# Stress analysis of hinge L AA nylon

**Date: 13-Oct-2007**


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## 1. Introduction

Run with nylon instead of Al
Stress and distortion analysis for hinge structure loads that result from engaging and disengaging the precision mounts.

There are three issues:
1. failure of the aluminum
2. distortion of the structure that causes ladders to collide.
3. distortion of the structure that causes bearing binding.

**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.

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## 2. Description

The assumed load is 15 lbs remotely located in the region of one of the precision mounts. This is a bit of a worse case scenario where a single precision mount engages before the others, plus the insertion and withdrawal force on a mount will probably be less than 15 lbs. This load greatly exceeds gravitational loads which have been neglected in this analysis.

The distortions must be projected to the end of the ladders and compared to the designed separation of the two detector modules. The designed ladder separation is approximately a mm so the distortion should be limited to significantly less than 1 mm to avoid collisions.

The distortion of the structure determines the tolerance that must be designed into the bearings to avoid binding.

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## 3. File Information

| | |
|---|---|
| **Model name:** | hinge L AA |
| **Model location:** | C:\Documents and Settings\Howard Wieman\My Documents\aps project\mechanical\HFT Alice July 2007 restore\HFT Alice July 2007\hinge L AA.SLDASM |
| **Results location:** | C:\Program Files\SolidWorks\COSMOS\work |

**Study name:** hinge AB 4 (-Default-)

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# 4. Materials

| No. | Part Name | Material | Mass | Volume |
|---|---|---|---|---|
| 1 | hinge back plate AA-1 | [SW]Nylon 6/10 | 0.211013 kg | 0.000150724 m^3 |
| 2 | hinge front plate L AA-1 | [SW]Nylon 6/10 | 0.109429 kg | 7.81633e-005 m^3 |
| 3 | hinge side plate AA-1 | [SW]Nylon 6/10 | 0.061325 kg | 4.38035e-005 m^3 |
| 4 | hinge side plate AA-2 | [SW]Nylon 6/10 | 0.061325 kg | 4.38035e-005 m^3 |

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# 5. Load & Restraint Information

| Restraint | |
|---|---|
| **Restraint-1 <hinge back plate AA-1>** | on **2 Face(s)** fixed. |
| **Description:** | |
| **Restraint-2 <hinge front plate L AA-1>** | on **1 Face(s)** with respect to reference geometry **Right** with displacement **0 m** normal to reference plane |
| **Description:** | |
| **Pin Connector-10 <hinge side plate AA-1, hinge front plate L AA-1>** | Pin Connectors on **2 Face(s)**; no pin translation; with rotational stiffness of 0.00000 N-m/rad |

| | |
|---|---|
| **Description:** | |
| **Pin Connector-11 <hinge side plate AA-1, hinge back plate AA-1>** | Pin Connectors on **2 Face(s)**; no pin translation; with rotational stiffness of 0.00000 N-m/rad |
| **Description:** | |
| **Pin Connector-12 <hinge side plate AA-2, hinge back plate AA-1>** | Pin Connectors on **2 Face(s)**; no pin translation; with rotational stiffness of 0.00000 N-m/rad |
| **Description:** | |
| **Pin Connector-13 <hinge side plate AA-2, hinge front plate L AA-1>** | Pin Connectors on **2 Face(s)**; no pin translation; with rotational stiffness of 0.00000 N-m/rad |
| **Description:** | |
| **Pin Connector-14 <hinge side plate AA-2, hinge front plate L AA-1>** | Pin Connectors on **2 Face(s)**; no pin translation; with rotational stiffness of 0.00000 N-m/rad |
| **Description:** | |
| **Pin Connector-15 <hinge side plate AA-1, hinge front plate L AA-1>** | Pin Connectors on **2 Face(s)**; no pin translation; with rotational stiffness of 0.00000 N-m/rad |
| **Description:** | |
| **Pin Connector-16 <hinge side plate AA-1, hinge back plate AA-1>** | Pin Connectors on **2 Face(s)**; no pin translation; with rotational stiffness of 0.00000 N-m/rad |
| **Description:** | |
| **Pin Connector-17 <hinge side plate AA-2, hinge back plate AA-1>** | Pin Connectors on **2 Face(s)**; no pin translation; with rotational stiffness of 0.00000 N-m/rad |
| **Description:** | |

