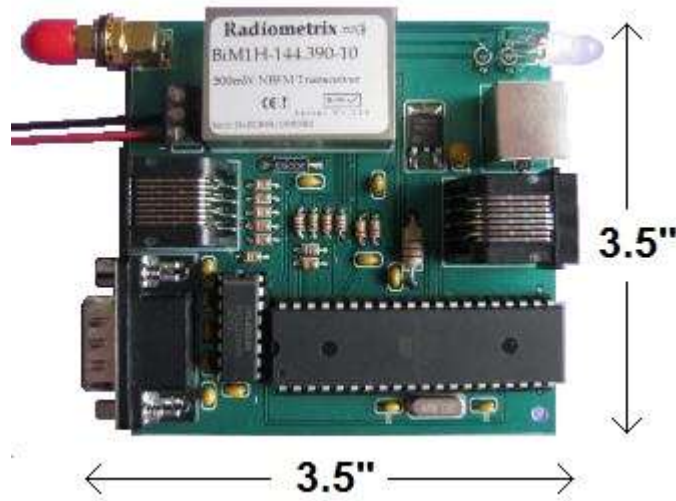


PSAT Remote Data Transponder

Polar Technology Conference April 2013



*US Naval Academy Satellite Lab
410-293-6417
bruninga@usna.edu*

Sponsor: US Naval Academy



Data Exfiltration

UNCLASS
2013 DoD SERB

Psat Transponder Mission

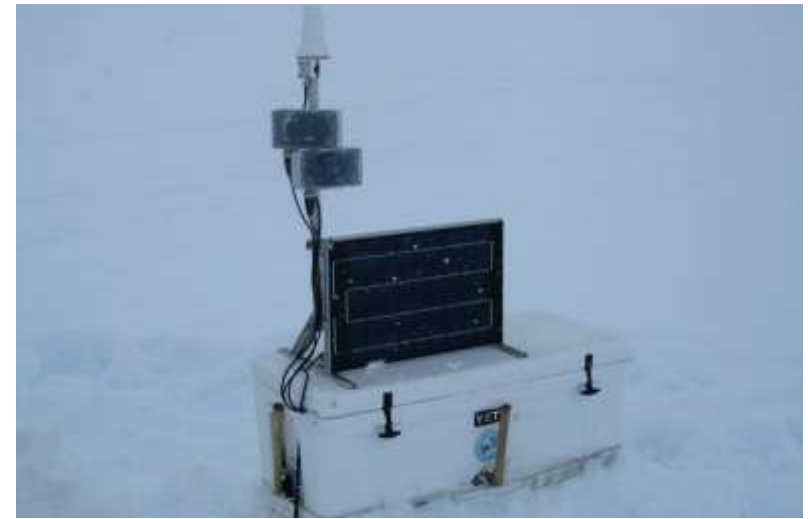


Psat Xponder relays remote data for Student Science Experiments

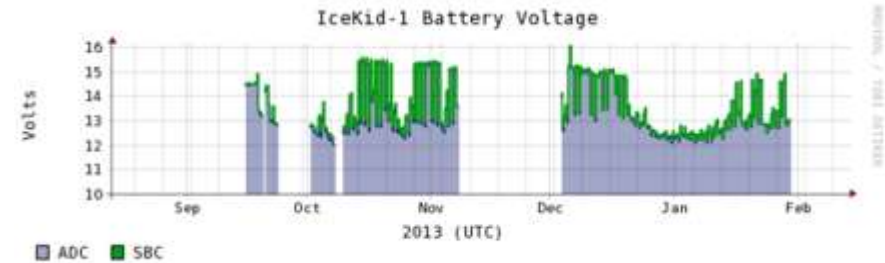
IceGoat



IceKid

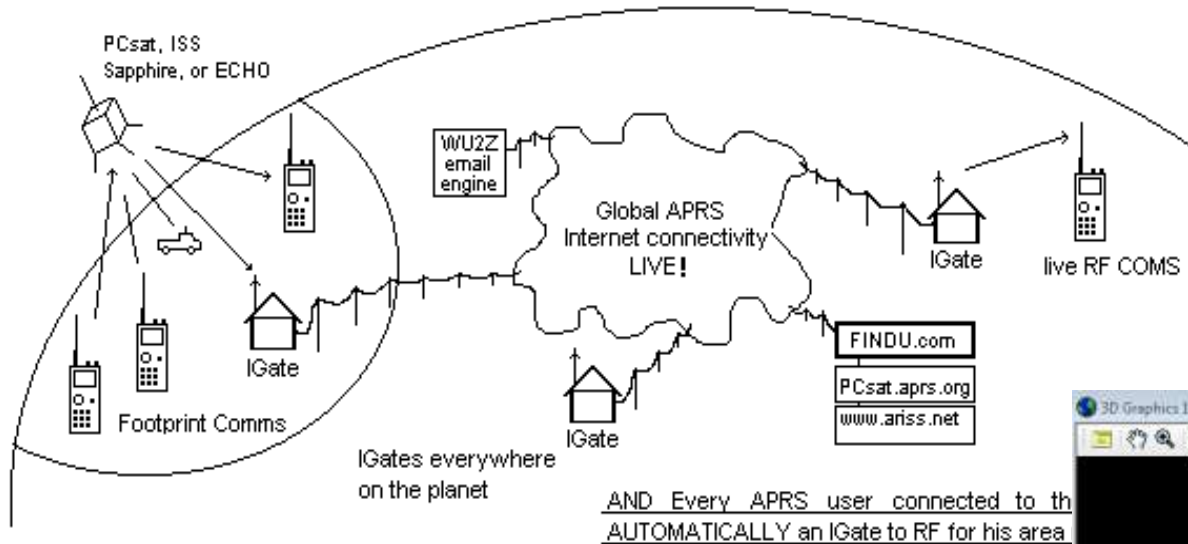


Iridium subscription is \$200/month per sensor.
PSAT usage is free.



