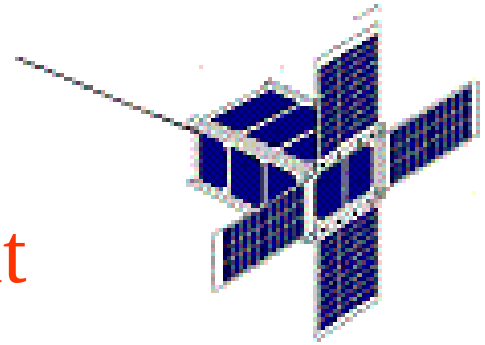
Amateur Satellite and APRS Data Links

Polar Technology Conference
April 2012

ODTML

Psat



Bob Bruninga
Midns: Kren, Aspholm

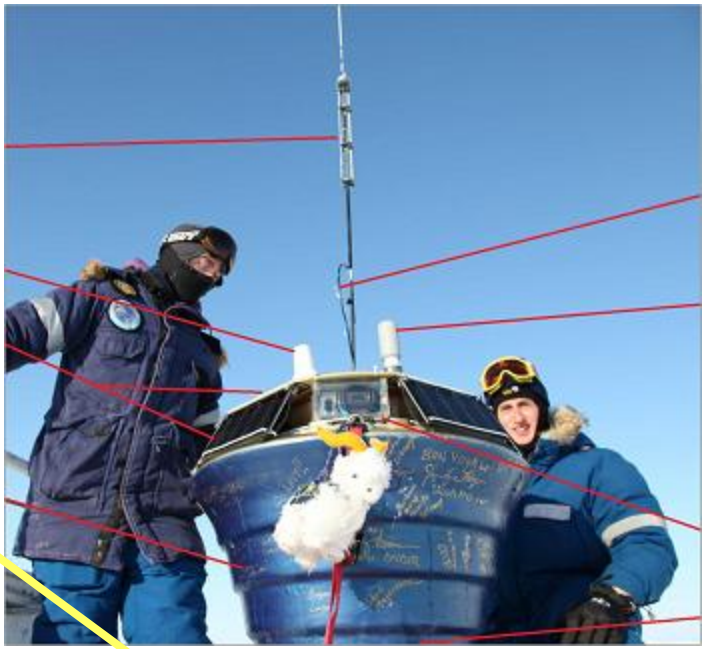
US Naval Academy Satellite Lab
410-293-6417
bruninga@usna.edu

