	HERSCHEL SPIRE	SPIRE Beam Steering Mirror Design Description v 0.1	Ref: SPIRE-ATC-PRJ-587 Page : Page 1 of 14 Date : 19-June-01 Author: IP
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Section 10

Appendix 3B: Structural Interface FEA Results

1 Scope

This document records a Finite Element Analysis performed on the SPIRE Beam Steering Mirror structure component,

2 Model

2.1 Design

The model is based on Pro/Engineer drawing number BSM-02-001-001 dated Rev 1 (WIP) 29.May.01.

2.2 FEA representation

The FEA was performed as a solid model in integrated Pro/Mechanica. Multi-pass adaptive meshing was used, with convergence set at 10%. Small fillets and holes were generally suppressed, with the exception of connector pin and base mounting features. Material was assigned as Aluminium 6082

2.3 Software

- Pro/Engineer 2000i2
- Pro/MECHANICA STRUCTURE Version 22.3(305) (integrated mode)

3 Results

3.1 50 G acceleration load case

3.1.1 Deflection results

Maximum displacement is predicted at 43 microns under this load case, with prime deflections occurring in a twisting mode (from the side loading) and a pistoning mode around the front mounting hole (from vertical and fore-aft loads).

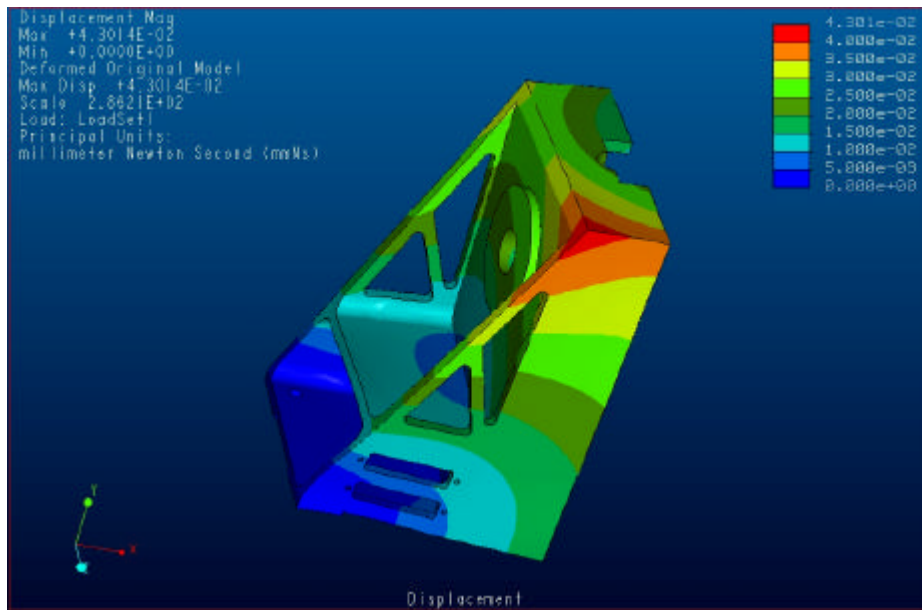


Figure 1 : displacement results (millimetres)

3.1.2 Von Mises Stress results

stresses peak at 36 MPa.

Permissible is per BS8118 (IP's design log no 9, p57)

For fatigue with FoS of 1.0

- 67 MPa friction grip bolted zones (not strictly applicable here as loads are not construction level friction grip)
- 96MPa for re-entrant features
- 76MPa small holes (dia < 3t)