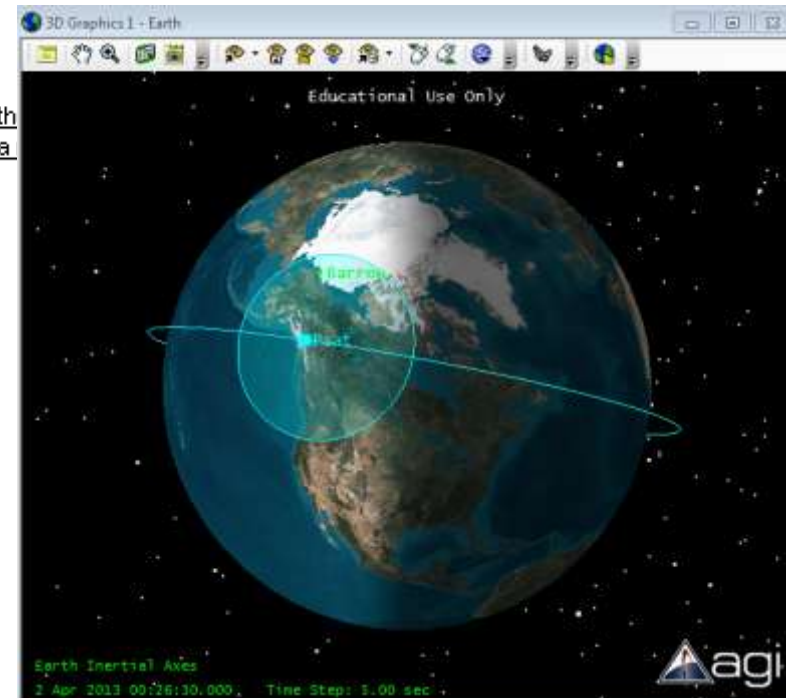
Global Amateur Satellite Service Situational Awareness Network

Global APRS Real-Time Connectivity (End-to-End Everywhere)



Description:

- VHF Data Transponder
- 9 dB link advantage to UHF
- Remote TDMA Data Relay
- w Global Internet Gateways
- Scaleability and Constellation
- Using low cost COTS



Other Experiments through AMSAT Transponders



The Flashline Mars Arctic
Research Station (FMARS)
2002 Field Season



- **Antarctic WX station**
- **F-16 downed flyer demo** (Rome Air Development Center)
- **Arctic Tracking** (trucks up frozen rivers $>70^\circ$ Latitude)
- **2200 other users worldwide**

USNA-0601 PSAT Data System



Space Segment



Comms
mission

Buoy Segment

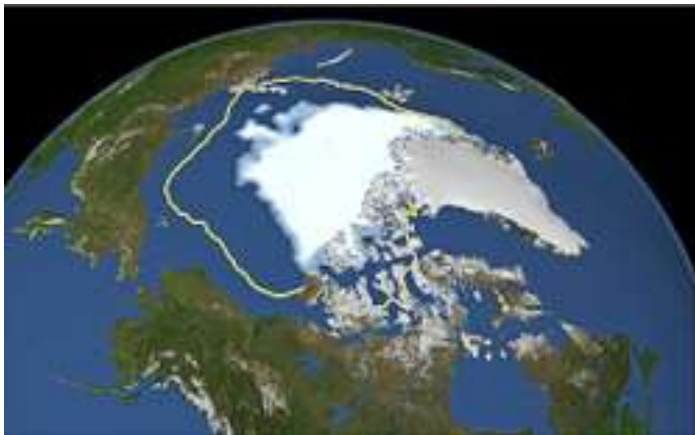


Science app

Remote Science Data Importance



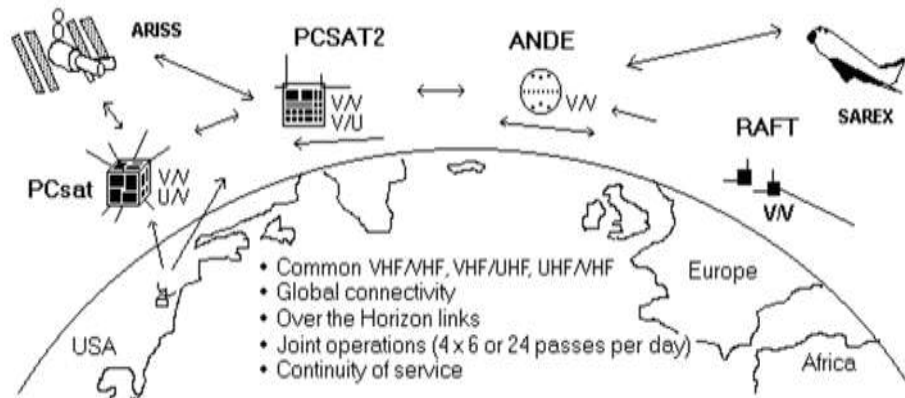
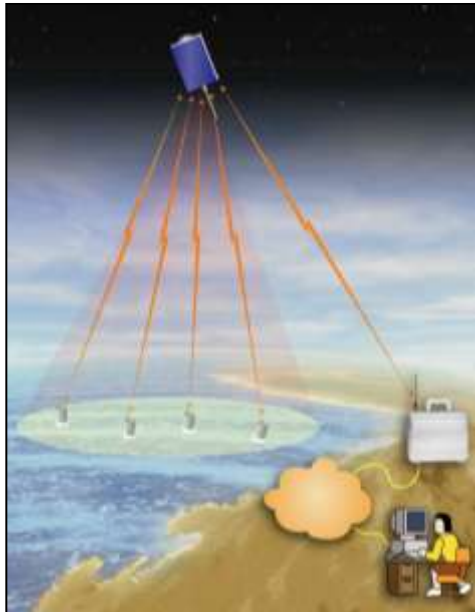
- Arctic region is part of the Global Environmental System
- Record low levels of sea ice has large global and socio-economic impacts.
- CNO has stated that the US Navy will be in the Arctic in the future.
 - ONR needs: *Data Collection*, Assessment, Prediction



Psat Mission Legacy



Psat Xponder relays remote data and provides the C&DH for the spacecraft



Psat continues our Int'l data channel in space

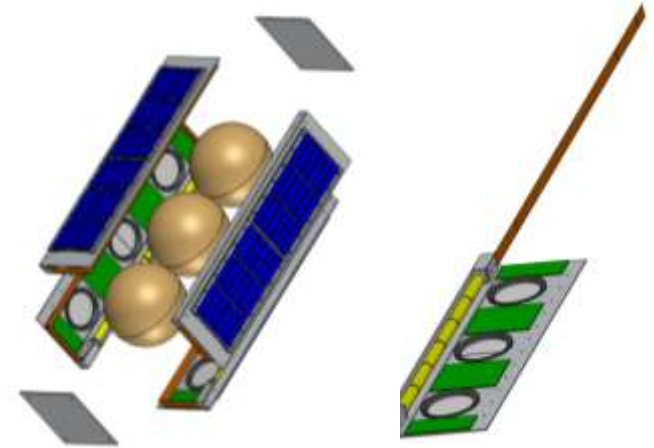
- 2001 PCsat is unreliable (battery issues)
- Xponder on ISS is shared with other use
- PCsat2, ANDE LEO orbits below ISS have decayed
- Reliability needed for other science experiments

