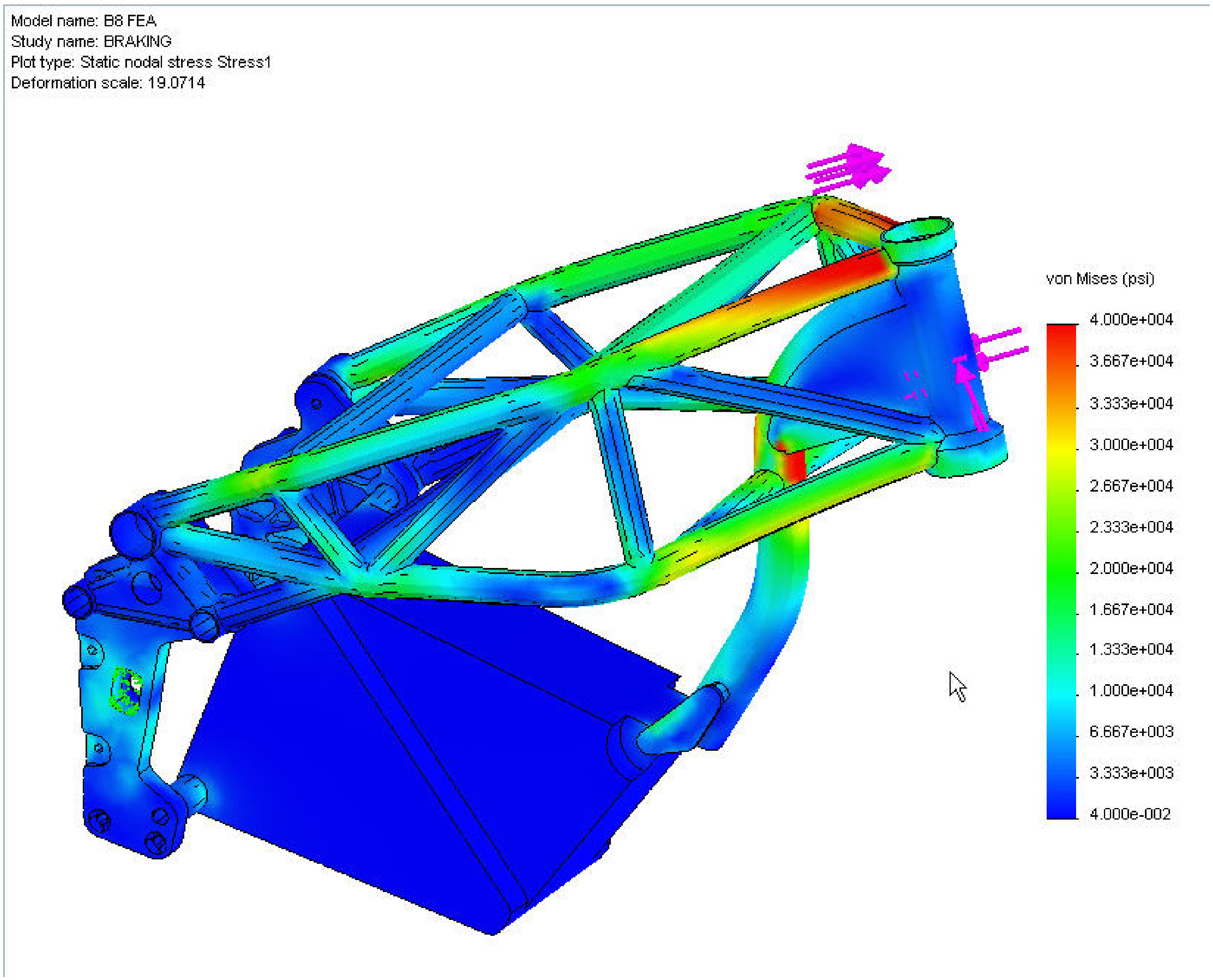




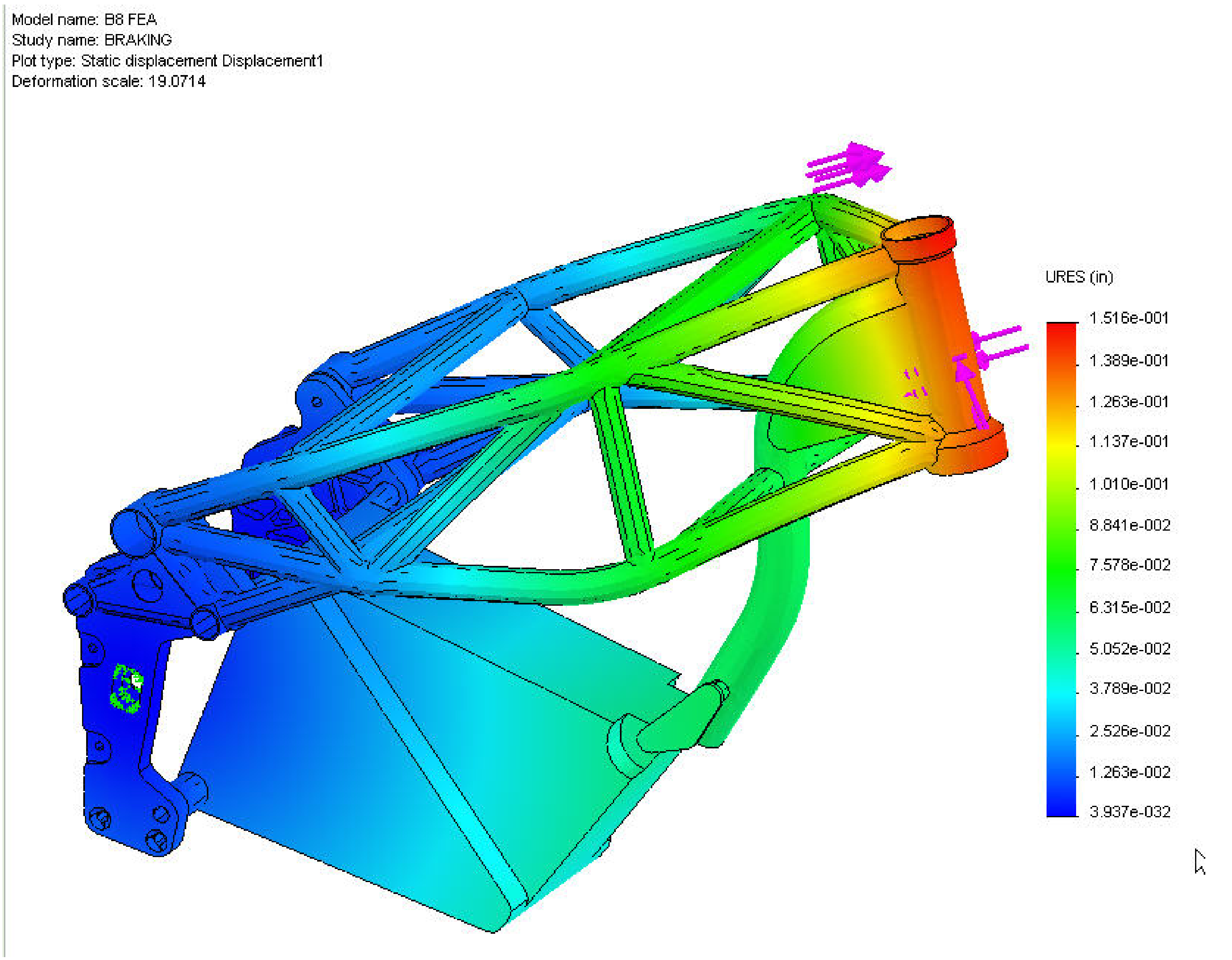
4-H. Results – Bimota 8

Even with the added tubes, the trellis frame was still not as stiff as the Egli backbone style. The 400F motor is a bit of a pain to design around the front engine mount. The stock frame is a single downtube design and the front mount is only 60mm wide. This makes attaching the engine to a perimeter style frame a bit of a challenge. I thought that maybe by combining a single downtube with the perimeter trellis design I might have a winner. Since this was the 8th variant of the Bimota style frame I had modeled, it became Bimota8

