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# CubeSat Communications Survey Update

2011 Summer Developers' Workshop  
Utah State University

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# Background

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- “A Survey of CubeSat Communication Systems,” by Bryan Klofas, Kyle Leveque, and Jason Anderson
- Presented at the 2008 Developers Workshop at Cal Poly
  - PSLV-C9 CubeSats published in November/December 2009 AMSAT-NA Journal

# Previous CubeSats

(2003-2008)



- Eurockot Launch
  - AAU1 CubeSat
  - DTUsat-1
  - CanX-1
  - Cute-1 (CO-55)
  - QuakeSat-1
  - XI-IV (CO-57)
- SSETI Express
  - XI-V (CO-58)
  - NCube-2
  - UWE-1
- M-V-8 Launch
  - Cute-1.7+APD (CO-56)
- Dnepr Launch 1
- Minotaur Launch 1
  - GeneSat-1
- Dnepr Launch 2
  - CSTB1
  - AeroCube-2
  - CP4
  - Libertad-1
  - CAPE1
  - CP3
  - MAST
- PSLV-C9
  - Delfi-C3 (DO-64)
  - SEEDS-2 (CO-66)
  - CanX-2
  - AAUSAT-II
  - Cute 1.7+APD II (CO-65)
  - Compass-1
- Falcon Launch 1

**Total: 24**

# Current CubeSats

(2009-August 2011)



- Minotaur-1
  - AeroCube-3
  - CP-6
  - HawkSat-1
  - PharmaSat
- ISILaunch 01
  - BEESAT
  - UWE-2
  - ITUpSAT1
  - SwissCube
- Japanese H-IIA F17
  - K-Sat
  - Waseda-SAT2
  - Negai Star
- PSLV-C15
  - TIsat-1
  - STUDSAT
- STP-S26
  - RAX-1
  - O/ORES
  - NanoSail-D2
- Falcon 9-002
  - Perseus (4)
  - QbX (2)
  - SMDC-ONE
  - Mayflower
- Taurus XL

**Total: 24**

# Minotaur 1

19 May 2009



- AeroCube-3
  - FreeWave Technologies
  - 900 MHz frequency hopping, 2 watts
- CP-6
  - CC1000
  - 437 MHz, 1200 baud, 1 watt
- HawkSat-1
  - MicroHard MHX-425
  - 425 MHz, 1 watt
  - Never heard from in space
- PharmaSat
  - 437 MHz beacon, 1 watt
  - MicroHard MHX-2400



AeroCube-3



CP6

# ISILaunch 01

PSLV-C14, 23 September 2009



- BEESAT-1
  - 436 MHz custom radio
  - 4800 and 9600 bps GMSK
- UWE-2
  - 437.385 MHz, 1200 bps AX.25
- ITUpSAT1
  - 437.325 MHz 19.2 kbps and CW
  - 1 watt
- SwissCube
  - Custom built radio
  - 437.505 MHz, 1200 bps FSK and CW
  - 500 mW



BEESAT-1



ITUpSAT1

# Japanese H-IIA F17

20 May 2010



- K-Sat

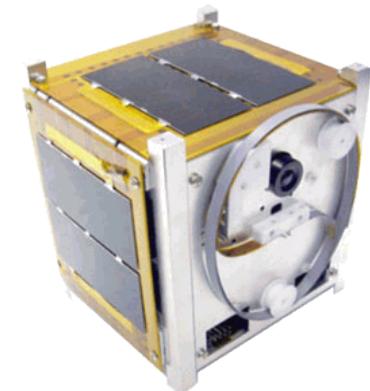
- Uplink: 10 kbps S-band
- Downlink: 10 kbps/1 Mbps 13.275 GHz
- 200mW BPSK

