Austerity 2-8-0 90733
Horn Guide and Frame Re-design

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Hello

About me

A keen railwayman for 10 years

I've operated on both the KWVR and the mainline railway network for the past 5 years.

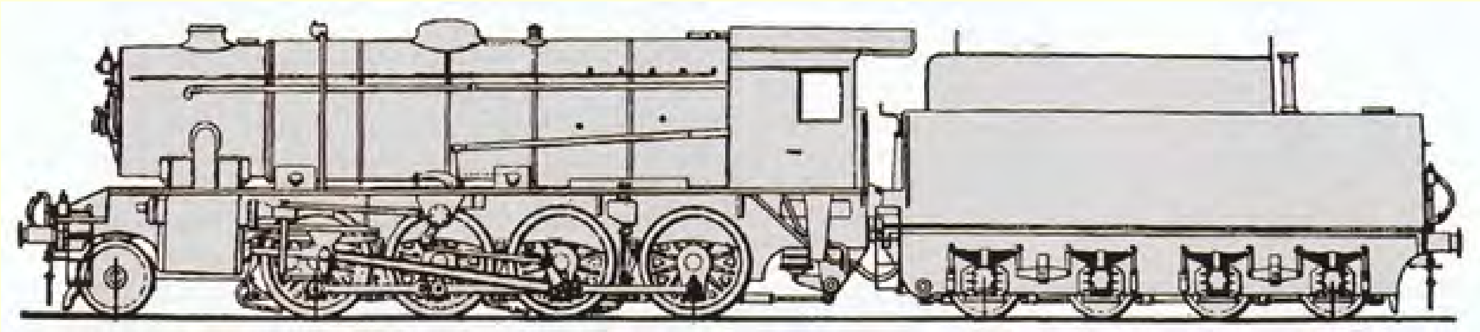
Became a fireman at age 19

Completed my final year at Huddersfield University and attained a degree in Mechanical Engineering, my dissertation being this subject talked about today.

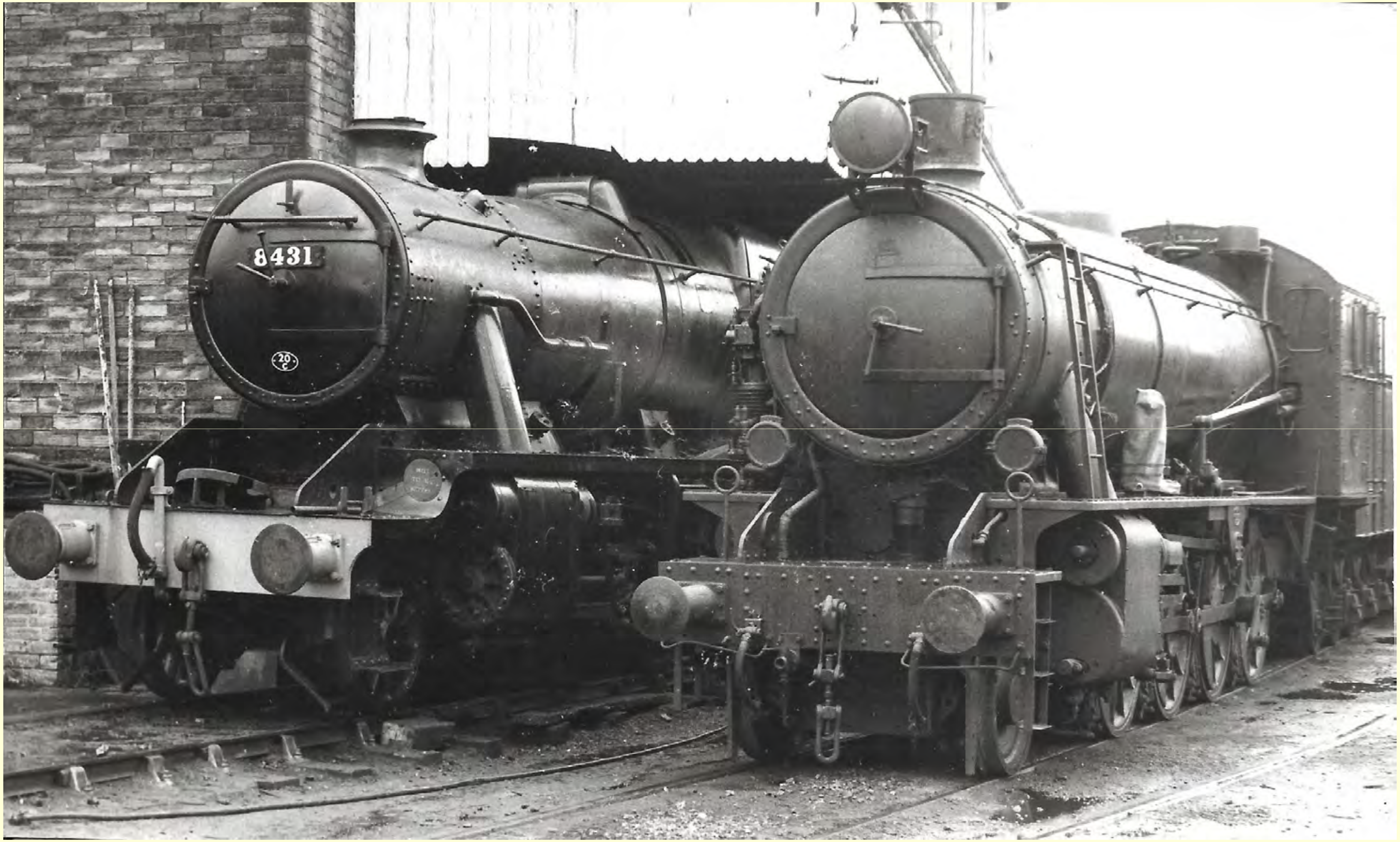
Carrying on this year and next to hopefully attain a Masters qualification.

Introduction

War Department locomotive number 79257 was built at Vulcan Foundry Newton Le- Willows Preston in January 1945. Constructed to aid the war effort.

