ABSTRACT
The purpose of the project is to work with Northrop Grumman to design and build a passive joint hinge. This hinge allows satellite booms or fixtures to be folded and stowed during launch and deployed in space. The hinge mechanism is to withstand requirements common to the launch and deployment of spacecraft payloads. The hinge is to deploy the fixture and lock in place in a zero-g environment while containing no parts or materials that will interfere with its surroundings and environment.

DESIGN REQUIREMENTS

<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>SPECIFICATION</th>
<th>REQUIREMENT</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stowed Angle</td>
<td>0 deg</td>
<td>Deployment Angle</td>
<td>60 deg</td>
</tr>
<tr>
<td>Minimum 1st Mode Frequency, Stowed</td>
<td>30 Hz</td>
<td>Deployment Latch-up Angle Error</td>
<td>X: +/- 0.015 deg</td>
</tr>
<tr>
<td>Minimum 1st Mode Frequency, Deployed</td>
<td>3 Hz</td>
<td>Maximum Allowable Angular Distortion Error</td>
<td>X: +/- 0.025 deg</td>
</tr>
<tr>
<td>Withstood Launch G- Loads</td>
<td>X: +/- 5 g</td>
<td>Maximum Allowable Base Moment Imparted to Spacecraft</td>
<td>Z: +/- 13 g</td>
</tr>
<tr>
<td>Maximum Fastener Load Impacted on Spacecraft</td>
<td>5000 N</td>
<td>Operational Temperature Range</td>
<td>-100 – 150 C</td>
</tr>
<tr>
<td>Hinge Assembly Mass Limit</td>
<td>0.375 Kg</td>
<td>Yield Safety Factor</td>
<td>1.25</td>
</tr>
</tbody>
</table>

MODELING & ANALYSIS

With a strict weight requirement we needed to carefully design each part in the hinge assembly to be as light weight as possible while still maintaining the yield and ultimate strength requirements. We used SolidWorks to model the parts while using COSMOS Express to place loads and restraints on each part and examine the stresses and displacements throughout the parts. Considering the need for high tolerances when building the hinge, CNC machining was necessary to replicate the computer design.

Other requirements such as deployment angle and thermal gradients were considered while modeling the hinge components.

RESULTS

When analyzing the results of our test data, we found that we easily met the vast majority of our requirements. With all the necessary mounting hardware and the springs, we remain 100g under the weight requirement. Similarly, our maximum fastener load imparted and maximum latch-up base moment imparted were significantly lower than required.

With a last iteration of the spring-loaded locking pin mechanism, the angular distortion error requirement and minimum 1st mode frequency in the deployed position would be met.

Acknowledgments
Robert Leedom (NGC)                Dave Bothman
Dan Daily (NGC)                   Andy Weinburg
Professor Keith Kedward          Kirk Fields
Stephen Laguette                  MTD Machining

TESTING & TEST FIXTURE

A test fixture was designed and built to simulate a zero-g environment in order to test some of the hinge’s more stringent requirements. The fixture utilizes a potentiometer, load cell, and accelerometer to verify the deployment angle, maximum latch-up moment imparted to spacecraft, and minimum 1st mode deployed frequency, respectively.

Figure 1. Von Mises analysis
Figure 2. Final Hinge design.
Figure 3. Initial Concept to Final Design
Figure 4. Test Set-Up and Data Collected.

DESIGN HISTORY

After performing a capability assessment on all the requirements we developed an initial design. Each iteration thereafter was done to address weakness that were found in previous designs.

ITERATION 1:
- Made from Titanium.
- Plate to stop deployment at 60 degrees.
- Pin placed in bending which could inhibit deployment.

ITERATION 2:
- Material changed to 6061 Aluminum.
- Hinge geometry changed to put the pin in shear.
- Bolt hole pattern modified to better suit deployment forces.
- Cutouts in base plate for weight savings
- Dual hinge stops to insure 60 degree deployment

ITERATION 3:
- Incorporation of a spring loaded locking mechanism.

ME 189: Capstone Project June 5, 2009
Anthony Flores, Dillon Kwiat, Ranulfo Morales, Sean Jamieson

Figure 3. Initial Concept to Final Design

Acknowledgments
Robert Leedom (NGC)                Dave Bothman
Dan Daily (NGC)                   Andy Weinburg
Professor Keith Kedward          Kirk Fields
Stephen Laguette                  MTD Machining

A test fixture was designed and built to simulate a zero-g environment in order to test some of the hinge’s more stringent requirements. The fixture utilizes a potentiometer, load cell, and accelerometer to verify the deployment angle, maximum latch-up moment imparted to spacecraft, and minimum 1st mode deployed frequency, respectively.

Figure 4. Test Set-Up and Data Collected.

RESULTS

When analyzing the results of our test data, we found that we easily met the vast majority of our requirements. With all the necessary mounting hardware and the springs, we remain 100g under the weight requirement. Similarly, our maximum fastener load imparted and maximum latch-up base moment imparted were significantly lower than required.

With a last iteration of the spring-loaded locking pin mechanism, the angular distortion error requirement and minimum 1st mode frequency in the deployed position would be met.