| **Load** | |
|---|---|
| **RemoteLoads/Mass-1 <hinge front plate L AA-1>** | Load ( Rigid Connection ) on **8 Face(s)** apply force **15 lb** along Z direction at location (-3.8 in, 3.4 in, 14.9 in) |

| | |
|---|---|
| **Description:** | |

# 6. Study Property

| Mesh Information | |
|---|---|
| Mesh Type: | Solid mesh |
| Mesher Used: | Standard |
| Automatic Transition: | Off |
| Smooth Surface: | On |
| Jacobian Check: | 4 Points |
| Element Size: | 0.26768 in |
| Tolerance: | 0.013384 in |
| Quality: | High |
| Number of elements: | 31122 |
| Number of nodes: | 61597 |
| Time to complete mesh(hh;mm;ss): | 00:00:21 |
| Computer name: | WIEMAN-M90 |

| Solver Information | |
|---|---|
| Quality: | High |
| Solver Type: | Direct sparse solver |
| Option: | Include Thermal Effects |
| Thermal Option: | Input Temperature |
| Thermal Option: | Reference Temperature at zero strain: 298 Kelvin |

# 7. Contact

**Contact state: Touching faces - Bonded**

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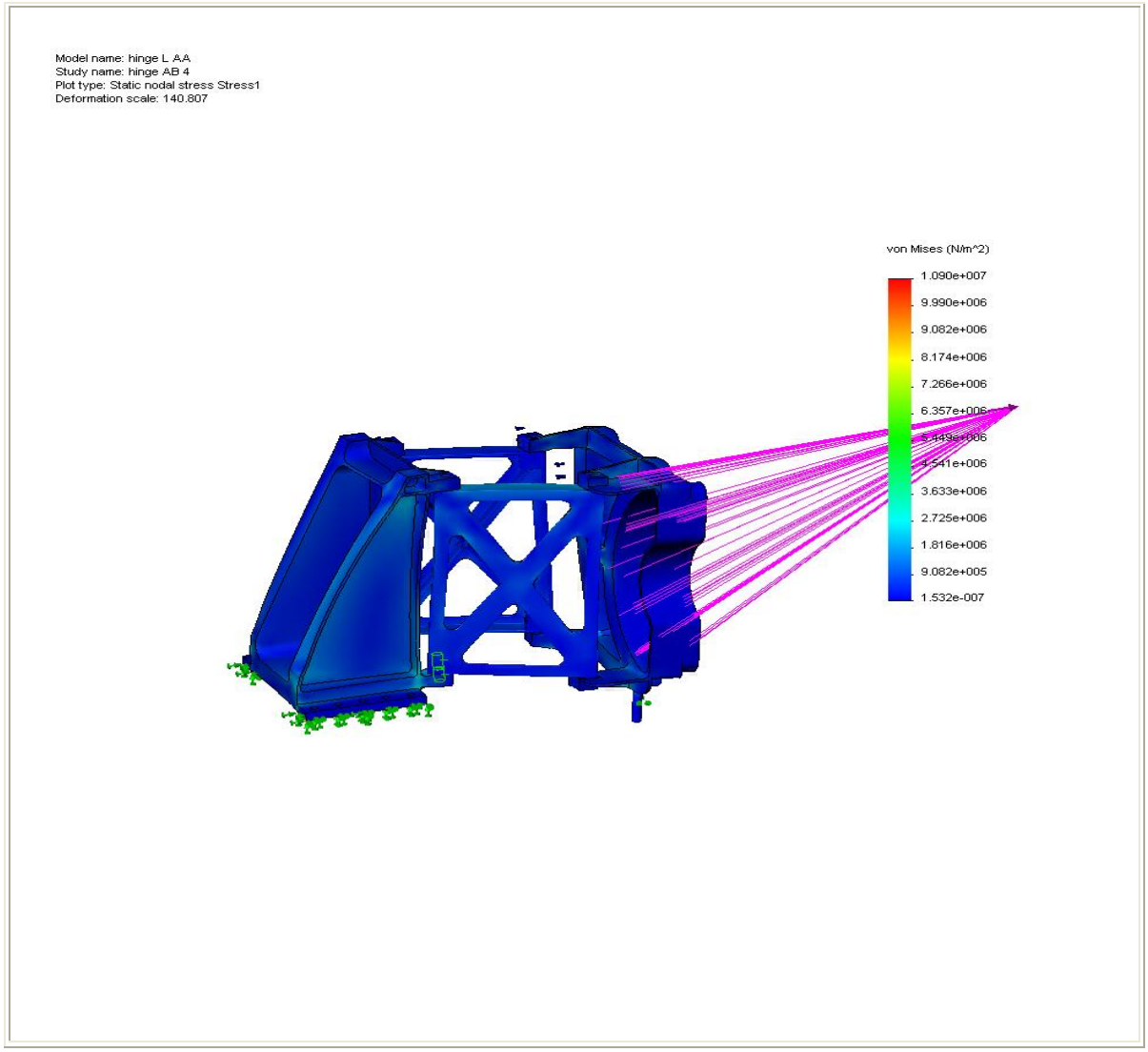
# 8. Results

