



## Upcoming CubeSat Launches: The Flood Has Arrived

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# Upcoming CubeSat Launches

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

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- 12 satellites using unpublished frequencies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

- FCC released “Guidance on Obtaining Licenses for Small Satellites” DA-13-445
  - 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'oponopono-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)

Radio License:

Green = Amateur

Red = Experimental

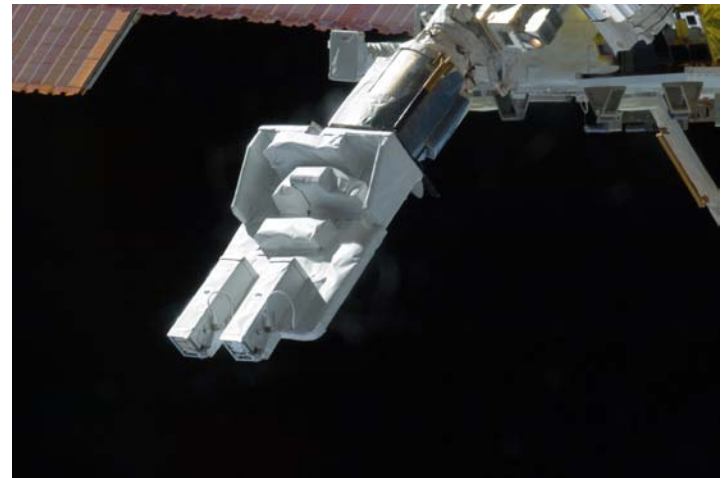
Blue = Government

Orange = Other Satellite

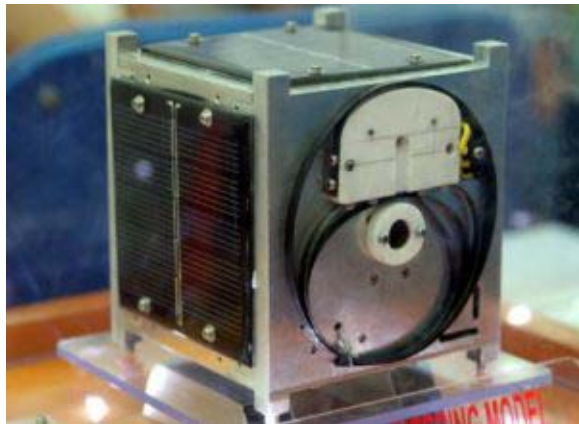
# ISS

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

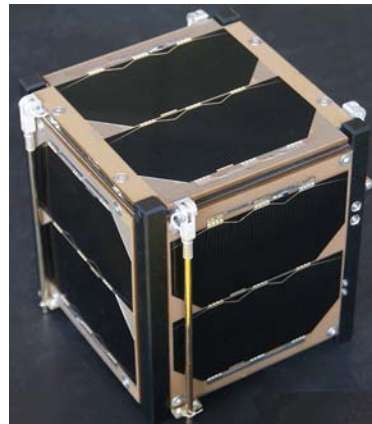
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J-SSOD



Pico Dragon



ArduSat

# Dnepr

Radio License:  
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Red = Experimental  
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Orange = Other Satellite

- 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
  - FUNcube linear transponder
- TRITON-1
  - AIS receiver testing
  - FUNcube linear transponder

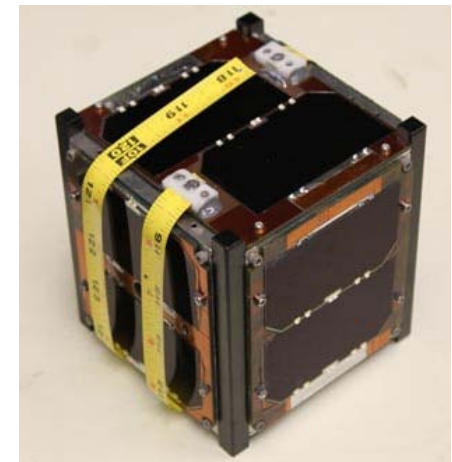


FUNcube-1

# 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)

Radio License:  
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Red = Experimental  
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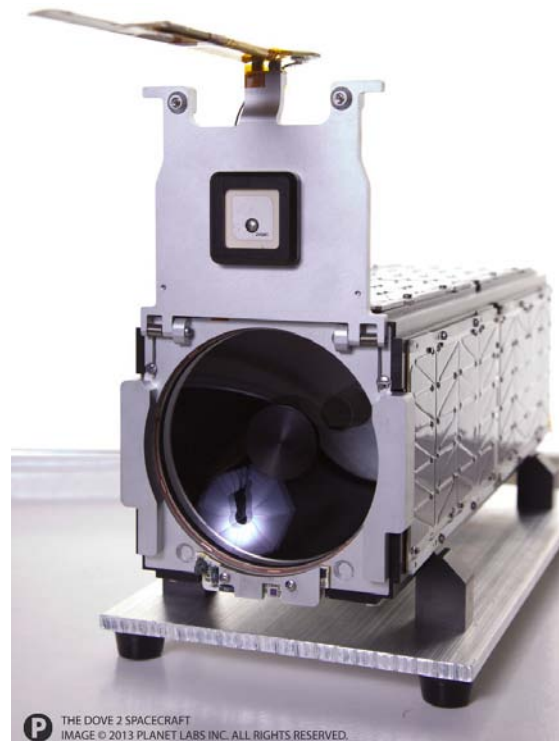



MCubed-2

# 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



 THE DOVE 2 SPACECRAFT  
IMAGE © 2013 PLANET LABS INC. ALL RIGHTS RESERVED.

Dove-2

# Soyuz

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

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



UKube-1

# UniSat-6

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

Radio License:

Green = Amateur

Red = Experimental

Blue = Government

Orange = Other Satellite

# 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

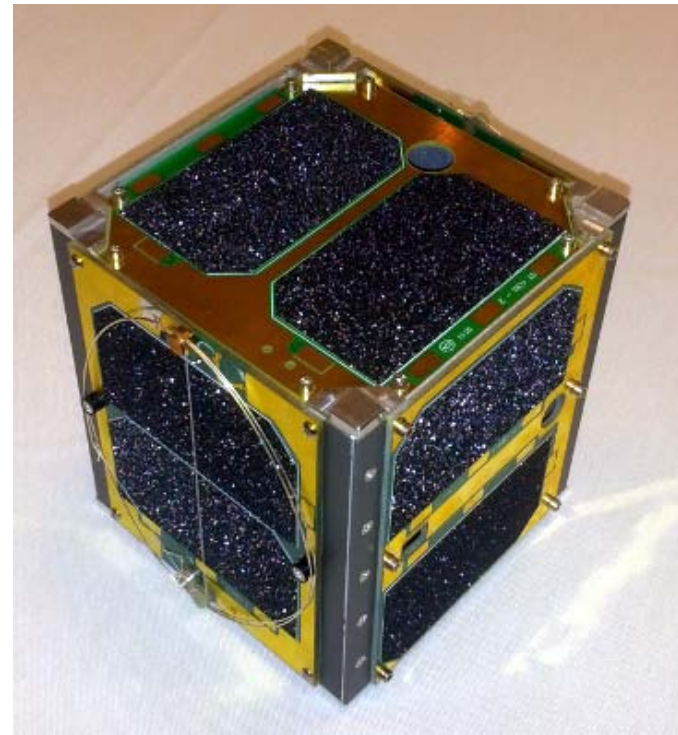
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# Future AMSAT CubeSats

- 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



Fox-1 mock up

# 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
  - Symlinks: 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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