



## CubeSat Communication Systems 2003-2013: A Historical Look

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# Two Survey Papers

- “A Survey of CubeSat Communication Systems”
  - Paper presented at the CubeSat Developers’ Workshop 2008
  - By Bryan Klofas, Jason Anderson, and Kyle Leveque
  - Covers the CubeSats from start of program to 2008
  
- “A Survey of CubeSat Communication Systems: 2009-2012”
  - Paper presented at the CubeSat Developers’ Workshop 2013
  - By Bryan Klofas and Kyle Leveque
  - Covers the CubeSats from 2009 to ELaNa-6/NROL-36 launch in 2012

# Summary of CubeSat Launches 2003 to 2013

- Eurockot (30 June 2003)
  - AAU1 CubeSat
  - DTUosat-1
  - CanX-1
  - Cute-1
  - QuakeSat-1
  - XI-IV
- SSETI Express (27 Oct 2005)
  - XI-V
  - NCube-2
  - UWE-1
- M-V-8 (22 Feb 2006)
  - Cute-1.7+APD
- Minotaur 1 (11 Dec 2006)
  - GeneSat-1
- Dnepr Launch 2 (17 Apr 2007)
  - CSTB1
  - AeroCube-2
  - CP4
  - Libertad-1
  - CAPE1
  - CP3
  - MAST
- NLS-4/PSLV-C9 (28 Apr 2008)
  - Delfi-C3
  - SEEDS-2
  - CanX-2
  - AAUSAT-II
  - Compass-1

# Summary of CubeSat Launches 2003 to 2013

- Minotaur-1 (19 May 2009)
  - AeroCube-3
  - CP6
  - HawkSat-1
  - PharmaSat
- ISILaunch 01 (23 Sep 2009)
  - BEESAT-1
  - UWE-2
  - ITUpSAT-1
  - SwissCube
- H-IIA F17 (20 May 2010)
  - Hayato
  - Waseda-SAT2
  - Negai-Star
- NLS-6/PSLV-C15 (12 July 2010)
  - Tisat-1
  - StudSat
- STP-S26 (19 Nov 2010)
  - RAX-1
  - O/OREOS
  - NanoSail-D2
- Falcon 9-002 (8 Dec 2010)
  - Perseus (4)
  - QbX (2)
  - SMDC-ONE
  - Mayflower
- PSLV-C18 (12 Oct 2011)
  - Jugnu

# Summary of CubeSat Launches 2003 to 2013

- ELaNa-3/NPP (28 Oct 2011)
  - AubieSat-1
  - DICE (2)
  - HRBE
  - M-Cubed
  - RAX-2
- Vega VV01 (13 Feb 2012)
  - Xatcobeo
  - ROBUSTA
  - e-st@r
  - Goliat
  - PW-Sat
  - Masat-1
  - UniCubeSat-GG
- ELaNa-6/NROL-36 (13 Sep 2012)
  - SMDC-ONE (2)
  - AeroCube-4 (3)
  - Aeneas
  - CSSWE
  - CP5
  - CXBN
  - CINEMA
  - Re
- ISS (4 Oct 2012)
  - FITSat-1
  - TechEdSat-1
  - F-1
  - WE-WISH
  - RAIKO

# Summary of CubeSat Launches 2003 to 2013

- PSLV-C20 (25 Feb 2013)
  - STRaND-1
  - AAUSAT3
- Bion M1 (19 April 2013)
  - OSSI-1
  - SOMP
  - BEESAT-2
  - BEESAT-3
  - Dove-2
- Antares (21 April 2013)
  - PhoneSat (3)
  - Dove-1

# Summary of CubeSat Launches 2003 to 2013

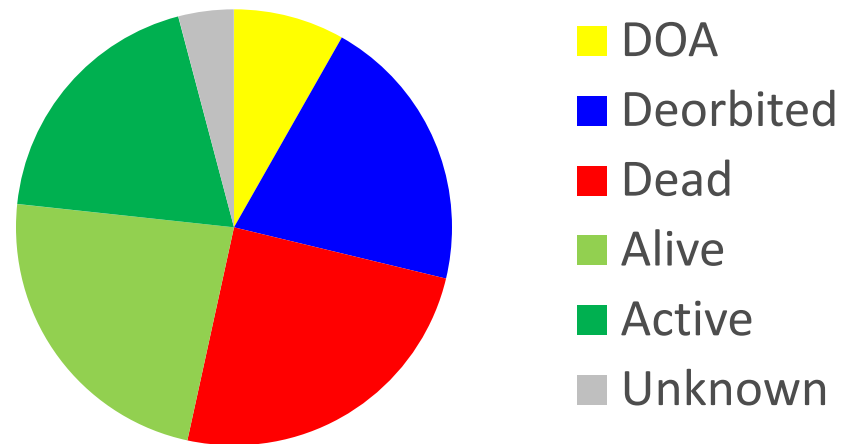
- 79 CubeSats Launched (+9 recently)

