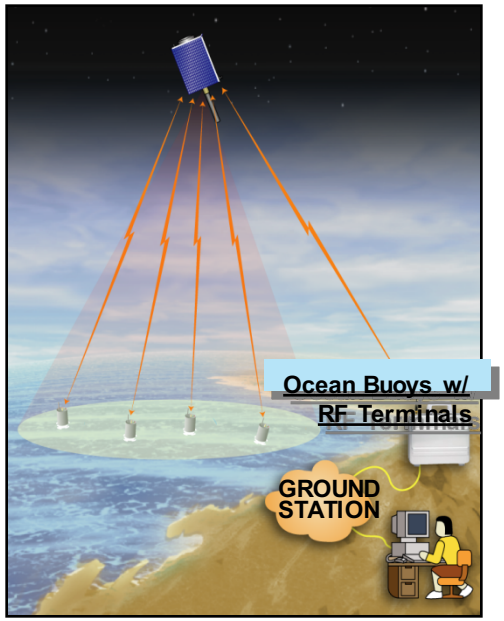
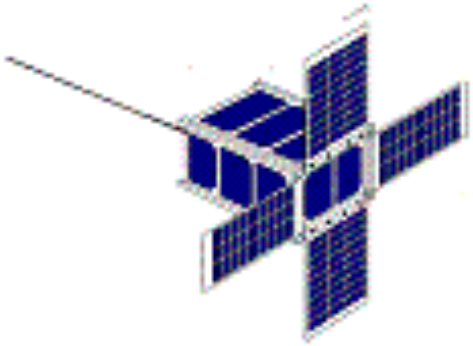
ParkinsonSAT Remote Data Relay (Psat)

Cubesat Conference
August 2011



ODTML

Psat

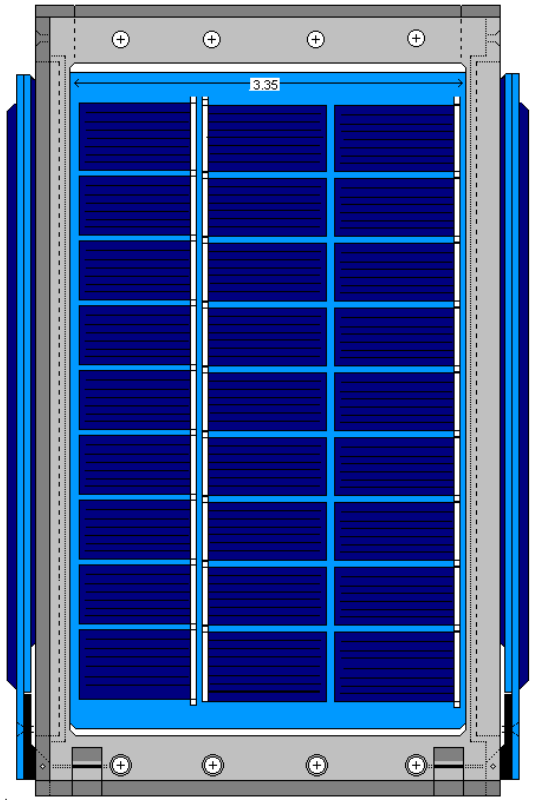


Bob Bruninga
Midns: Crawford, Guilfoyle, Lumsden,Randall,Pollock,Schlottmann

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

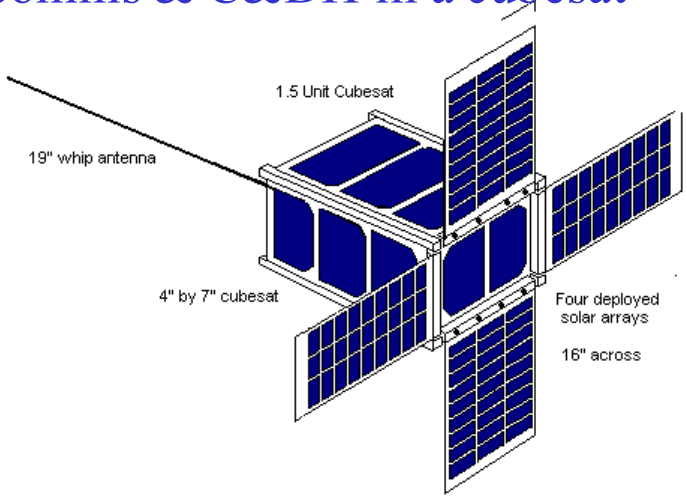
UNCLASS

ParkinsonSAT 1.5u CUBESAT



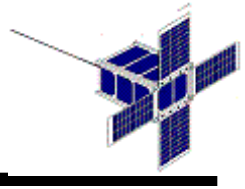
7”

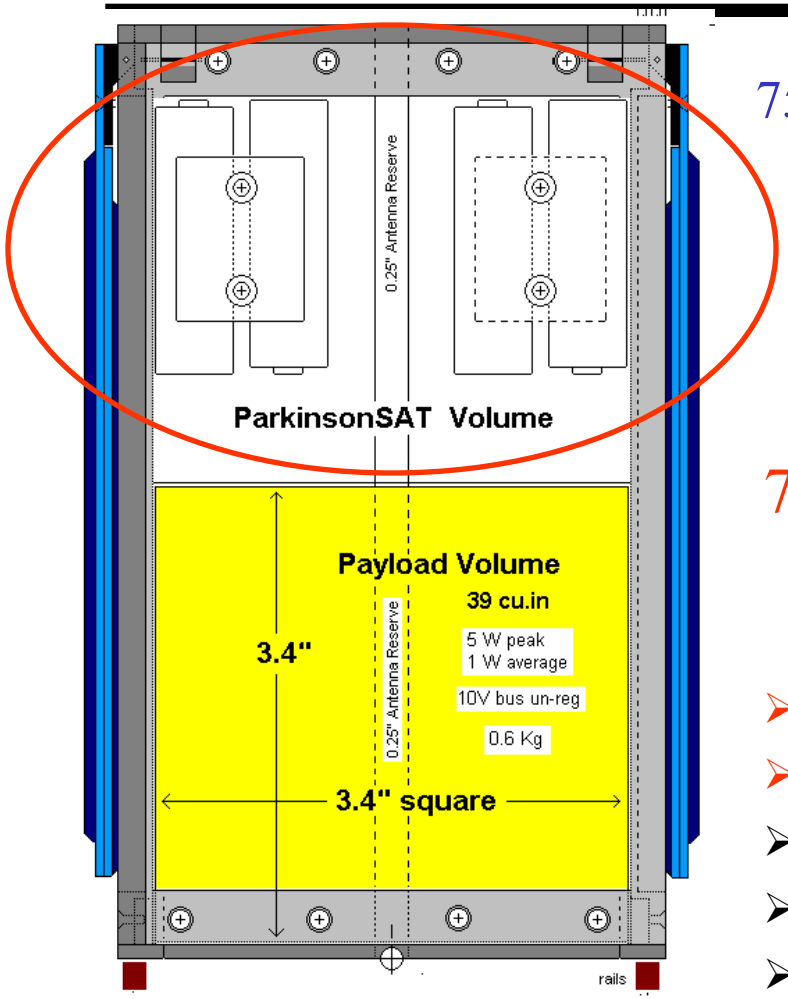
Psat Xponder can also serve as complete comms & C&DH in a cubesat



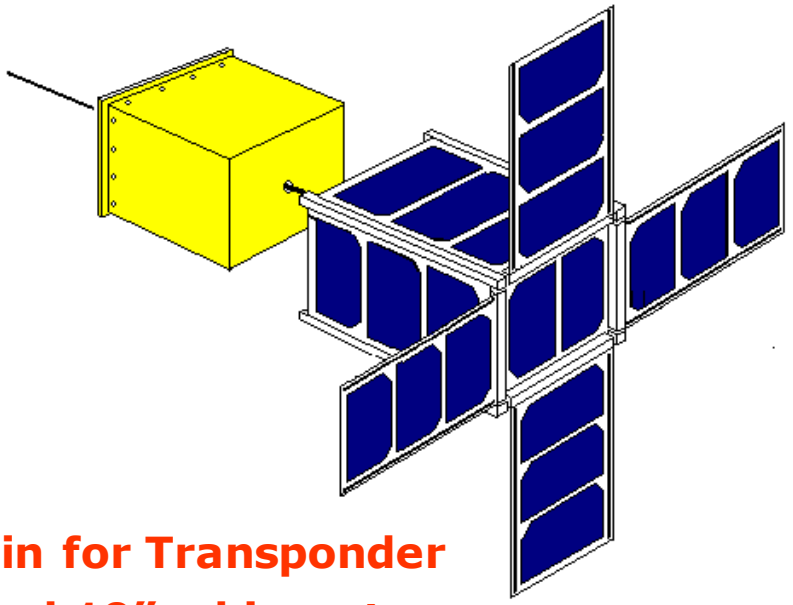
- New tiny 5W RF Xponder
- Simple Sun Pointing ADCS **$50** Magnetometer
- Can support other SERB Payloads
- COTS solar panels **$360 / ($15,000)**

Psat Transponder Aux Payload





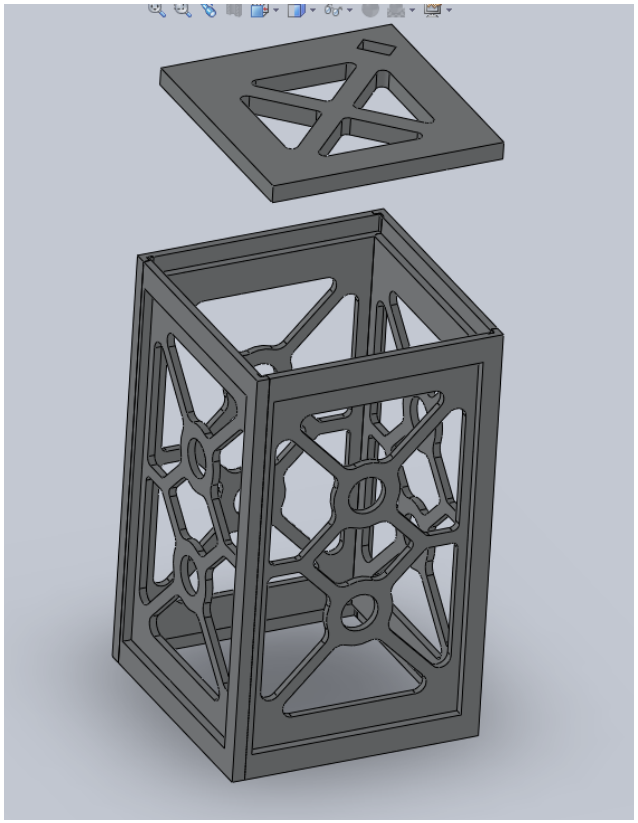
75% Payload Space Available! (only 50% shown here)

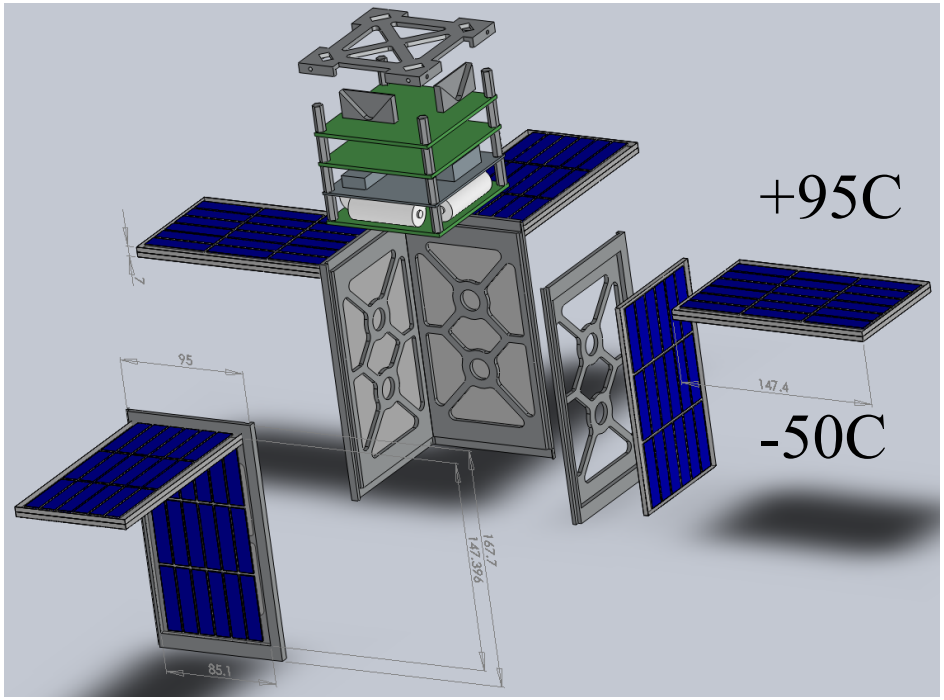


7”

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

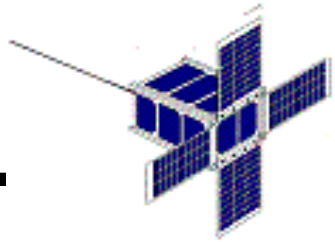
Psat Structure (& Thermal)