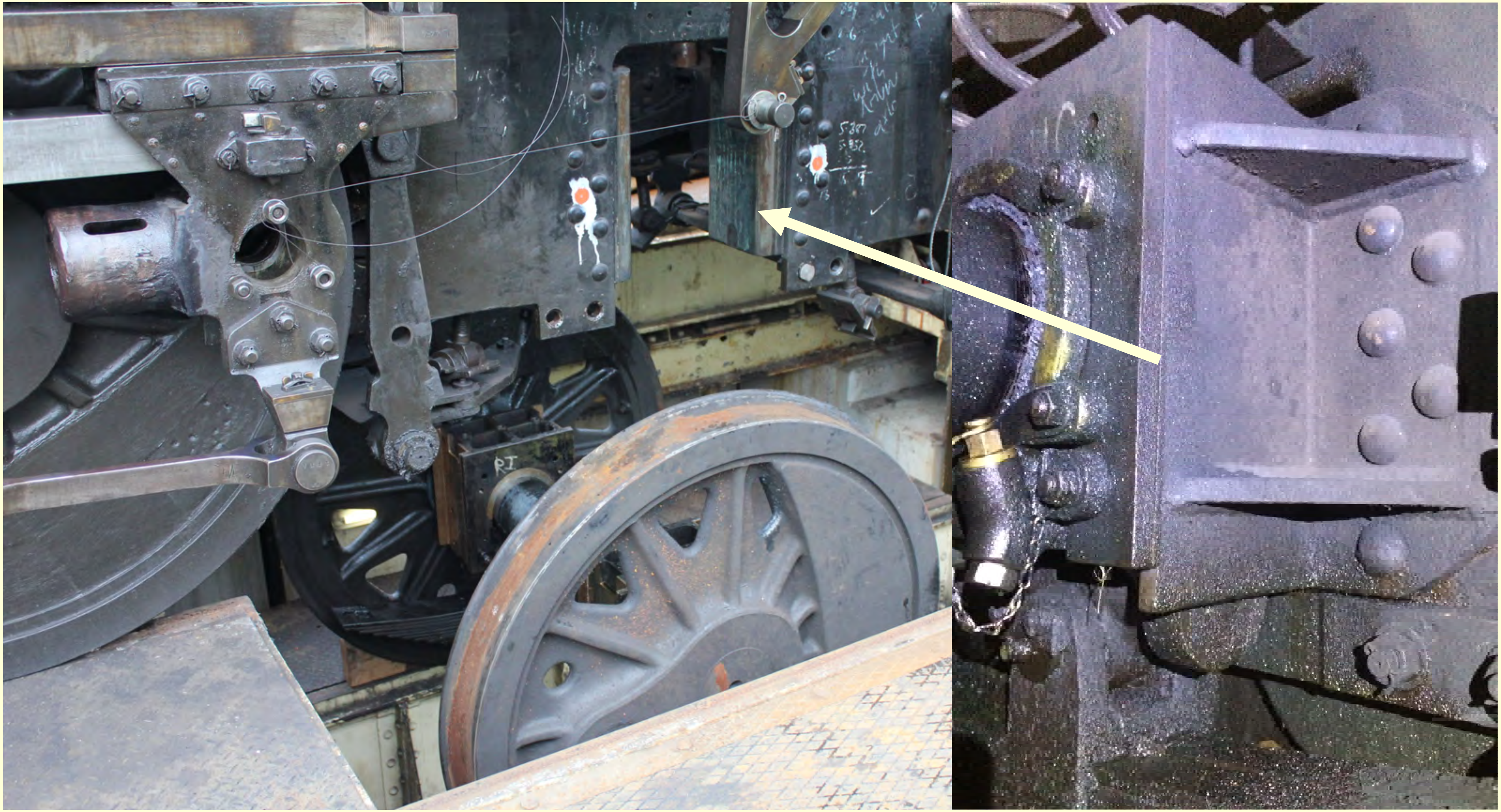


History


8431


1931


1931



Procedure

Step 1

Create a CAD model of the locomotive frame on Solidworks

Step 2

Calculate forces to be applied onto horn guides within frame

Step 3

Mesh and apply forces to frame

Step 4

Identify areas of high stress and attain displacement

Step 5

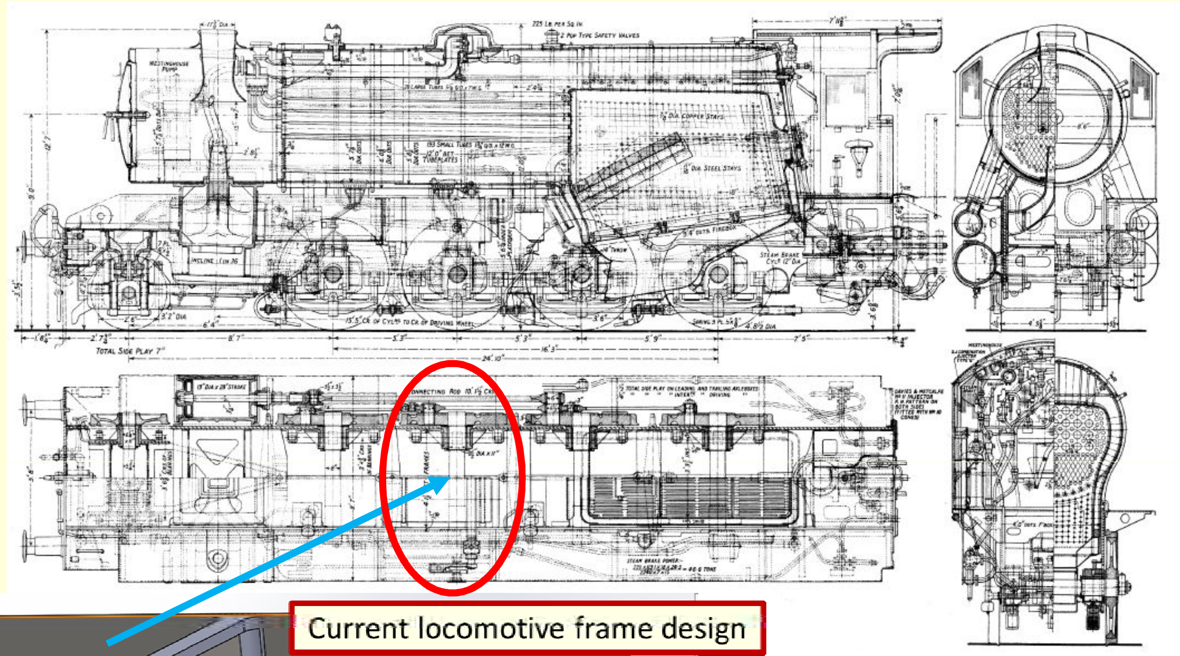
Create modifications and add to the frame to reduce the stress application

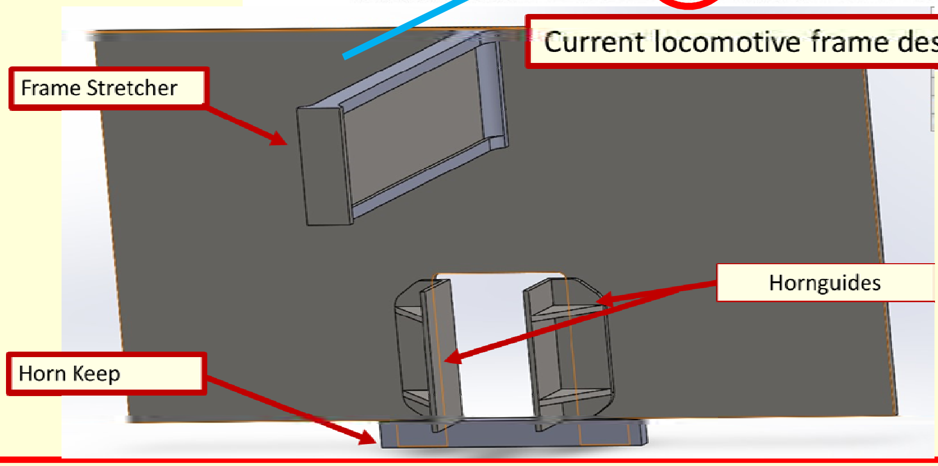
Step 6

Simulate, ascertain whether modifications have strengthened frame.

