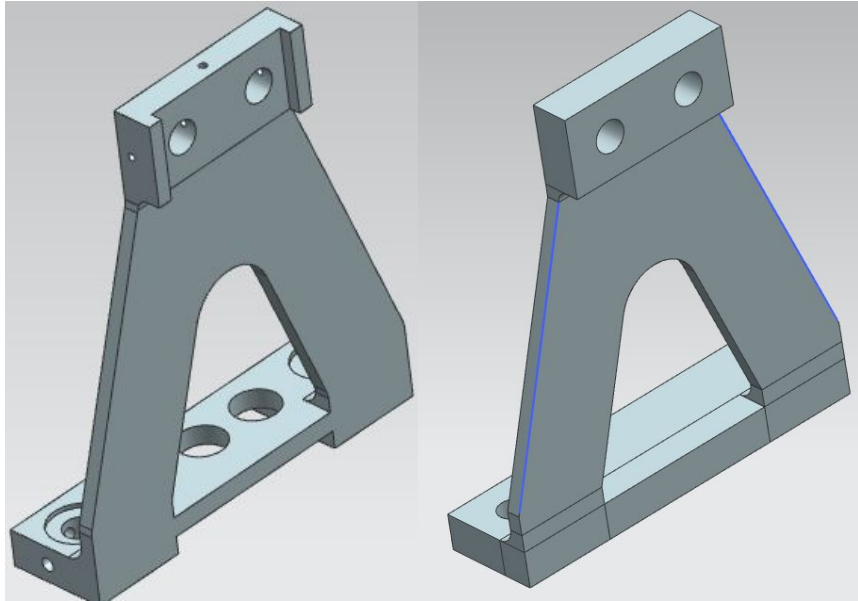

Structural Analysis

— Joy Arnold —

Flexure Idealization



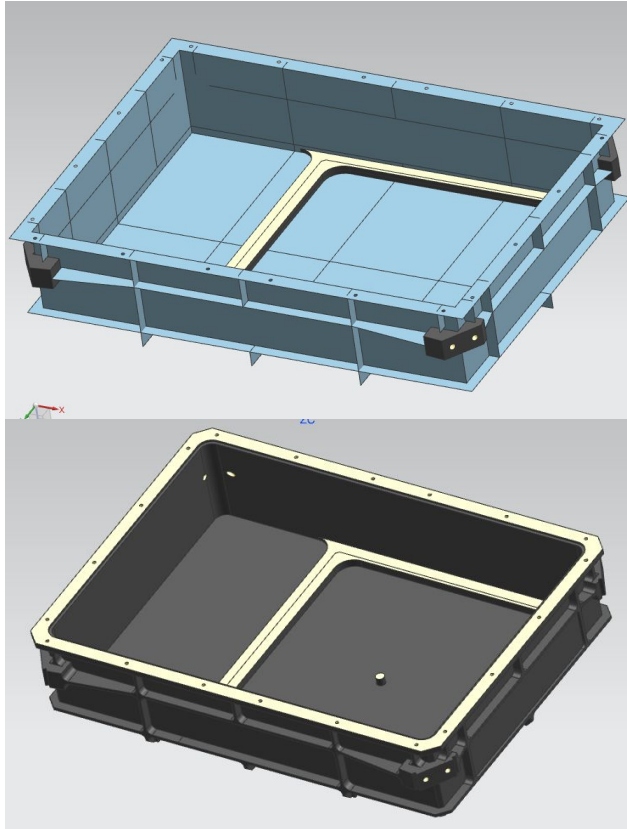
- Deleted epoxy holes (not structurally important)
- Replaced face on counterbored holes (not structurally important)
- Removed lips at top and bottom of flexure (not structurally important)
- Removed bottom 3 holes (only there to reduce mass)
- Trimmed sides of body leading up to top radius to make split body easier
- Kept fillets since they could impact movement and stress concentrations