Bimota8 FEA-Braking Stress

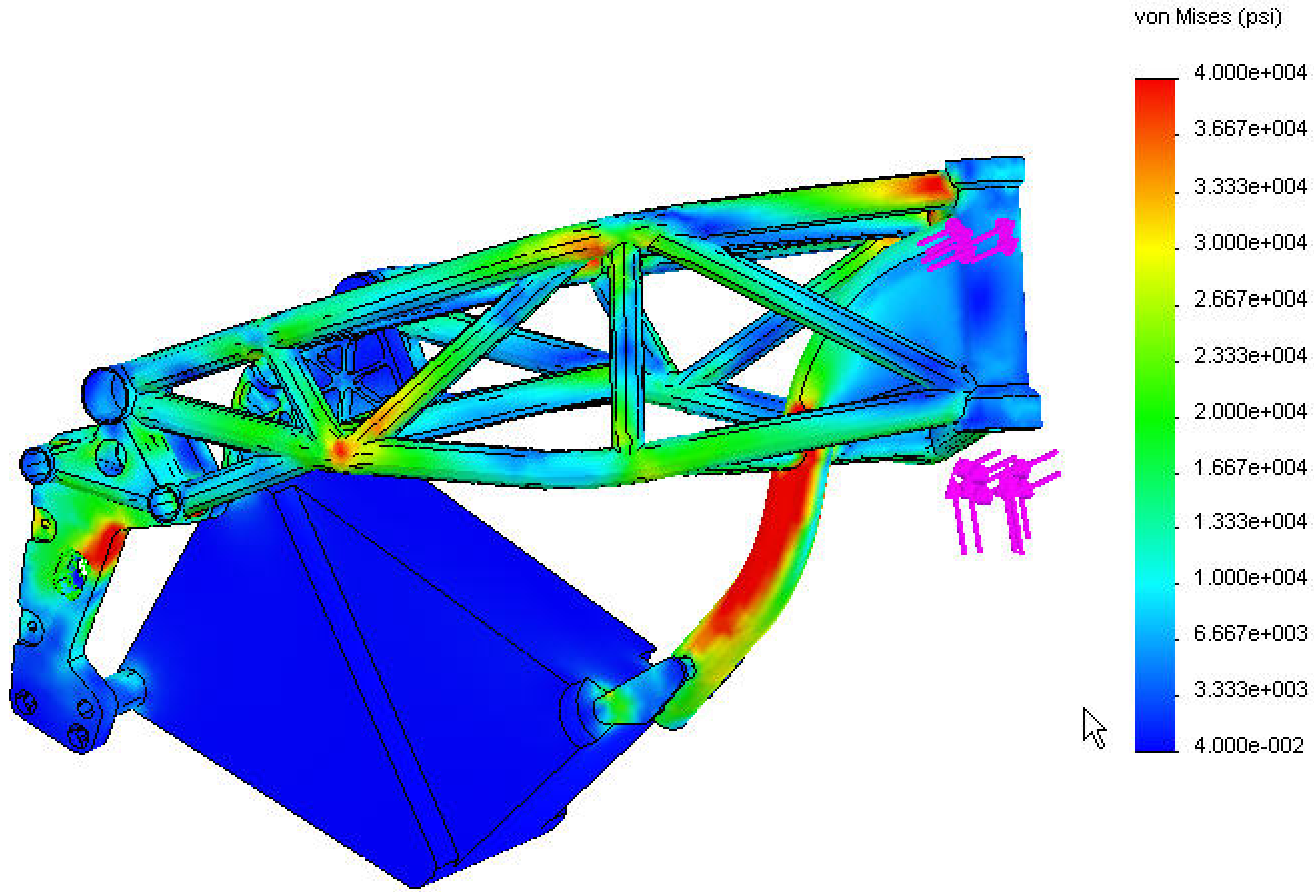


Bimota8 FEA-Braking Displacement



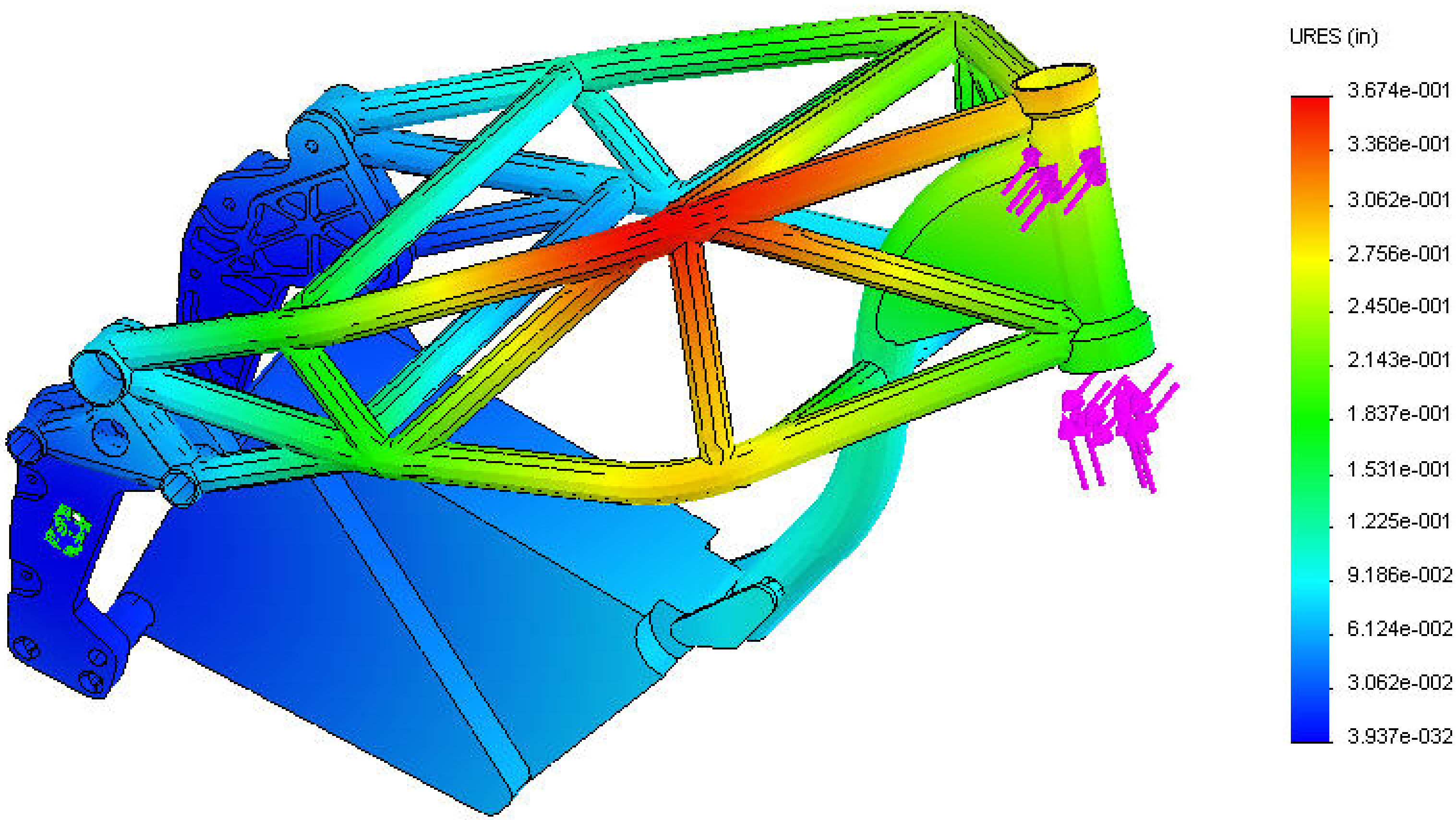
Bimota8 FEA-Torsion Stress

Model name: B8 FEA
Study name: TORSION
Plot type: Static nodal stress Stress1
Deformation scale: 9.90701