The Plan – Step 1

Using 21st century technology to improve a product of the mid 20th century.





Calculation of Forces longitudinal – Step 2

$$Piston\ Force\ =\ Steam\ Pressure\ x\ Piston\ Area$$

$$225\ \times \frac{\pi \times 19^2}{4}$$

225 psi boiler pressure, 19-inch diameter piston.

$$225\ \times\ 283.53 = 63794$$

$$63794lbs = 28936.47kg$$

Change from lbs to kg.

$$28936.47\ \times\ 9.81 = 283866.77N$$

Weight to force.

$$283866.77\ \times\ 0.7 = 198706.739\ N$$

30% reduction to account for steam losing energy through steam circuit.

$$T_1 = P(D - \frac{S}{D})$$

Equation used as shown opposite

$$T_1 = 198706.739(1.44 - \frac{0.3683}{1.44})$$

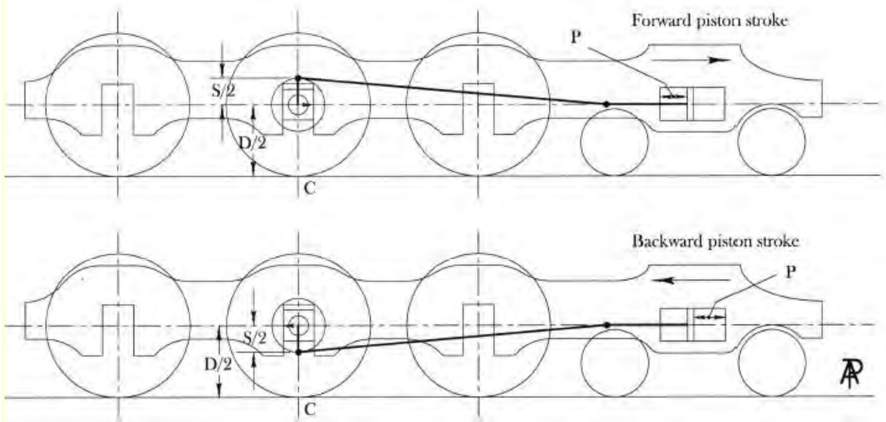
P is the piston force, D is wheel diameter and S is the length of piston stroke.

$$T_1 = 235315.6958$$

$$\frac{T_1}{4} = 58828.92$$

Thrust force divided by 4 as force shared to 4 coupled wheel sets.

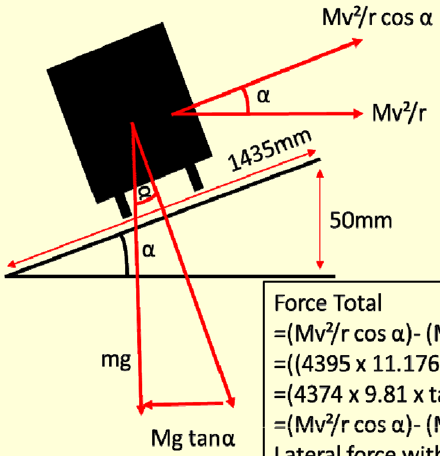
P= Piston Force D= Driving wheel diameter S= Length of piston stroke

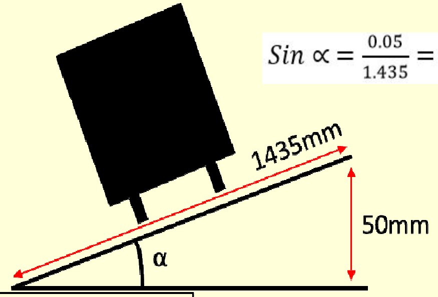


$$T_1 = P(D - \frac{S}{D})$$

Calculation of Forces lateral– Step 2

Lateral force calculation with cant





$$Sin \propto = \frac{0.05}{1.435} = Sin^{-1} = \propto = 2°$$

Force Total
=(Mv²/r cos α)- (Mg tanα)
=((4395 x 11.176²)/(200) x cos(2))=2731
=(4374 x 9.81 x tan(2))= 1498
=(Mv²/r cos α)- (Mg tanα) = 2731- 1498 = 1233
Lateral force with cant = 1233N

Lateral force calculation without cant

$$F_{Total\ Lateral} = \frac{M_{Total} \times v^2}{r}$$

$$F_{Total\ Lateral} = \frac{70000 \times 11.176^2}{200}$$

$$F_{Total\ Lateral} = 43716N$$

$$F_{TL}/4 = 10929N$$

$$2F_L = 10929/2 = 5464N$$

$$F_L = 5464/2 = 2732N$$

- M Total is the total weight of the locomotive in kg.
- V^2 = the cornering speed in m/s
- r = The radius of the corner in m

- The total force is divided by 4 across all driving axles.
- This then divided by 2 over each wheel
- Finally, the amount is divided again by two for application onto each of the 4-horn guide axlebox side contact faces.

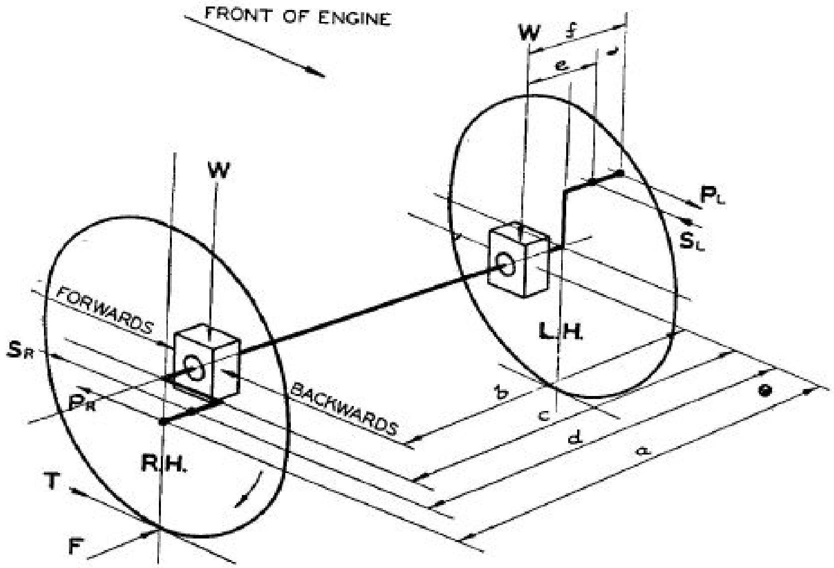


Fig. 2.

Axlebox Forces Outside Cylinder Engine. Right Hand Crank Leading.

(Symbols as on Fig. 1)

Forces on R.H. Axlebox due to:—

1.	Static weight.	W	Downwards.
2.	Nearside crank, R.H.	$P_R^{a/b}$	Backwards.
3.	Farside crank, L.H.	$P_L^{f/b}$	Backwards.
4.	Nearside coupling rod, R.H.	$S_R^{d/b}$	Forwards.
5.	Farside coupling rod, L.H.	$S_L^{e/b}$	Forwards.
6	Tractive force.	$T^{c/b}$	Forwards.
7.	Flange force.	F	Laterally.