- Launch Failures:

- Dnepr-1 launch (14)
- Falcon-1 (2)
- ELaNa-1/Taurus XL (3)

- Status of CubeSats as of April 2013:

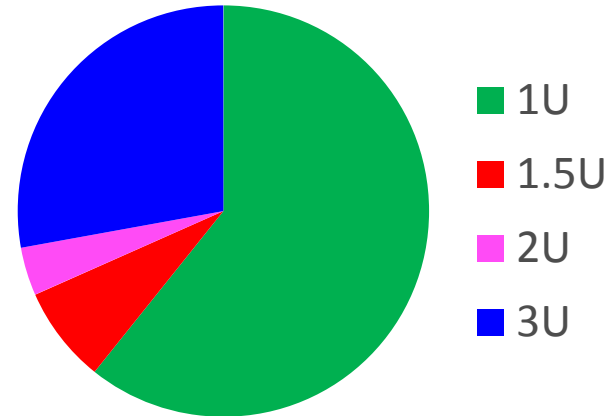
- DOA: 6
- Deorbited: 15
- Dead: 18
- Alive: 17
- Active: 14
- Unknown: 3



# CubeSat Details: Size and Transmitters

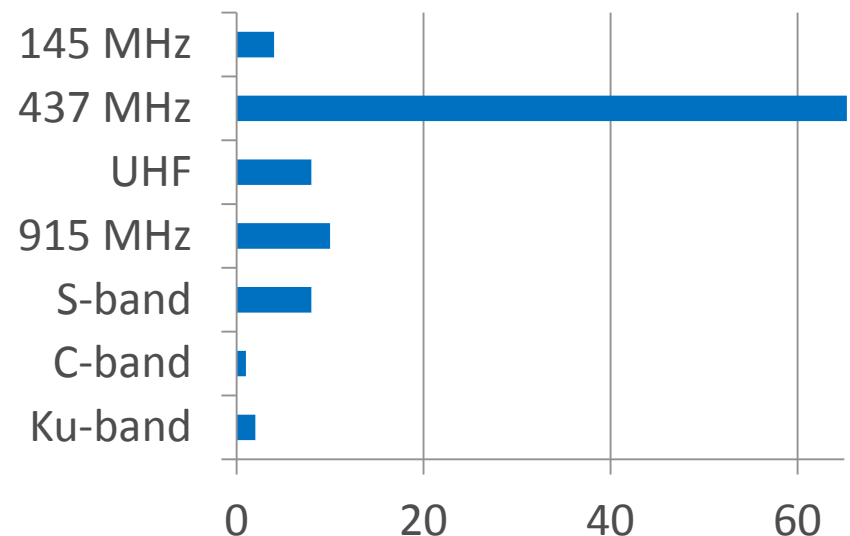
- Size of CubeSat (Total 79 CubeSats):

- 1U: 48
- 1.5U: 6
- 2U: 3
- 3U: 22



- Transmitters (Total 108 transmitters):

- 145 MHz amateur radio: 4
- 437 MHz amateur radio: 71
- Other UHF spectrum: 9
- 915 MHz experimental: 13
- S-band: 8
- C-band: 1
- Ku-band: 2



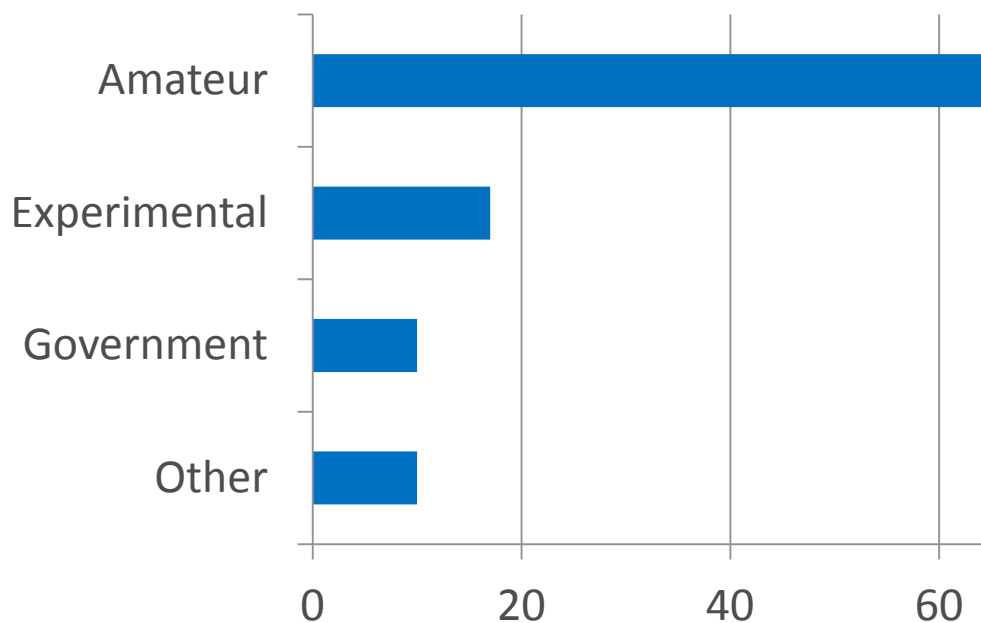
Note: 70% of transmitters using amateur-satellite frequencies!