## 8a. Default Results

| Name | Type | Min | Location | Max | Location |
|---|---|---|---|---|---|
| Stress1 | VON: von Mises stress | 1.53156e-007 N/m^2<br>Node: 29954 | (-2.69439 in,<br>-2.20794e-007 in,<br>5.82381 in) | 1.08984e+007 N/m^2<br>Node: 15893 | (-2 in,<br>-3.41563 in,<br>-0.08 in) |
| Displacement1 | URES: Resultant displacement | 0 m<br>Node: 1 | (-2.45 in,<br>-3.43125 in,<br>-2.6795 in) | 0.000209041 m<br>Node: 27119 | (-3.34347 in,<br>2.73357 in,<br>6.32381 in) |
| Strain1 | ESTRN: Equivalent strain | 1.14314e-017<br>Element: 10852 | (-2.7766 in,<br>-0.37225 in,<br>5.88631 | 0.000553014<br>Element: 5753 | (-2.02999 in,<br>-3.40989 in, |

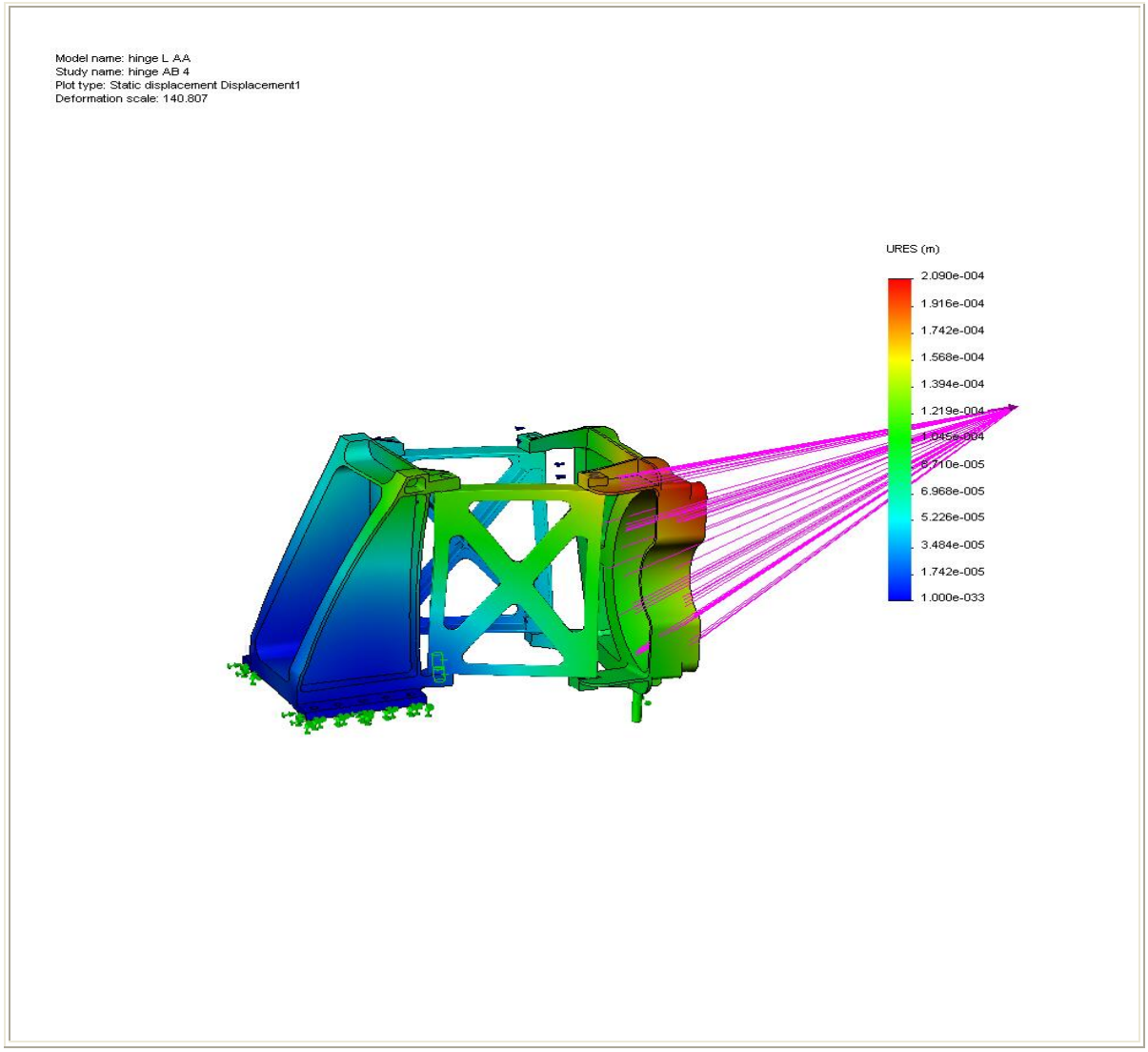
| | | | | | |
|---|---|---|---|---|---|
| | | | in) | | -0.173294 in) |
| Displacement2 | UX: X Displacement | -0.0503275 mm Node: 4530 | (-1.70275 in, 3.0425 in, -0.73625 in) | 0.0540822 mm Node: 30991 | (-3.12115 in, 2.80328 in, 6.32381 in) |
| Displacement3 | UY: Y Displacement | -0.1347 mm Node: 19843 | (-1.01561 in, 3.44902e-015 in, 6.32381 in) | 0.0152714 mm Node: 5828 | (-0.654762 in, -3.11 in, -3.08 in) |
| Displacement4 | UZ: Z Displacement | -0.0340283 mm Node: 19628 | (-2.34129 in, -4.4 in, 5.26405 in) | 0.169634 mm Node: 26143 | (-3.35355 in, 3.25355 in, 5.15381 in) |