PR= Piston thrust - right hand side PL=Piston thrust – left hand side

W = Static weight T = Tractive force F = Flange force

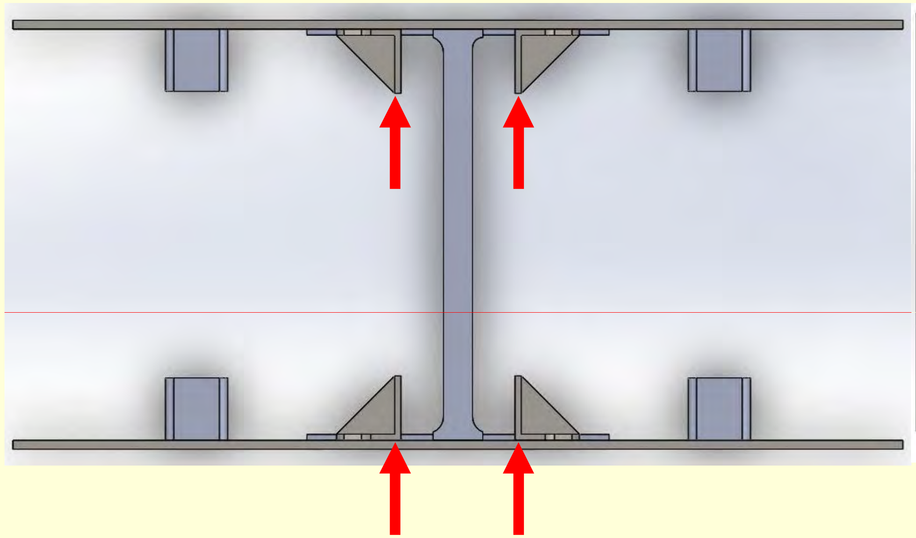
SR= Resistance to motion of other coupled wheels transmitted along Side rods – right hand side

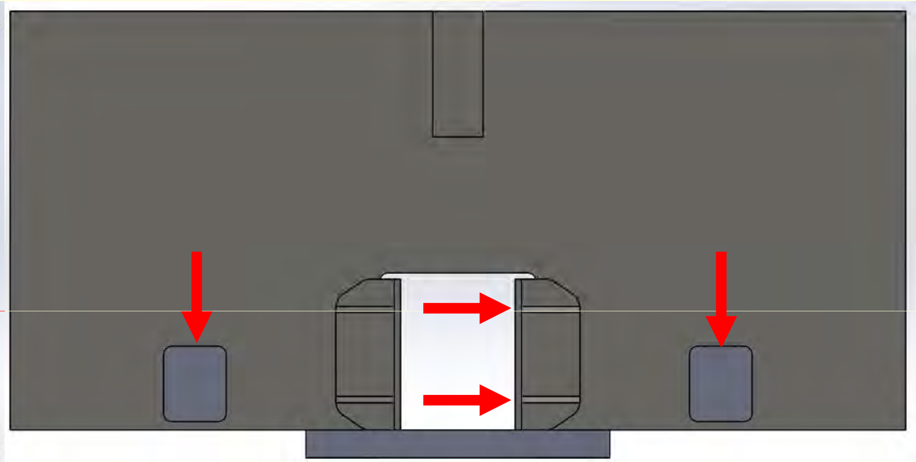
SL = Resistance to motion of other coupled wheels transmitted along Side rods – left hand side

Application Forces – Step 2

Top View Lateral forces applied

Side view longitudinal and vertical forces applied

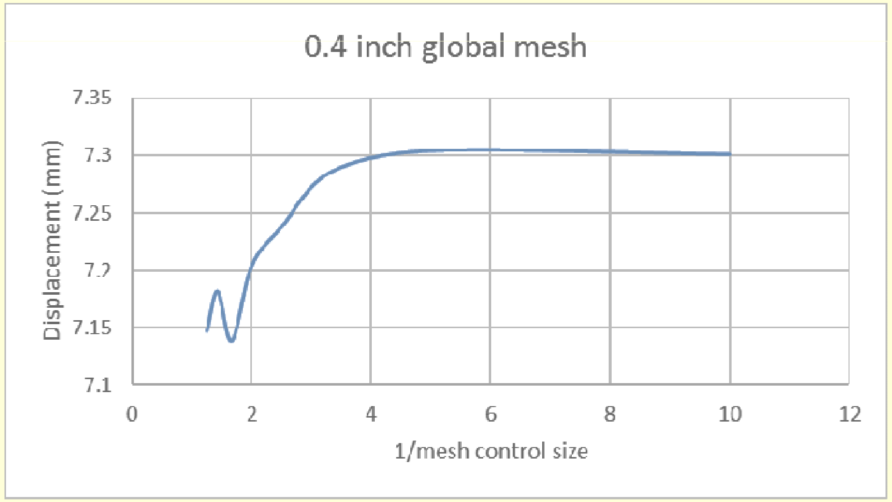


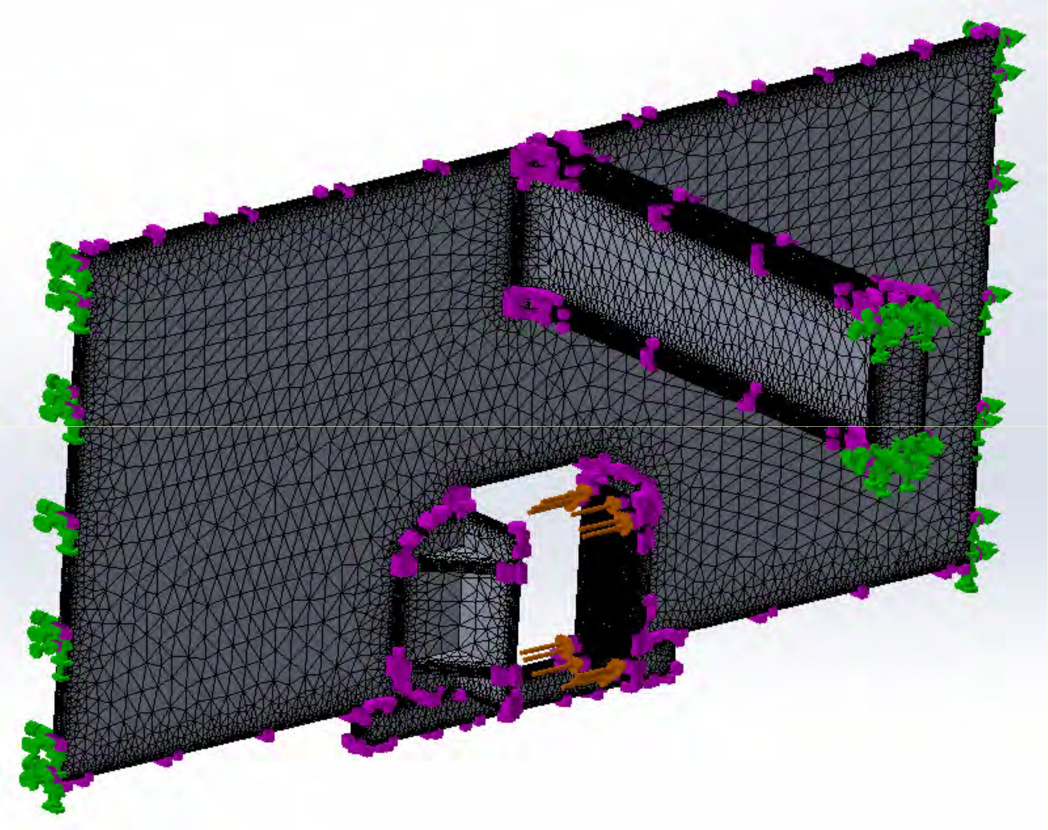


To correctly simulate the horn guides, working loads for the relevant forces had to be calculated. These comprised of a longitudinal force from the piston thrusts, a lateral forces for when the loco negotiates track curvature and a vertical static force for the weight of the locomotive.