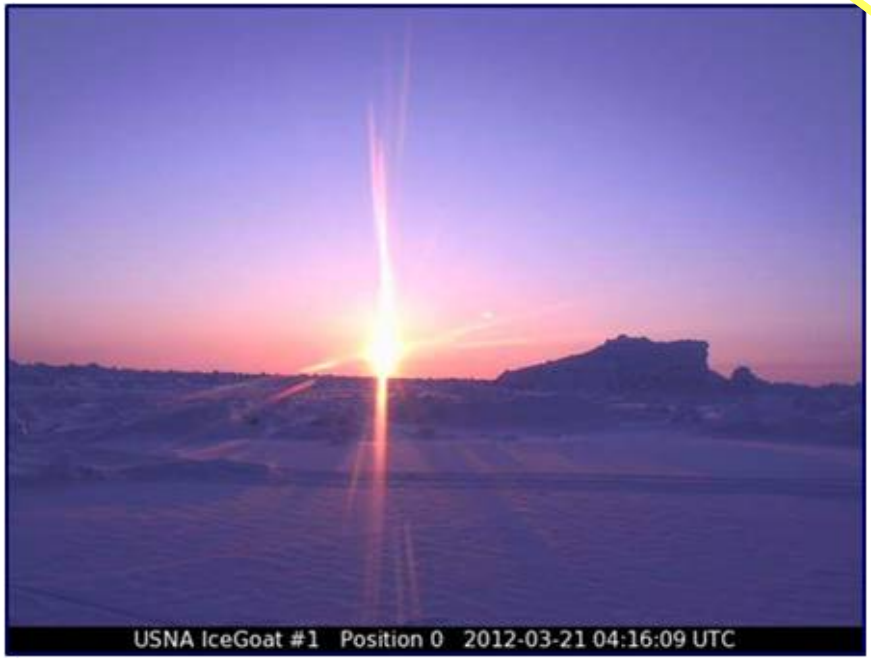
UNCLASS

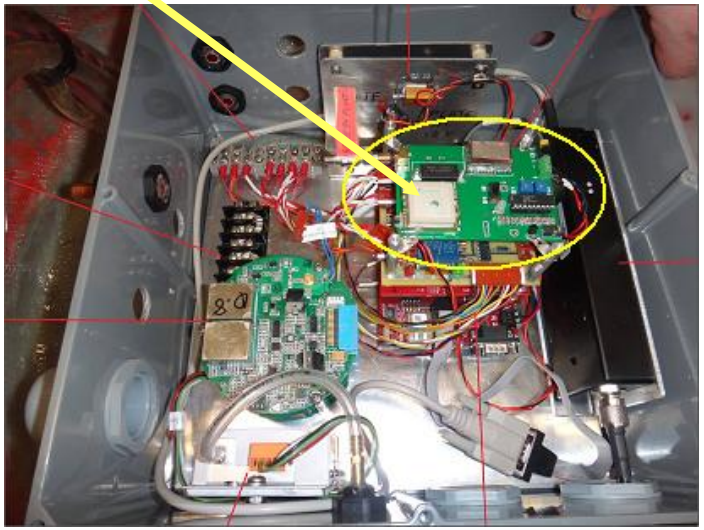
USNA Das Goat

- USNA Buoy deployed March 2012

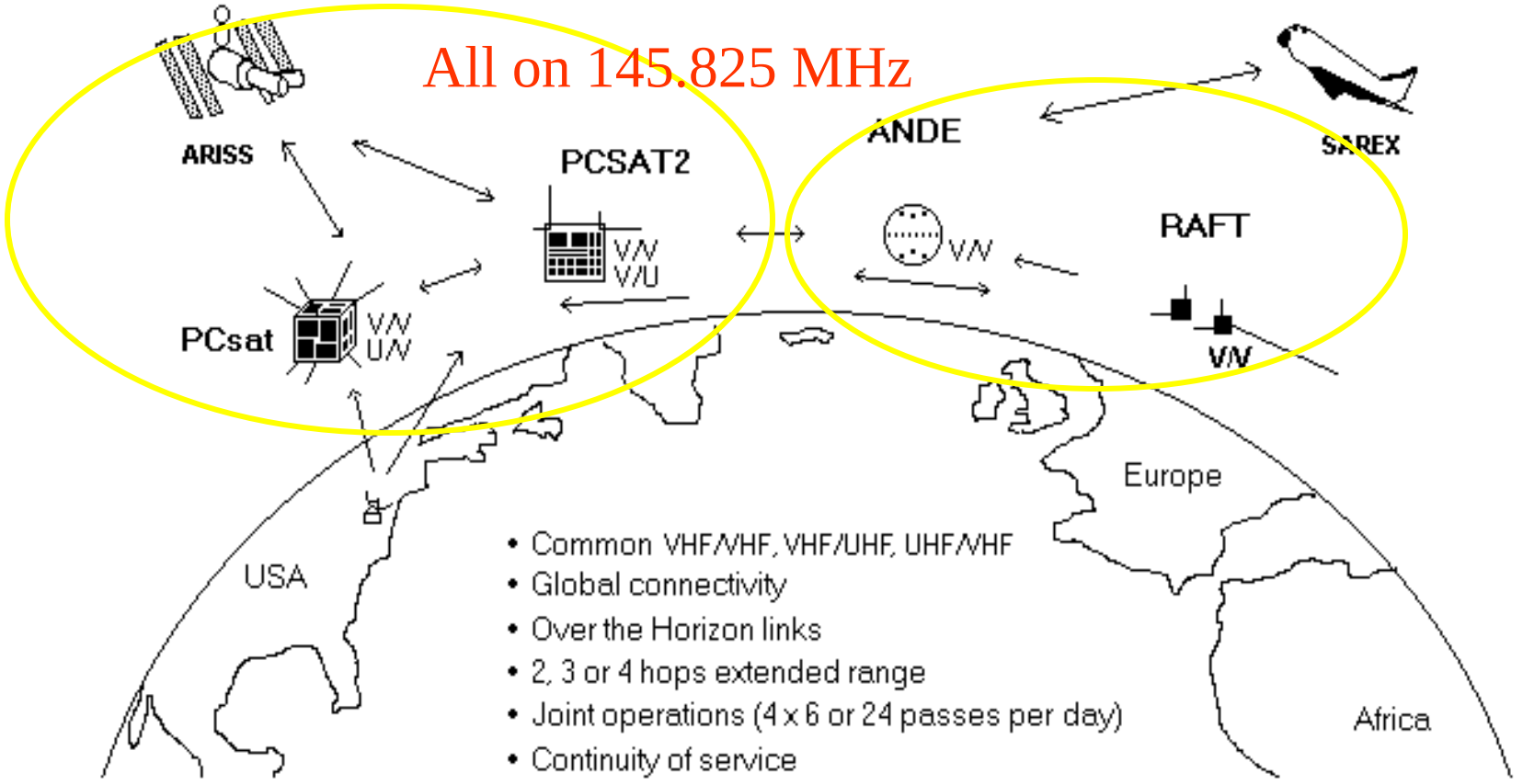
My tiny piece







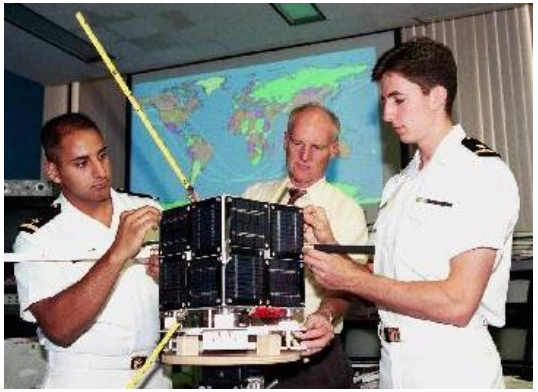