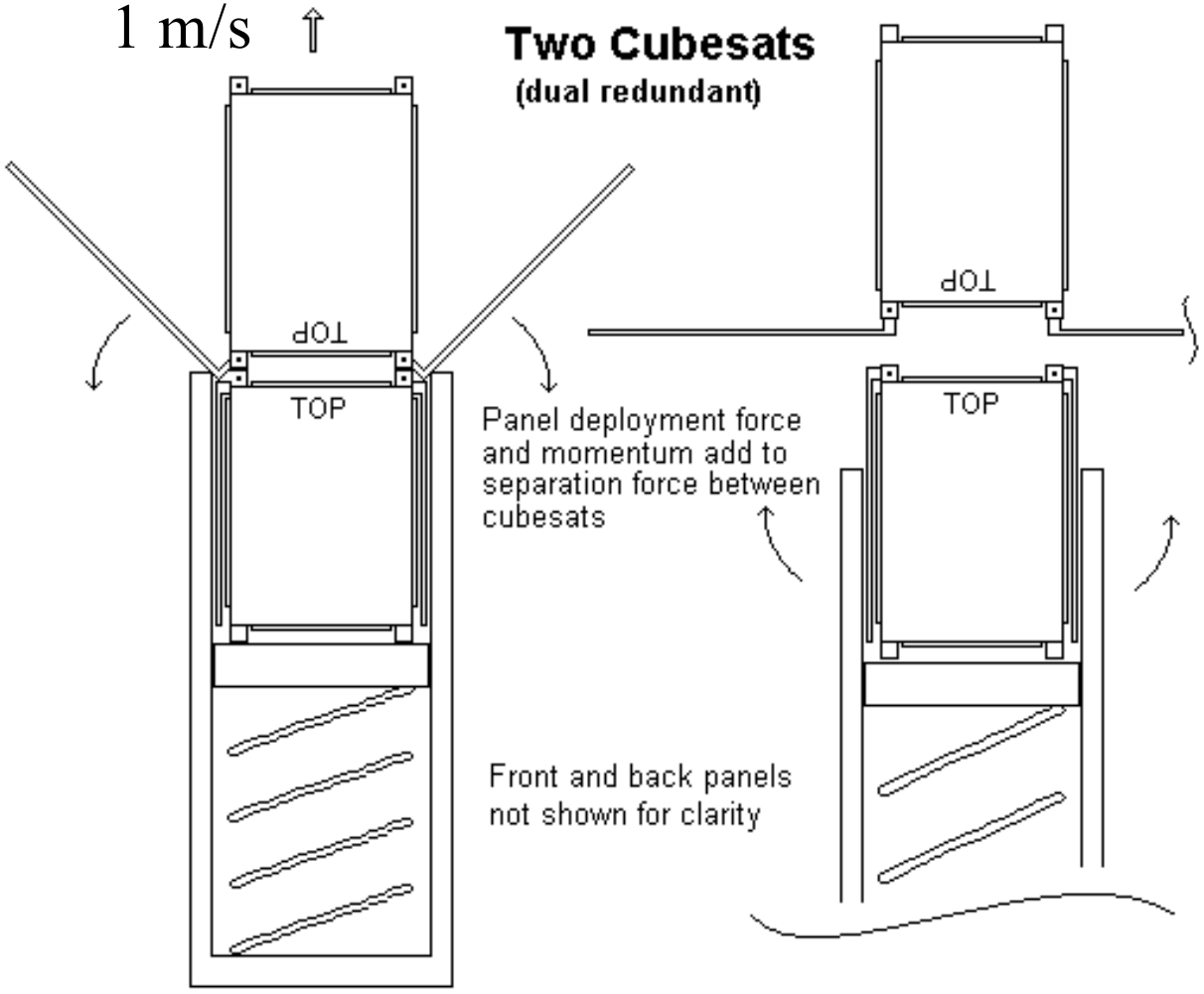




Was 0 C to 40 C on body

CUBESAT Deployment

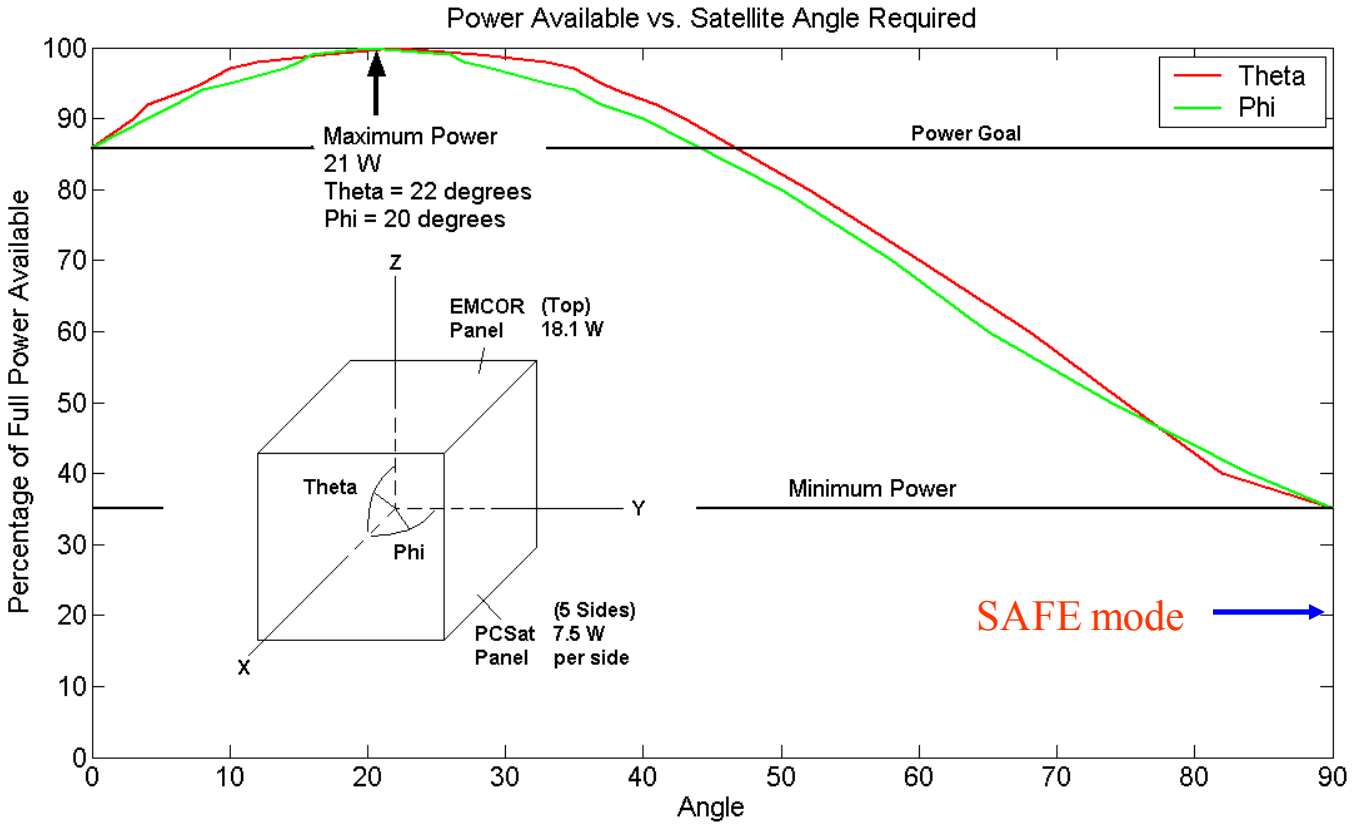




Sun Pointing Attitude Control System

✓ Pointing requirements are relaxed +/- 32 deg for 85% power

✓ High precision attitude control not required

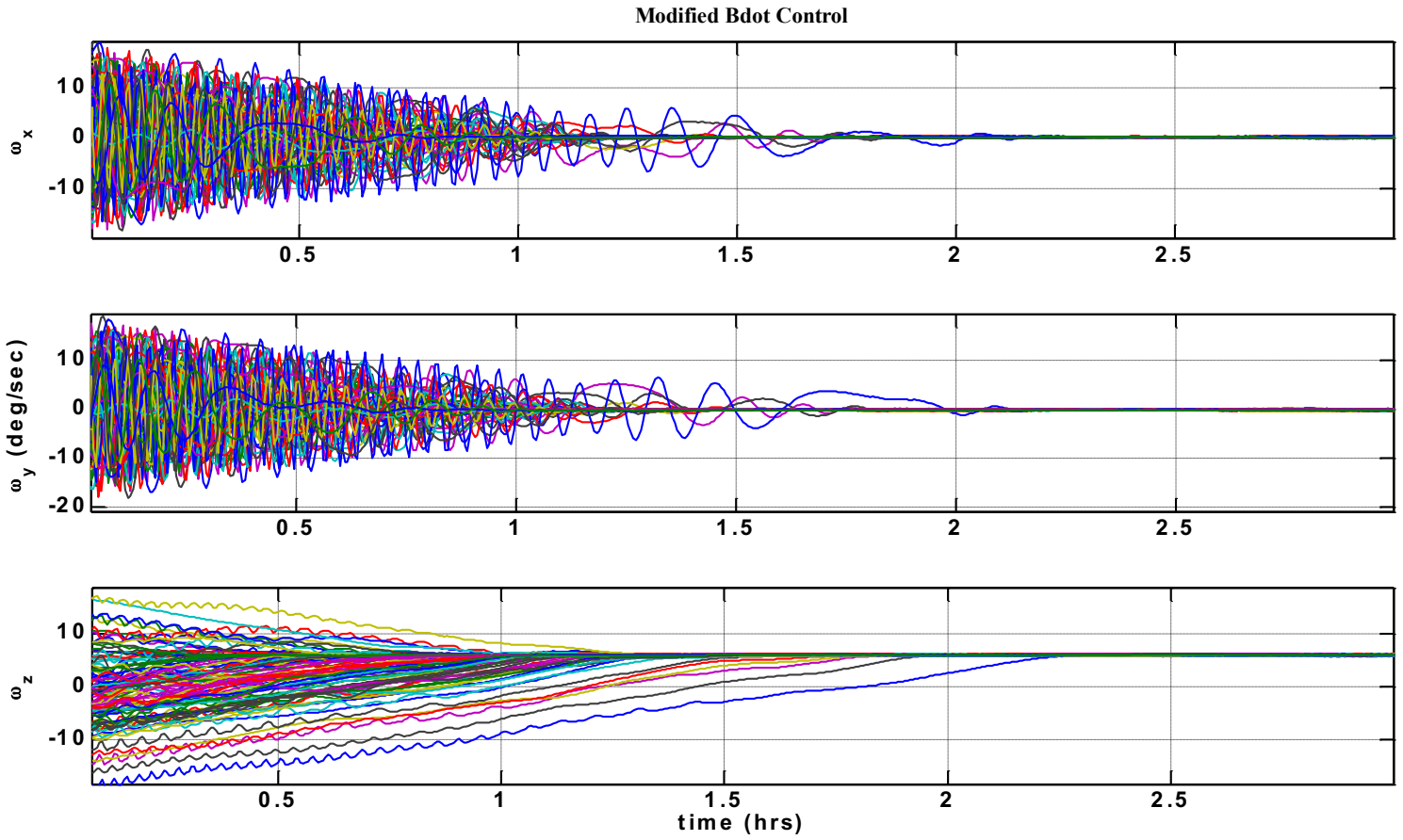


Cubesat

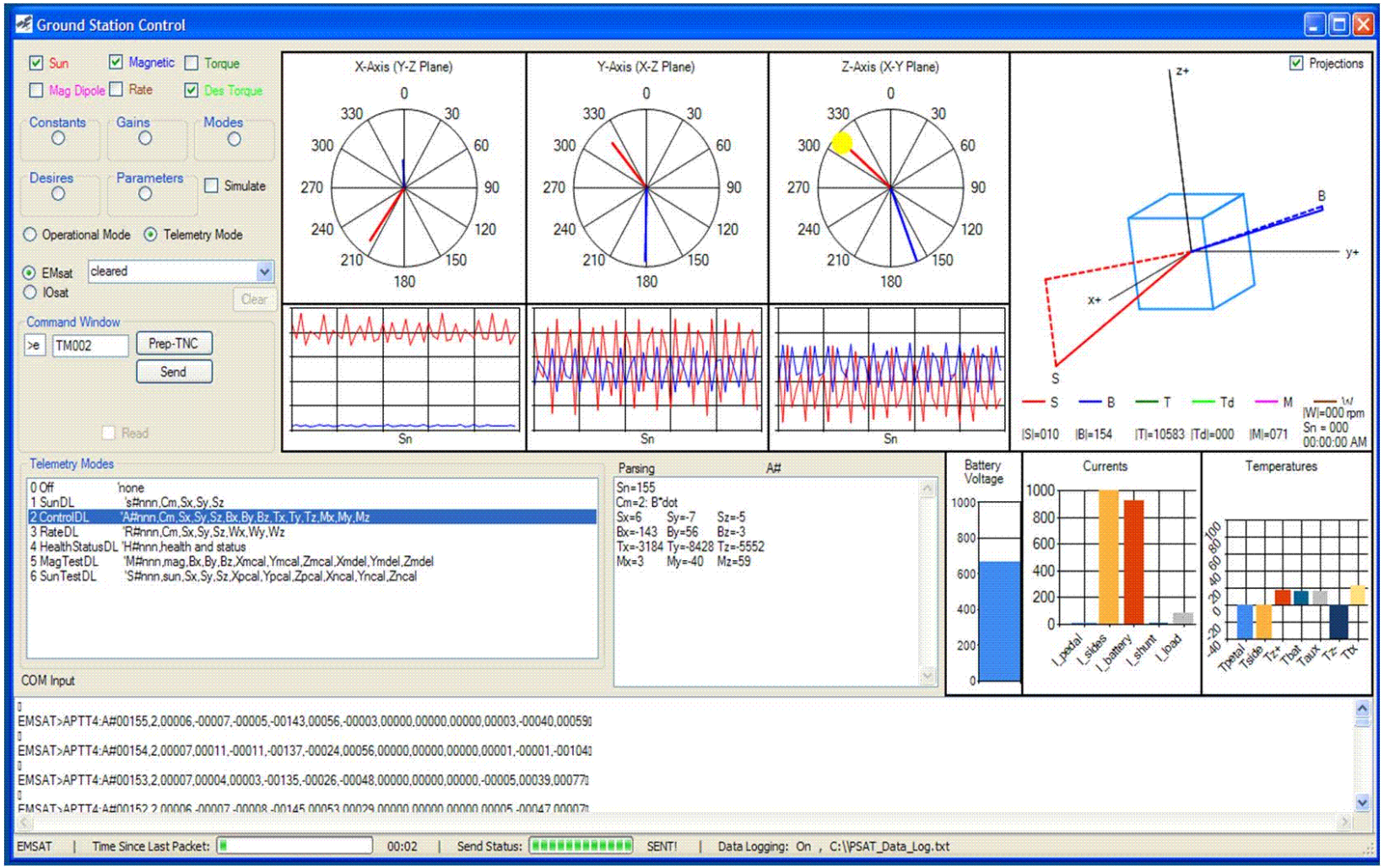
3.5W

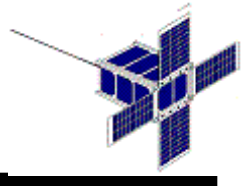
1.5W

Matlab Simulation of Modified B*dot

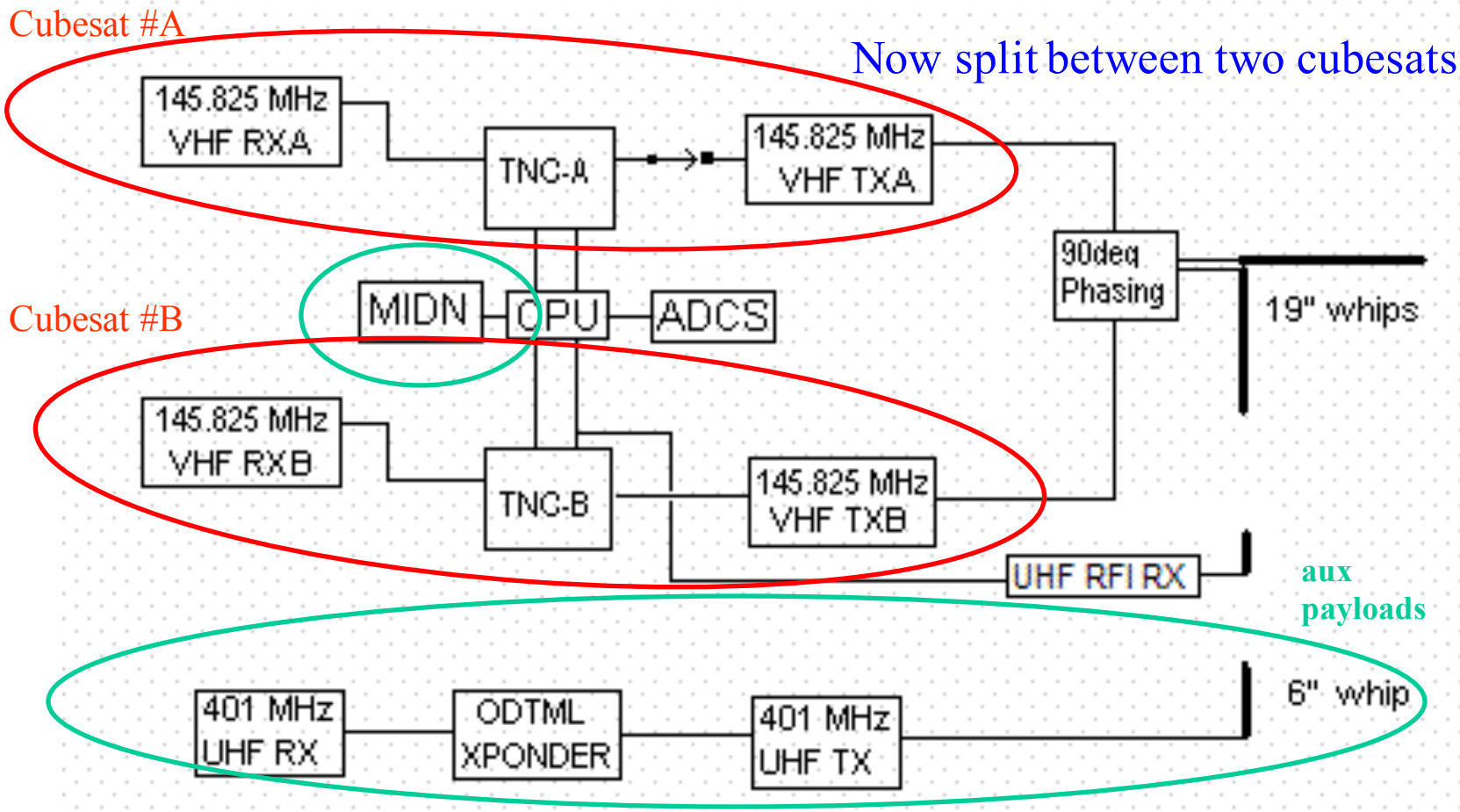


Ground Station Software

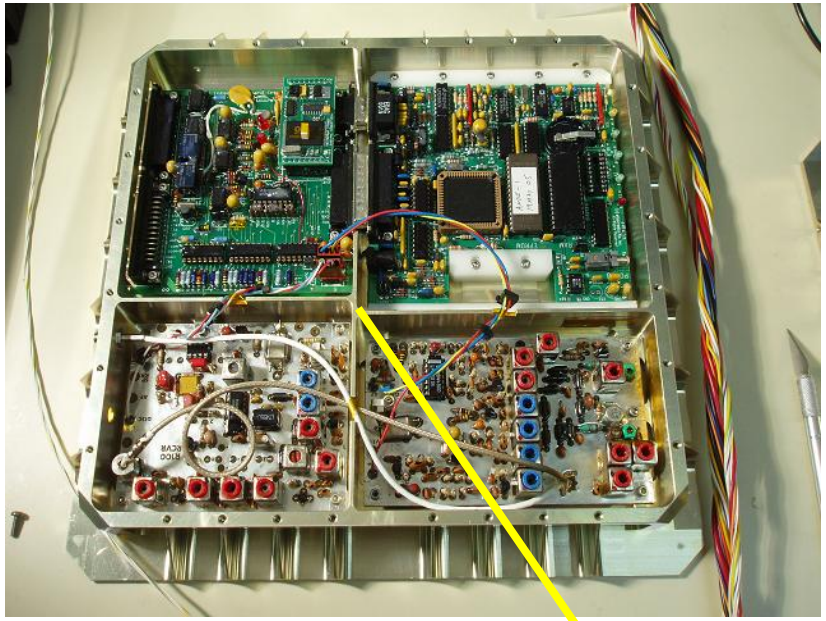




USNA Transponder Block Diagram



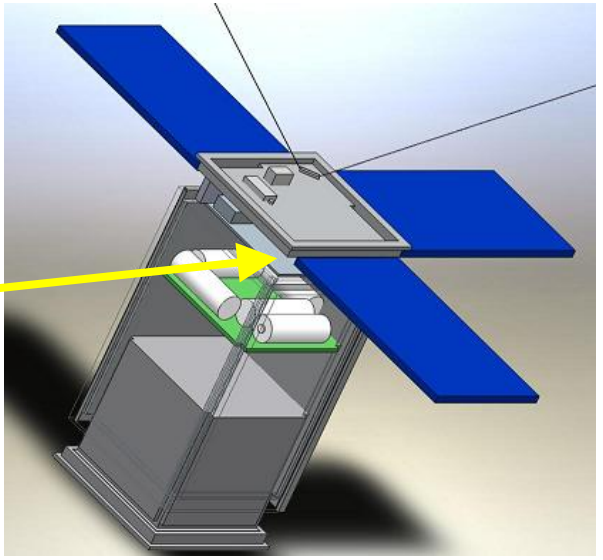
Huge reduction from transponders on PCSAT's 1,2, ANDE and RAFT missions



Earlier reductions to 5" cubesat on RAFT (2006)

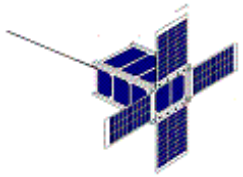
4:1

Now reduced 18:1 in volume/mass for 4" cubesat 2009

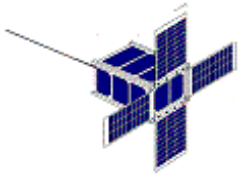


Psat (USNA-0601)
Operational Concept Graphic

Ground Terminal Applications Focus (force tracking and text-messaging)