TDMA bent pipe

Psat Alternate Launch Configurations

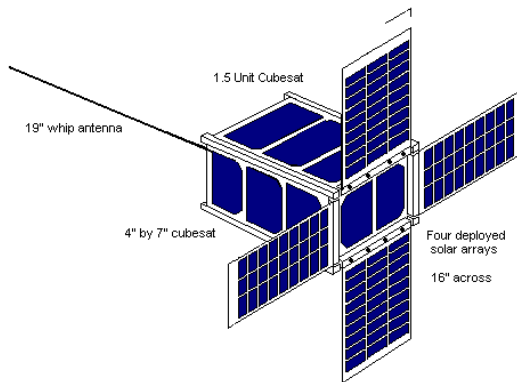


- ✓ 1.5U CubeSat – sun pointing
- ✓ 1U Psat – better launch availability
- ✓ 1U BRICsat – life extension for low LEO
- ✓ Any other opportunity
 - ✓ i.e. Part of frame for Radar Spheres

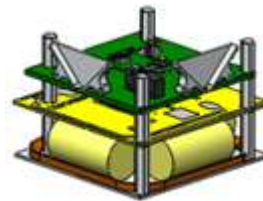


SLIM - Satellite Launch Independent Missions of
JIMS - Joint Integrated Micro Systems

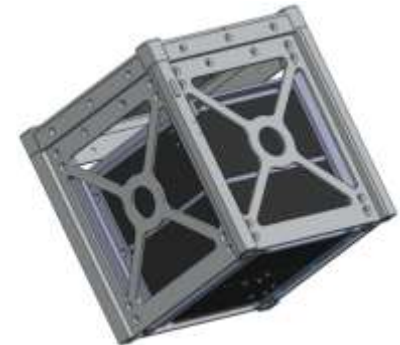
1.5U CubeSat



1U Psat



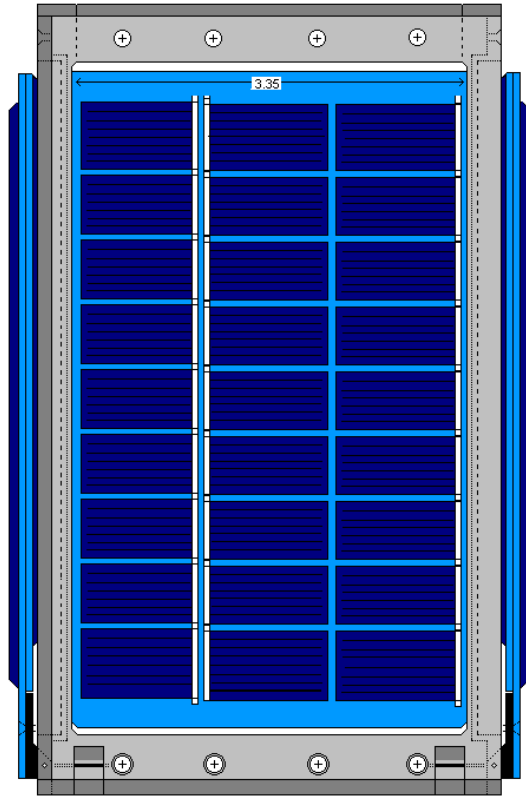
1U BRICsat



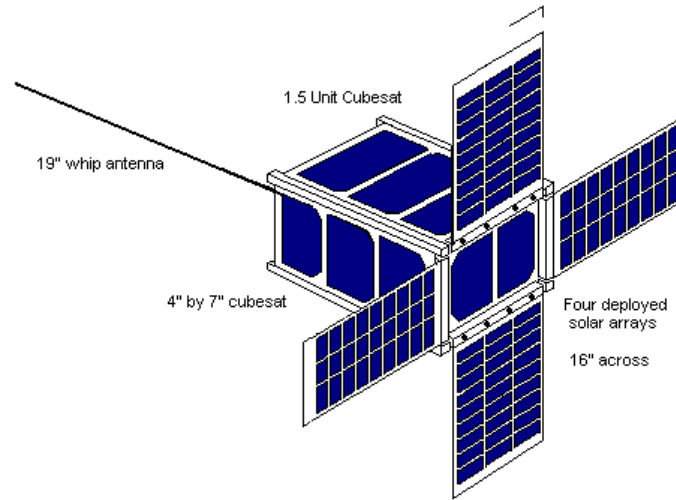
ParkinsonSAT 1.5u CUBESAT



1.5U cubesat designed for higher power

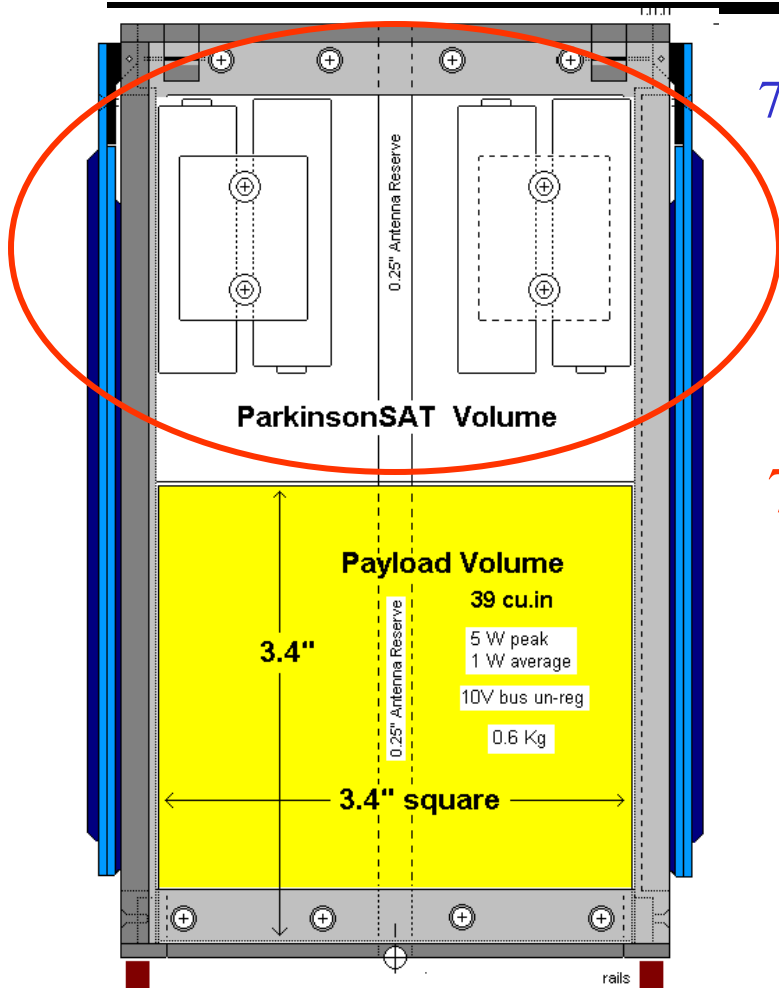


7"

