Initial Flight Results of the RAX-2 Satellite

John Springmann, Benjamin Kempke, James Cutler, Hasan Bahcivan

Small Satellite Conference
August 16, 2012
# Radio Aurora Explorer (RAX) overview

<table>
<thead>
<tr>
<th><strong>Purpose:</strong></th>
<th>High resolution mapping of ionospheric irregularities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Team:</strong></td>
<td>SRI International, University of Michigan</td>
</tr>
<tr>
<td><strong>Timeline:</strong></td>
<td>Fall 2008: project start</td>
</tr>
<tr>
<td></td>
<td>Nov 2010: RAX-1 launch</td>
</tr>
<tr>
<td></td>
<td>Oct 2011: RAX-2 launch</td>
</tr>
<tr>
<td><strong>Funding:</strong></td>
<td>NSF. RAX-2 launch provided by NASA</td>
</tr>
<tr>
<td></td>
<td>CubeSat Launch Initiative</td>
</tr>
<tr>
<td><strong>Payload:</strong></td>
<td>UHF radar receiver (426-510 MHz)</td>
</tr>
<tr>
<td><strong>RAX-2 Launch:</strong></td>
<td>Delta II with NPP, 102° inclination, 400 x 820 km elliptical</td>
</tr>
</tbody>
</table>
RAX studies ionospheric irregularities using a bistatic radar

Poker Flat Advanced Modular Incoherent Scatter Radar (PFISR), located in Alaska
RAX is a U. Michigan bus and SRI radar receiver

CAD model showing subsystems  Partially-integrated spacecraft  Radar receiver
RAX-2 has been operating since October 28, 2011

- First radar experiment occurred November 22, 2011
- 22 experiments fully processed and downloaded
- 201,000+ beacons received
- 180+ MB of data received

Active MXL HAM network
First detection of radar scatter from irregularities occurred March 8

SOHO
X5.4 Flare
6 March

8 March Substorm

STEREO
Earth-Directed CME
7 March
First detection of radar scatter from irregularities occurred March 8

Range-time-intensity plot for the experiment
Zoomed-in portion of data from March 8:
April 25: PFISR – RAX-2

Range-time-intensity plot for the experiment
June 12: RISR – RAX-2

Range-time-intensity plot for the experiment
August 9: MUIR – RAX-2 with HAARP

Range-time-intensity plot for the experiment
RAX-2 has provided the highest resolution characterization of auroral irregularities, ever.
RAX-2 has provided the highest resolution characterization of auroral irregularities, ever

"The RAX radar echo discovery has convincingly proved that miniature satellites, beyond their role as teaching tools, can provide high caliber measurements for fundamental space weather research."

Therese Moretto Jorgensen, Ph.D.
Geospace program director, Division of Atmospheric and Geospace Sciences
National Science Foundation
RAX-2 has also provided valuable secondary data products

Received Signal Strength Indicator (RSSI) versus time – 1st week after launch:

- Decay as spacecraft separate
- Satellite-to-Satellite communication demonstrated with RAX-2 decoding MCubed
RSSI data provides a global survey of UHF signal strength
Data for the analysis of subsystem performance

Effect of the passive magnetic control system:

- **Kinetic Energy, J**
  - Date: 10/28, 11/27, 12/27, 01/26, 02/25, 03/26, 04/25
  - Energy values range from $7 \times 10^{-4}$ to 6

- **Alignment angle, deg**
  - Date: 10/28, 11/27, 12/27, 01/26, 02/25, 03/26, 04/25
  - Angle values range from 180 to 0 degrees
Data for the analysis of subsystem performance

Temperature and power:

FCPU temperature:

Power from a single solar panel:
• Unprecedented characterization of ionospheric irregularities achieved

• Scientific utility of a CubeSat has been demonstrated

• Currently daily operations involve running experiments and downloading data

• Analysis of 200,000+ telemetry points will feed into the design of future satellites with increased capabilities, improved modeling, etc.
Acknowledgements

NASA CubeSat Launch Initiative

RAX-1 and RAX-2 teams

Global HAM community
Questions?

John Springmann: jspringm@umich.edu
James Cutler: jwcutler@umich.edu
Hasan Bahcivan: hasan.bahcivan@sri.com

http://exploration.engin.umich.edu