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



The Yard Patrol Craft

Education

Force

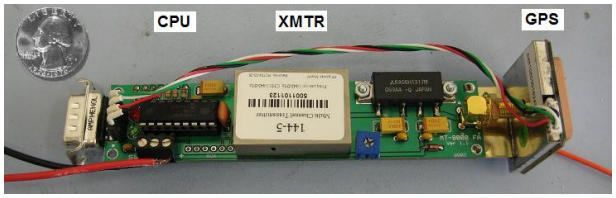
Multiplier!

Ground Terminal Applications Focus

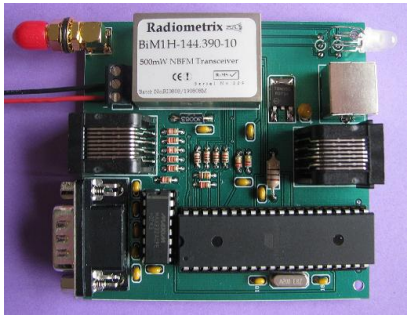
Supports Student Experimenters world wide

OR

OR

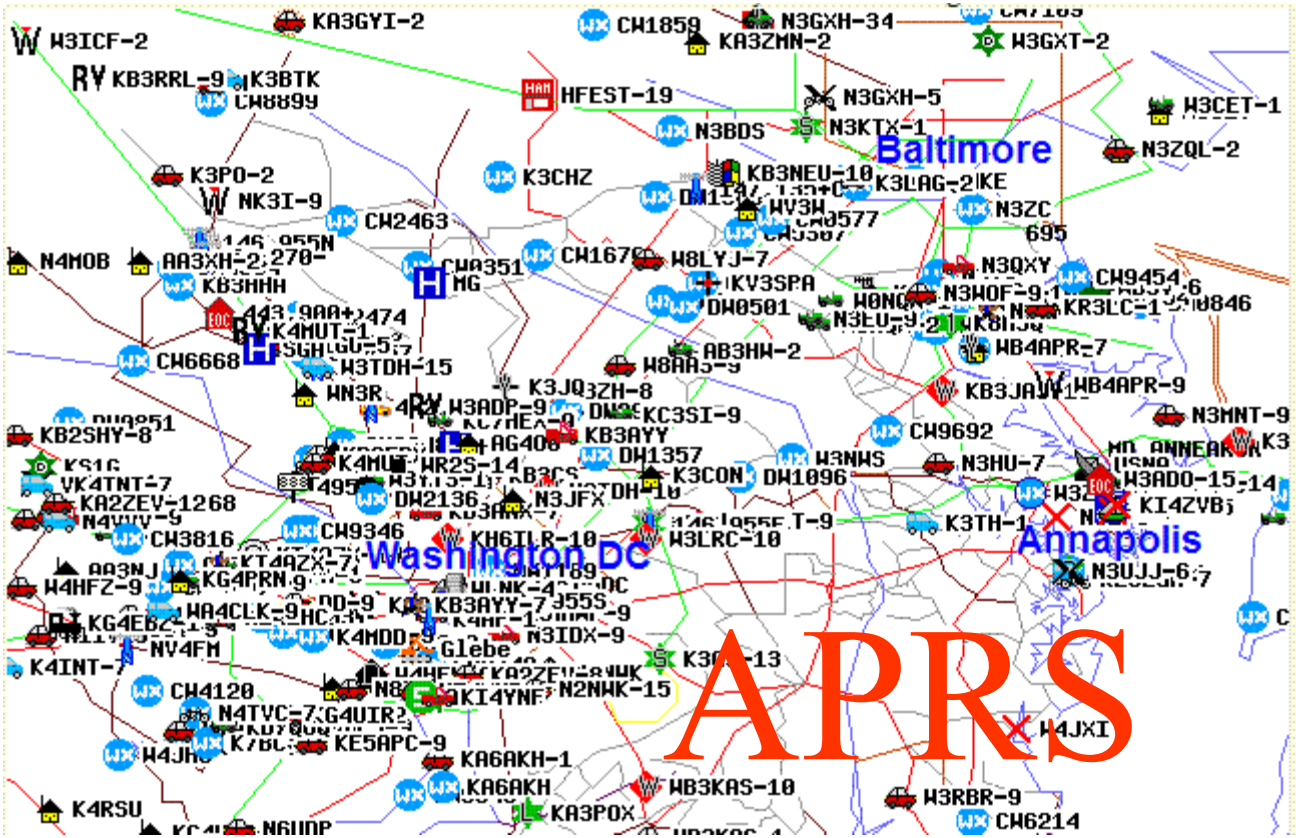


OR



Mission Background

Psat Xponder Mission (Remote Data Relay)



FOCUS:

"Network Centric" & Remote Sensor Experiments

300 stations
In 35 miles

Find any station - http://aprs.fi/WB4APR*

Ground Terminal Applications Focus

Tactical Situational Awareness and Text Messaging

Last 100 stations!

Direction & Distance

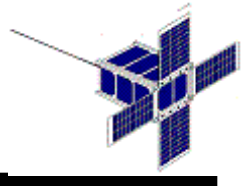
Frequency and Tone

Example Situational Awareness (in SLC Utah)

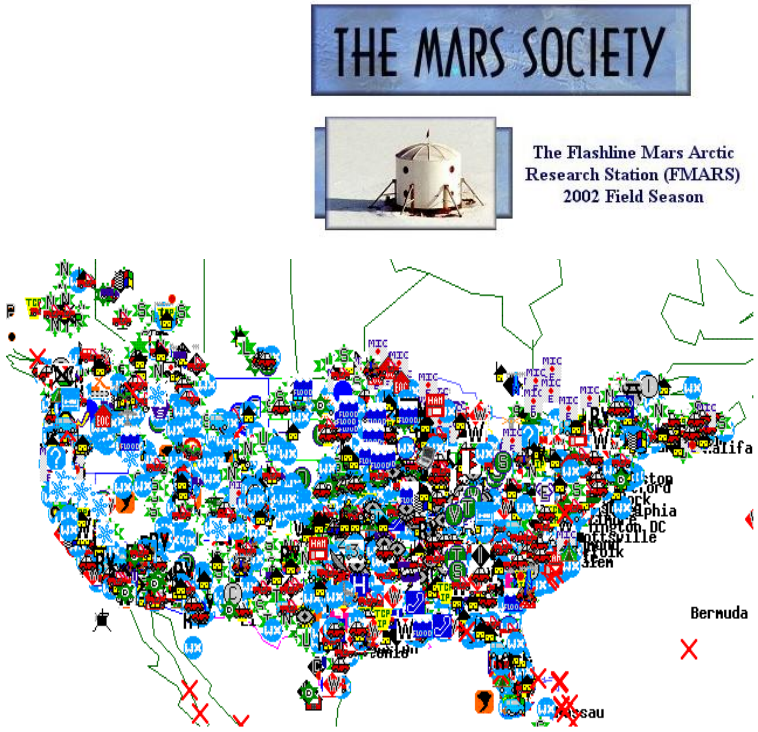
27 users in S.L.C

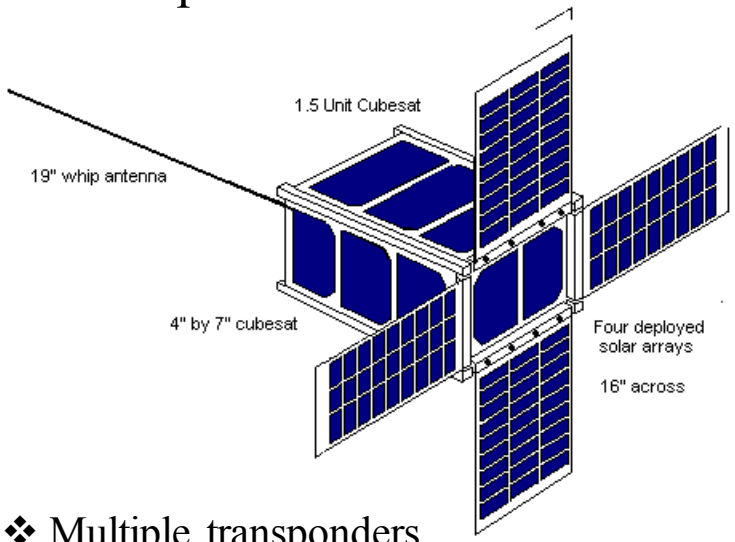
map.findu.com/N7RKB*

P-SAT Data Exfiltration Background



- Psat transponder can draw from thousands of experimenters for large scale loading experiments and other SERB experiments.