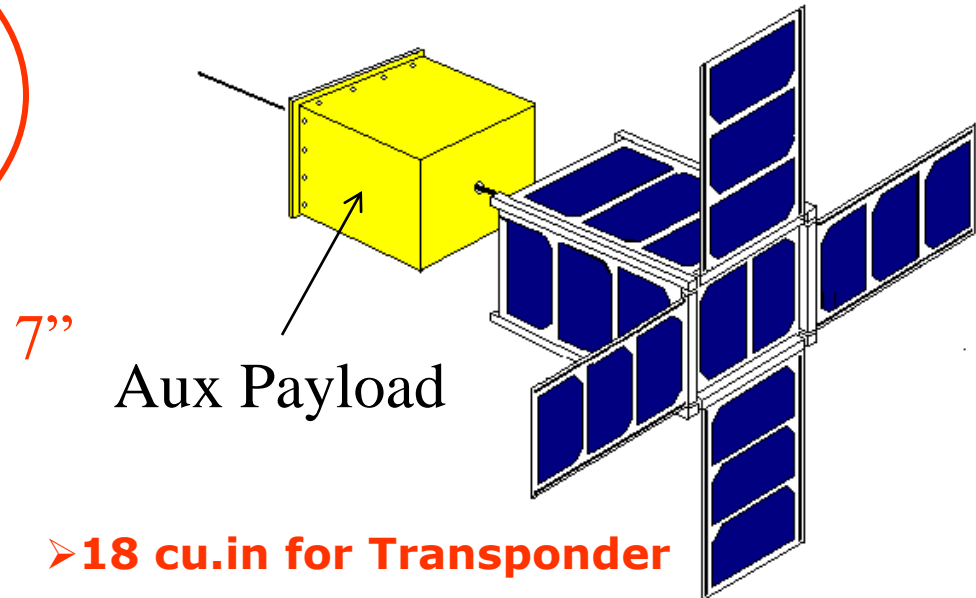


- New tiny 5W RF Xponder
- Simple Sun Pointing ADCS **\$50** Magnetometer
- COTS solar panels **\$360** compared to **(\$15,000)**

Psat Transponder Aux Payload



70% Payload Space Available! (only 50% shown here)

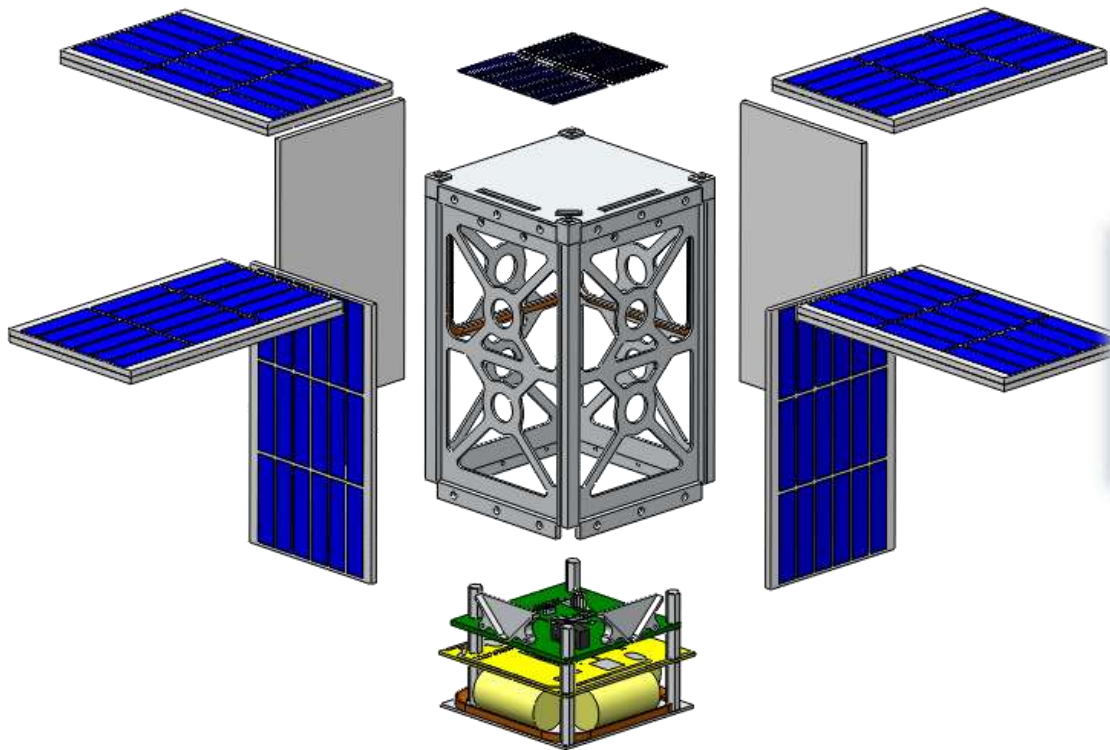


7"

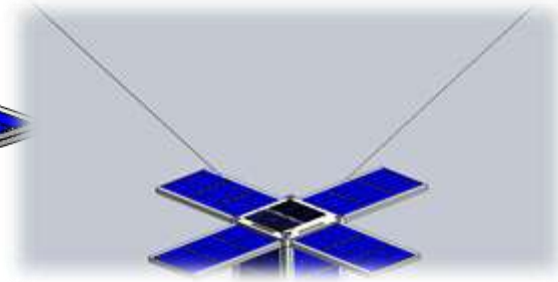
Aux Payload

- **18 cu.in for Transponder**
- **External 19" whip antenna**
- 68 cu.in for Aux Payload
- Aux payload gets 4" external panel
- Aux payload gets .5 kg – self contained
- 1 to 3W average power for aux payload

