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

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photo credit: NASA/ESA Tim Peake
First launched NASA SMD science CubeSat

Prototype
Flight model 1 (on orbit)
Flight model 2 (late 2016)

Soft  
**Miniature X-ray Solar Spectrometer CubeSat**
Lesson: Don’t go home after multiple scrubs

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ISS capture of Cygnus
LASP UHF ground station
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>
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<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>
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</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>
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</tbody>
</table>

*cross-boresight, caveat, caveat, caveat

Figure courtesy of Matt Baumgart

RMS Error (arcsec)

one orbit
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
Sindhuja Bandapalle, Gare Bereshnev, Michael Bonnici, Felix Bidner, Matt Carton, Matt Cell, Andrew Dahir, Alberto Lopez Dayer, Chloe Downs, Logan Finch, Seth Folley, David Hall, Rohit Kandurwar, Andrew Kelley, Marten Kendall, Abhijet Kumar, Caroline Leaman, Dongxue Li, Sam Liner, Jake Mashburn, James Paul Mason, Katelynn McCalmont, Sarah McNamara, Bena Mero, Chris Miller, Chris Moore, Michael Murry, Siddhesh Naik, Divya Pai, Omkar Rao, Brijen Raival, Varun Ravichandran, Golden Rouleau, Chris Sawyer, Neeraj Sharma, Amarjit Singh, Jordan Stone, Bhaskar Vaish, Christina Wilson, Matt Yavorsky, Chen Zhao, Hong Zhao, Andrew Zizzi

Professionals & Advisors
Gregg Allison, Matt Baumgart, Jake Beckner, Chris Belting, Conor Brown, Amir Caspi, Phil Chamberlin, Frank Eparvier, Don Farneth, Alex Farrell, Mitch Furst, Ed Hagley, Dan Hegel, Scott Higginbotham, Thomas Johnson, Andrew Jones, Sierra Kelley, Michael Klapetzyk, Rick Kohnert, Arian Lalezari, Bret Lamprecht, Xinlin Li, Stephen McCormick, Darren O'Connor, Scott Palo, Norm Perish, Pat Smith, Nathan Sheiko, Stan Solomon, George Stafford, Steve Steg, Joe Tanner, Gail Tate, Blake Vanier, Neil White, Tom Woods, Jenny Young

MINXSSCubeSat
LASP.COLORADO.EDU/HOME/MINXSS
BCT
LASP

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

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story - performance - science