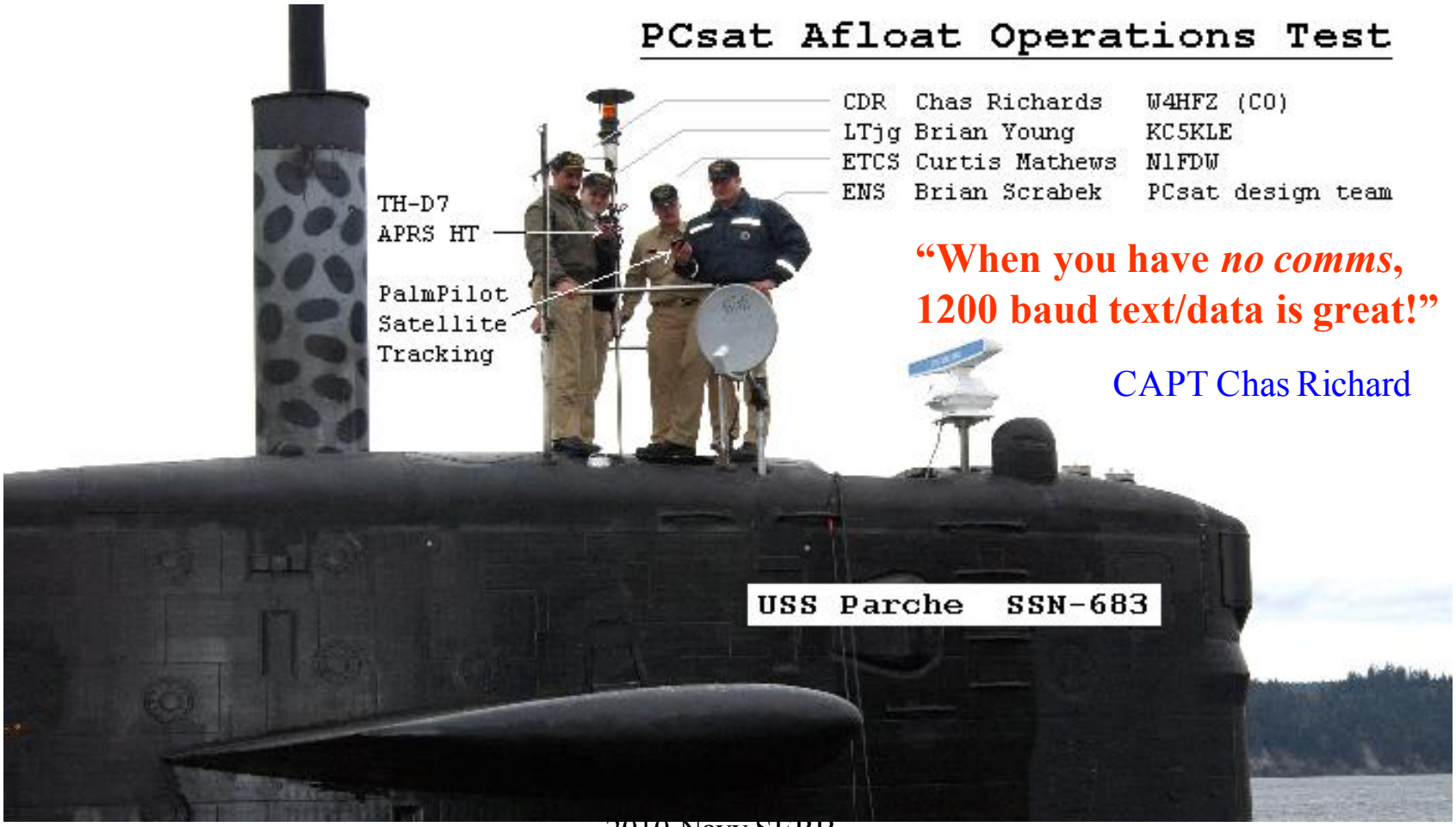


❖ Multiple transponders on smaller picosats can form a constellation for greater coverage and reduced latency.

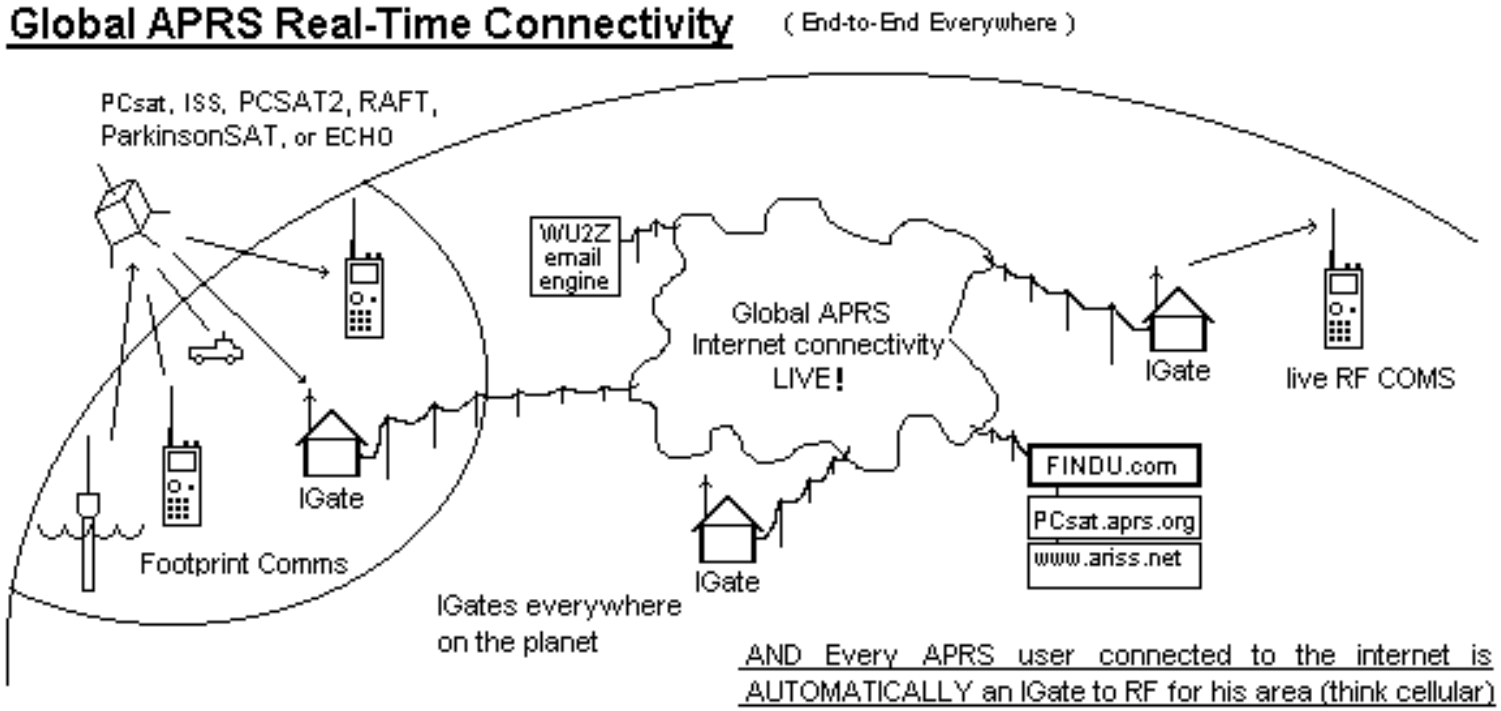
- Not only the sensors and users exist, but the global Internet collection and distribution system also exists from PCSAT1 & 2.

