Upcoming CubeSat Launches: The Flood Has Arrived

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# Upcoming CubeSat Launches

<table>
<thead>
<tr>
<th>Name</th>
<th>Vehicle</th>
<th>Deployers</th>
<th>Date</th>
<th># CS</th>
<th># PQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORS-3/ELaNa-4</td>
<td>Minotaur 1</td>
<td>8 P-POD/8 NLAS (2 CubeStack)</td>
<td>19 Nov 2013</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>ISS</td>
<td>ISS/HTV-4</td>
<td>2 J-SSOD</td>
<td>20 Nov 2013</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Dnepr</td>
<td>Dnepr</td>
<td>9 ISIPOD UniSat-5</td>
<td>21 Nov 2013</td>
<td>18</td>
<td>5</td>
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<tr>
<td>NROL-39/ELaNa-2</td>
<td>Atlas V</td>
<td>8 P-POD (NPSCuL)</td>
<td>5 Dec 2013</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>ISS</td>
<td>ISS/Antares</td>
<td>16 NanoRacks 6U</td>
<td>Dec 2013</td>
<td>28+</td>
<td></td>
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<tr>
<td>Soyuz</td>
<td>Soyuz</td>
<td>1 ISIPOD</td>
<td>Feb 2014</td>
<td>1</td>
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<tr>
<td>Dnepr</td>
<td>Dnepr</td>
<td>3 P-POD</td>
<td>April 2014</td>
<td>3+</td>
<td></td>
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<tr>
<td>ORS-4</td>
<td>Super Strypi</td>
<td>8 NLAS (1 CubeStack)</td>
<td>April 2014</td>
<td>10+</td>
<td></td>
</tr>
</tbody>
</table>

Totals: 100+ 5
Statistics of Upcoming Four Launches

• 63 CubeSats and PocketQubs (discussed in paper)
  – Exact frequencies and services listed if known

• 9 satellites using 145 MHz amateur satellite band for downlink
  – 2 under experimental license (DragonSat-1, CAPE-2)
  – 7 under amateur satellite service (non-US)

• 31 satellites using 437 MHz amateur satellite band for downlink
  – 23 under experimental license (US)
  – 8 under amateur-satellite service (non-US)

• 4 satellites using 2.2 GHz for downlink

• 12 satellites using unpublished frequencies

• Remaining 8 satellites using 402, 425, 915, 980 MHz
Frequency Licensing

  - Clarifies the licensing process and rules related to small satellites
  - Does not provide guidance on which service to use
- Separately, the FCC is pushing non-amateur CubeSats to file for experimental licenses, even if they are using amateur frequencies
  - Starting with ORS-3/ELaNa-4, all US-launched CubeSats (Cal Poly) using amateur radio frequencies are experimentally-licensed
  - IARU has coordinated satellites between 437.220 MHz and 437.525 MHz
- International CubeSats aren’t bound by these rules
  - They continue to obtain an amateur license from their local administration
Frequency Licensing (continued)

• The IARU sees the value of coordinating all satellites using amateur satellite frequencies
• However, IARU has recognized the severe overcrowding in the amateur 2m band (allocated 144-146 MHz, actually 145.8-146 MHz worldwide)
• ITU Resolution 757 recognizes that many CubeSat missions appear to be inconsistent with the definitions of their satellite service
• Beginning 1 July 2014, the IARU will no longer be able to accept frequency coordination requests for experimental stations in the 2m band
  – They will still continue to coordinate amateur radio CubeSats
  – Little effect on US CubeSats; only DragonSat-1 and CAPE-2 using 2m downlink
  – Only affecting 2m due to lack of bandwidth

• Note: This is my interpretation of “Overcrowding of the Two Metre Satellite Band,” by Hans van de Groendaal (ZS6AKV). Please read his paper in the Proceedings, page 197.
ORS-3/ELaNa-4

- 19 November 2013
- Minotaur 1 from Wallops Island
- ORS and NASA LSP
- 8 P-PODs and 8 NLAS on 2 CubeStack adapters with 24 CubeSats:
  - Copper (1U)
  - TJ3Sat (1U)
  - Vermont Lunar Cube (1U)
  - SwampSat (1U)
  - CAPE-2 (1U)
  - Ho’oponoopono-2 (3U+)
  - PhoneSat-v2.4 (1U)
  - Trailblazer (1U)
  - DragonSat-1 (1U)
  - KySat-2 (1U)
  - ChargerSat-1 (1U)
  - NPS-SCAT (1U)
  - Black Knight 1 (1U)
  - ORS 1 (3U)
  - ORS 2 (3U)
  - ORS 3 (3U)
  - Prometheus 1 (3U)
  - Prometheus 2 (3U)
  - Prometheus 3 (3U)
  - Prometheus 4 (3U)
  - SENSE 1 (3U)
  - SENSE 2 (3U)
  - FireFly (3U)
  - Horus (3U)
ISS

- 20 November 2013
- NanoRacks LLC
- Two J-SSOD deployers with four CubeSats:
  - ArduSat-1 (1U)
  - ArduSat-X (1U)
  - Pico Dragon (1U)
  - TechEdSat-3P (3U)
Dnepr