Flexure FEM



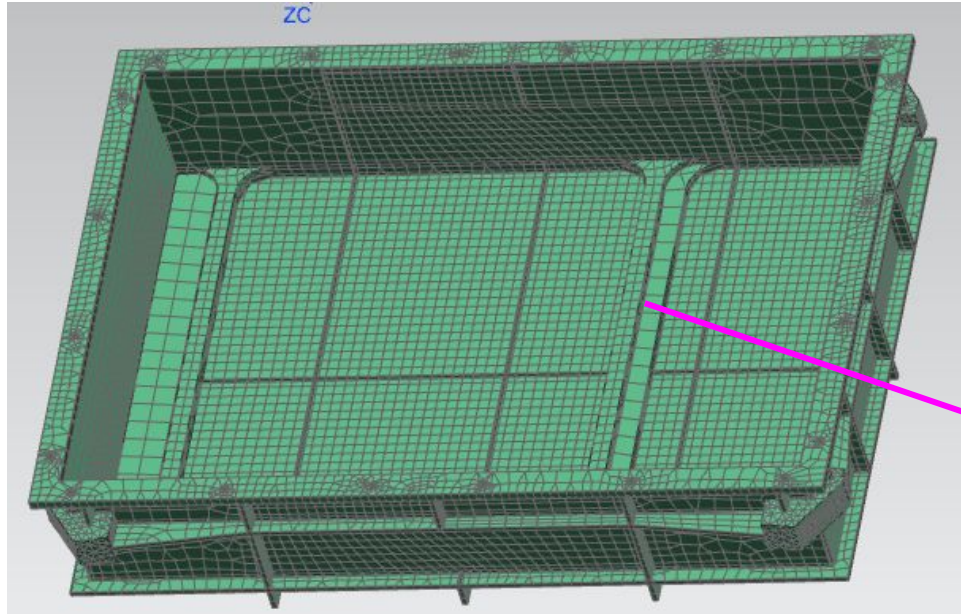
- Split body and used 3D swept mesh for each split body since the flexure is a complex shape and would not be represented well by a 2D mesh.

Enclosure Idealization



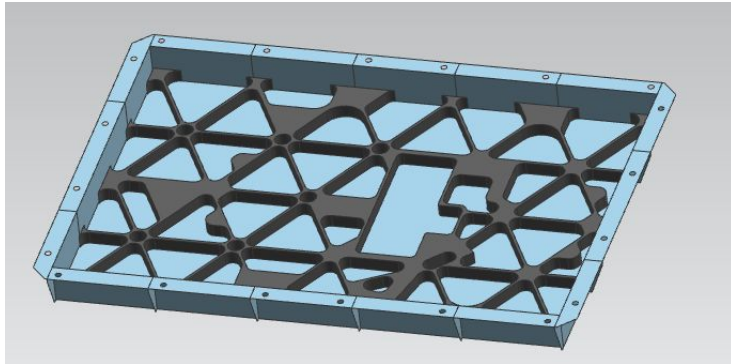
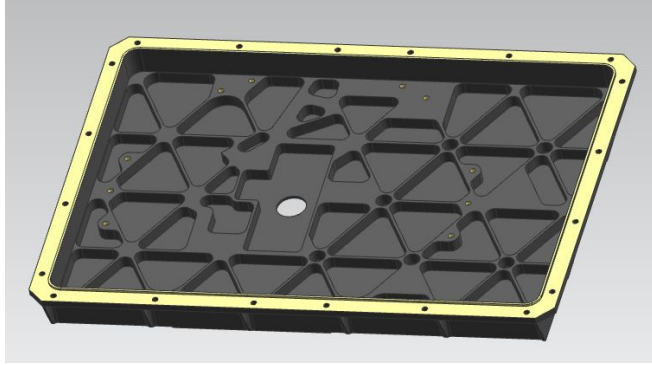
- Removed all fillets on walls of object in order to midsurface
- Removed protruding cylinder in body (not structurally important)
- Made top of enclosure (with holes for connection) flesh with walls for better mesh and since overhang was not structurally important.
- Made all four walls even and flesh to each other for mid surfacing.
- Removed holes on bottom of enclosure (not structurally important)

