On-Orbit Performance
and the
First Flight of the BCT XACT 3-axis ADCS

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(CU/LASP) Andrew Jones, Rick Kohnert, Xinlin Li, Christopher S. Moore, Colden Rouleau

photo credit: NASA/ESA Tim Peake
**Miniature X-ray Solar Spectrometer CubeSat**

First launched NASA SMD science CubeSat

Soft PI: Tom Woods
Lesson: Don’t go home after multiple scrubs
ISS capture of Cygnus
LASP UHF ground station
Reverse assembly

Lesson: Pick 1 or 2 hard things to do, outsource the rest
Power performance: almost too good

- XACT consumes 1.9 W

<table>
<thead>
<tr>
<th>Mode</th>
<th>Average power consumed [W]</th>
<th>Min eclipse margin [%]</th>
<th>Max eclipse margin [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td>8.0</td>
<td>59</td>
<td>35</td>
</tr>
<tr>
<td>Safe</td>
<td>5.3</td>
<td>73</td>
<td>57</td>
</tr>
<tr>
<td>Phoenix</td>
<td>2.6</td>
<td>87</td>
<td>79</td>
</tr>
</tbody>
</table>

Lesson: No critical monitors on shared I2C bus
Thermal performance: on target

Figure courtesy of Chloe Downs
Pointing performance — safe mode

- MinXSS deployment → XACT booted to safe
- XACT autonomously placed spacecraft in safe attitude with arrays on sun and low total momentum
  - Per first pass telemetry
- Safe mode algorithms reliably find and track the sun
  - Uses XACT coarse sun sensors (CSS)
  - In Fine Pointing data (right), albedo induces 2-3° error on CSS sun measurements

Figure courtesy of Matt Baumgart

one orbit
Typical MinXSS attitude control scenario

- Spacecraft +X axis is sun-pointed (nearly constant in inertial space)
- One rotation about +X axis per orbit (star tracker to zenith)
Pointing performance — momentum accurately controlled

- Nonzero commanded momentum bias
  - [0, 1.5, 1.5] Nms — don’t want wheel to stick at 0
  - Still have 0-crossings 4x / orbit — unavoidable with 3 wheels
    - XACT can support 4 wheels
- Momentum is accurately provided
  - Sawtooth in plot is artifact of reconstructing inertial frame momentum from telemetry points with different quantizations
  - Some telemetry frame errors
  - Actual control error: ~0.2 mNms

Figure courtesy of Matt Baumgart
Pointing performance highly accurate overall

- Two independent measures of attitude control error
  - XACT’s based on star tracker, high-fidelity sun model
  - MinXSS’s fine Sun Position Sensor (SPS) with 2 arcsec dark noise
- Z-axis in spec but more sensitive to disturbance torques due to low inertia
- Significant unmeasured high-frequency motion is unlikely
  - (right) 2/3 wheel speeds often within tracker bandwidth
  - Same accuracy measured when 3rd wheel is also within tracker bandwidth

<table>
<thead>
<tr>
<th></th>
<th>Per XACT</th>
<th>Per SPS</th>
<th>Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>5.3</td>
<td>—</td>
<td>11</td>
</tr>
<tr>
<td>Y</td>
<td>15.8</td>
<td>20.1</td>
<td>25</td>
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<tr>
<td>Z</td>
<td>9.4</td>
<td>6.8</td>
<td>11*</td>
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</tbody>
</table>

*RMS Error (arcsec)

*cross-boresight, caveat, caveat, caveat

one orbit

Figure courtesy of Matt Baumgart
Science objectives achieved

- 7 M-class, > 40 C-class flares observed
- Met minimum success criteria
- Comprehensive success in mid-September (3 months observation)
- First science paper in prep
- Dedicated session at AGU

Figure courtesy of Tom Woods, lasp.colorado.edu/home/minxss/science/minxss-science-nugget-1
Thank You

Students
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For more
BCT booth: 70
LASP booth: 95
Talk: Dan Hegel (BCT)
Wednesday 5:45