- 21 November 2013 from Yasny
- ISILaunch and GAUSS with UniSat-5
- Two PEPPOD with 4 CubeSats:
  - PUCP-SAT-1/Pocket-PUCP (1U/1Q)
  - ICUBE-1 (1U)
  - HUMSAT-D (1U)
  - Dove-4 (3U)
- Three MR-FOD with 4 PocketQubs:
  - SWEsat (1Q)
  - $50Sat (1Q)
  - QBScout-S1 (2Q)
  - WREN (1Q)

- Nine ISIPOD with 14 CubeSats:
  - FUNcube-1 (1U)
  - ZACube-1 (1U)
  - HiNcube (1U)
  - First-MOVE (1U)
  - UWE-3 (1U)
  - Velox-PII (1U)
  - NEE-02 KRYSAOR (1U)
  - CubeBug-2 (2U)
  - KHUSAT-1 (3U)
  - KHUSAT-2 (3U)
  - TRITON-1 (3U)
  - Delfi-n3xt (3U)
  - OPTOS (3U)
  - Dove-3 (3U)
Dnepr (continued)

- **FUNcube-1**
  - Built by ISIS for AMSAT-UK
  - Primary mission is STEM education
  - 20 kHz Inverting linear transponder
  - 435.140 MHz up/145.960 MHz down

- **ZAcube-1**
  - Built by AMSAT-SA
  - 14.099 MHz transmitter
  - See talk tomorrow by Hans

- **Delfi-n3xt**
  - Built by ISIS
  - Delfi-C3 (FM to DSB) transponder

- **TRITON-1**
  - AIS receiver testing
  - Delfi-C3 (FM to DSB) transponder
NROL-39/ELaNa-2

- 5 December 2013
- Atlas V from Vandenberg, California
- NRO and NASA LSP
- NPSCuL with 12 CubeSats:
  - IPEX (1U)
  - MCubed-2 (1U)
  - CUNYSat-1 (1U)
  - FIREBIRD A (1.5U)
  - FIREBIRD B (1.5U)
  - Alice (3U)
  - AeroCube-5a (1.5U)
  - AeroCube-5b (1.5U)
  - SMDC-ONE 2.2 (3U)
  - SMDC-ONE 2.3 (3U)
  - TacSat-6 (3U)
  - SNAP (3U)
  - MCubed-2
ISS

- Antares to station on 15 December 2013
- NanoRacks LLC
- NanoRacks 6U+ Deployer with 28+ CubeSats:
  - Flock-1 (28) (3U+)

Radio License:
- Green = Amateur
- Red = Experimental
- Blue = Government
- Orange = Other Satellite
Soyuz

- February 2014
- ISILaunch
- One ISIPOD with 1 CubeSats:
  - UKube-1 (3U)

Radio License:
Green = Amateur
Red = Experimental
Blue = Government
Orange = Other Satellite
UniSat-6

- April 2014
- Dnepr from Yasny, Russia
- GAUSS/Tyvak
- 3 P-PODs inside UniSat-6 with 3+ CubeSats:
  - TigriSat (3U)
  - SERPENS (3U)
ORS-4/ELaNa-7

- April 2014
- Super Strypi from Barking Sands, Kauai
- ORS and NASA LSP
- 8 NLAS deployers (CubeStack adapter) with 10+ CubeSats:
  - EDSN (8) (1.5U)
  - Argus (2U)
  - PrintSat (1U)

Radio License:
Green = Amateur
Red = Experimental
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Future AMSAT CubeSats

- **Fox-1**
  - To be launched on NROL-55/ELaNa-12 in Dec 2014
  - 470 x 780 km at 63 deg
  - FM transponder: 435.180 MHz uplink, 145.980 MHz downlink
  - 15 kHz wide, 400 to 800 mW
  - Vanderbilt radiation experiment
  - VT camera experiment
  - Penn State MEMS gyro experiment

- **RadFxSat (Fox-1B)**
  - ELaNa Approved
  - Vanderbilt radiation experiment
  - RIT MPPT experiment

- **More info in Tony’s talk**
Future High-Speed Communications

- A meeting was held during SmallSat 2013, focusing on CubeSat hardware
  - Higher than 1 Mbps and higher than 450 MHz
  - Licensing issues not discussed
- Several teams are working this problem
  - NASA JPL: X-band, DSN-compatible
  - Planet Labs (Cosmogia): 8.2 GHz, 4 Mbps
  - SRI International: C-band, 5 Mbps
  - University of Michigan: 3.4 GHz, 5 Mbps
  - AstroDev: S-band, 2 Mbps
  - Canopus: Ka-band, 40 Mbps
  - Syrlinks: X-band, 50 Mbps
- Not using amateur radio spectrum
Conclusion

• If all launches happen on time (unlikely), there will be more than 100 CubeSats launched in the next six months
• Most CubeSats continue to use 437 MHz amateur satellite frequencies for downlink, but higher frequency and higher speed radios are being built
• Several amateur radio linear and FM transponders will be launched

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Thank You

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