Maintaining a Healthy CubeSat: Analysis of MinXSS FM-1 Data and Preparations for FM-2

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What is MinXSS?
The Miniature X-ray Solar Spectrometer (MinXSS) is a CubeSat built to take spectra in the solar soft X-ray (SXR) spectrum in order to observe how solar emissions vary in the SXR and how those variations affect Earth’s upper atmosphere. MinXSS Flight Model 1 (FM-1) was deployed in May 2015 and will be in orbit for about six months, and MinXSS Flight Model 2 (FM-2) will be launched in Dec. 2016 and could be operational for up to five years.

A model of MinXSS, FM-1, and FM-2
Photo by James Mason
Analysis of data from the FM-1 mission can be used to determine the health of FM-1 and can help identify problems with the CubeSat that need to be addressed on FM-2 prior to launch. These analyses ensure that FM-1 and 2 will remain healthy and functioning as expected for the duration of their missions.

Power Analysis
A basic power diagram of MinXSS. It is essential that the battery is large enough to support MinXSS during its longest eclipse and that the solar arrays provide enough power to power MinXSS and charge the batteries in all three of MinXSS’s modes: Science, Safe, and Phoenix.

difference (%) = \frac{\text{generated} - \text{consumed}}{\text{generated}} \times 100

Generated capacity at \( \beta = 73^\circ \) is 19.6 Whr; \( \beta = 0^\circ \) is 30.0 Whr.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Consumed</th>
<th>( \beta = 0^\circ )</th>
<th>( \beta = 73^\circ )</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td>12.9 Whr</td>
<td>35 %</td>
<td>58 %</td>
<td></td>
</tr>
<tr>
<td>Safe</td>
<td>8.4 Whr</td>
<td>57 %</td>
<td>72 %</td>
<td></td>
</tr>
<tr>
<td>Phoenix</td>
<td>4.1 Whr</td>
<td>79 %</td>
<td>86 %</td>
<td></td>
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</tbody>
</table>

This means FM-1 and FM-2 will likely survive for the duration of their missions and will not drain away their batteries.

Data Capture Rate
How many of the requested packets do we decode? We have two ground stations decoding packets: one at LASP in Boulder, CO, and one in Parker, CO, run by Jim White.

The two ground stations combined have a 63.18% data capture rate. This rate increased from 61% after the antenna was fixed, ensuring that the antenna was in fact improved.

A plot of the data capture rate per playback, showing that the rate appears to be improving as the mission progresses.

Commanding FM-1
An anomaly in the I2C bus has occurred three times to date during FM-1’s mission. This problem involves a large amount of error messages being transmitted, making it difficult to communicate with MinXSS.

This problem is solved with a power reset, which is not something FM-1 can be commanded to do. To solve this problem on FM-2, a mechanical relay (right) was added, allowing us to command FM-2 to do a power reset, solving this problem on orbit.

Photo by Tom Woods

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