| **hinge L AA-hinge AB 4-Stress-Stress1** |
|---|
| **JPEG** |



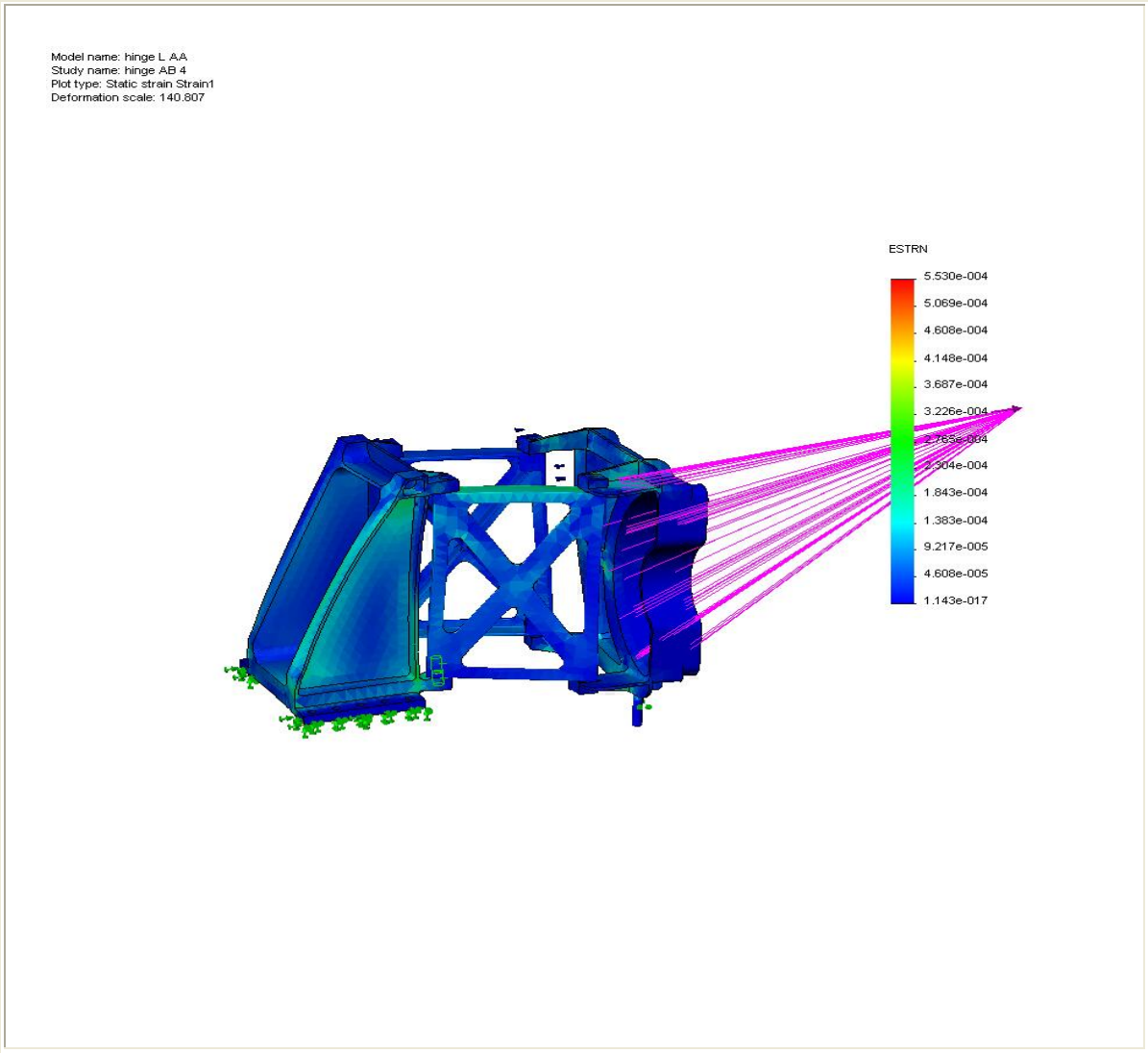

**hinge L AA-hinge AB 4-Displacement-Displacement1**

**JPEG**



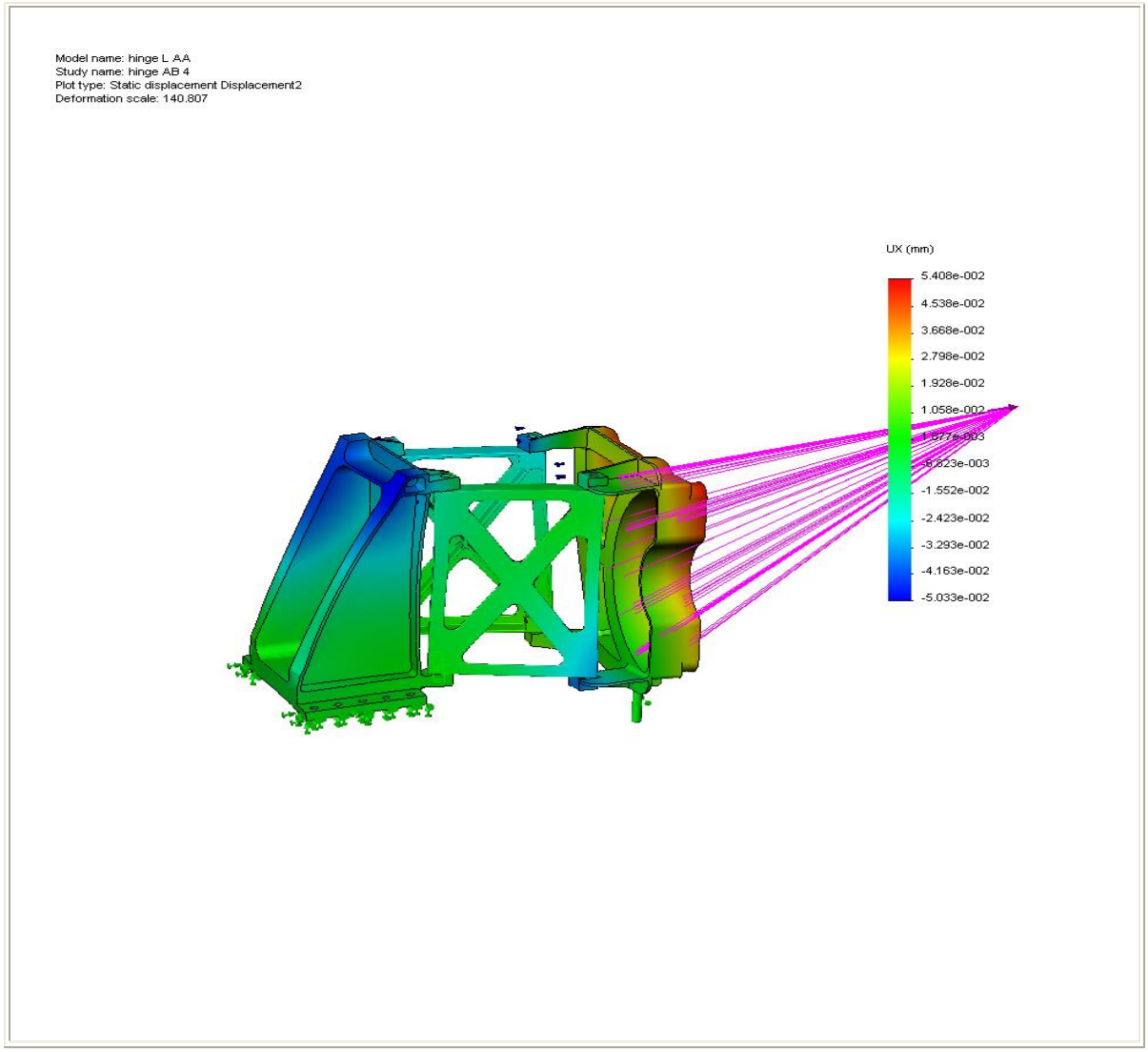

**hinge L AA-hinge AB 4-Strain-Strain1**

**JPEG**



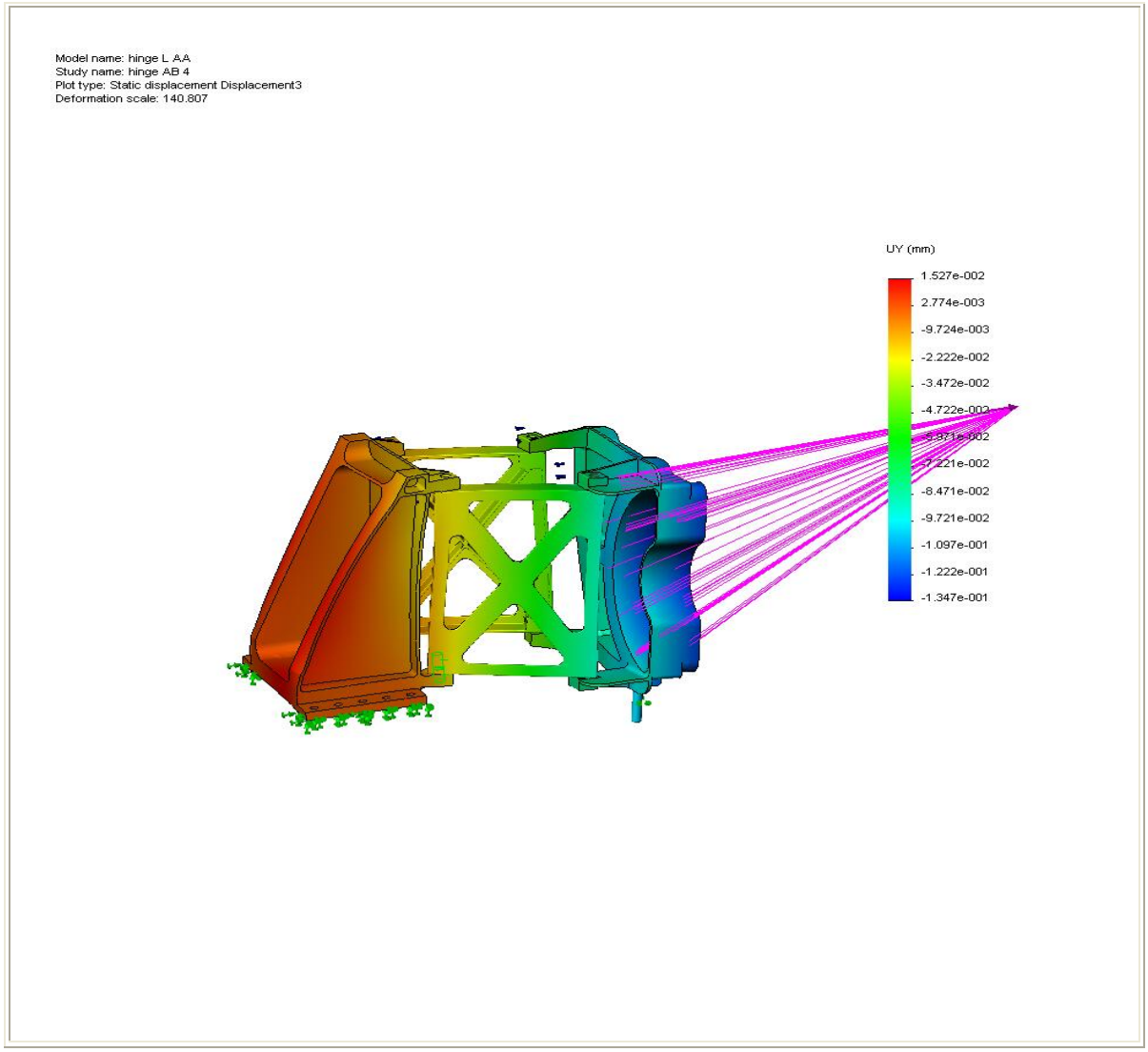

**hinge L AA-hinge AB 4-Displacement-Displacement2**

**JPEG**



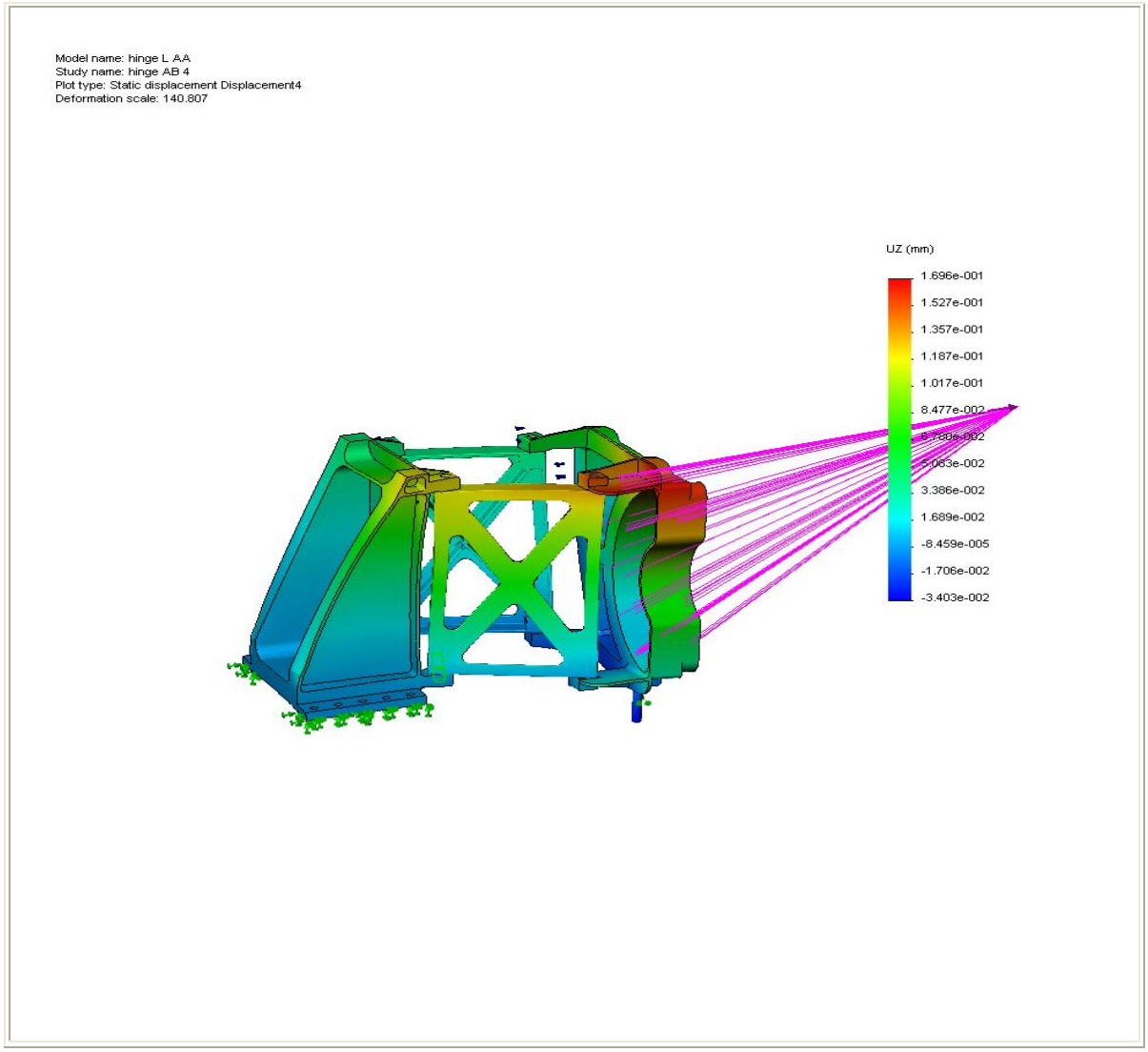