Small Platform Minimum Satcom (SPMS) Background

Ground Terminal is Walkie-Talkie, and Palm Pilot



Psat Global Internet linked Comms Network

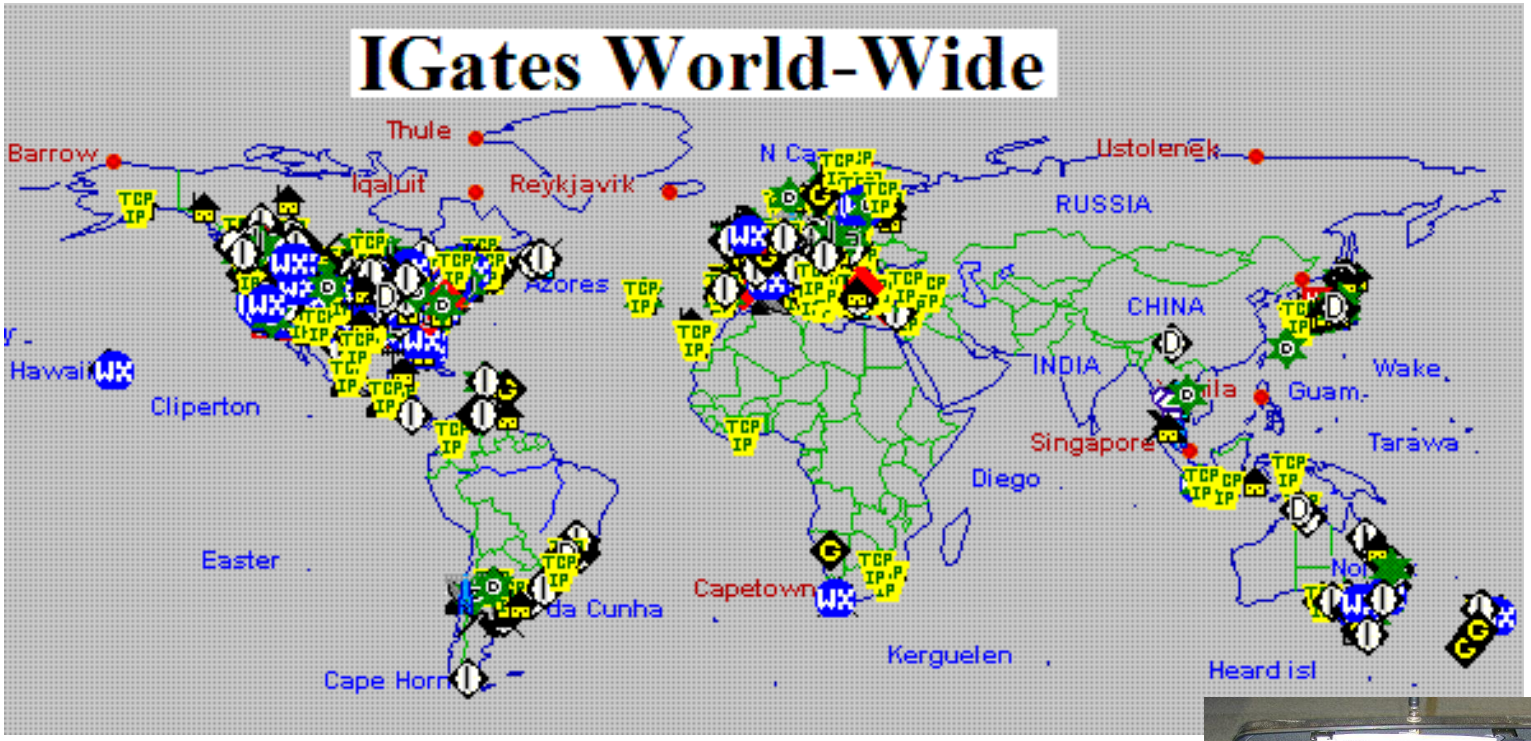


APRS Global Packet Radio Network

Internet Linked for live Communications

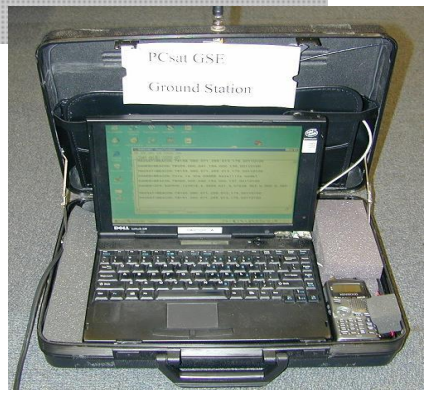
Automatic Packet Reporting System

Psat APRS Network Architecture



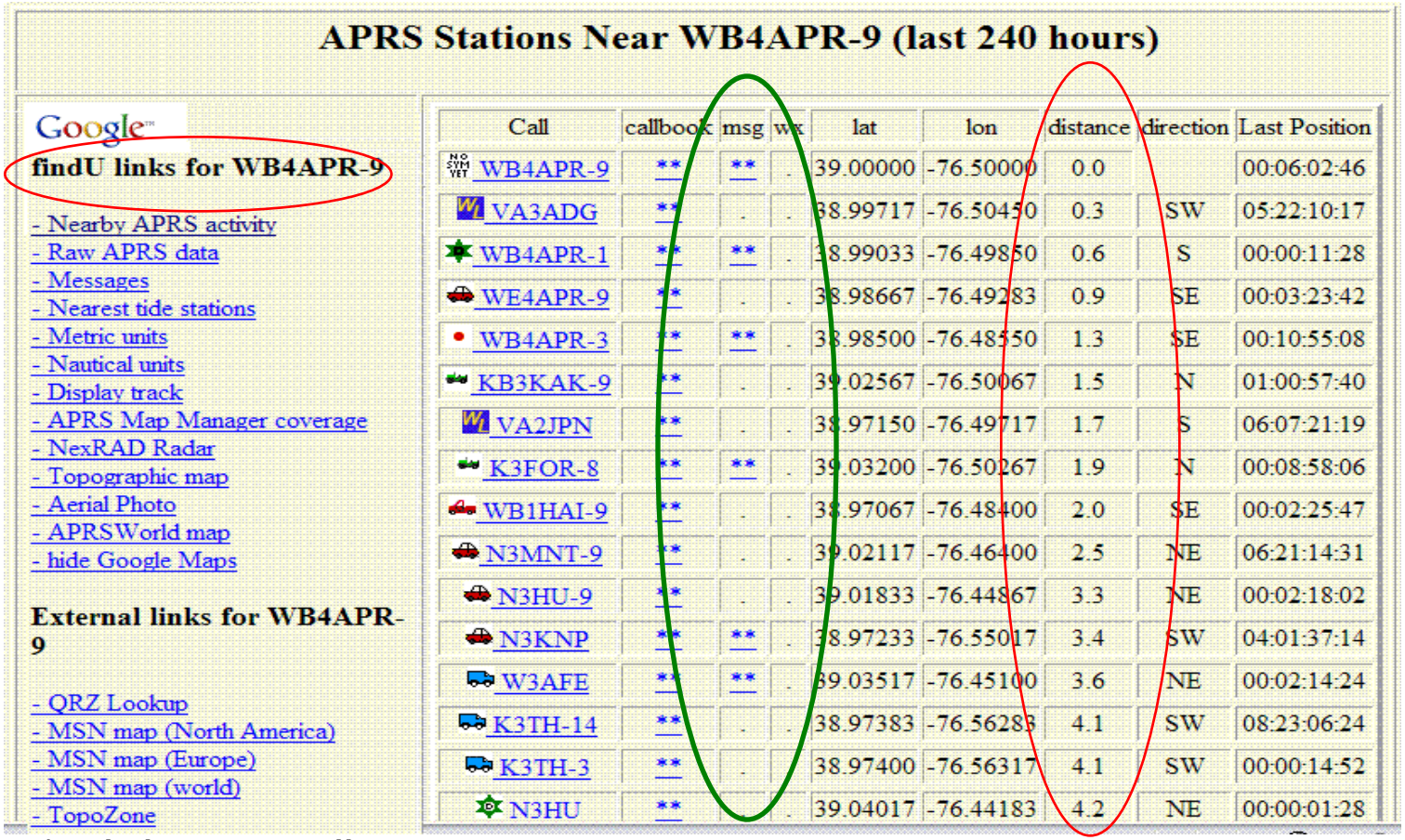
Global Volunteer Ground Station Network

Internet Linked for live Telemetry



APRS Experiment Data Access (via internet)

http://map.findu.com/wb4apr* to see data on ANY experiment in the world



APRS Stations Near WB4APR-9 (last 240 hours)

Google

findU links for WB4APR-9

- Nearby APRS activity
- Raw APRS data
- Messages
- Nearest tide stations
- Metric units
- Nautical units
- Display track
- APRS Map Manager coverage
- NexRAD Radar
- Topographic map
- Aerial Photo
- APRSWorld map
- hide Google Maps

External links for WB4APR-9

- QRZ Lookup
- MSN map (North America)
- MSN map (Europe)
- MSN map (world)
- TopoZone

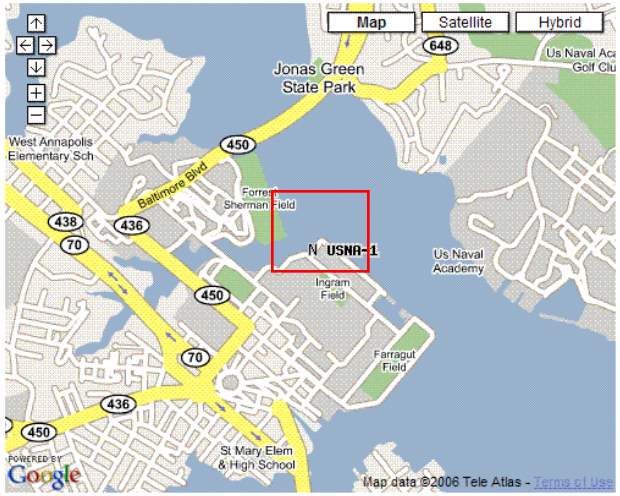
Call	callbook	msg	wx	lat	lon	distance	direction	Last Position
WB4APR-9	**	**	.	39.00000	-76.50000	0.0		00:06:02:46
VA3ADG	**	.	.	38.99717	-76.50450	0.3	SW	05:22:10:17
WB4APR-1	**	**	.	38.99033	-76.49850	0.6	S	00:00:11:28
WE4APR-9	**	.	.	38.98667	-76.49283	0.9	SE	00:03:23:42
WB4APR-3	**	**	.	38.98500	-76.48550	1.3	SE	00:10:55:08
KB3KAK-9	**	.	.	39.02567	-76.50067	1.5	N	01:00:57:40
VA2JPN	**	.	.	38.97150	-76.49717	1.7	S	06:07:21:19
K3FOR-8	**	**	.	39.03200	-76.50267	1.9	N	00:08:58:06
WB1HAI-9	**	.	.	38.97067	-76.48400	2.0	SE	00:02:25:47
N3MNT-9	**	.	.	39.02117	-76.46400	2.5	NE	06:21:14:31
N3HU-9	**	.	.	39.01833	-76.44867	3.3	NE	00:02:18:02
N3KNP	**	**	.	38.97233	-76.55017	3.4	SW	04:01:37:14
W3AFE	**	**	.	39.03517	-76.45100	3.6	NE	00:02:14:24
K3TH-14	**	.	.	38.97383	-76.56283	4.1	SW	08:23:06:24
K3TH-3	**	.	.	38.97400	-76.56317	4.1	SW	00:00:14:52
N3HU	**		.	39.04017	-76.44183	4.2	NE	00:00:01:28

* Click to see all stations on map

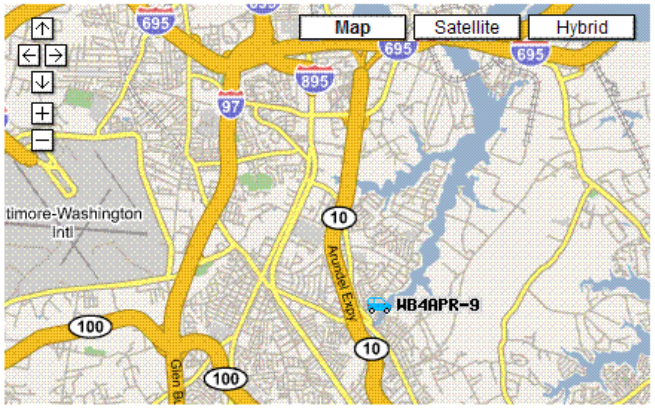
Based on the USNA Automatic Packet Reporting System

“Purple Force” Tracking

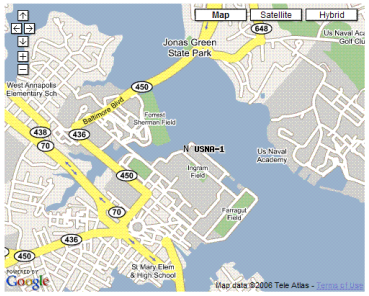
Map.findu.com/wb4apr*

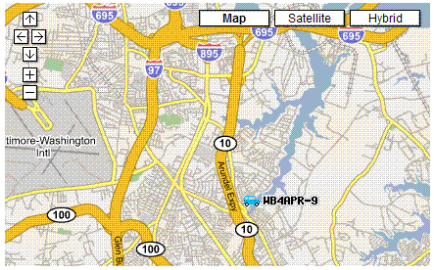


Tactical situational awareness



Where to See it ALL



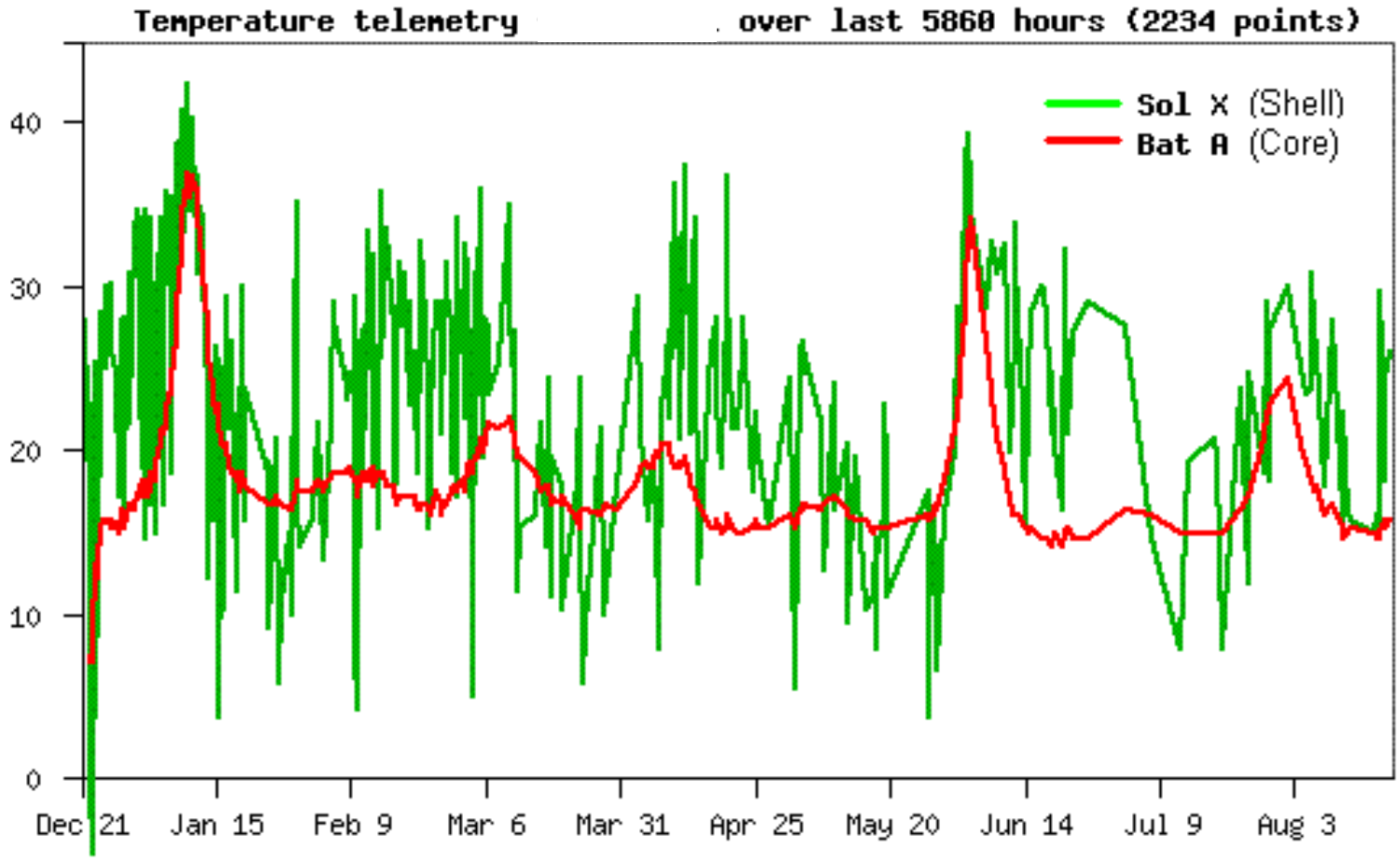


Global Comm system

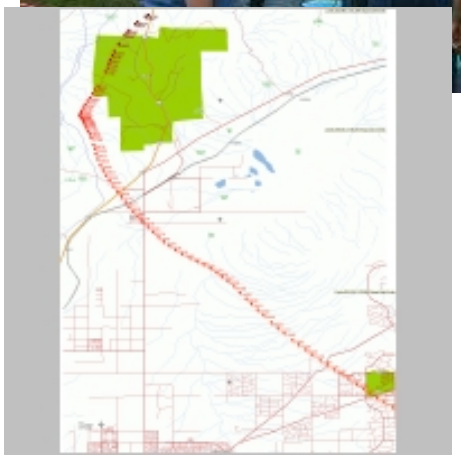
http://aprs.fi

Findu.com Telemetry Plots

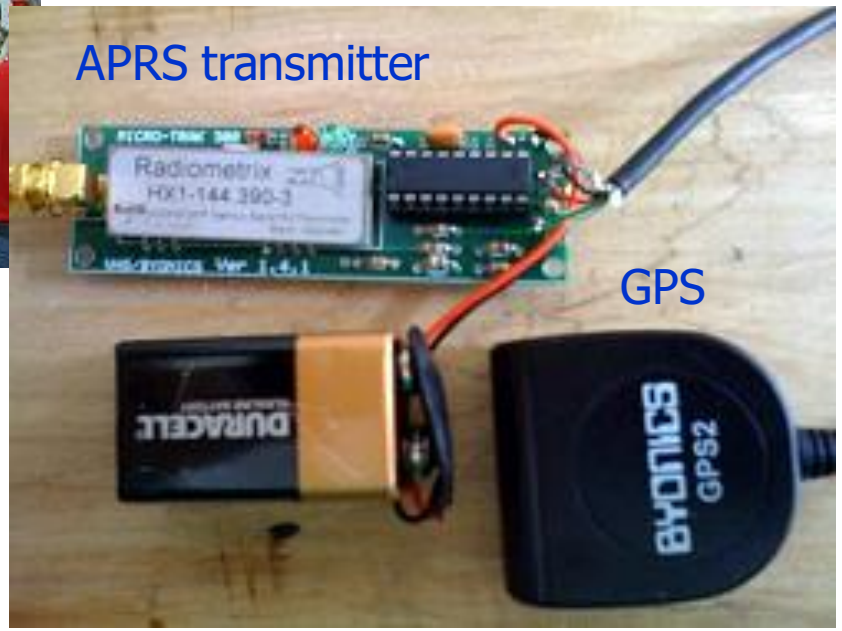
Live Example: www.aprs.org/wb4apr-15.html



Example Remote Sensors using APRS Protocol



Very Simple



Based on the USNA Automatic Packet Reporting System

Universal Ham Radio Text Messaging Initiative

TH-D7

TM-D700

DJ-135

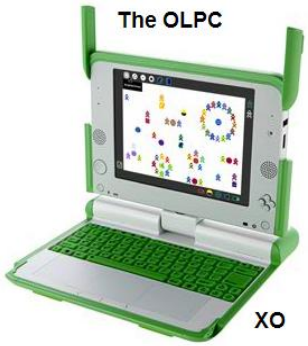
HAMHUD

TM-D710

VX-8R

cell

wireless



XO

APRS

DTMF

Send/RX anytime, anywhere, any device by callsign

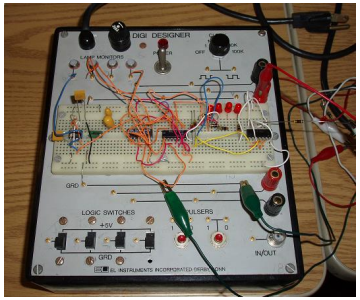
26 separate systems!