For parent plate

240 MPa with suggested load factor of 2.5, ie a target of 96 MPa in this case

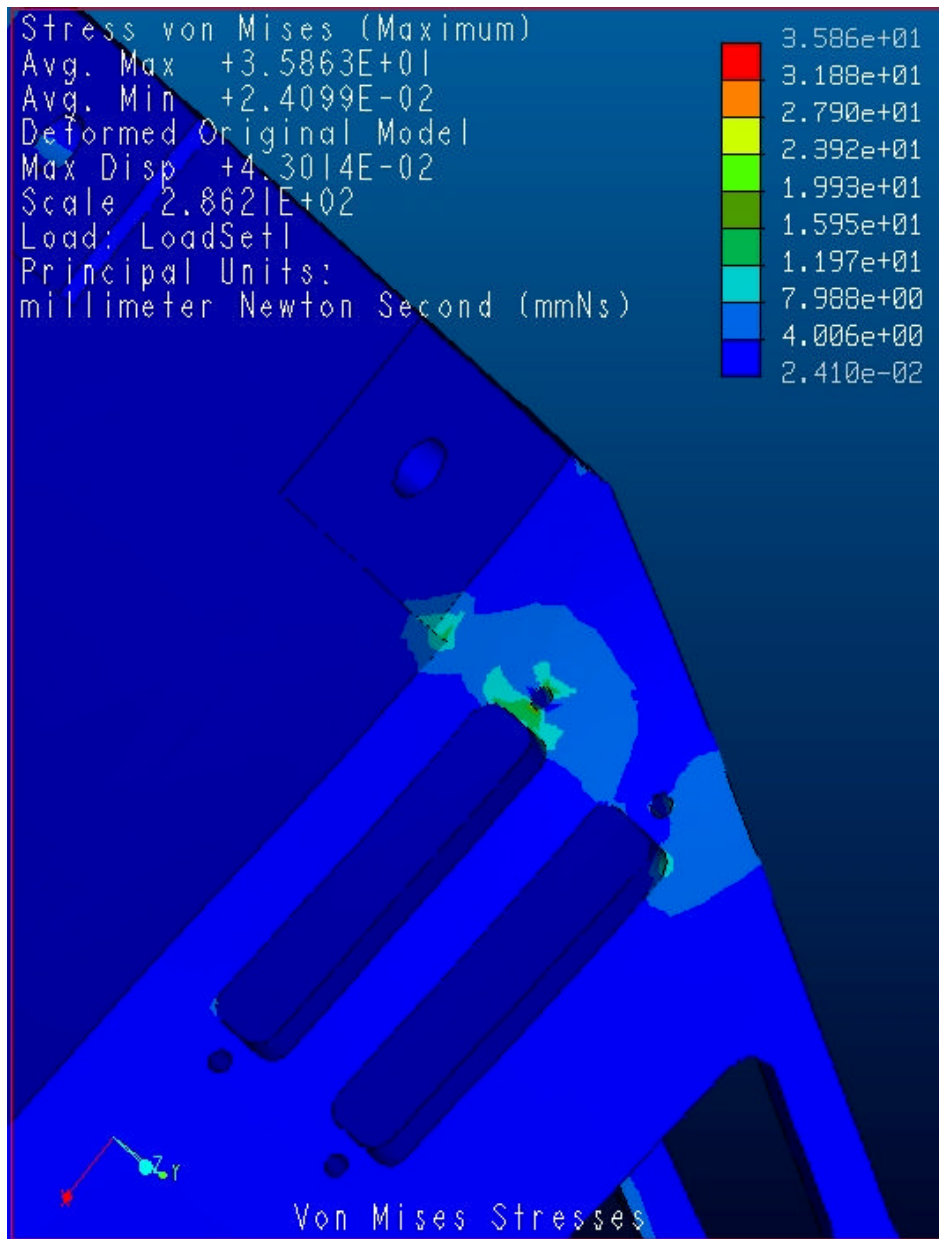


Figure 2 stress distribution around connector cut out and mounting feet

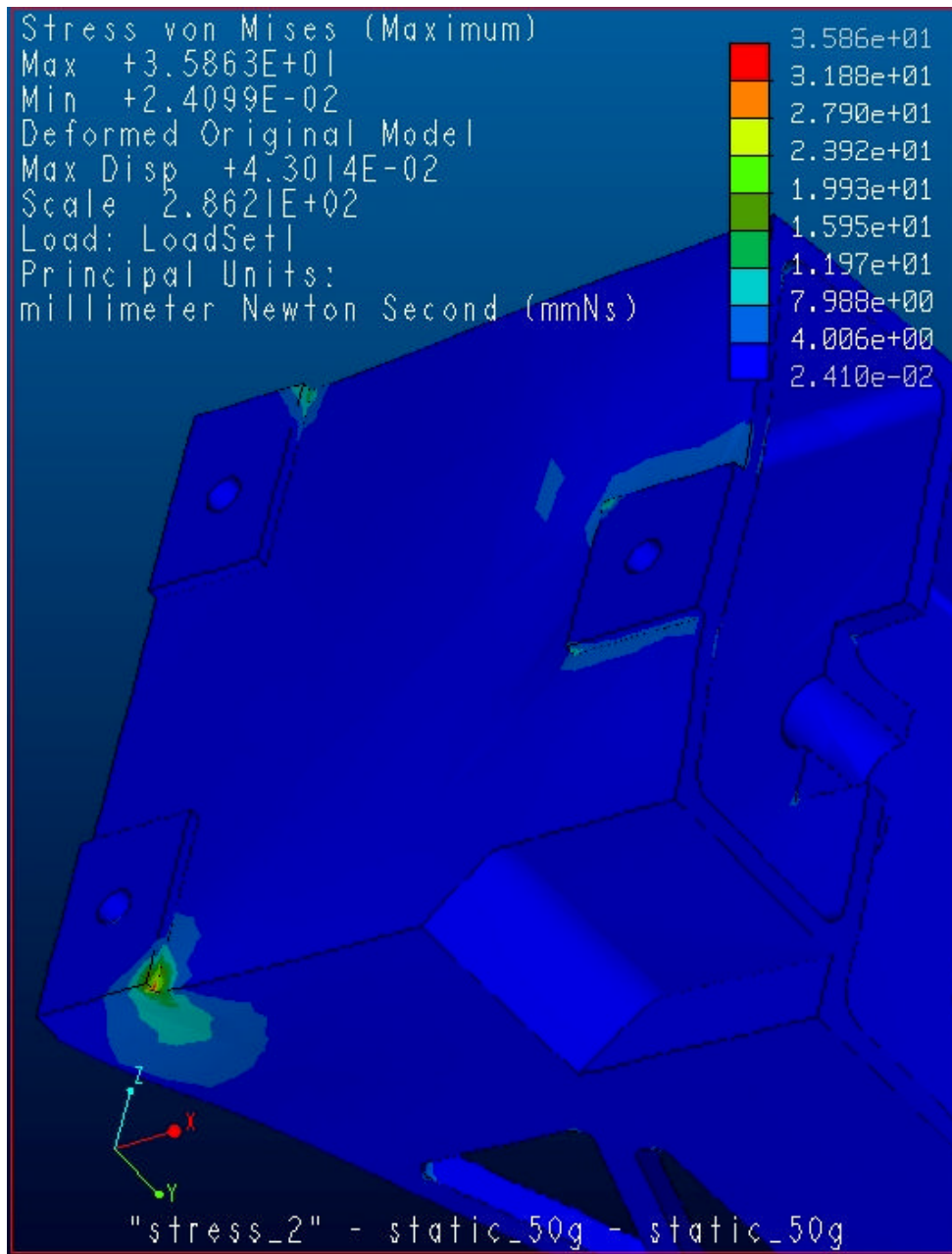


Figure 3 stress distribution around rear mounting foot

3.1.3 Analysis report (extracts)

Pro/MECHANICA STRUCTURE Version 22.3(305)
Summary for Design Study "static_50g"
Mon Jun 04, 2001 19:10:01

No errors were found in the model.

Pro/MECHANICA STRUCTURE Model Summary

Principal System of Units: millimeter Newton Second (mmNs)

Length: mm
Force: N
Time: sec
Temperature: C

Model Type: Three Dimensional

Points: 1146
Edges: 5435
Faces: 7465

Springs: 0
Masses: 0
Beams: 0
Shells: 0
Solids: 3189

Elements: 3189

Standard Design Study

Description:
50G loads applied in x,y,z

Static Analysis "static_50g":

Convergence Method: Multiple-Pass Adaptive
Plotting Grid: 4

>> Pass 1 <<

Total Number of Equations: 3330
Maximum Edge Order: 1

Elements Not Converged: 3189
Edges Not Converged: 5435
Local Disp/Energy Index: 100.0%
Global RMS Stress Index: 100.0%

>> Pass 2 <<

Total Number of Equations: 19418
Maximum Edge Order: 2

Elements Not Converged: 1956
Edges Not Converged: 4627
Local Disp/Energy Index: 100.0%
Global RMS Stress Index: 84.8%