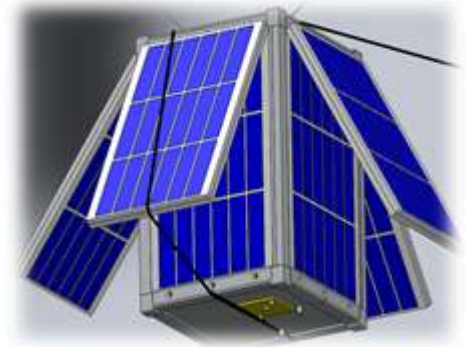
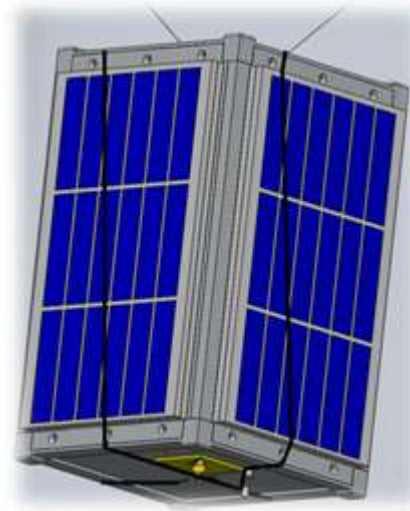
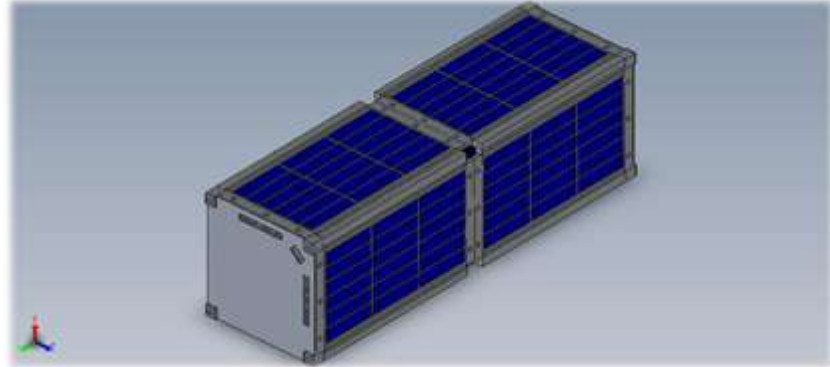
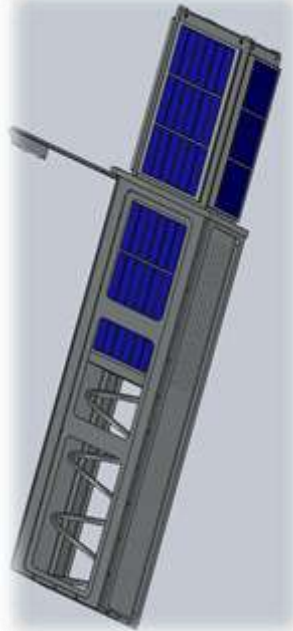
1.5U Psat Transponder Structure



19" VHF Antennas



Dual Psat Deployment



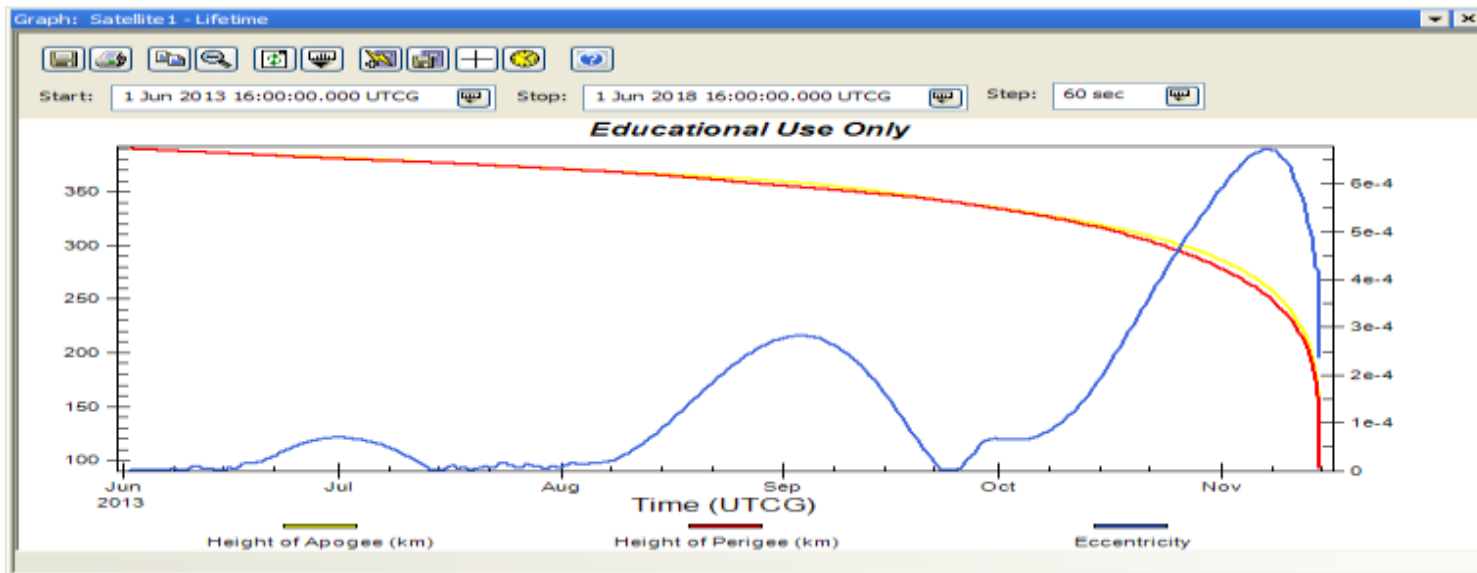
Deploy a pair of
1.5U PSATs from
dispenser

Deploy Solar Panels and Antenna



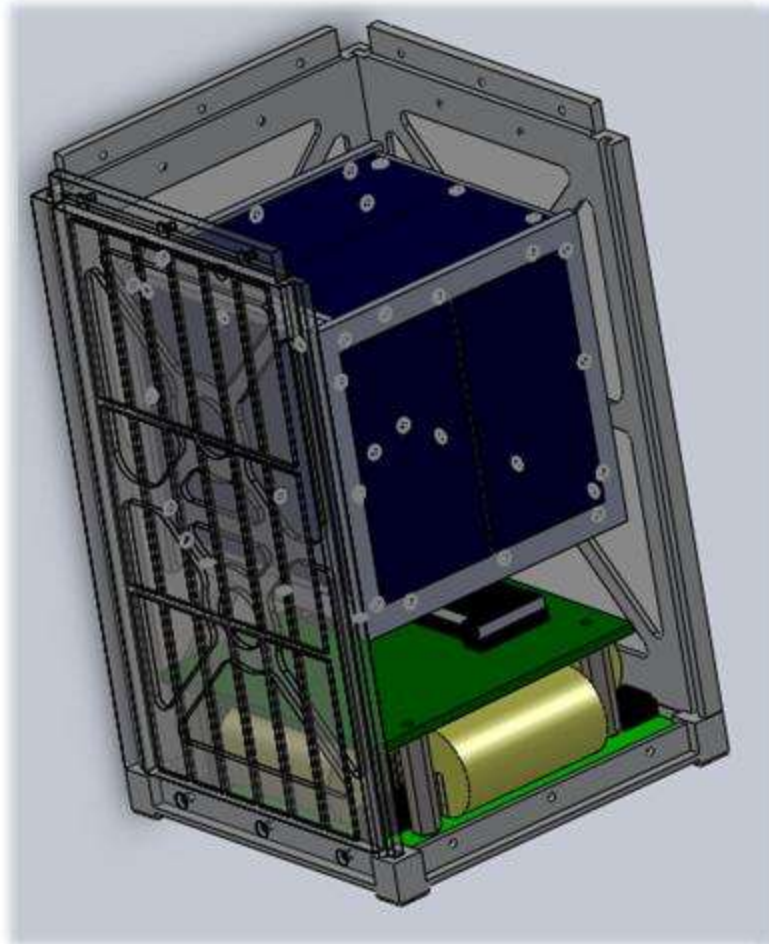
Problem: Short life for LEO cubesat

BRICsat– Ballistic ReInforCed Satellite



- About 2-3 months for LEO below ISS
- Not long enough for useful Comms support
- SO: BRICsat - Double Density, half cross section area
 - Quadruple the life up to a year