Bimota8 FEA-Torsion Displacement

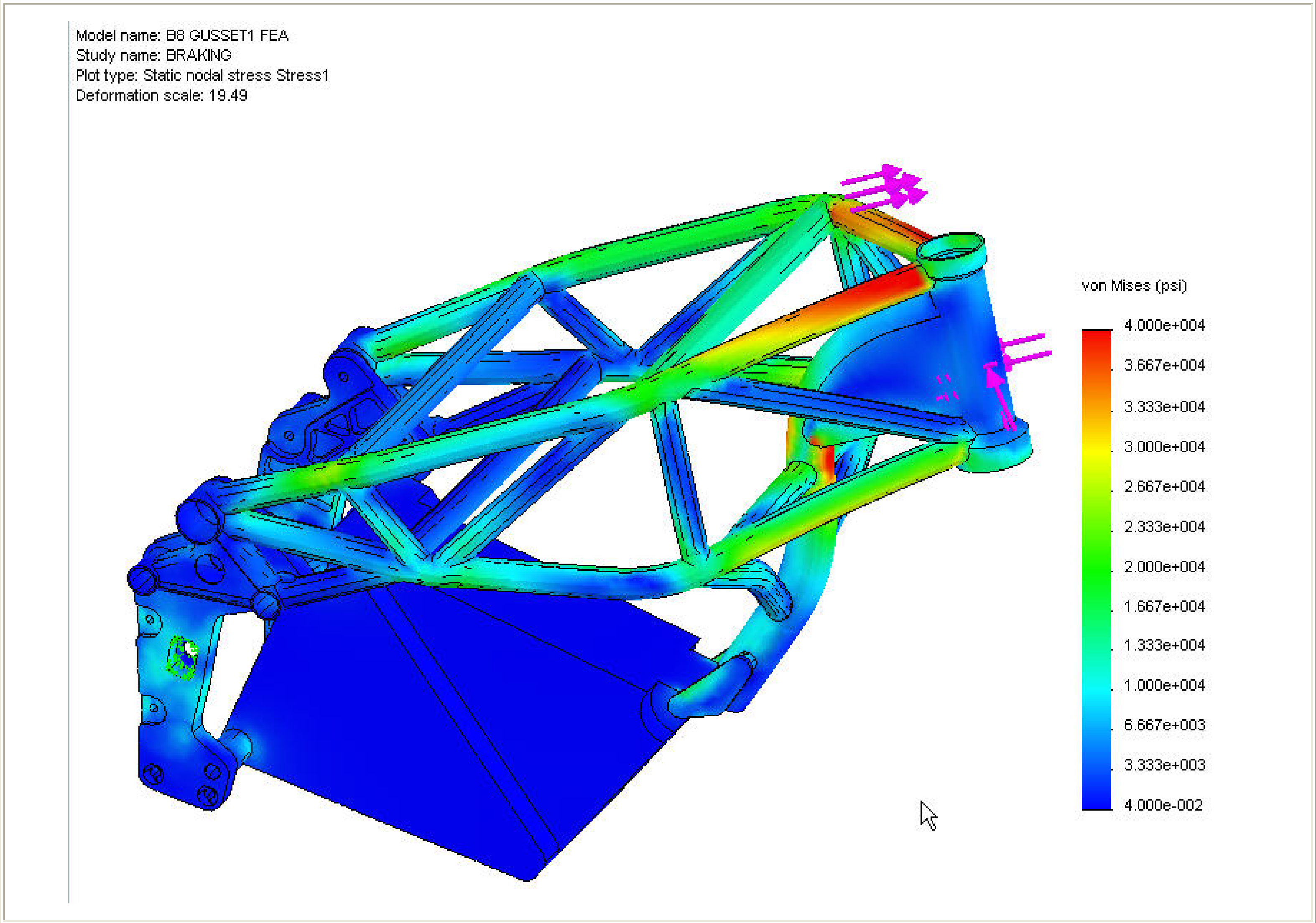
Model name: B8 FEA
Study name: TORSION
Plot type: Static displacement Displacement1
Deformation scale: 9.90701