Constellation Operation of USNA Satellites



WB4APR

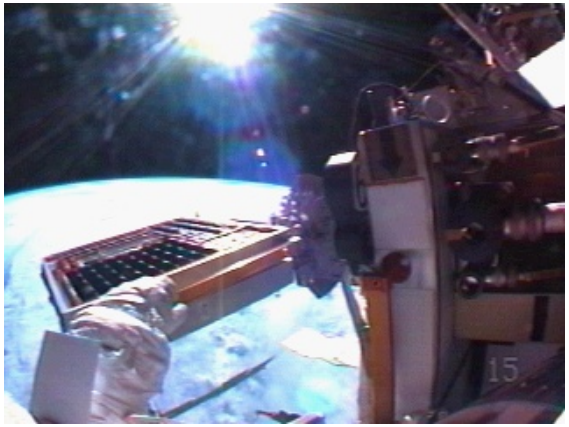
See live downlink on http://pcsat.aprs.org and www.ariss.net

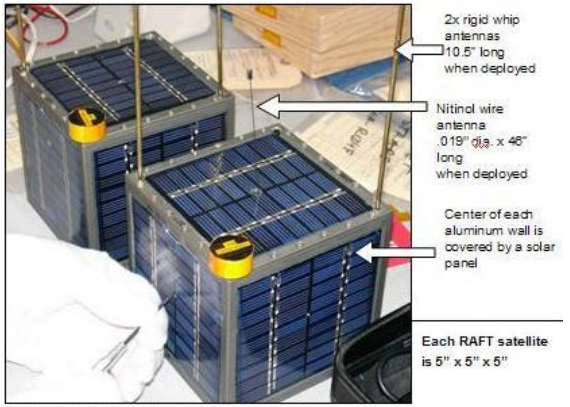
APRS in Space
Automatic Packet Reporting System