Enclosure FEM



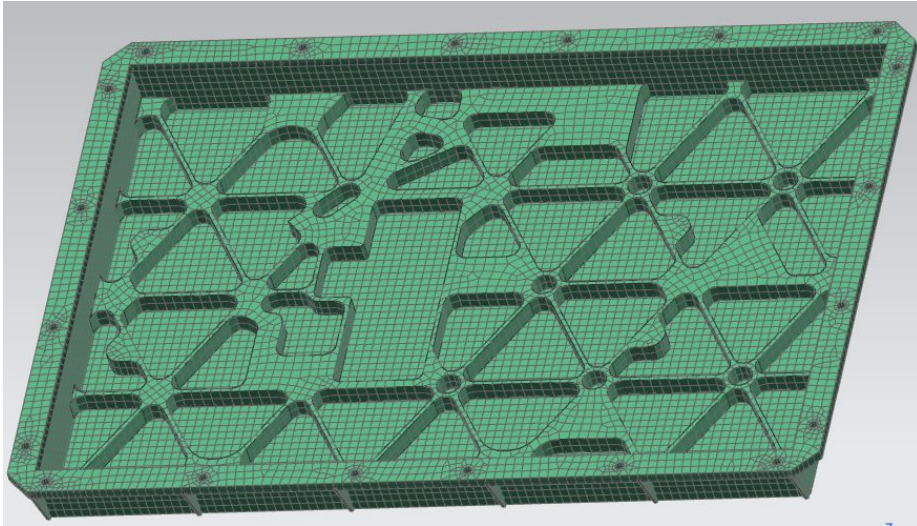
- Mid surfaced walls of enclosure and made 2D mesh since simple rectangular geometry
- Did tetrahedral mesh of connection points for flexure due to complex and unsymmetrical geometry.
- Did 3D swept mesh since complex geometry that would not be represented well in 2D.

AFT Plate Idealization



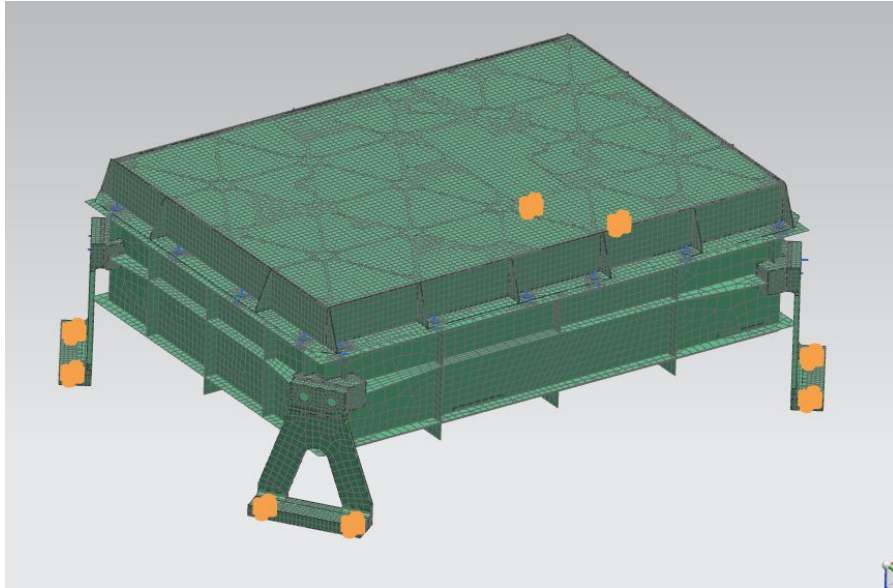
- Made top of AFT Plate flat and removed center hole in order to more easily mesh since the circular ring did not seem structurally essential for this assembly
- Made bottom of AFT Plate (with holes for connection) flesh with walls for better mesh and since overhang was not structurally important.
- Removed small holes in 3D geometry since did not seem structurally important.

AFT Plate FEM



- Mid surfaced walls of AFT Plate and made 2D mesh since simple rectangular geometry
- Did 3D swept mesh of the rest of the body since complex geometry that would not be represented well in 2D.

Constraints and Bolted Connections



- Used fixed constraints for bottom of flexures
- Used bolted connections (nut and bolt) to connect AFT Plate to enclosure.
- To connect flexure to enclosure: created spider connections (face to midpoint) in holes of flexure and enclosure and connected those through node to node connection.