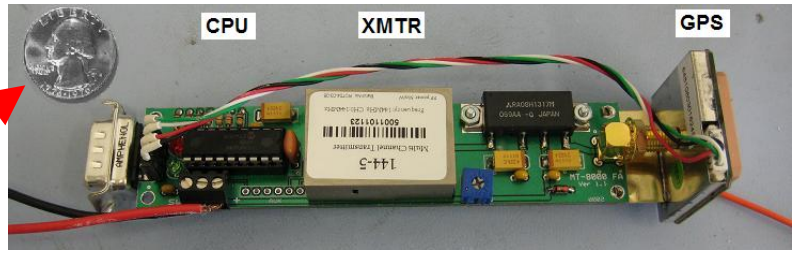
Sensor Buoy Baseline (prototype)

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 15:1 reduction 2008





See Buoy Location and Telemetry at
http://www.ew.unsa.edu/~bruninga/buoy4.html

Piggrem

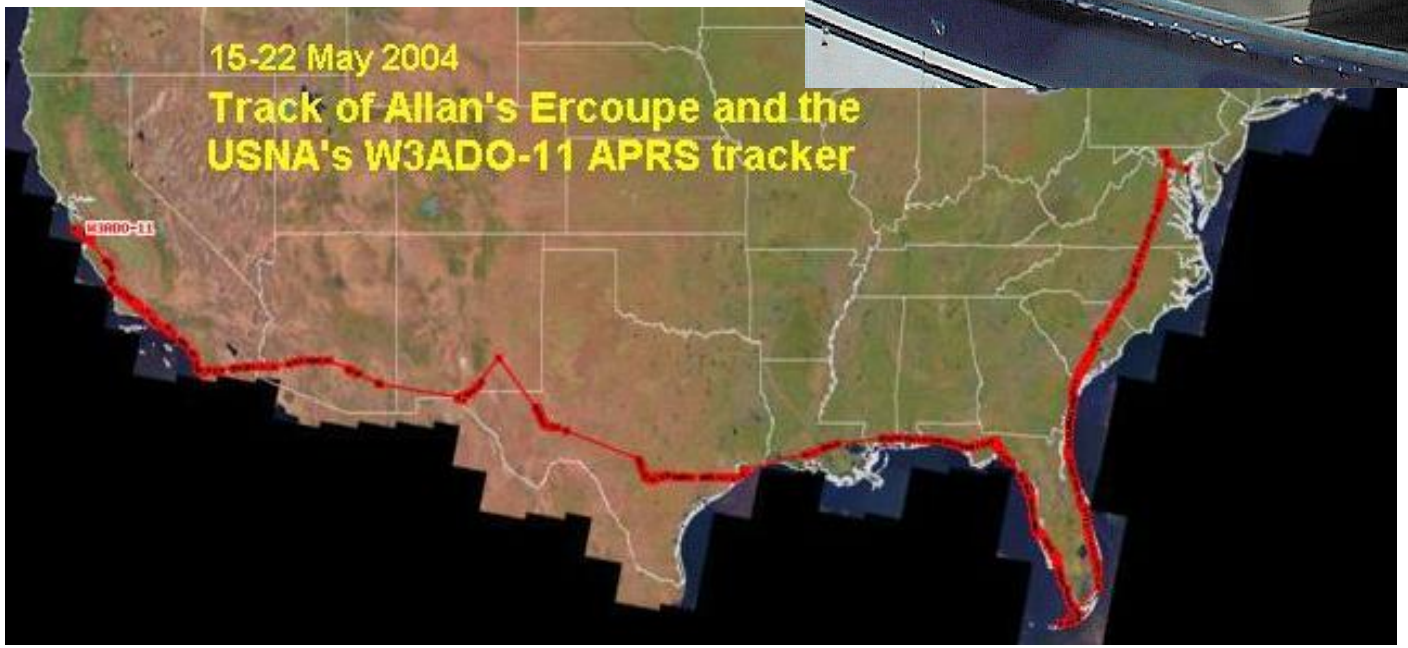
DOD Synergy with Educational Experimenters

Based on the USNA Automatic Packet Reporting System

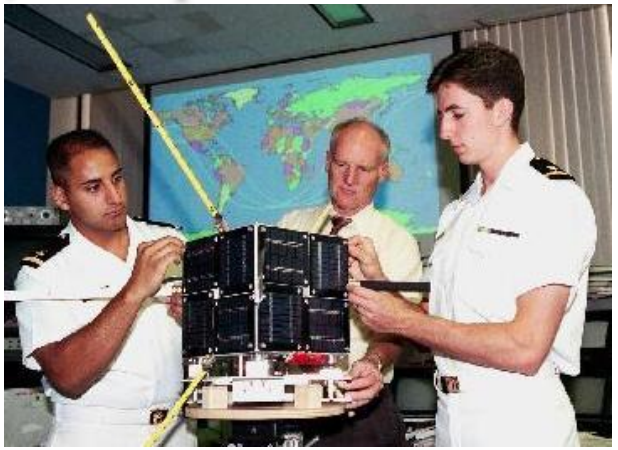
“Purple Force” Tracking

Map.findu.com/w3ado*

Tactical situational awareness

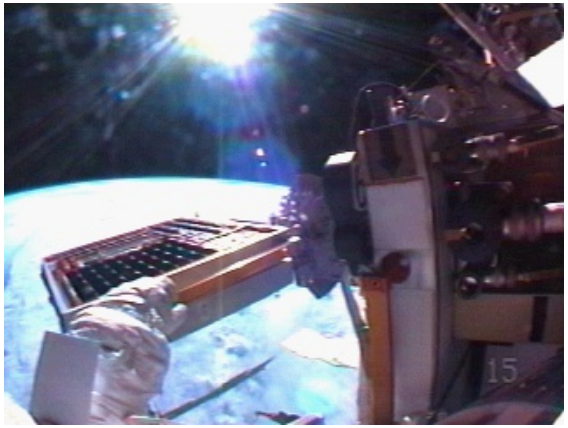


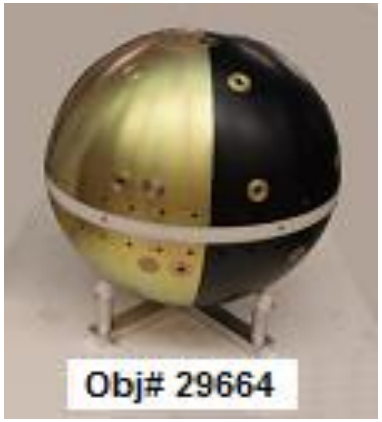
APRS (Psat Transponders) in Space

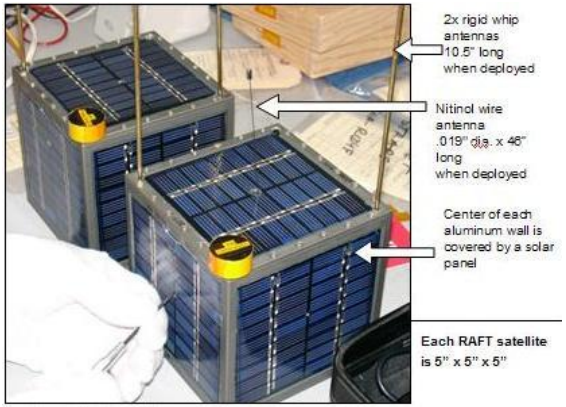


- 2001 PCSAT-1 Prototype Comm (semi-operational)
- 2006 PCSAT2 on ISS (returned after 1 year)
- 2007 ANDE de-orbited in 1 year
- 2008 RAFT de-orbited in 5 months
- 2007 Present ISS semi-operational due crew settings

Experimenters need a continuous Transponder in Space



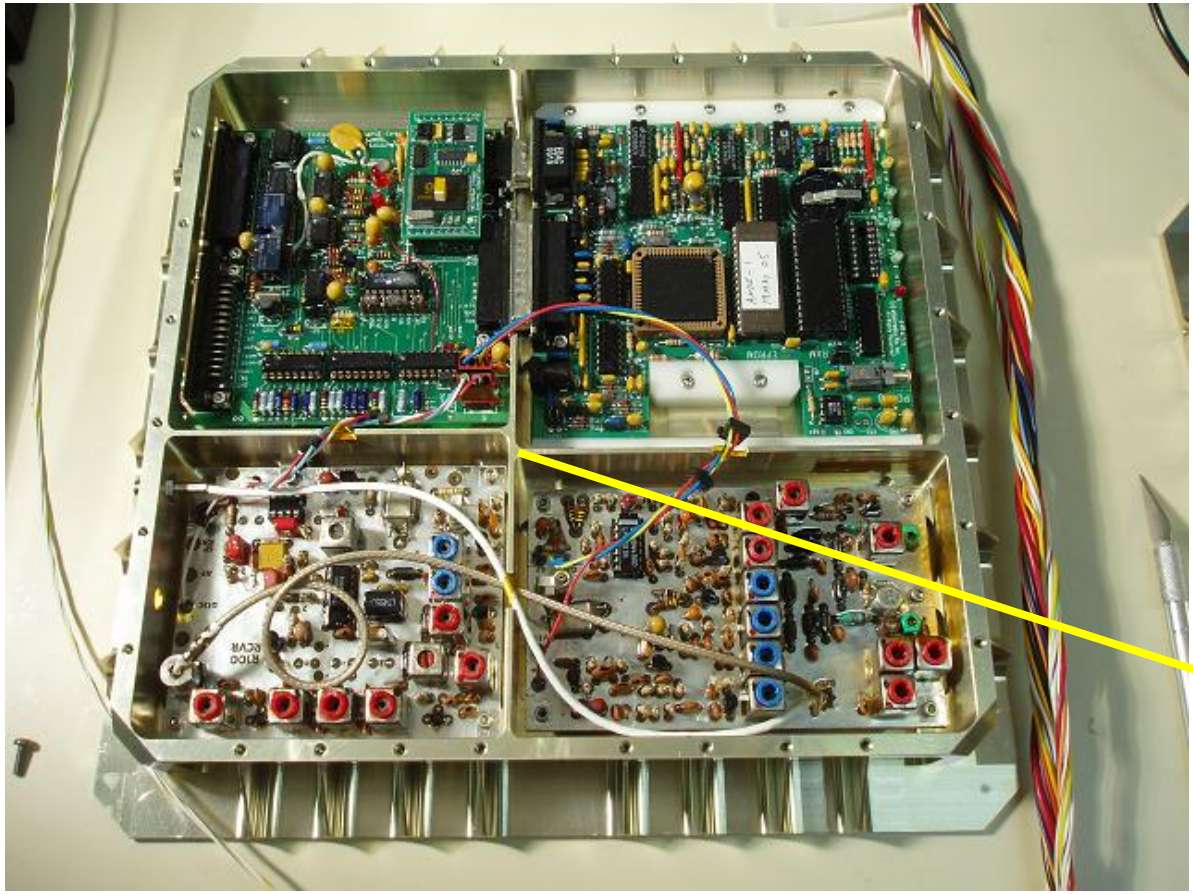




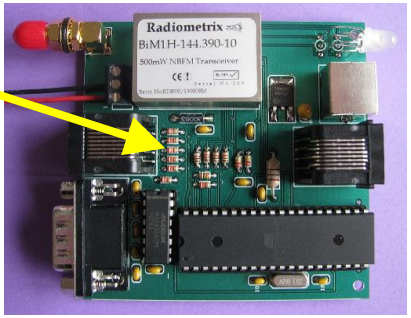
APRS space frequency is published as 145.825

See live downlink on http://pcsat.aprs.org and www.ariss.net

Huge reduction from Previous APRS transponders on PCSAT's 1,2, ANDE and RAFT missions



Now reduced 18:1 in volume/mass



AX.25

New slide (post presentation)

One-Page Summary for Psat

145.825 MHz

Mission: Remote Data Relay, Data Exfiltration, Remote Sensor Relay

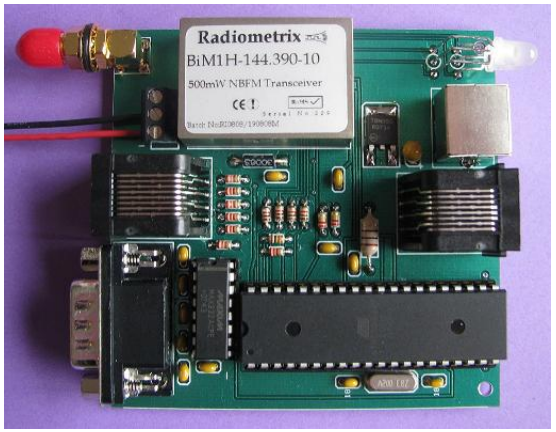
Benefit: Support Space Education on the ground through space applications and student experimental access

Hardware: VHF simplex data Xsponder 145.825 MHz

Size/Mass: < 10 cu.in (1 PCB 3.4" square), <0.1kg

Power: < 1W orbit average, 5 volts.