**hinge L AA-hinge AB 4-Displacement-Displacement3**

**JPEG**




**hinge L AA-hinge AB 4-Displacement-Displacement4**

**JPEG**




# 9. Conclusion

The hinge structure weighs .6 lb in nylon

1. The maximum observed stress in the structure is 1.0 N/m^2 which is a factor of 5.5 less than the aluminum yield stress.

2. The projected ladder tip motion is 5 microns in x
and 100 microns in y. This should not cause collisions since it is well below than the 1 mm ladder separation.

3. The structure only twists out of nominal position by at most 10 microns so it is not expected that binding will occur, but this can be looked at in more detail.

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# 10. Appendix

**Material name:** [SW]Nylon 6/10

**Description:**

**Material Source:** Used SolidWorks material

**Material Library Name:** solidworks materials

**Material Model Type:** Linear Elastic Isotropic

| Property Name | Value | Units | Value Type |
|---|---|---|---|
| Elastic modulus | 8.3e+009 | N/m^2 | Constant |
| Poisson's ratio | 0.28 | NA | Constant |
| Shear modulus | 3.2e+009 | N/m^2 | Constant |
| Mass density | 1400 | kg/m^3 | Constant |
| Tensile strength | 1.4256e+008 | N/m^2 | Constant |
| Yield strength | 1.3904e+008 | N/m^2 | Constant |
| Thermal expansion coefficient | 3e-005 | /Kelvin | Constant |
| Thermal conductivity | 0.53 | W/(m.K) | Constant |
| Specific heat | 1500 | J/(kg.K) | Constant |