Solution Parameters

Solution Parameters2

Modeling Object

Name: Solution Parameters2

Label: 10

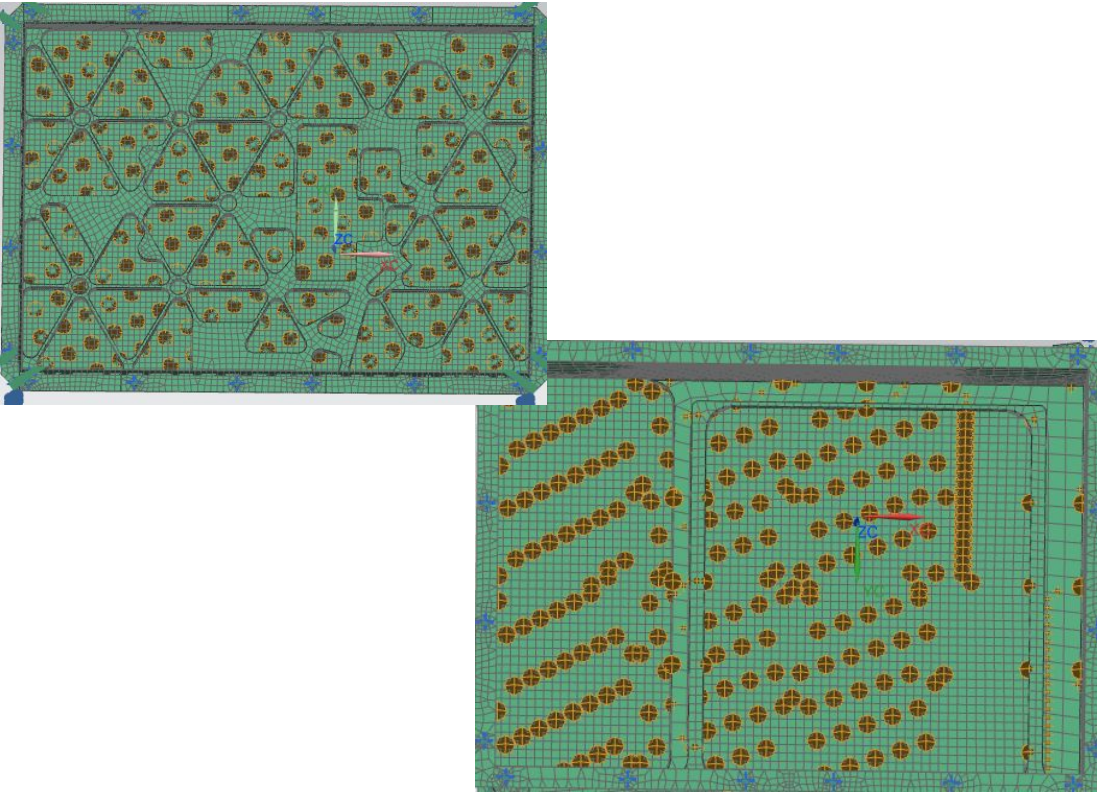
Properties

Card Name: PARAM

| | | | |
|--------------|-----------|---------|--|
| A-B | ALPHA2 | | |
| C-D | Real | 0.0000 | |
| E-F | Imaginary | 0.0000 | |
| G-H | ALTRED | NO | |
| I-J | ALTSHAPE | 0 | |
| K-L | AMPCZ | 1e-06 | |
| M-N | ASCOUP | YES | |
| O-P | ASING | 0 | |
| Q-R | AUNITS | 1 | |
| S-T | AUTOADJ | YES | |
| U-V | AUTOMPC | NO | |
| W-Z | AUTOSEEL | NO | |
| User Defined | AUTOSPC | Default | |
| | AUTOSPCR | NO | |
| | AUTOSPRT | YES | |
| | BAILOUT | 0 | |
| | BDMNCON | 2 | |
| | BETA | | |
| | Real | 0.3333 | |