- Waseda-SAT2

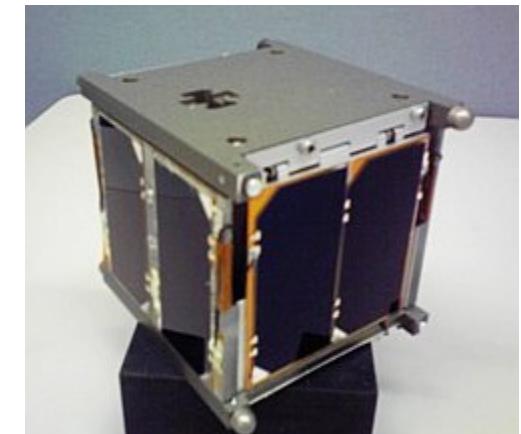
- Institute of Western Wireless radio
- 437.485MHz CW, 9600bps FSK

- Negai Star

- 437.305MHz CW, Packet 1200bps FSK AX.25



Negai Star



Waseda-SAT2



- TIsat-1
  - Alinco DJC-6 and Custom CW radio
  - 437.305 MHz, 1200 baud AFSK
- STUDSAT
  - 437.505 MHz, 9600 baud FSK and CW beacon



TIsat-1



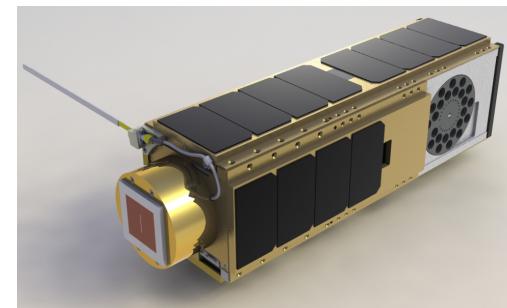
STUDSAT

# STP-S26

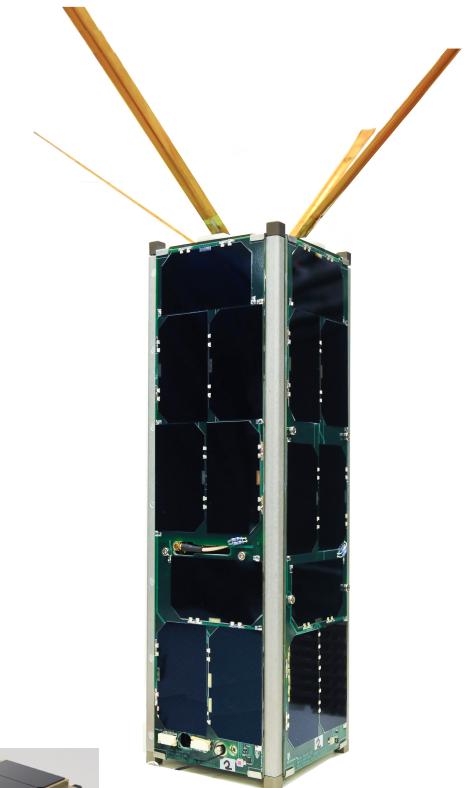
Minotaur 4, 19 November 2010



- RAX-1
  - AstroDev Helium Radio
  - 437.505 MHz, 9600 baud FSK, 2W
  - MHX-2400, never turned on
- O/ORES
  - 437.305 MHz AX.25 Stensat beacon
  - MHX-2420 S-band
- NanoSail-D2
  - Stensat beacon only
  - 437.270 MHz AX.25