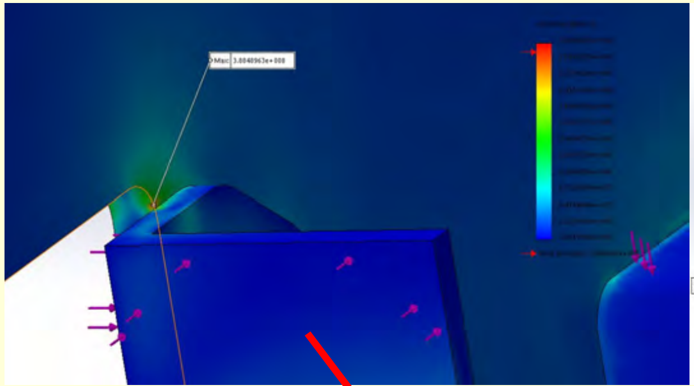
Meshing on CAD drawing - Step 3

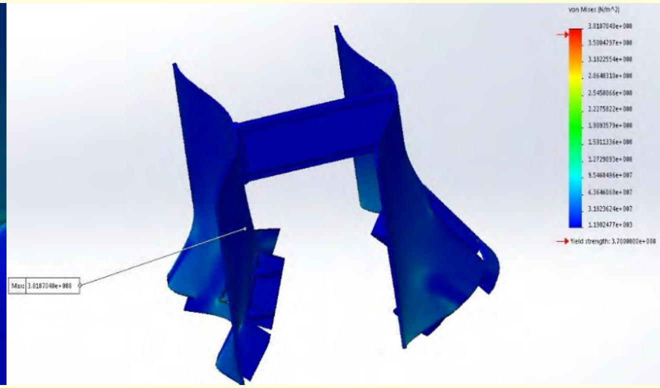
Global mesh size	mesh control size	displacement	1/ mesh control size
4	0.8	7.1472836	1.25
	0.7	7.1819429	1.428571429
	0.6	7.1387687	1.666666667
	0.5	7.2039609	2
	0.4	7.2377839	2.5
	0.3	7.2857637	3.333333333
	0.2	7.3039393	5
	0.1	7.3006802	10