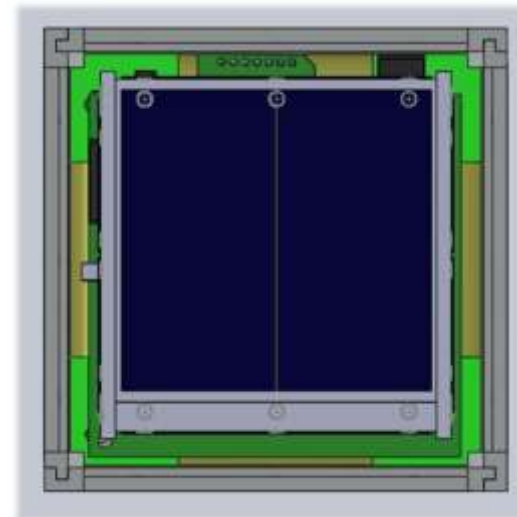
Psat-B Transponder & BRICsat



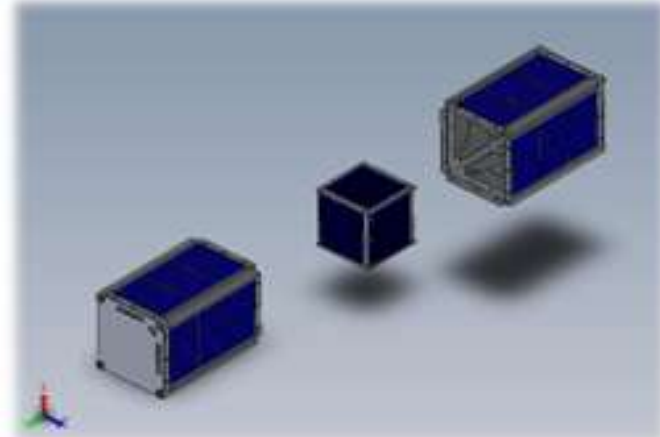
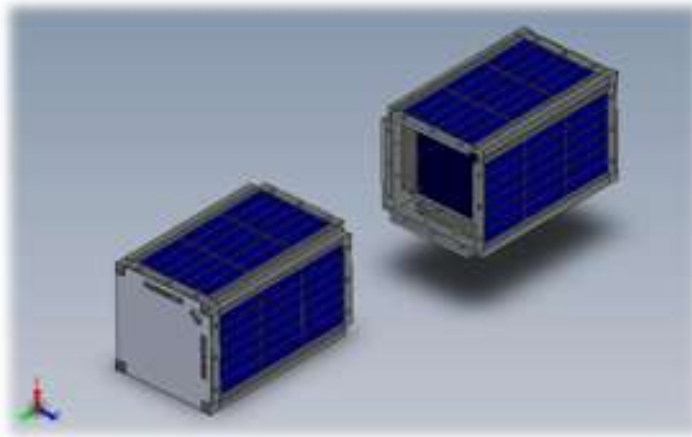
Psat-B contains same VHF xponder but only body solar panels.

➤ **Allows for 3"x3" BRICsat as Psat-B aux payload**

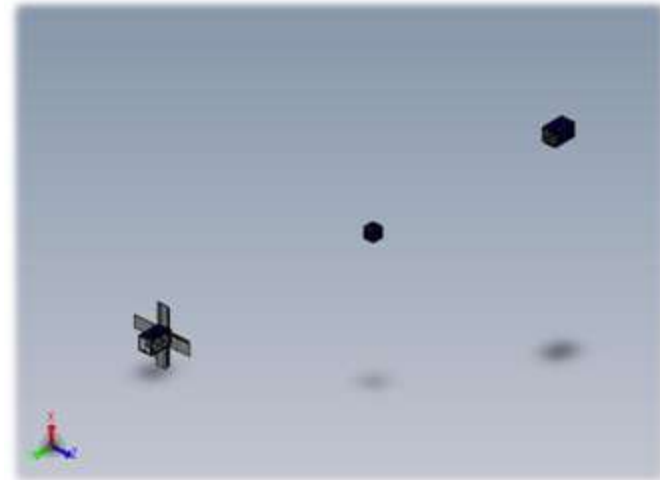
- Twice density, half area
- Quadruple the life
- 1W average power



Psat Separation @ T+30m



Psat-A with Solar Petals (not shown)
Psat-B with body panels
BRICsat with body cells



Common Separation Mechanism

Remote Sensor Applications (Science, force tracking, and text-messaging)



Supports Student Science Experiments
School missions/movements
Theater area communications
and Emergency Response Comms



13th Co Army/Navy Football Run
Comms by USNA Radio Club
W3ADO



The Yard Patrol Craft

Education
Force
Multiplier!

Ground Terminal is Hand Held



Ground Terminal is Walkie-Talkie, and Palm Pilot



Flight Heritage



Education of new Military Aerospace Design Engineers is an annual New-Start

- Maximizing hands-on Engineering and Technical Skills
- Expanding on Engineering management and systems engineering
- Mission simplicity. Avoiding overburdening complex programs
- Optimized to the Academic Schedule
- Yet pushes low cost, COTS, ORS concepts