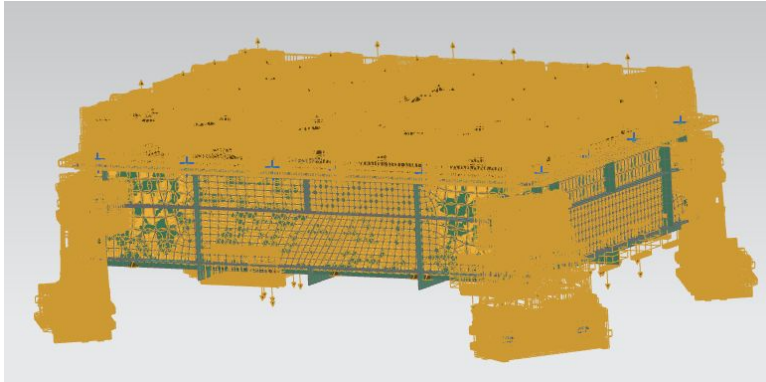
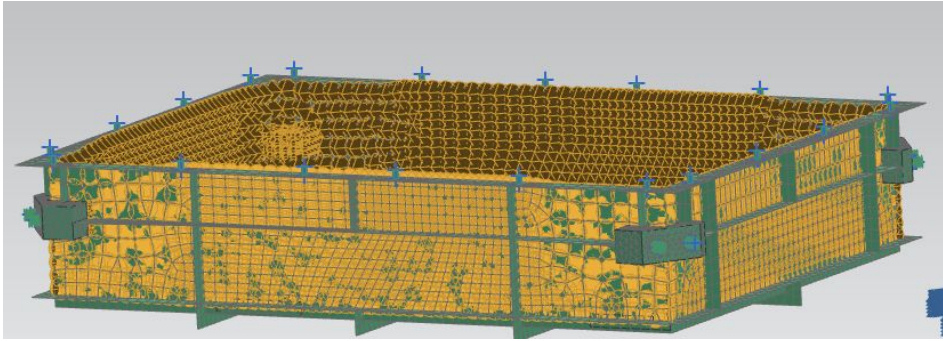
- Bailout = 0

Simulation Objects



- Glued 2D mesh of AFT plate to 3D swept mesh (face to face gluing using WELD conditions)
- Glued 2D mesh of enclosure to 3D swept mesh (face to face gluing using WELD conditions)

Simulation Objects



- Glued tetrahedral mesh to 2D walls of enclosure (face to face gluing using WELD conditions)
- Added non-structural mass to FEM: the difference between FEM mass and original assembly mass (approx .14kg)

Modal Results

MODAL EFFECTIVE MASS FRACTION

| MODE NO. | FREQUENCY | T1 | | T2 | | T3 | |
|----------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| | | FRACTION | SUM | FRACTION | SUM | FRACTION | SUM |
| 1 | 3.857389E+02 | 9.167393E-01 | 9.167393E-01 | 6.601360E-03 | 6.601360E-03 | 1.882118E-04 | 1.882118E-04 |
| 2 | 4.323752E+02 | 4.183047E-05 | 9.167811E-01 | 2.681497E-04 | 6.869510E-03 | 3.235244E-01 | 3.237126E-01 |
| 3 | 5.058278E+02 | 6.977391E-03 | 9.237585E-01 | 8.780091E-01 | 8.848786E-01 | 7.679358E-06 | 3.237203E-01 |
| 4 | 5.529793E+02 | 2.545111E-04 | 9.240130E-01 | 1.484602E-03 | 8.863632E-01 | 1.249758E-01 | 4.486961E-01 |
| 5 | 7.871940E+02 | 7.963356E-06 | 9.240209E-01 | 3.946326E-04 | 8.867578E-01 | 4.115851E-02 | 4.898546E-01 |
| 6 | 8.420052E+02 | 1.410463E-05 | 9.240351E-01 | 7.386557E-05 | 8.868317E-01 | 1.078981E-01 | 5.977527E-01 |
| 7 | 8.972222E+02 | 1.125045E-05 | 9.240463E-01 | 2.766701E-05 | 8.868594E-01 | 8.121982E-02 | 6.789725E-01 |
| 8 | 9.376367E+02 | 2.872422E-04 | 9.243335E-01 | 5.891322E-03 | 8.927507E-01 | 5.014480E-04 | 6.794740E-01 |
| 9 | 1.021849E+03 | 2.490148E-05 | 9.243584E-01 | 1.516877E-02 | 9.079194E-01 | 2.131944E-02 | 7.007934E-01 |
| 10 | 1.071698E+03 | 2.226768E-04 | 9.245811E-01 | 6.715180E-04 | 9.085910E-01 | 8.642079E-02 | 7.872142E-01 |

Primary modes highlighted (largest fractions)