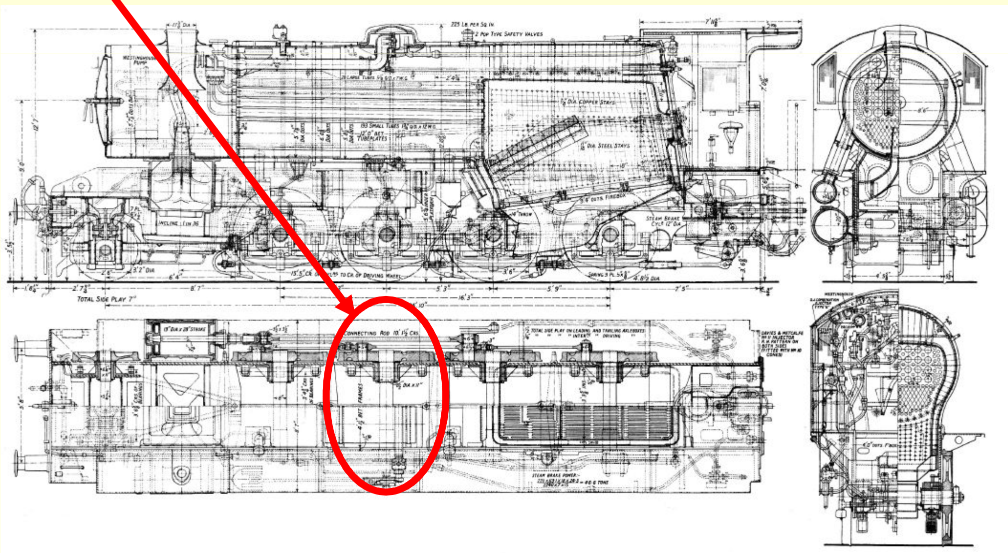


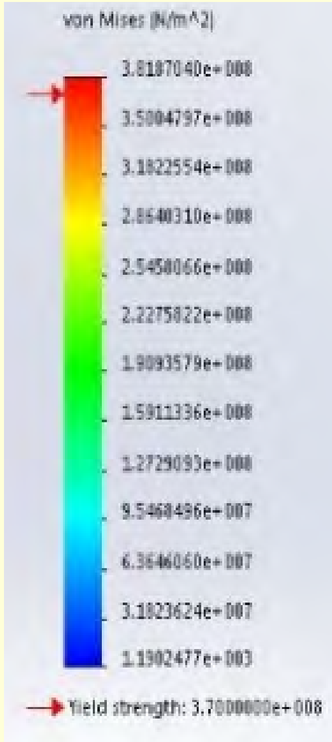


Identification of high stress areas – Step 4

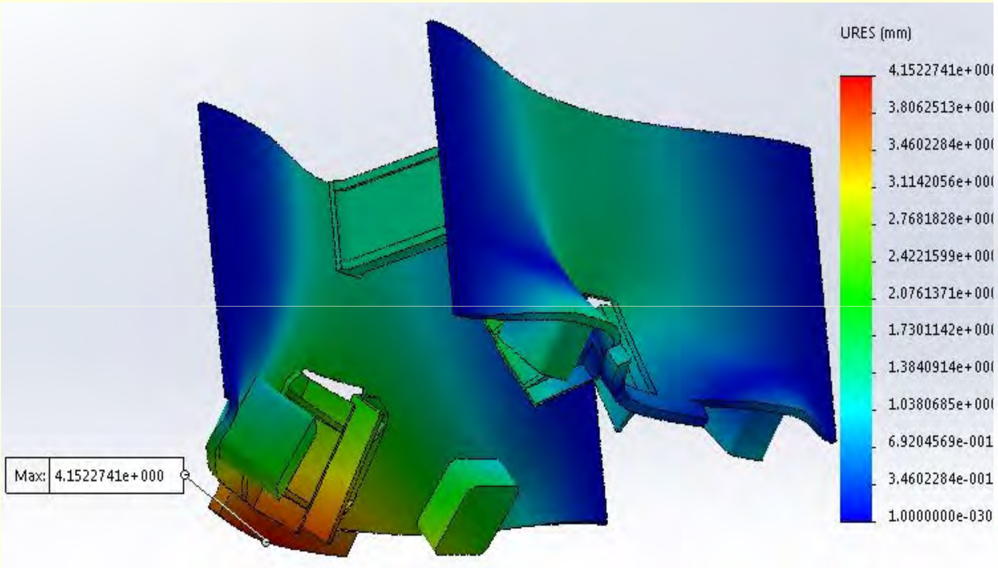


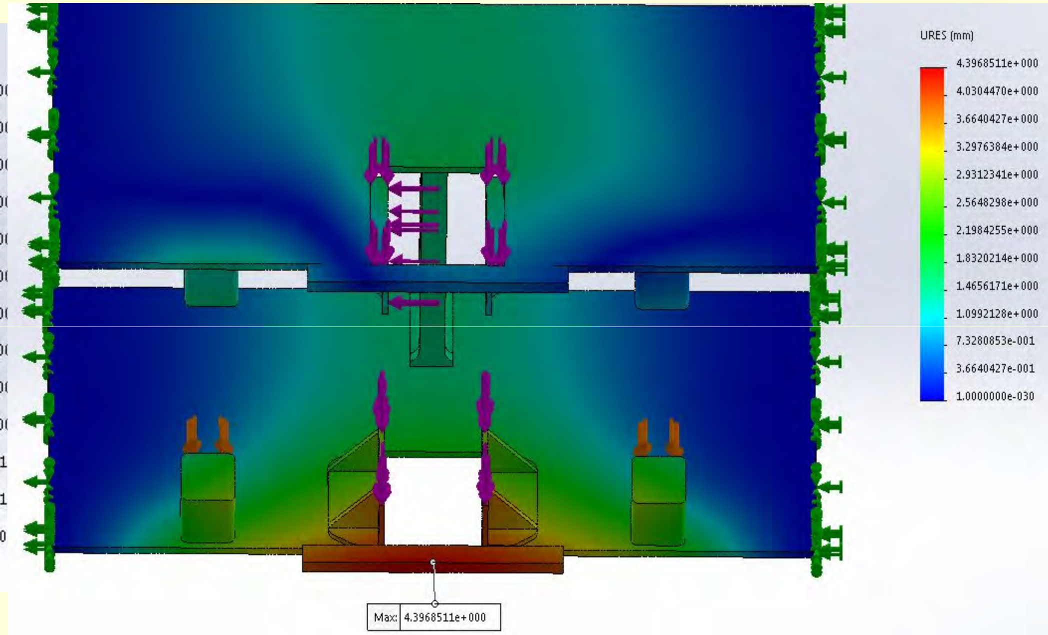




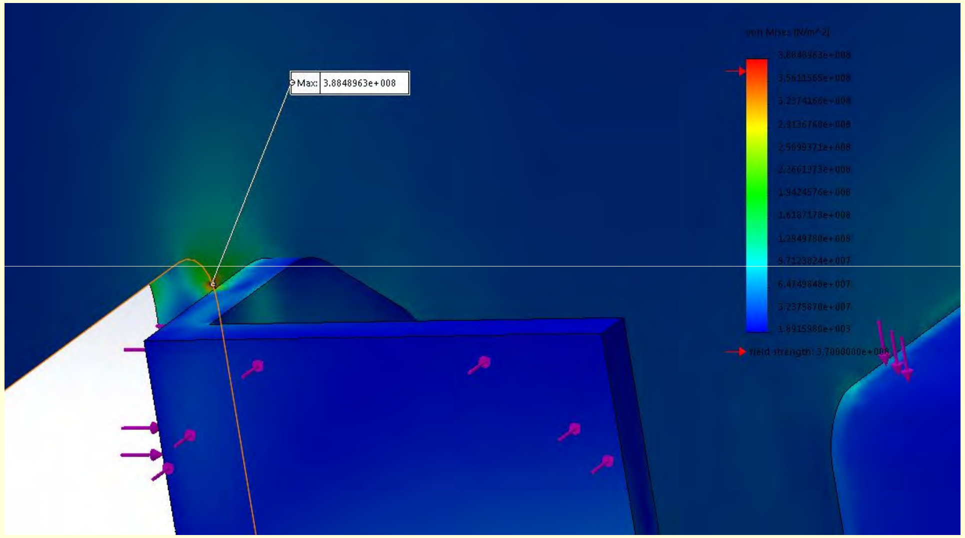


Identification of high displacement– Step 4





Identification of high stress areas with cant applied to track – Step 4

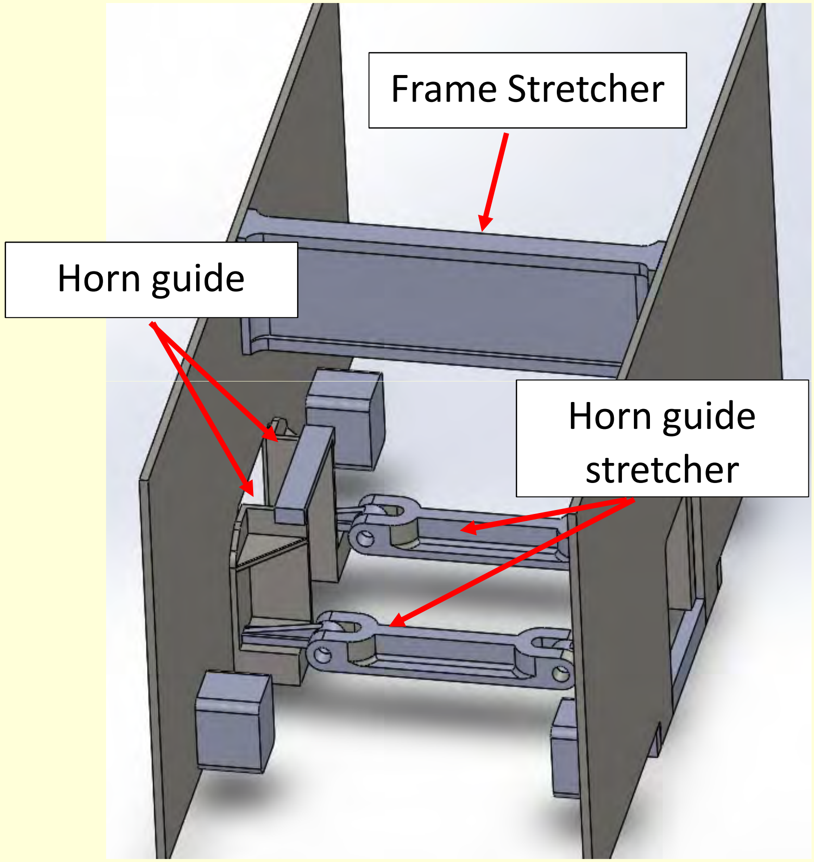


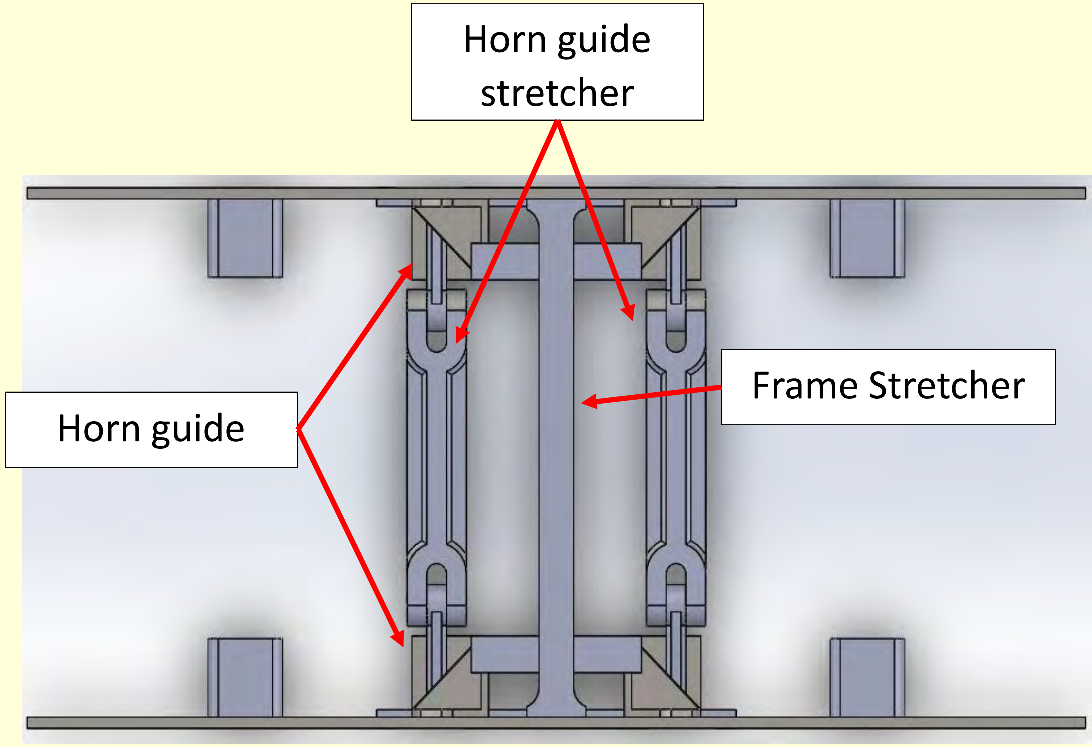
Without cant

With cant

Create frame modifications – step 5