>> Pass 3 <<

Total Number of Equations: 63723
Maximum Edge Order: 4
Elements Not Converged: 1639
Edges Not Converged: 2628
Local Disp/Energy Index: 100.0%
Global RMS Stress Index: 80.9%

>> Pass 4 <<

Total Number of Equations: 117789
Maximum Edge Order: 5



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Elements Not Converged: 815
Edges Not Converged: 207
Local Disp/Energy Index: 100.0%
Global RMS Stress Index: 36.4%

>> Pass 5 <<

Total Number of Equations: 174100
Maximum Edge Order: 6
Elements Not Converged: 146
Edges Not Converged: 0
Local Disp/Energy Index: 54.9%
Global RMS Stress Index: 13.1%

>> Pass 6 <<

Total Number of Equations: 199893
Maximum Edge Order: 6
Elements Not Converged: 22
Edges Not Converged: 0
Local Disp/Energy Index: 30.1%
Global RMS Stress Index: 12.0%

RMS Stress Error Estimates:

Table with 3 columns: Load Set, Stress Error, % of Max Prin Str. Row 1: LoadSet1, 4.56e-01, 1.3% of 3.63e+01

** Warning: Convergence was not obtained because the maximum polynomial order of 6 was reached.

The analysis did not converge to within 10% on edge displacement and element strain energy.

Total Mass of Model: 2.943847e-04

Mass Moments of Inertia about WCS Origin:

Ixx: 1.41233e+00
Ixy: -2.35807e-01 Iyy: 3.84633e-01
Ixz: -4.52996e-03 Iyz: 1.01220e-03 Izz: 1.29888e+00

Principal MMOI and Principal Axes Relative to WCS Origin:

Table with 3 columns: Max Prin, Mid Prin, Min Prin. Rows for WCS X, Y, Z coordinates.

Center of Mass Location Relative to WCS Origin: (1.02862e+01, 4.89316e+01, -5.38177e-02)

Mass Moments of Inertia about the Center of Mass:

Ixx: 7.07486e-01
Ixy: -8.76379e-02 Iyy: 3.53484e-01
Ixz: -4.69293e-03 Iyz: 2.36968e-04 Izz: 5.62882e-01

Principal MMOI and Principal Axes Relative to COM:

Table with 3 columns: Max Prin, Mid Prin, Min Prin. Rows for WCS X, Y, Z coordinates.

Constraint Set: ConstraintSet1

Load Set: LoadSet1

Resultant Load on Model: in global X direction: 1.451317e+02

in global Y direction: 1.451317e+02
in global Z direction: 1.451317e+02

Measures:

Name	Value	Convergence
max_disp_mag:	4.301418e-02	0.8%
max_disp_x:	3.048651e-02	0.8%
max_disp_y:	-1.805561e-02	0.9%
max_disp_z:	2.839908e-02	0.8%
max_prin_mag:	3.626618e+01	3.8%
max_stress_prin:	3.626618e+01	3.8%
max_stress_vm:	3.586344e+01	0.2%
max_stress_xx:	2.019206e+01	15.5%
max_stress_xy:	1.101872e+01	15.7%
max_stress_xz:	7.227989e+00	0.5%
max_stress_yy:	3.609924e+01	2.9%
max_stress_yz:	-7.932948e+00	0.6%
max_stress_zz:	-1.609714e+01	0.5%
min_stress_prin:	-3.532419e+01	1.2%
strain_energy:	9.345811e-01	0.6%

3.1.4 Verification

Reaction loads

- need checking

Manual verification

- required,

3.2 Modal Analysis

3.2.1 Modal Analysis Results

To limit run time, the maximum number of modes to sweep for was set to 12. The results were:

Mode	Frequency
1	6.881738e+02
2	8.638142e+02
3	1.780816e+03
4	2.715497e+03
5	3.058290e+03
6	3.283797e+03
7	3.344646e+03
8	3.614443e+03
9	3.957047e+03
10	4.096691e+03
11	4.676689e+03
12	5.185199e+03