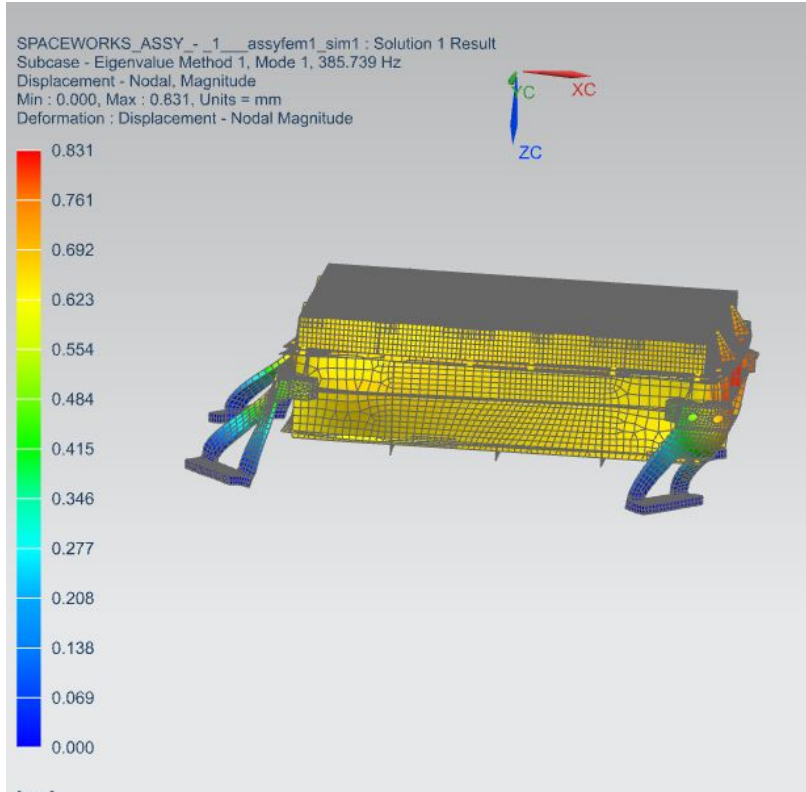
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SUBCASE 1

MODAL EFFECTIVE MASS FRACTION

| MODE NO. | FREQUENCY | R1 | | R2 | | R3 | |
|----------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| | | FRACTION | SUM | FRACTION | SUM | FRACTION | SUM |
| 1 | 3.857389E+02 | 5.251490E-03 | 5.251490E-03 | 6.757747E-01 | 6.757747E-01 | 5.138258E-04 | 5.138258E-04 |
| 2 | 4.323752E+02 | 1.304714E-05 | 5.264537E-03 | 3.094610E-03 | 6.788693E-01 | 6.006701E-06 | 5.198325E-04 |
| 3 | 5.058278E+02 | 6.964801E-01 | 7.017446E-01 | 4.587150E-03 | 6.834564E-01 | 7.369720E-03 | 7.889553E-03 |
| 4 | 5.529793E+02 | 2.587290E-03 | 7.043319E-01 | 4.174061E-05 | 6.834982E-01 | 4.973801E-06 | 7.894527E-03 |
| 5 | 7.871940E+02 | 2.979386E-02 | 7.341257E-01 | 2.890062E-02 | 7.123988E-01 | 2.876811E-04 | 8.182208E-03 |
| 6 | 8.420052E+02 | 2.876660E-02 | 7.628923E-01 | 2.658055E-02 | 7.389793E-01 | 2.582573E-03 | 1.076478E-02 |
| 7 | 8.972222E+02 | 3.027312E-02 | 7.931655E-01 | 1.128789E-02 | 7.502672E-01 | 8.399985E-03 | 1.916477E-02 |
| 8 | 9.376367E+02 | 9.120269E-03 | 8.022857E-01 | 2.709252E-06 | 7.502699E-01 | 7.499294E-01 | 7.690942E-01 |
| 9 | 1.021849E+03 | 2.412146E-02 | 8.264072E-01 | 1.237449E-03 | 7.515074E-01 | 1.623503E-02 | 7.853292E-01 |
| 10 | 1.071698E+03 | 2.515975E-03 | 8.289232E-01 | 7.324457E-03 | 7.588319E-01 | 5.518485E-04 | 7.858810E-01 |

Modal Shape



Modal shape of a primary mode (mode 1).