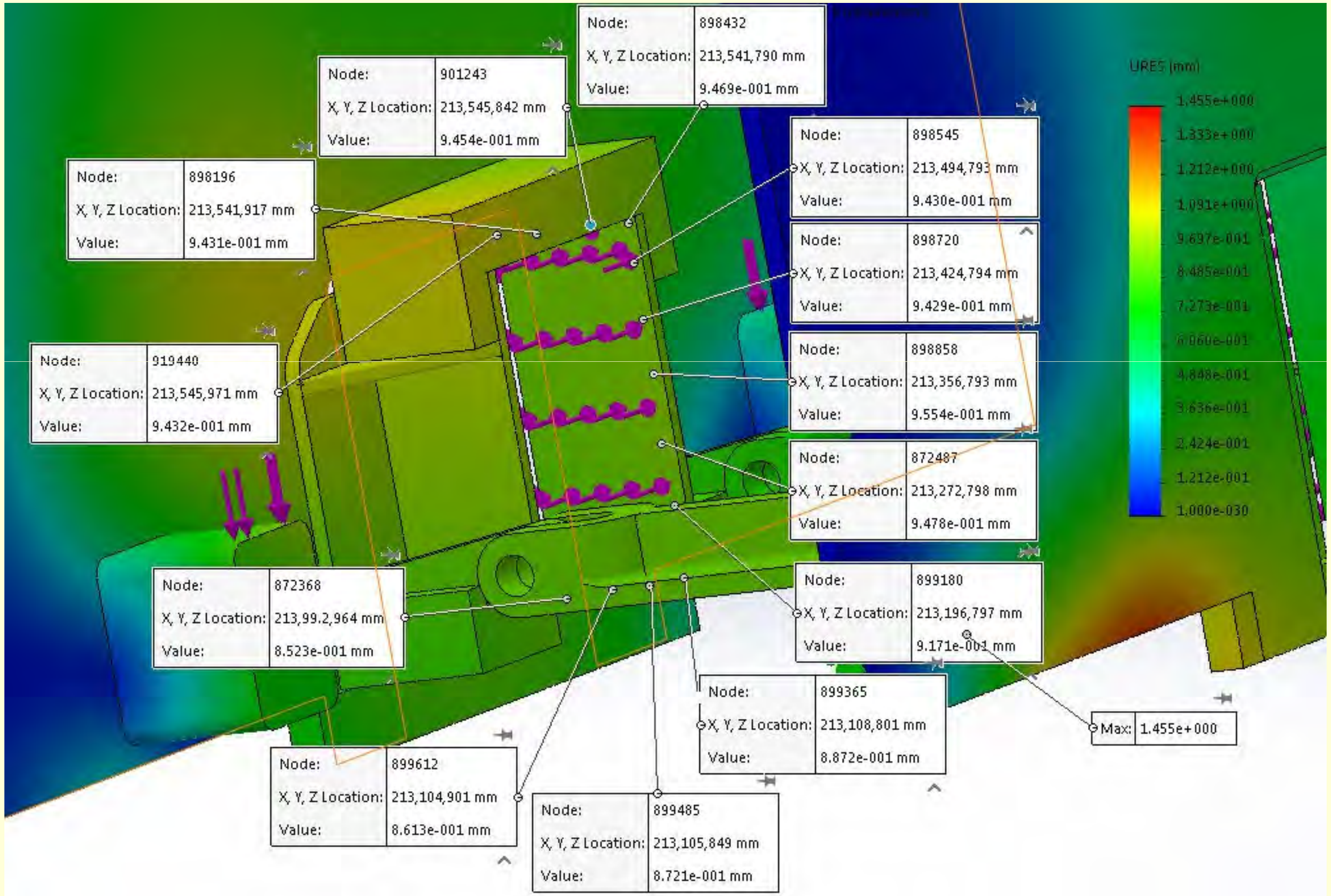
First Modification





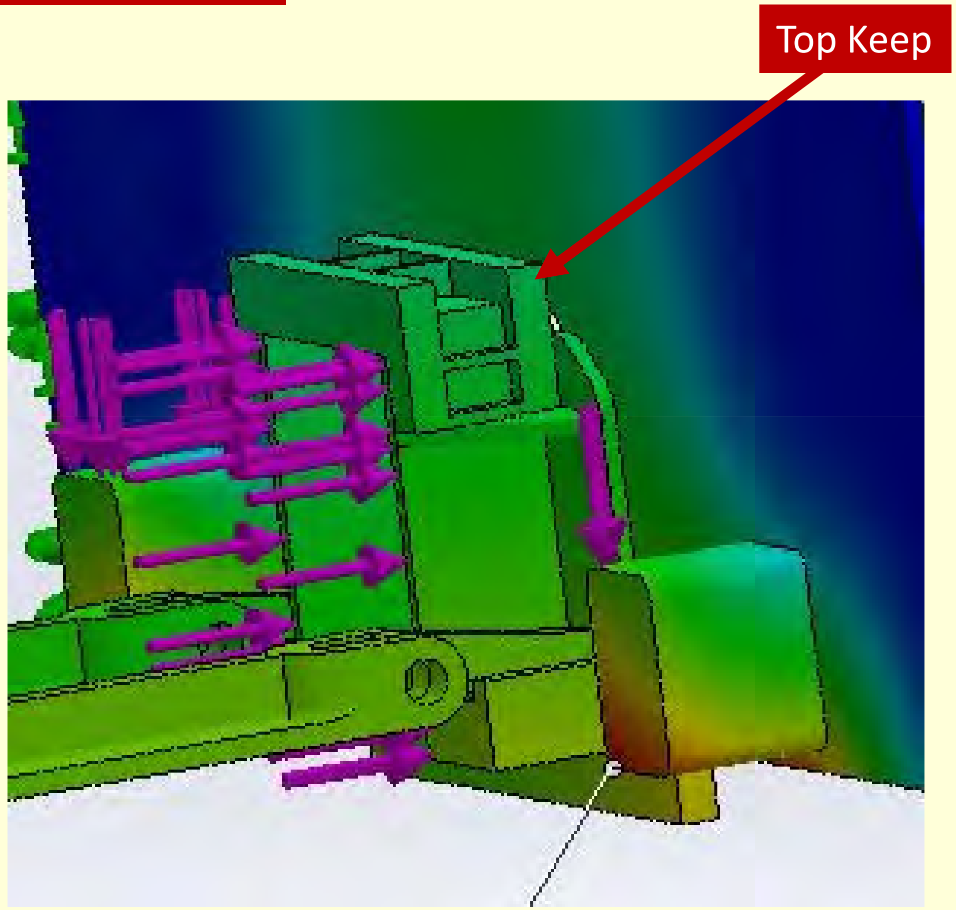
Create frame modifications – step 5

Fourth modification- enlarged top keep



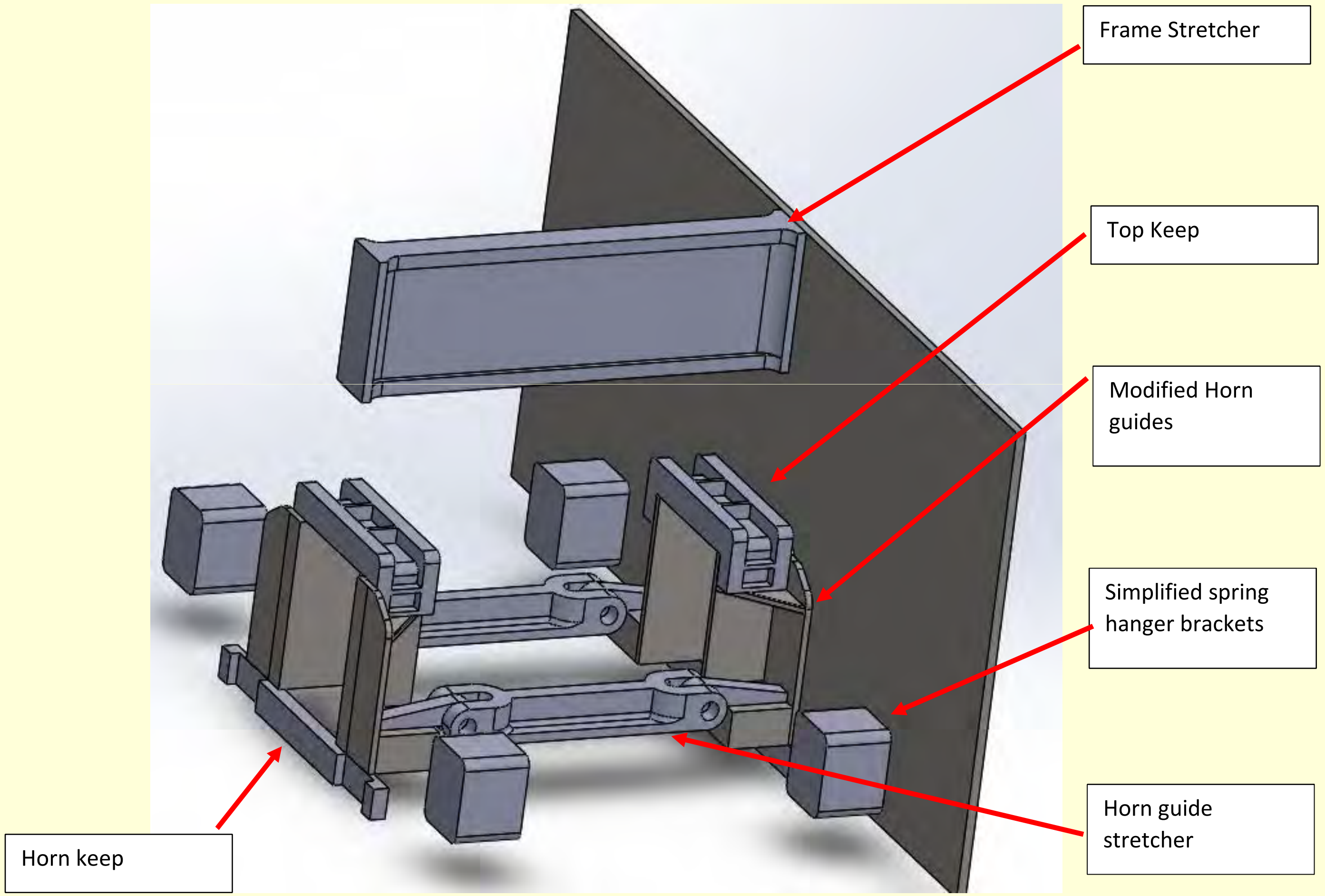
Create frame modifications – step 5

Fifth modification, reduced material on top keep



Create frame modifications – step 5

Final design



Have modifications strengthened the frame? – Step 6

Modification number	With Cant		Without Cant	
	Stress N/m^2 (x10^8)	Displacement (mm)	Stress N/m^2 (x10^8)	Displacement (mm)
Current design	3.631	3.457	3.885	4.397
1	3.878	1.278	3.650	1.566
2	3.174	1.237	3.278	1.522
3	N/A	N/A	4.003	1.257
4	2.849	1.191	2.829	1.455
5	2.914	1.192	2.910	1.457
6	2.482	1.191	2.677	1.384

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3	N/A	N/A	4.003	1.257
4	2.849	1.191	2.829	1.455
5	2.914	1.192	2.910	1.457
6	2.482	1.191	2.677	1.384

% decrease= 32% **% decrease= 65.5%** **% decrease= 31%** **% decrease=69 %**

Final Comment

Pictures


SJ

Thank You!

Any Questions?