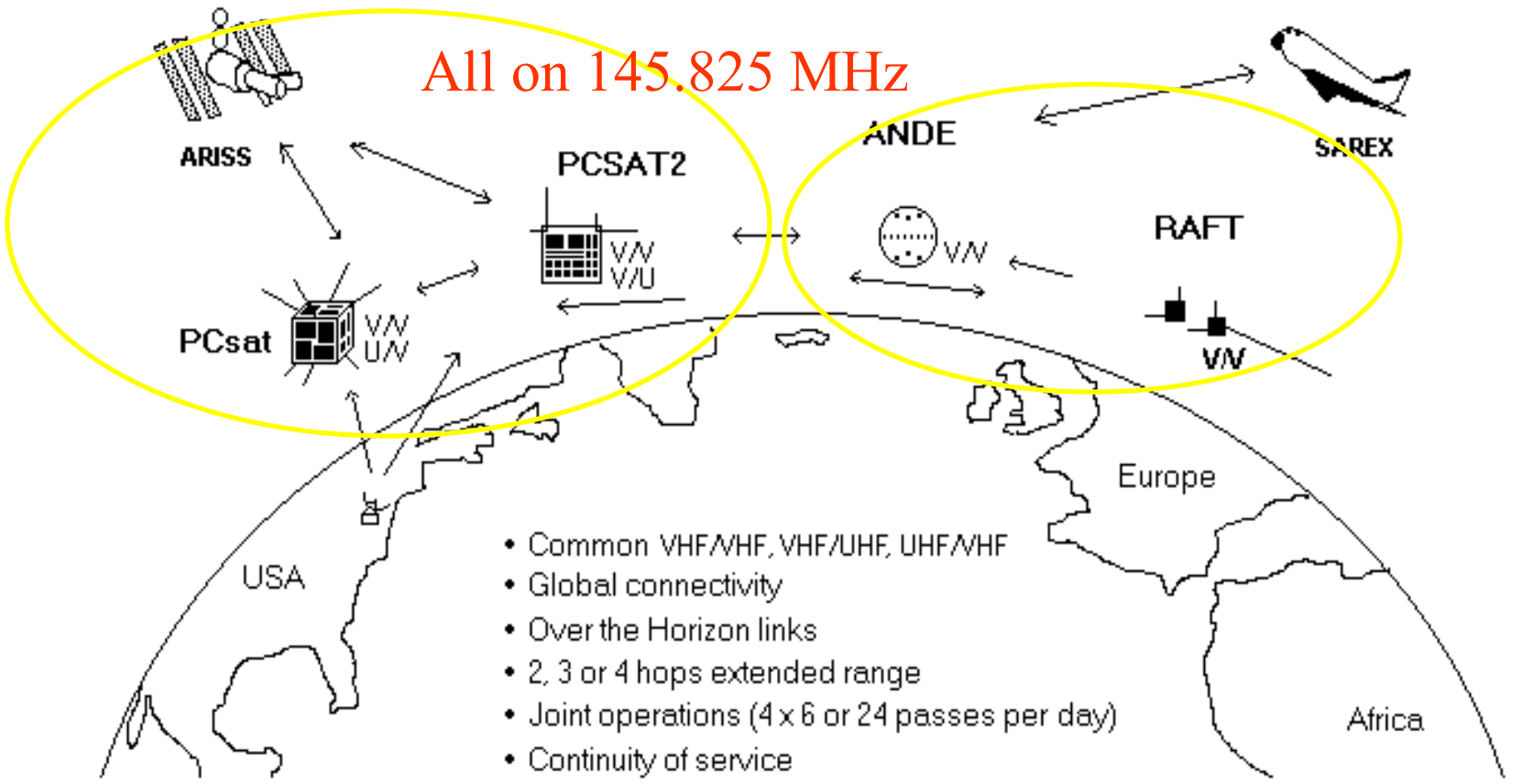
Integration Requirement: Simply, on/off (or *)



Structure Impact: Needs 19" thin wire whip antenna (1 cu.in)

Benefit to Spacecraft: High visibilty to worldwide educational institutions, fosters collaboration, orders of magnitude greater student experimental access to space systems (ground segment). * Independent back-up telemetry command/ control channel, RS232 serial data, 16 on/off discretes, backdoor reset capability. Worldwide Telemetry Beacon access via global station network.

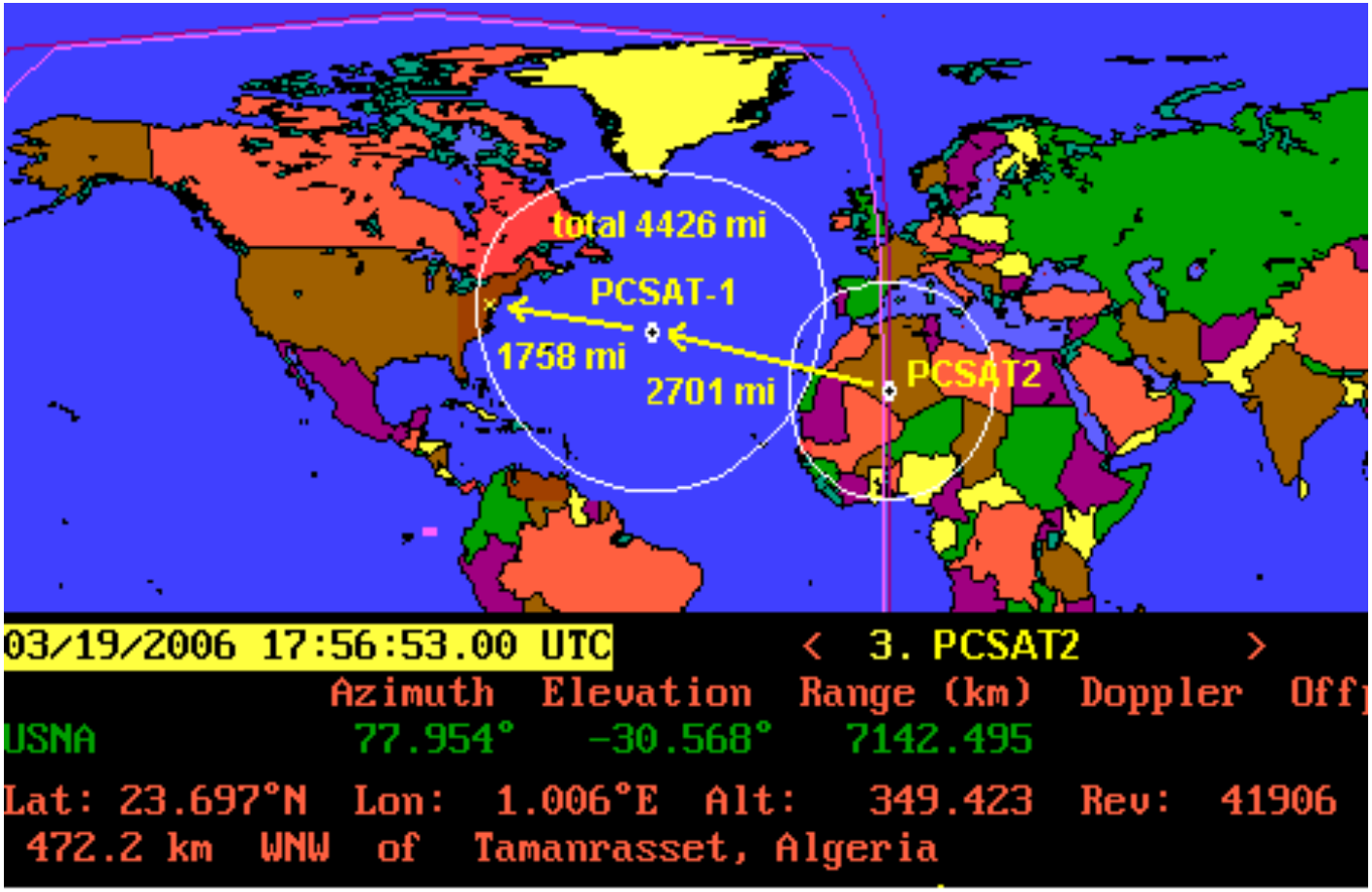
Constellation Operation of USNA Satellites



WB4APR

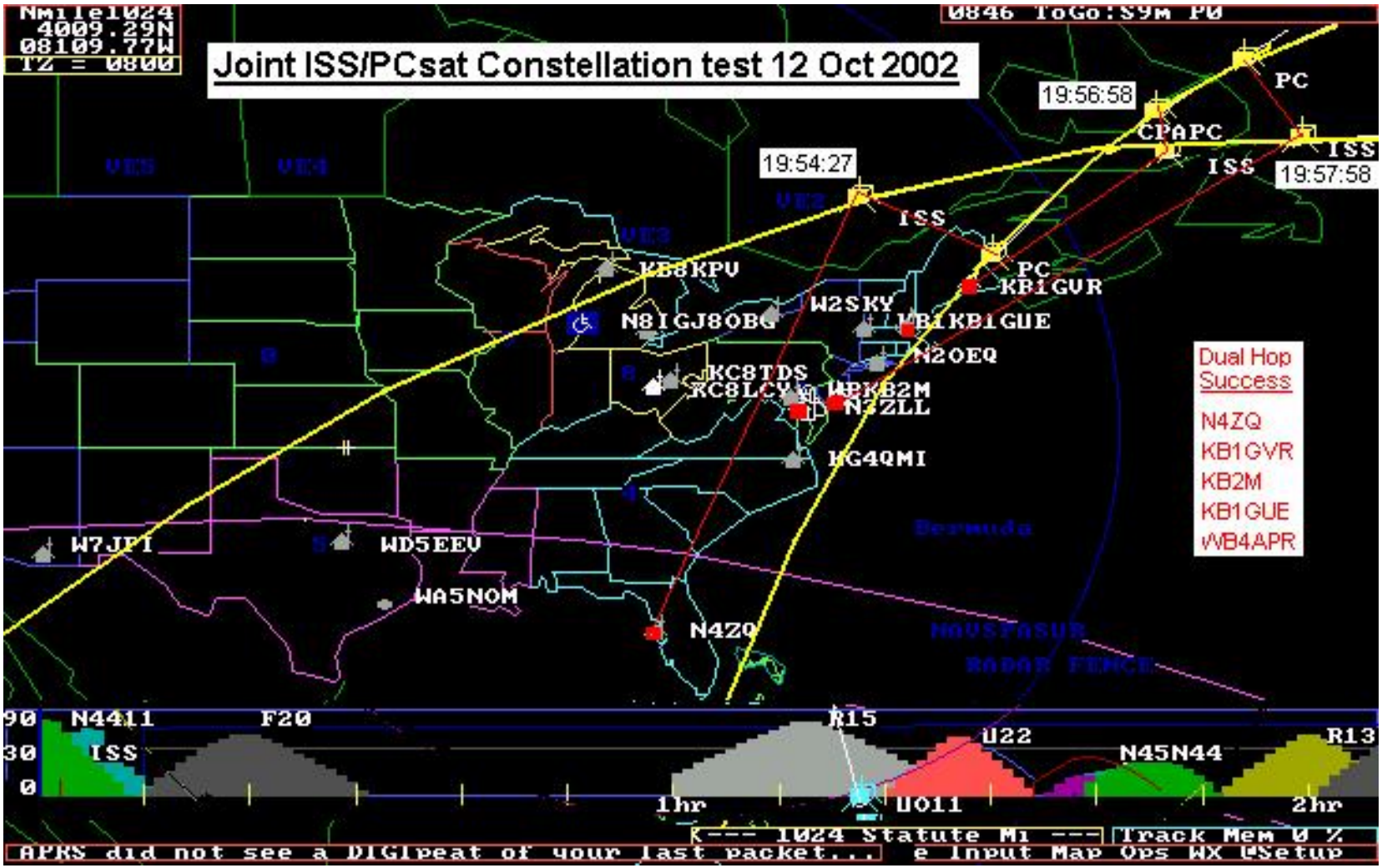
See live downlink on http://pcsat.aprs.org and www.ariss.net

Dual Hop Operations with PCSAT-1 and PCSAT2:



During the March 2006 joint PC1<=>PC2 operations period, numerous dual hop elemetry and user packets were observed. This telemetry packet from PCSAT2 is just about as far as we can get with satellite-to-satellite-to USNA. Notice how few European or USA users were in the footprint making it more probable that PCSAT-1 could hear PCSAT2's signal. WB4APR