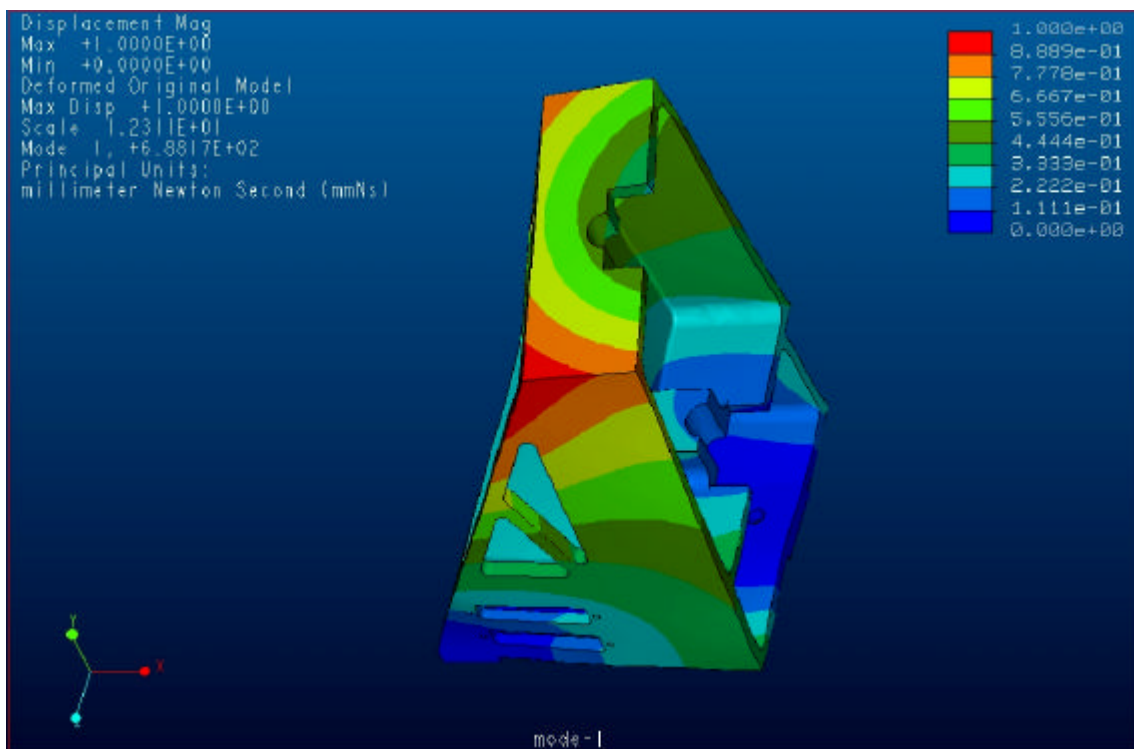


Figure 4 First resonant mode, twisting of entire structure, 688 Hz

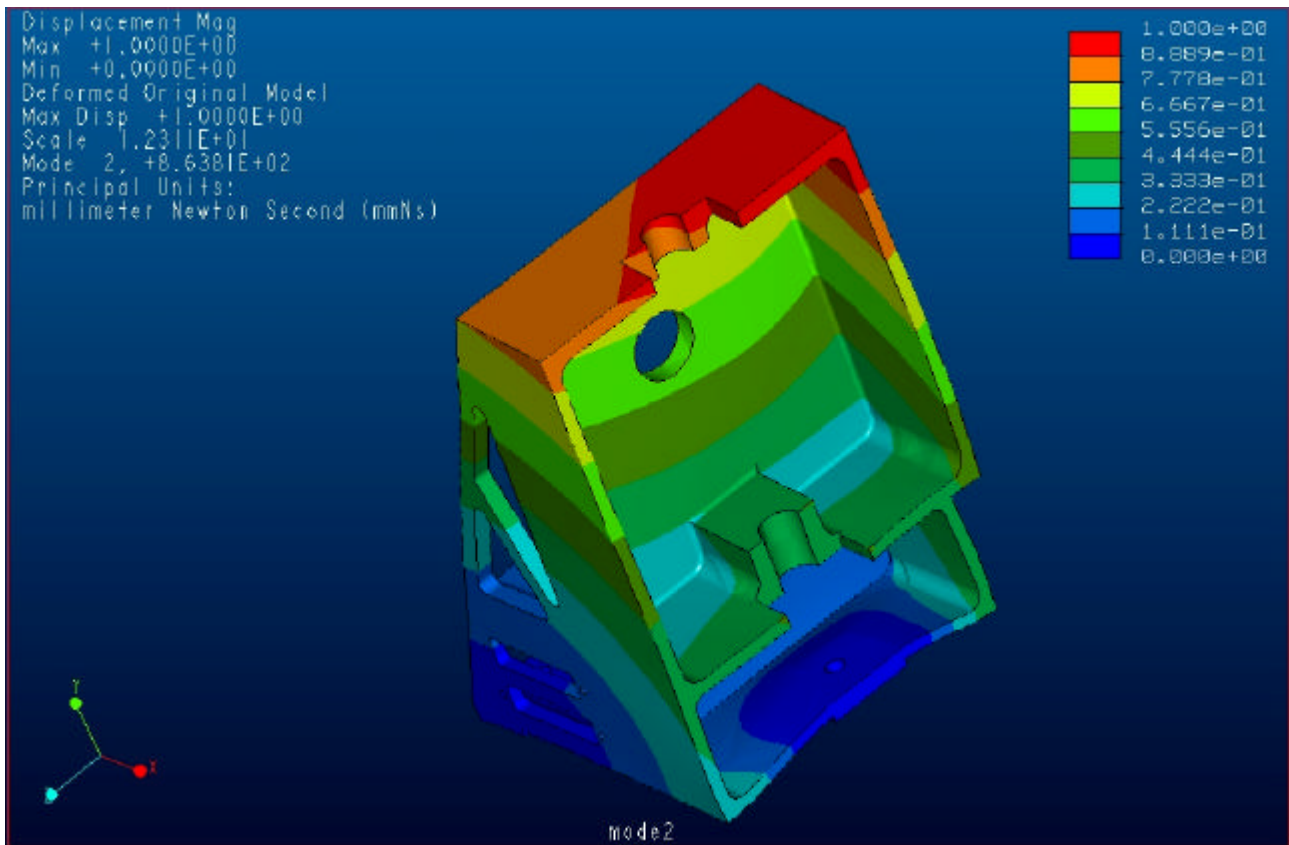


Figure 5 mode 2 , 864Hz. Piston and twist of whole structure

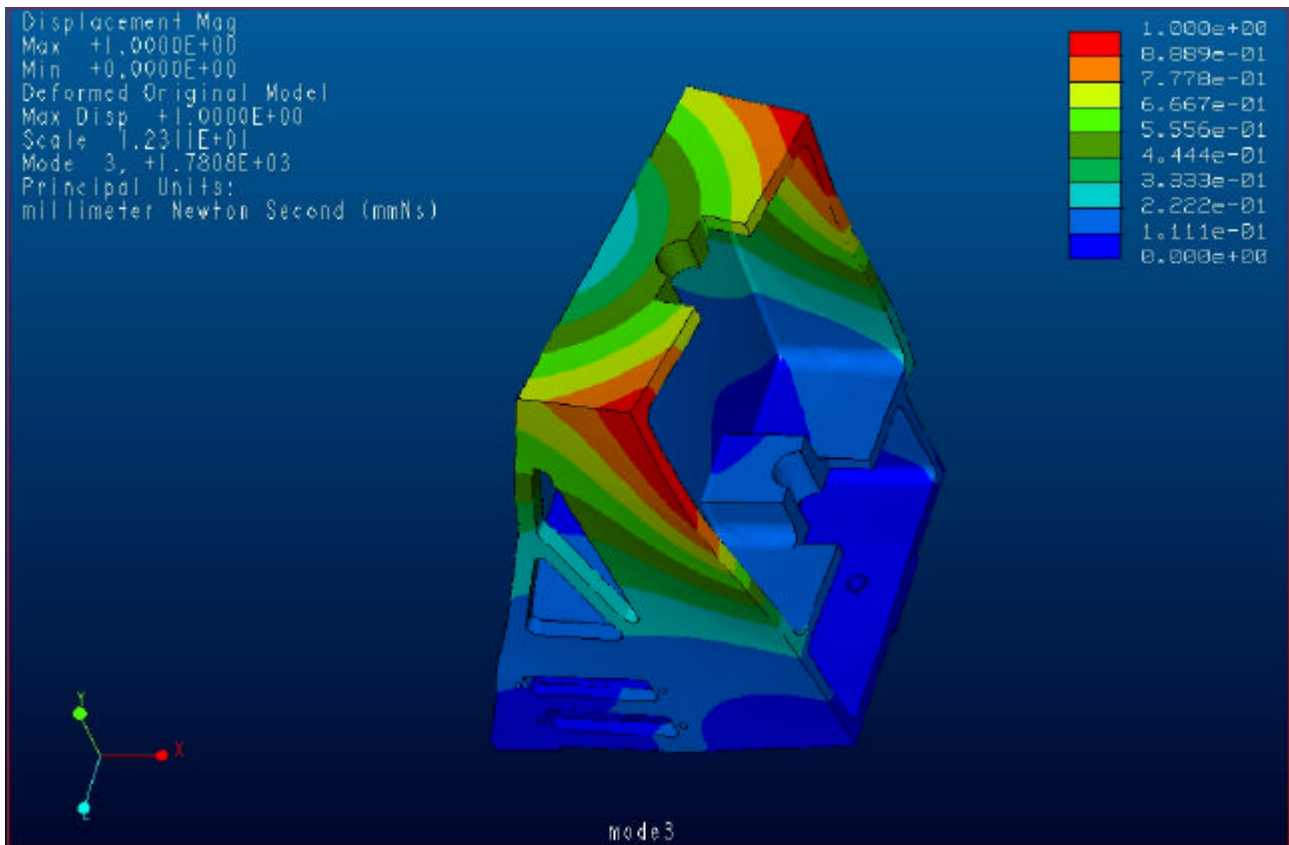


Figure 6 Mode 3 , 1780- Hz, rocking forward of whole structure

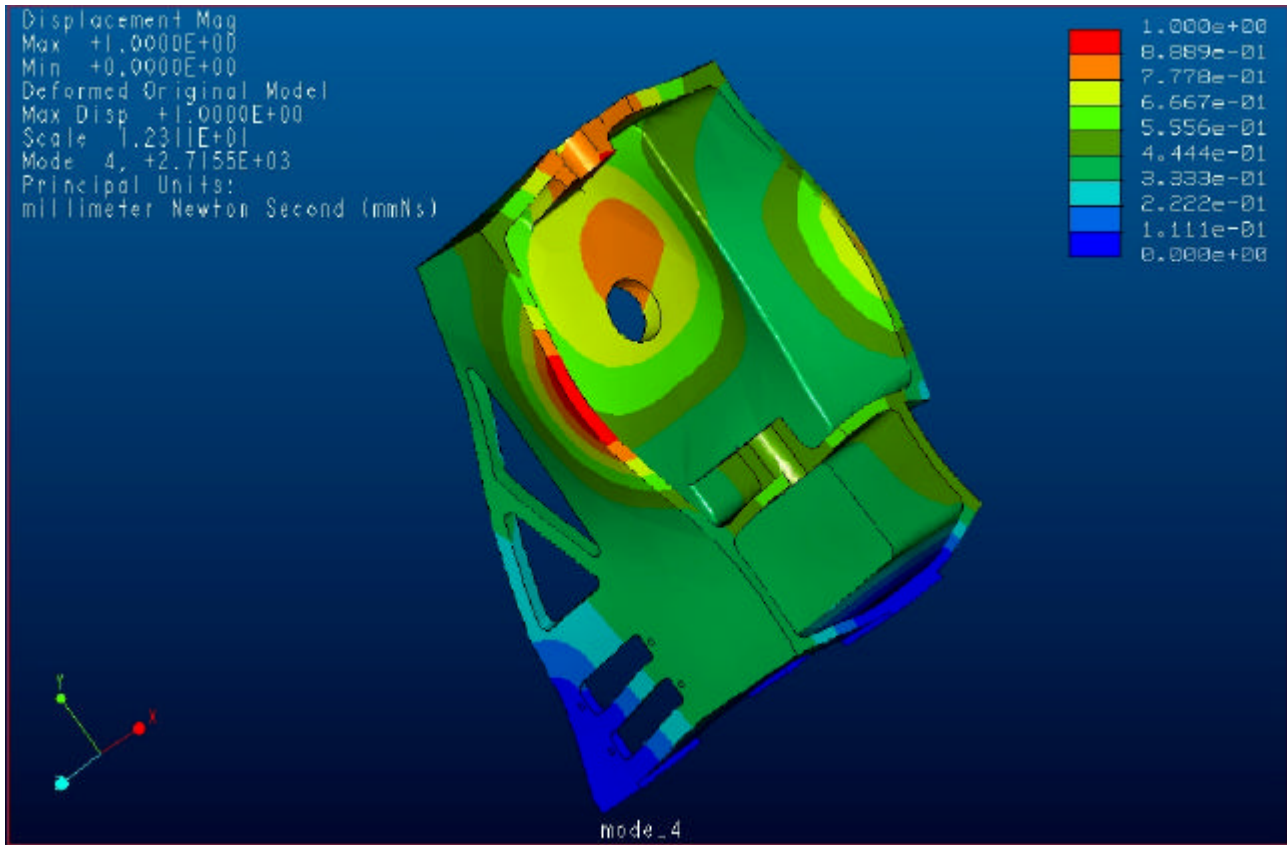


Figure 7 Mode 4, 2716 Hz, local resonance of plates

3.2.2 Model report (extracts)

Pro/MECHANICA STRUCTURE Version 22.3(305)
Summary for Design Study "modal"
Tue Jun 05, 2001 08:32:47

No errors were found in the model.

Pro/MECHANICA STRUCTURE Model Summary

Principal System of Units: millimeter Newton Second (mmNs)