# CubeSat Details: Satellite Service Used

- Satellite Service (Total 108 transmitters):

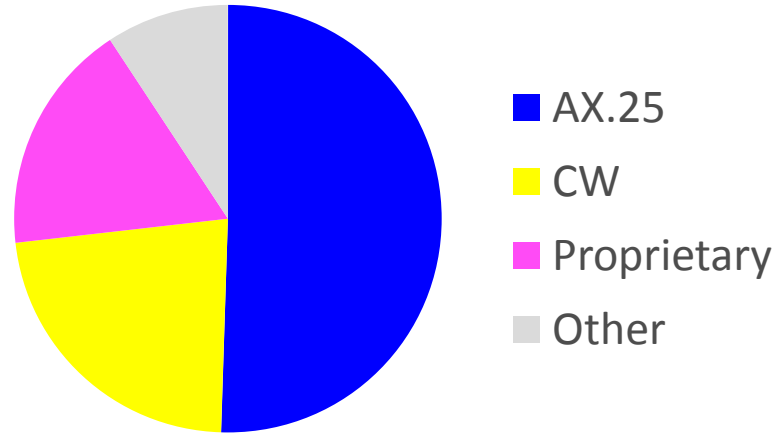
- Amateur: 71
- Experimental: 17
- Government: 10
- Other:
  - Earth exploration: 1
  - Meteorological: 2
  - Space research: 2
  - Unlicensed/unknown: 5



# CubeSat Details: Protocols and Data Rates

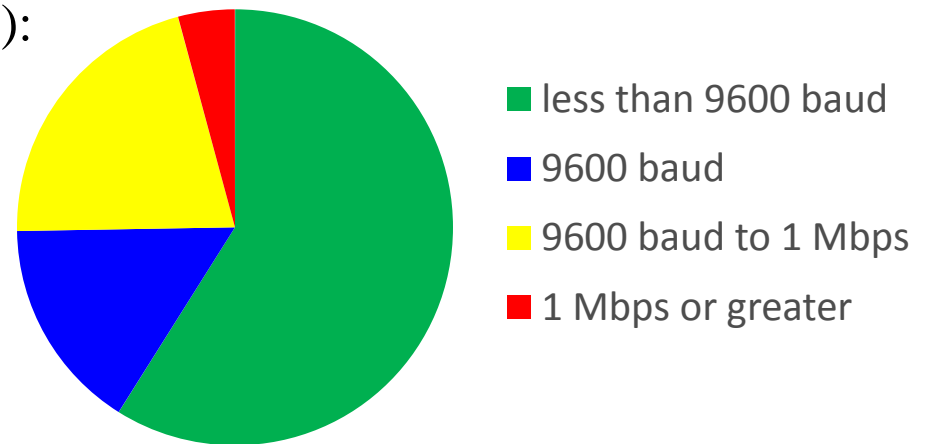
- Protocols (Total 97 transmitters):

- AX.25: 49
- CW: 22
- Proprietary: 17
- Other: 9



- Max data rates (Total 95 transmitters):

- < 9600 baud or CW: 56
- 9600 baud: 15
- 9600 baud to < 1 Mbps: 20
- 1 Mbps or greater: 4
  - Hayato, DICE, CINEMA



# CubeSat Details: Countries

- Countries (Total 19 countries, 79 CubeSats):
  - USA: 41
  - Japan: 11
  - Denmark: 4
  - Germany: 4
  - Canada: 2
  - India: 2
  - Italy: 2
  - Switzerland: 2
  - Colombia: 1
  - England: 1
  - France: 1
  - Hungary: 1
  - Netherlands: 1
  - Norway: 1
  - Poland: 1
  - Romania: 1
  - Spain: 1
  - Turkey: 1
  - Vietnam: 1

# Thank You



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