Dual Satellite 2-hop links

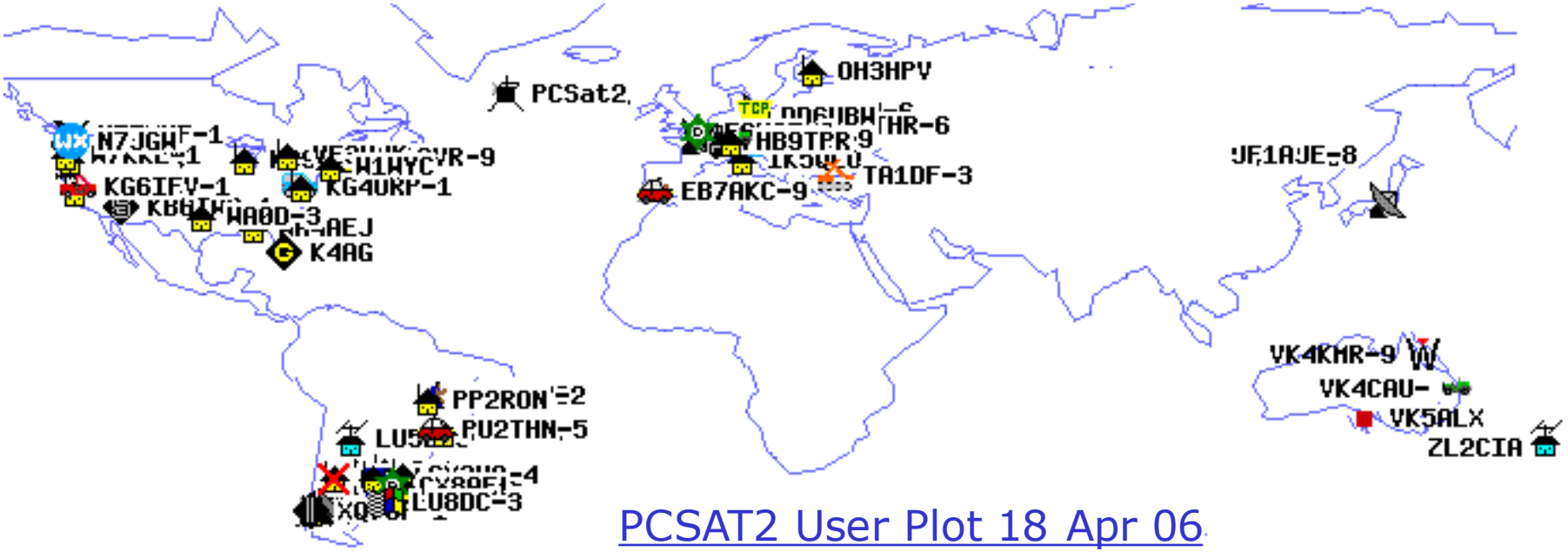


Global Volunteer Groundstations

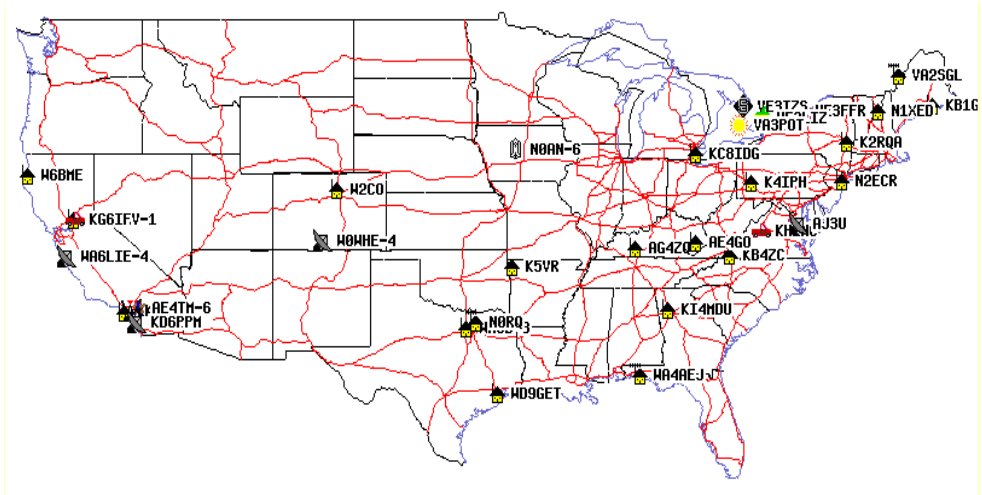
feed live downlink into Internet

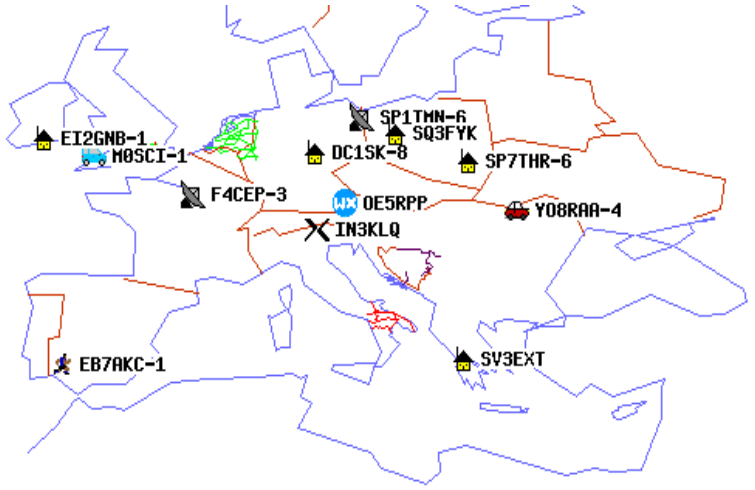
Sensor Buoy Baseline

PCSAT validates our links

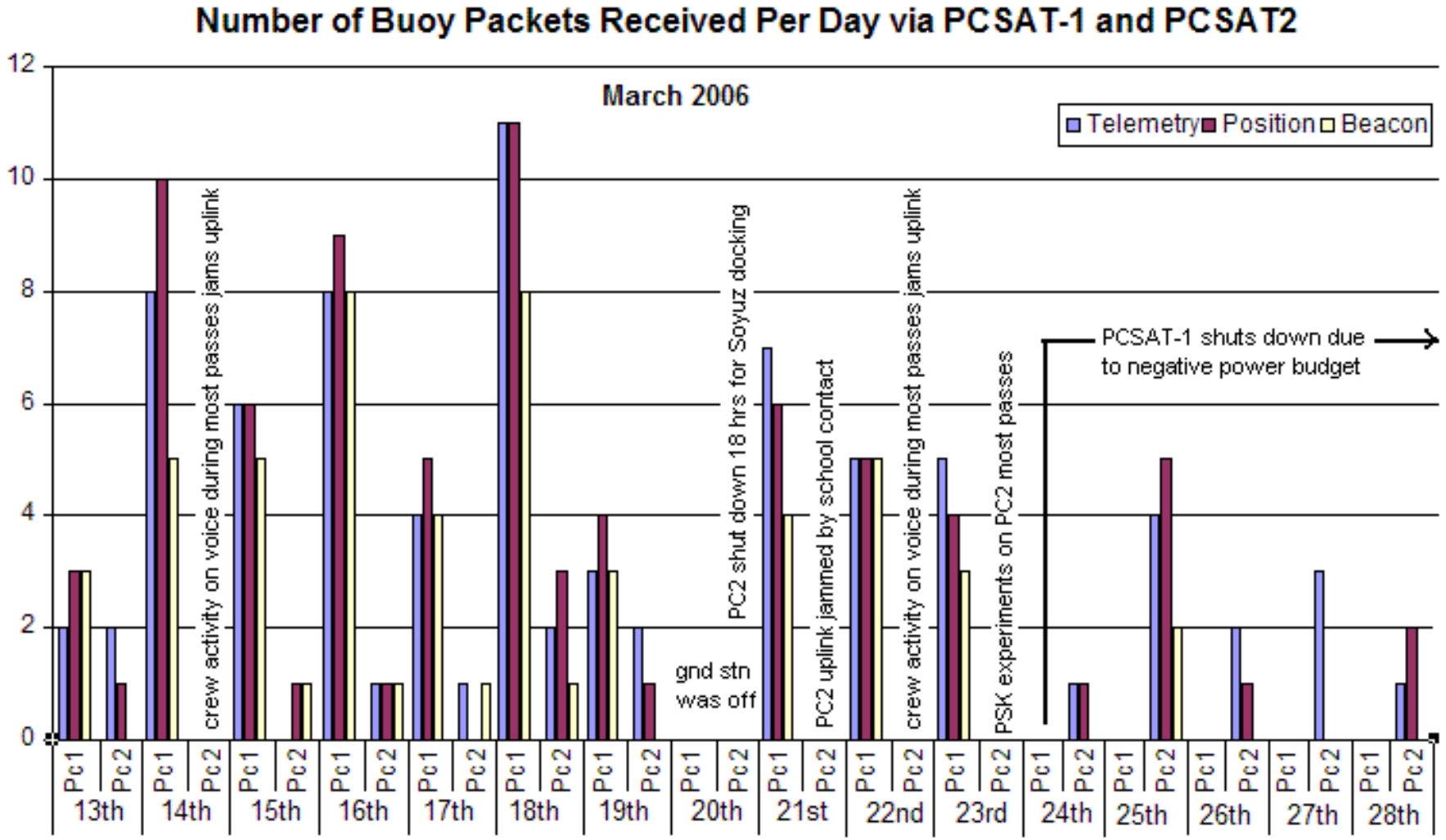


PCSAT2 User Plot 18 Apr 06

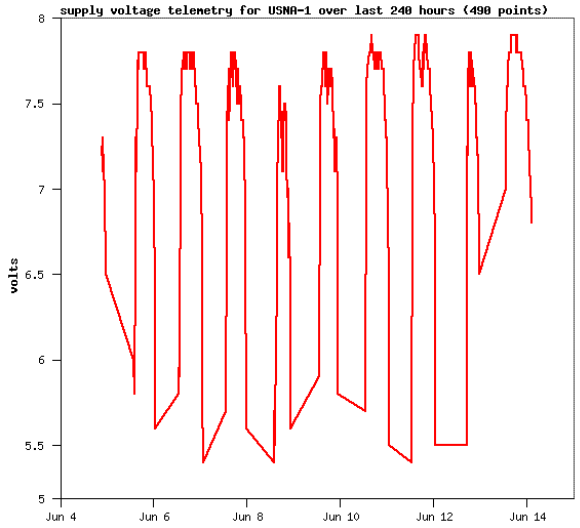


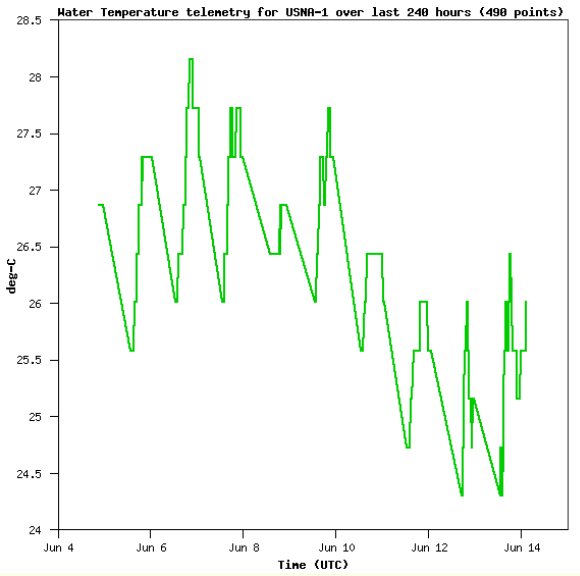


Sensor Buoy Baseline Test



Prototype Buoy Data



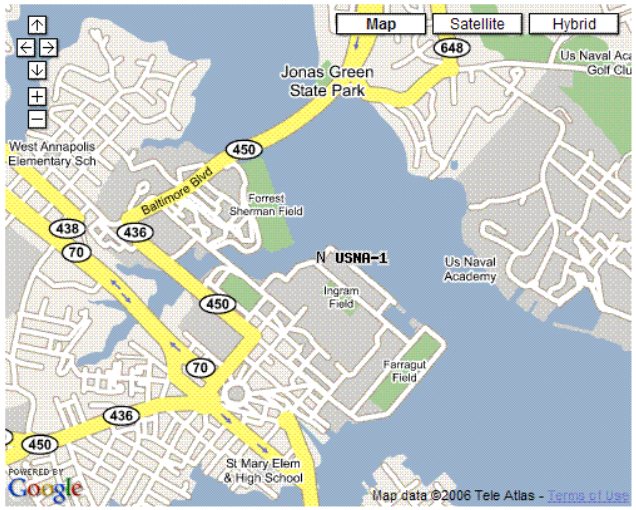


Google for

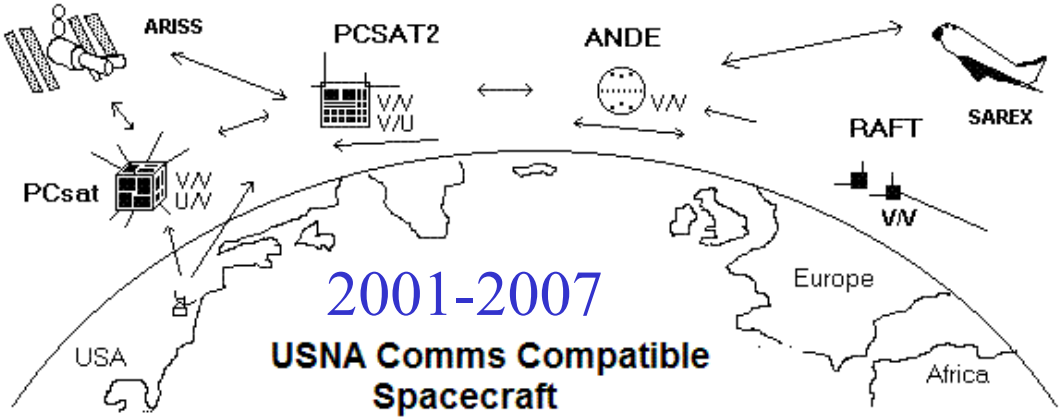
"USNA Buoy"

Select USNA-1

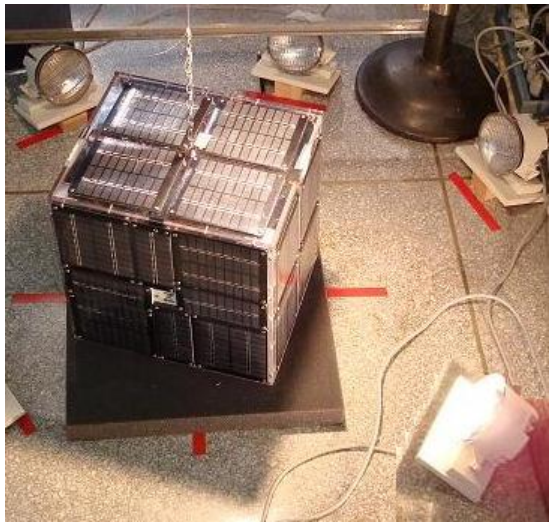
(or Buoy4)



Questions?

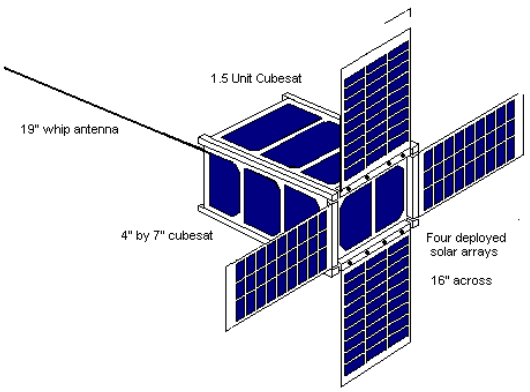


2006



2007

2009



2010 Navy SERB