Northwest Nazarene University

MakerSat-0 Mission Data from Orbit

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NNU is an undergraduate university
High-g launch requires satellites to be overdesigned
Overview of the presentation

1. Motivation/Overview
   - Manufacturing in Space
   - Polymer Degradation
   - MakerSat-0

2. Polymer Mass Measurement
   - Cantilever Theory
   - Analog Circuit

3. Results
   - Material Selection
   - Mass Loss Data

4. Lessons Learned
   - Battery Voltage
   - Packet Size

5. MakerSat-1
   - MakerSat-1 Completion
   - Completion Needs
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The 3D printer onboard the ISS opens up a unique opportunity to manufacture, assemble, and deploy small satellites, all while in space.
Polymers degrade in space

Before Launch  →  After 4 years

The MISSE 2 PEACE Polymers experiment post flight.
MakerSat-0 was launched into a polar orbit on November 18, 2017.
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To measure mass in space, a gravity independent solution is needed

\[ f_{res} = \frac{1}{2\pi} \sqrt{\frac{3EI}{L^3m}} \]

Cantilever Beam
An experiment was designed to measure the frequency of several polymer-loaded cantilevers.
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Samples of 3-D printed ABS, ULTEM, NYLON12, and PLA were tested.
Polymer mass loss data from orbit over a two week period

<table>
<thead>
<tr>
<th></th>
<th>Brass</th>
<th>ABS</th>
<th>Nylon12</th>
<th>ULTEM</th>
<th>PLA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density (g/cm³)</strong></td>
<td>0</td>
<td>1.04</td>
<td>1.06</td>
<td>1.2</td>
<td>1.24</td>
</tr>
<tr>
<td><strong>Preflight poly mass (mg)</strong></td>
<td>0</td>
<td>246</td>
<td>251</td>
<td>293</td>
<td>354</td>
</tr>
<tr>
<td><strong>Initial frequency (Hz)</strong></td>
<td>87.4 (+0%)</td>
<td>NA</td>
<td>67.4 (+8.0%)</td>
<td>55.3 (+0.5%)</td>
<td>54.6 (+0%)</td>
</tr>
<tr>
<td><strong>Final frequency (Hz)</strong></td>
<td>87.4 (+0%)</td>
<td>NA</td>
<td>68.6 (+9.9%)</td>
<td>58.6 (+6.5%)</td>
<td>54.6 (+0%)</td>
</tr>
<tr>
<td><strong>Initial mass loss (mg)</strong></td>
<td>0 (-0%)</td>
<td>NA</td>
<td>-84.0 (-33.4%)</td>
<td>-6.0 (-2.0%)</td>
<td>-0 (-0%)</td>
</tr>
<tr>
<td><strong>Final mass loss (mg)</strong></td>
<td>0 (-0%)</td>
<td>NA</td>
<td>-101.0 (-40.3%)</td>
<td>-50.0 (-17.0%)</td>
<td>-0 (-0%)</td>
</tr>
</tbody>
</table>
Caldwell High School radiation experiment was successful
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Solar cell failure caused battery to discharge

Battery Discharge

Battery Voltage (V)

First two weeks

Four months

Safe Mode
Changing the radio packet size from 36 bytes to 9 bytes would have increased full packet reception by 90%.
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MakerSat-1 is ready for launch
Summary

• High-g launch forces satellites to be over designed
• High-g launch can be avoided
• Polymers degrade in space
• Lessons were learned from MakerSat-0
• MakerSat-1 is ready
Our Team
Thanks to....

• Scott Higginbotham - NASA
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• Grant Johnson - NNU

For more information visit https://engineering.nnu.edu/research/makersat