PCSAT1

Prior Flights

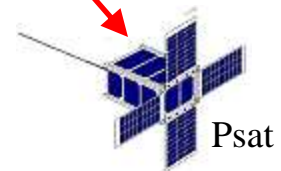


RAFT and MARScom



PCSAT2

Smaller, Better, Cubesat, Future



Psat

Low-Cost Satellite Heritage

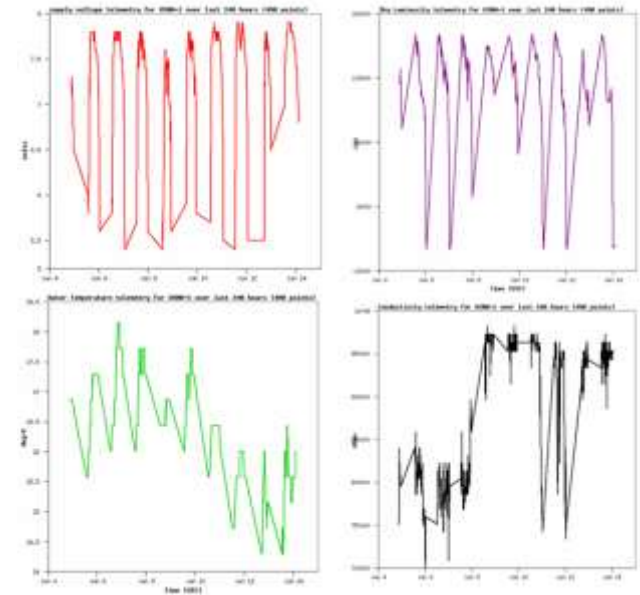
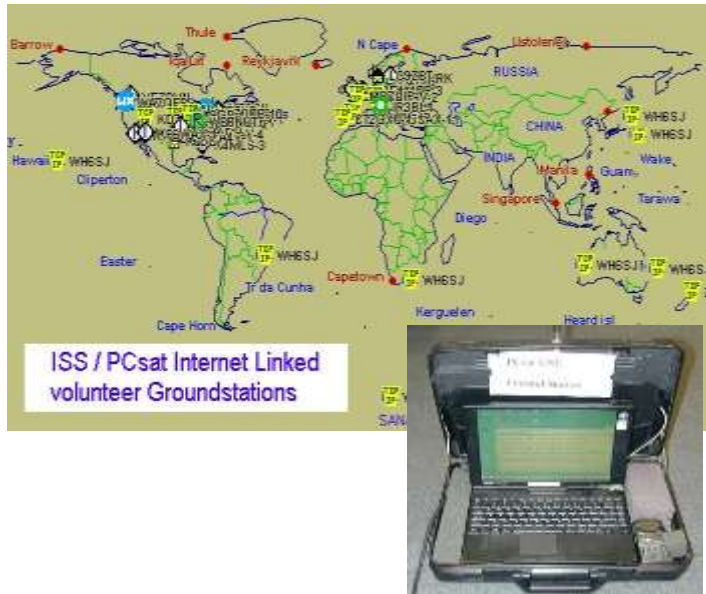
- *NATSw**eb*** — \$ 2k 1st Sea-Launch (1997 scrubbed in last week!)
- **PCsat** — \$30k **Launched Athena** 30 Sept 2001
- **Sapphire** - **\$3k?** **Launched Athena** 30 Sept 2001
- **PCSAT2** — \$35k **STS-114** 26 Jul 05 return to flight
- **ARISS** — \$ 2k **Launched on Progress** Aug 2003
- **ANDE** — \$35k **Launched STS-116** 21 Dec 06
- **RAFT1** — \$15K **Launched STS-116** 21 Dec 06
- **MARSc**om**** — \$15K **Launched STS-116** 21 Dec 06
- **ParkinsonSAT** — \$50k **Commenced** Fall 2006

Data Accessibility Plan



Data Exfiltration Direct to Internet for Experimenters

- All data from all experiments available live via Internet feeds from global ground stations
- All AX.25 Data and formats handled transparently by Satellite and Global Infrastructure
- Volunteer ground stations around the world
- Global infrastructure has existing WEB telemetry displays built-in.

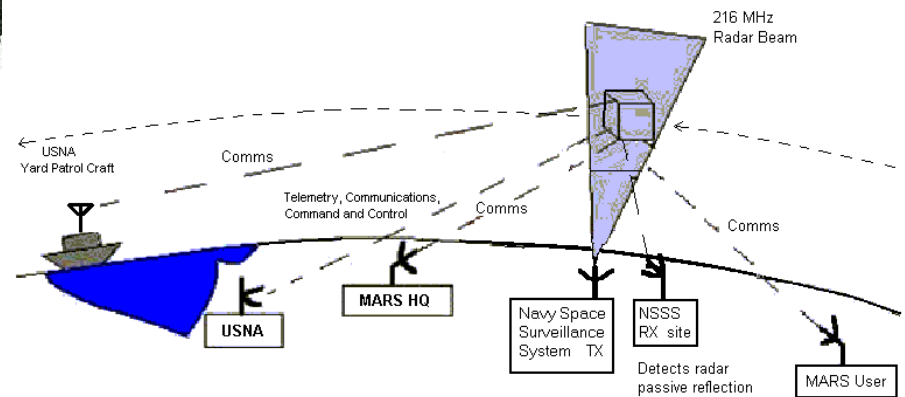
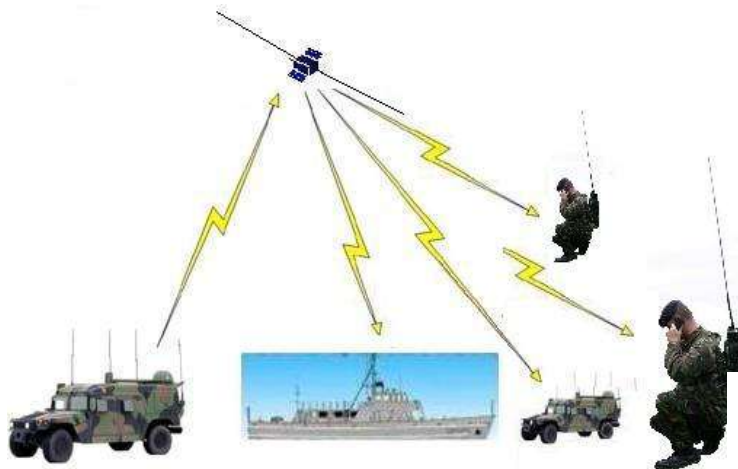




Can also Provide Text Messaging



- Experimental/Emergency comms for any Small Platform without existing Satcom
- Fulfills Emergency Response Mission
- National if not global infrastructure with >8,000 volunteers
- Naval Academy Yard Patrol Craft SATCOM access



Significant reduction from transponders on PCSAT's 1,2, ANDE and RAFT missions

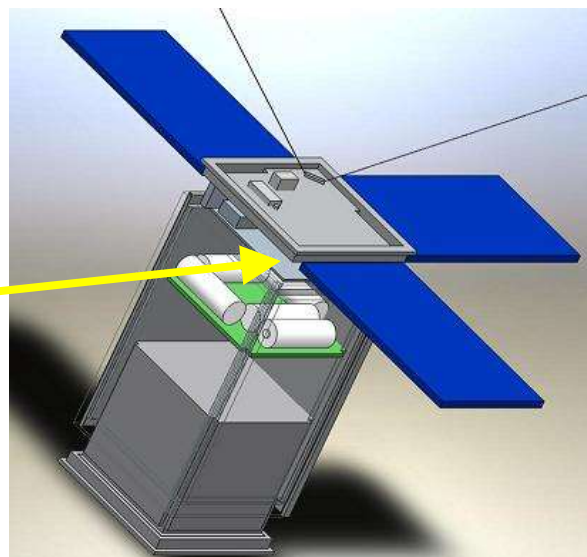
Psat USNA-0601



Earlier reductions to 5" cubesat on RAFT (2006)

4:1

Now reduced 18:1 in volume/mass for 4" cubesat 2010



2013 DoD SERB

Sensor Buoy Baseline (prototype)



- **Naval Academy Student Project** •
- * If free-floating, do not disturb.
- * If aground, move to deep water and advise bruninga@usna.edu
- * If later than 30 Nov 2006, recover and advise above.