Length: mm
Force: N
Time: sec
Temperature: C

Model Type: Three Dimensional

Points: 1146
Edges: 5435
Faces: 7465

Springs: 0
Masses: 0
Beams: 0
Shells: 0
Solids: 3189

Elements: 3189

Standard Design Study

Description:
basic modal analysis

Modal Analysis "modal":

Convergence Method: Single-Pass Adaptive
Plotting Grid: 4

Convergence Loop Log: (08:33:15)

>> Pass 1 <<

Calculating Element Equations (08:33:15)
Total Number of Equations: 57792
Maximum Edge Order: 3

>> Pass 2 <<

Calculating Element Equations (08:36:33)
Total Number of Equations: 65469
Maximum Edge Order: 5

RMS Stress Error Estimates:

Mode Stress Error (% of Max Modal Stress)

Mode	Stress Error (% of Max Modal Stress)
1	0.8%
2	0.7%
3	2.4%
4	1.3%
5	1.1%
6	0.8%
7	0.9%
8	1.6%
9	4.3%
10	2.4%
11	2.0%
12	1.0%

Total Mass of Model: 2.943847e-04

Mass Moments of Inertia about WCS Origin:

Ixx: 1.41233e+00
Ixy: -2.35807e-01 Iyy: 3.84633e-01
Ixz: -4.52996e-03 Iyz: 1.01220e-03 Izz: 1.29888e+00

Principal MMOI and Principal Axes Relative to WCS Origin:

Max Prin	Mid Prin	Min Prin
1.46399e+00	1.29874e+00	3.33110e-01

WCS X: 9.76566e-01 2.74581e-02 2.13461e-01
WCS Y: -2.13377e-01 -5.97632e-03 9.76952e-01
WCS Z: -2.81010e-02 9.99605e-01 -2.26723e-05

Center of Mass Location Relative to WCS Origin:
(1.02862e+01, 4.89316e+01, -5.38177e-02)

Mass Moments of Inertia about the Center of Mass:

Ixx: 7.07486e-01
Ixy: -8.76379e-02 Iyy: 3.53484e-01
Ixz: -4.69293e-03 Iyz: 2.36968e-04 Izz: 5.62882e-01

Principal MMOI and Principal Axes Relative to COM:

Max Prin Mid Prin Min Prin
7.28123e-01 5.62755e-01 3.32974e-01

WCS X: 9.73328e-01 2.64026e-02 2.27892e-01
WCS Y: -2.27705e-01 -9.92492e-03 9.73680e-01
WCS Z: -2.79695e-02 9.99602e-01 3.64820e-03

Constraint Set: ConstraintSet1

Number of Modes: 12

Mode Frequency

1 6.881738e+02
2 8.638142e+02
3 1.780816e+03
4 2.715497e+03
5 3.058290e+03
6 3.283797e+03
7 3.344646e+03
8 3.614443e+03
9 3.957047e+03
10 4.096691e+03
11 4.676689e+03
12 5.185199e+03

3.2.3 Verification

- need checking manually



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