4-H Results – Bimota 8B

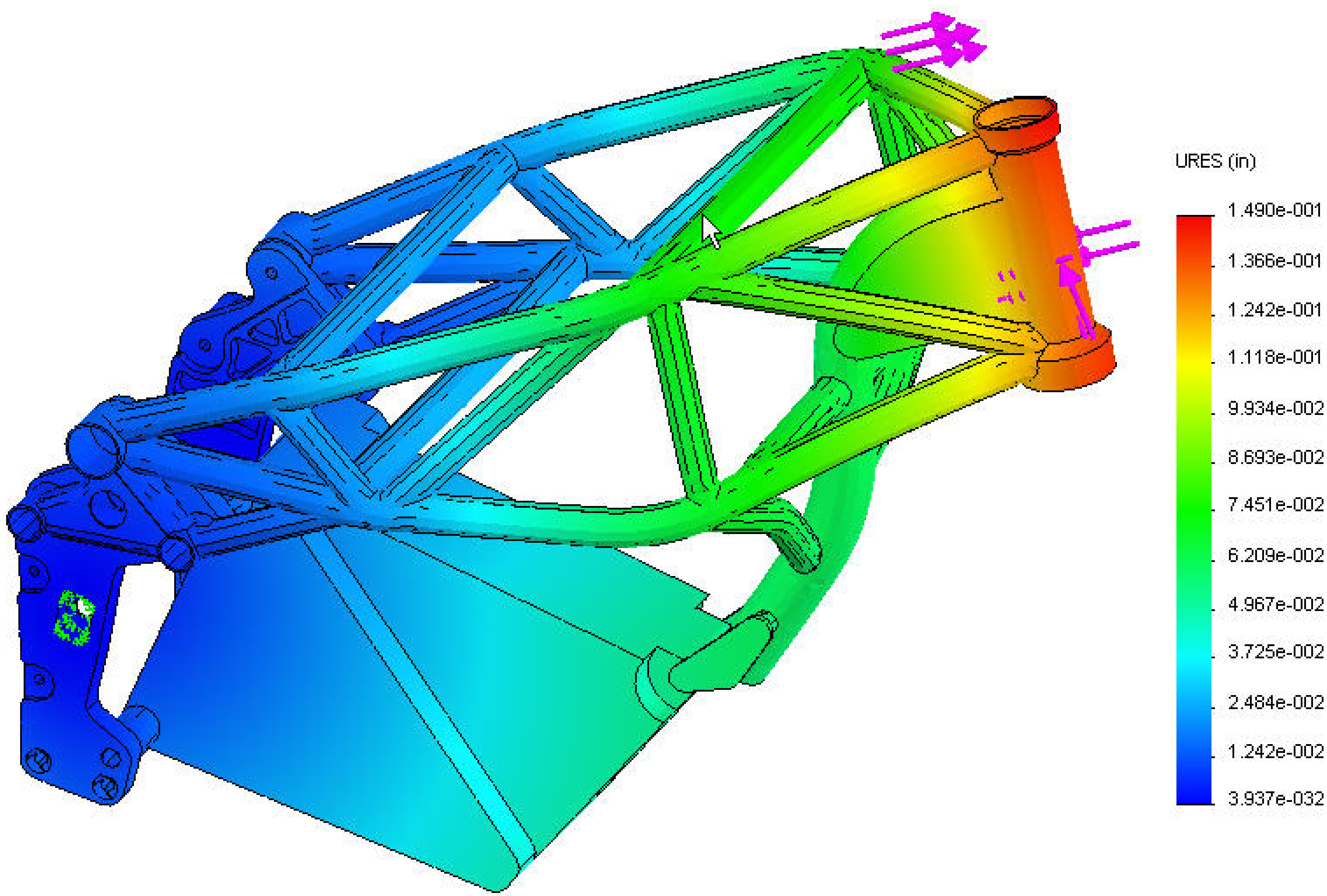
I thought that with a couple of additional tubes the Bimota8 might be improved.