2006 50:1 size reductions

2
0
0
8

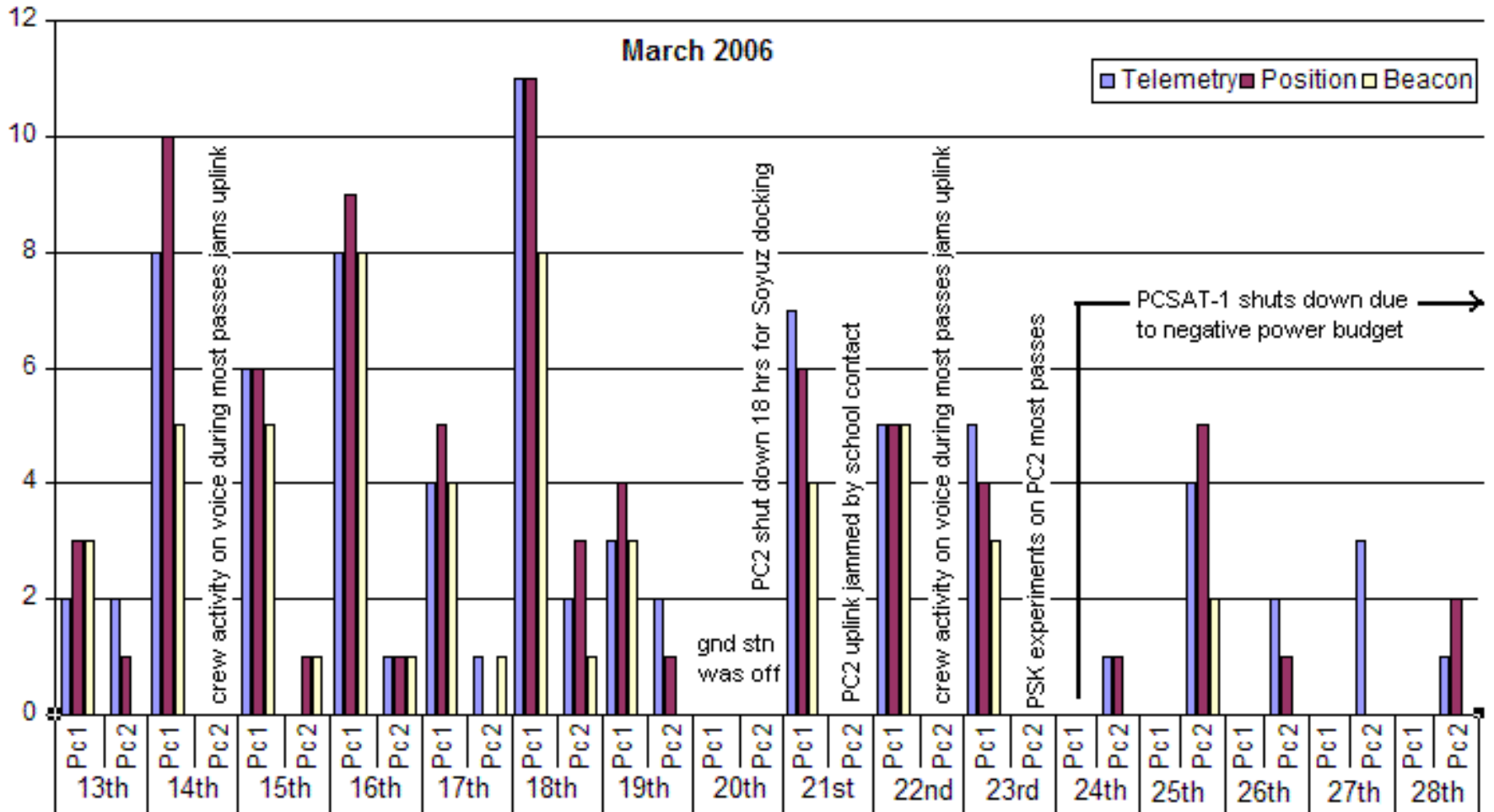


See Buoy Location and Telemetry at <http://map.findu.com/buoy4>

Sensor Buoy Baseline Test



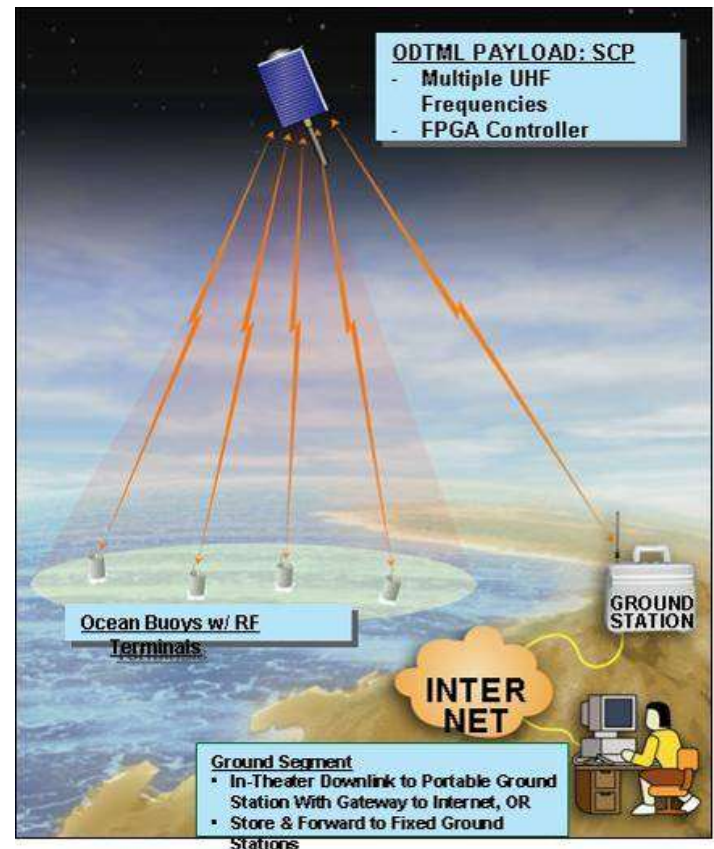
Number of Buoy Packets Received Per Day via PCSAT-1 and PCSAT2



Summary - Cubsat Data Relay



- VHF Links (145.825 MHz)
- +8 dB Link advantage compared to UHF
- Using Omni antennas on satellite and buoys
- Global network of volunteer ground stations linked to the internet
- Multi-satellite Transparency
- Low data rate 1200 baud channel
- Any University can build one



Questions?