O/OREOS



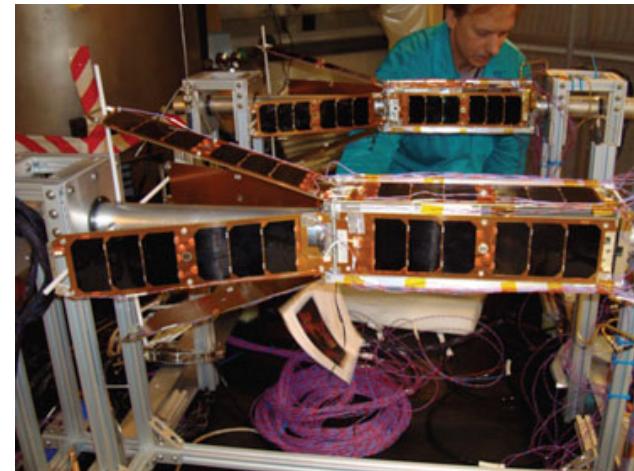
RAX-1

# Falcon 9-002

8 December 2010



- Perseus (4)
- QbX (2)
- SMDC-ONE
  - UHF
- Caerus/Mayflower
  - 437.600 MHz, 1200 baud AFSK
  - 900 mW



QbX



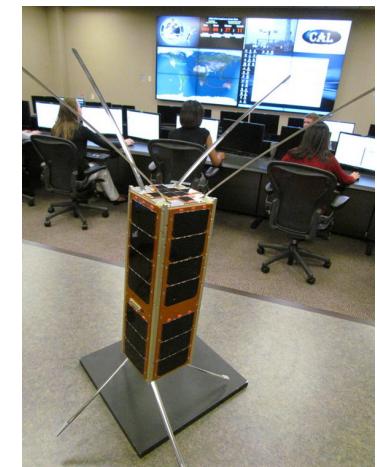
Perseus

An advertisement for the Caerus/Mayflower cubesat. It features a photograph of the satellite in space against a background of Earth and the sun. Text on the ad includes:

HIGH-POWER SOLAR ARRAYS | ADVANCED THERMAL REJECTION | PROPULSION  
**CAERUS/MAYFLOWER**  
NEXT GENERATION CUBESAT FLIGHT TESTBED  
Rapid Response | designed, manufactured, integrated, and tested in six-months

Logos for USC, Northrop Grumman, NovaWorks Advanced Concepts, PUMPKIN, and applied minds are present at the bottom.

Mayflower



SMDC-ONE



# Summary

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- Downlink Frequencies
  - 13: 437 MHz amateur band
  - 1: 900 MHz
  - 2: S-band
  - 1: 13 GHz
  - 7: unknown
- 9 of 18 teams outside of US (11 of 18 earlier)
- Organizations
  - 11 University
  - 6 Government
  - 2 Private



# NSF Current Approaches

	Downlink	Spacecraft TX	Ground Station RX
<b>RAX</b> (STP-S26)	437 MHz 9600 baud	AstroDev Helium	Icom 910
<b>FireFly</b> (Elana4/CRS-2)	401 MHz	AstroDev Colony-2	
<b>FIREBIRD</b>	145 MHz 19200 baud	AstroDev Helium	Icom 910
<b>DICE</b> (Elana3/NPP)	460 MHz 1.5 Mbps	L-3 Cadet	USRP
<b>CINEMA</b> (Elana6/OUTSat)	2.2 GHz 1 Mbps	Emhiser EDTC-01E1A102-UBC0	11m dish
<b>CSSWE</b>	437 MHz 9600 baud	SX1231 (all-in-one chip)	Kenwood TS-2000

# NSF Current Frequency Allocations



Award	Project	Pls	Type	License			Downlink Frequencies
				Agency	Sponsor	Status	
# 1	RAX	Cutler/Bahcivan	Amateur/ISM	FCC	UMich	Granted	437 MHz; 2.4 GHz ISM
	FireFly	Rowland/Weatherwax	Space Research	NTIA	NASA	Submitted	400 MHz
ARRA	FIREBIRD	Klumper/Spence	Amateur	FCC	MSU	Coordinated	145 MHz, 19200baud GMSK
	DICE	Crowley/Swenson	Meteorological Satellite	NTIA	NSF	Not submitted	460 MHz, 1.5Mbps
# 2	CINEMA	Lin	Space Research	NTIA	NSF	Submitted	2.2 GHz
	CSSWE	Li/Palo	Amateur	FCC	U Colorado	Coordinated	437 MHz

# Questions?

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