Bimota8B FEA-Braking Stress

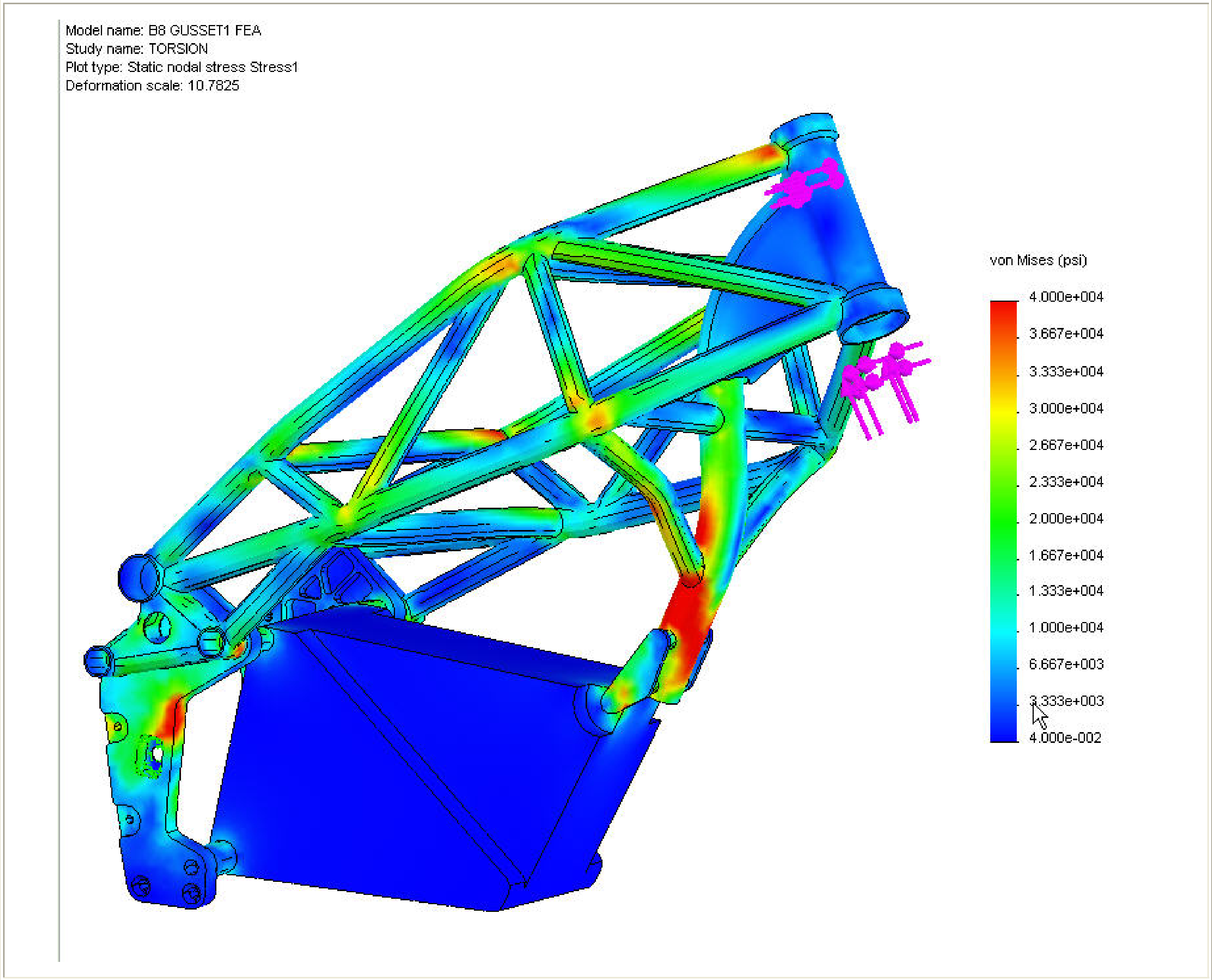


Bimota8B FEA-Braking Displacement

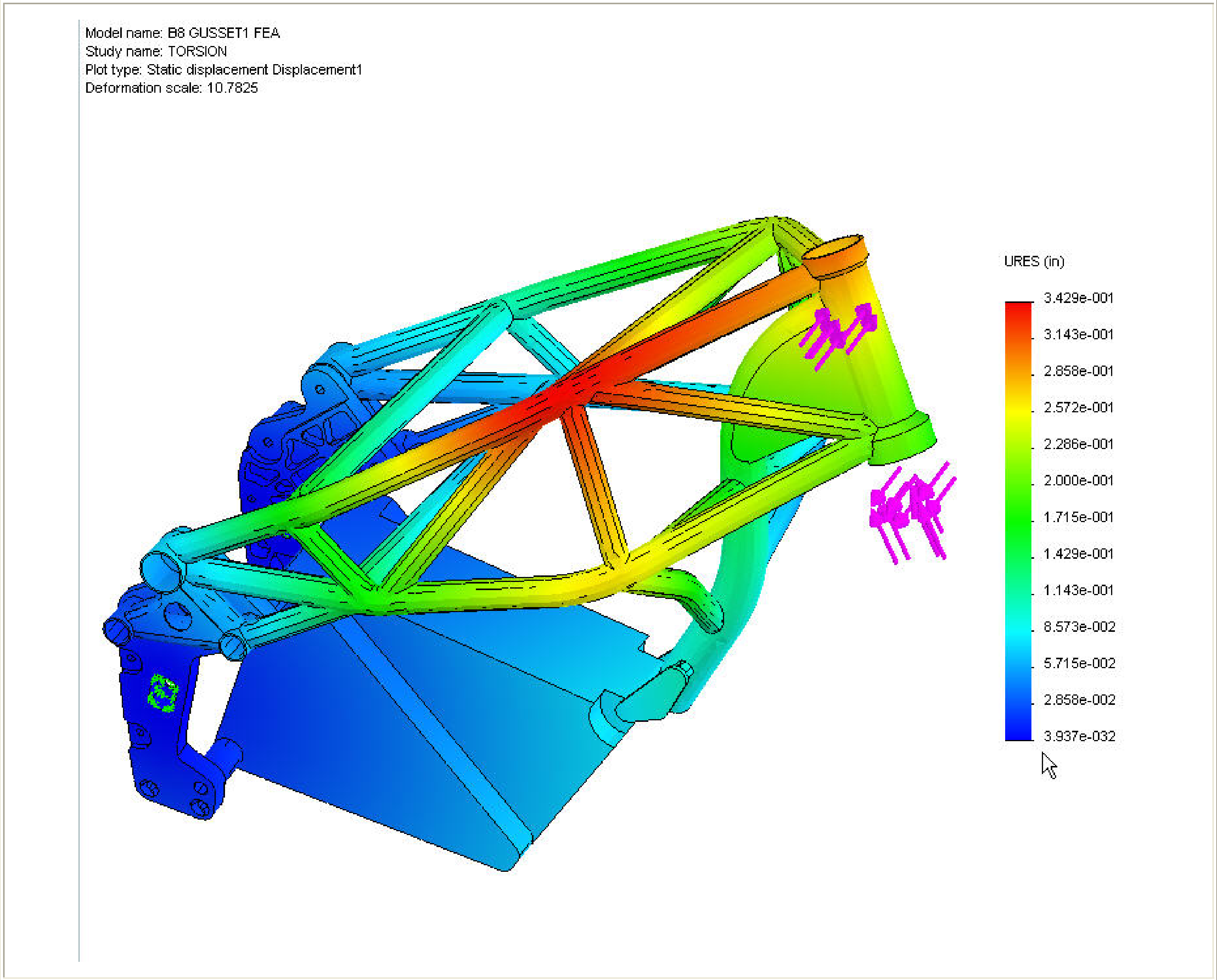
Model name: B8 GUSSET1 FEA
Study name: BRAKING
Plot type: Static displacement Displacement1
Deformation scale: 19.49



Bimota8 FEA-Torsion Stress



Bimota8 FEA-Torsion Displacement



5. Appendix

Material name:	[SW]AISI 1020
Description:	To try to allow direct comparisons between designs, all frames were defined with AISI 1020 Mild Steel The engine block and mounts were defined as 6061-T6
Material Source:	Used SolidWorks material
Material Library Name:	SolidWorks Materials
Material Model Type:	Linear Elastic Isotropic

Property Name	Value	Units	Value Type
Elastic modulus	2e+011	N/m^2	Constant
Poisson's ratio	0.29	NA	Constant
Shear modulus	7.7e+010	N/m^2	Constant
Mass density	7900	kg/m^3	Constant
Tensile strength	4.2051e+008	N/m^2	Constant
Yield strength	3.5157e+008	N/m^2	Constant
Thermal expansion coefficient	1.5e-005	/Kelvin	Constant
Thermal conductivity	47	W/(m.K)	Constant
Specific heat	420	J/(kg.K)	Constant

Material name:	[SW]6061-T6
Description:	To try to allow direct comparisons between designs, all frames were defined with AISI 1020

Mild Steel The engine block and mounts were defined as 6061-T6

Material Source:	Used SolidWorks material
Material Library Name:	denoonsp materials
Material Model Type:	Linear Elastic Isotropic

Property Name	Value	Units	Value Type
Elastic modulus	6.9e+010	N/m^2	Constant
Poisson's ratio	0.33	NA	Constant
Shear modulus	2.6e+010	N/m^2	Constant
Mass density	2700	kg/m^3	Constant
Tensile strength	3.1e+008	N/m^2	Constant
Yield strength	2.75e+009	N/m^2	Constant
Thermal expansion coefficient	2.4e-005	/Kelvin	Constant
Thermal conductivity	170	W/(m.K)	Constant
Specific heat	1300	J/(kg.K)	Constant