- 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



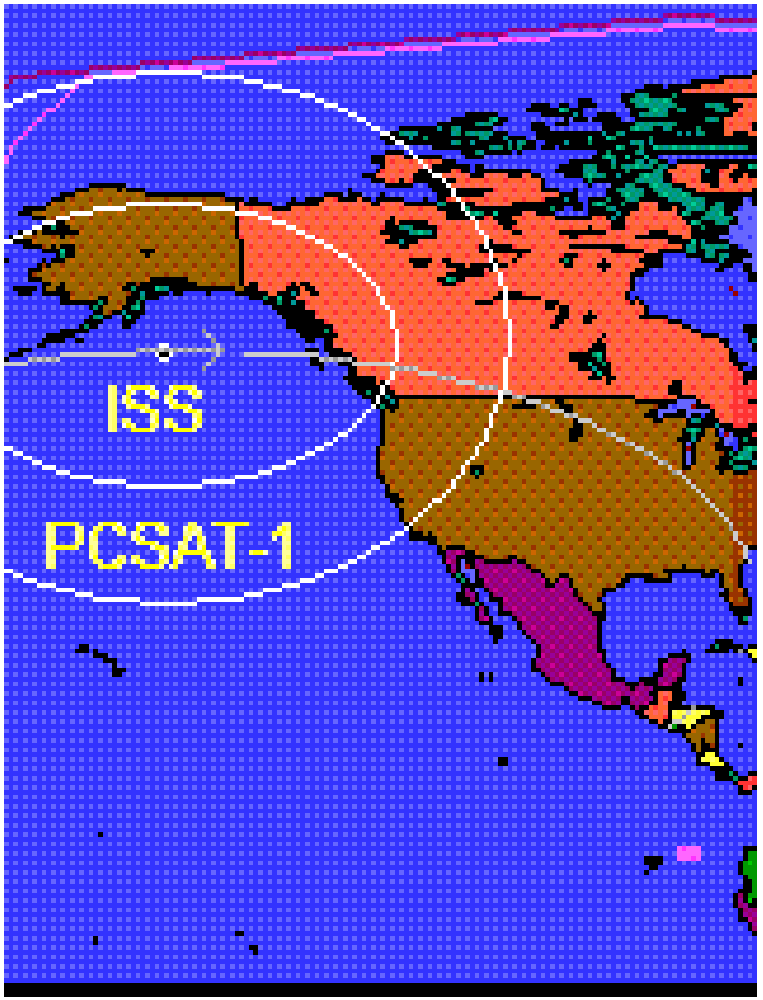


APRS space frequency is published as 145.825

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

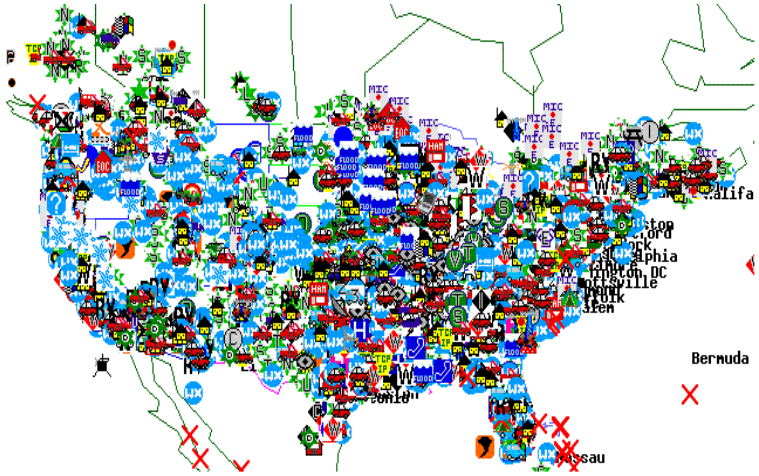
Our Amateur Satellite Problem

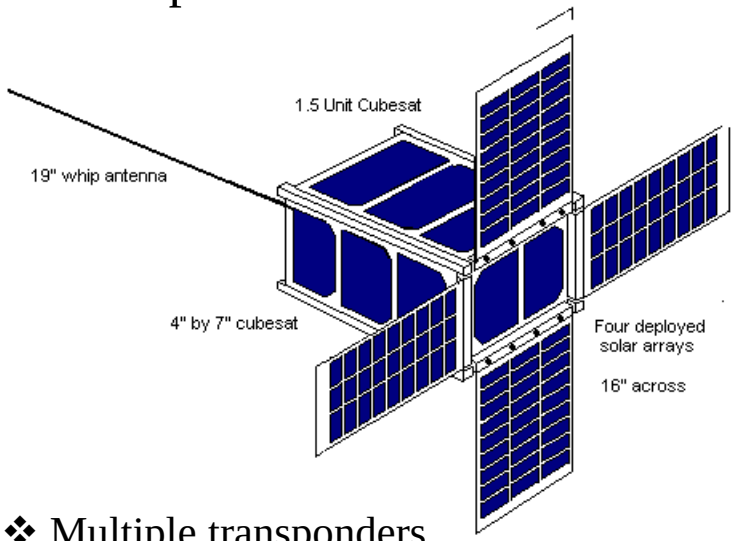
- ISS – Always there, but does not cover the poles
- PCSAT-1 since 2001, but only works when it wants…
- But there are other voice satellites (hardly used over the poles!)
- But they are old…



APRS Data Exfiltration Background

- APRS transponders can draw from 40,000+ experimenters for large scale loading experiments and other Ham Radio experiments.

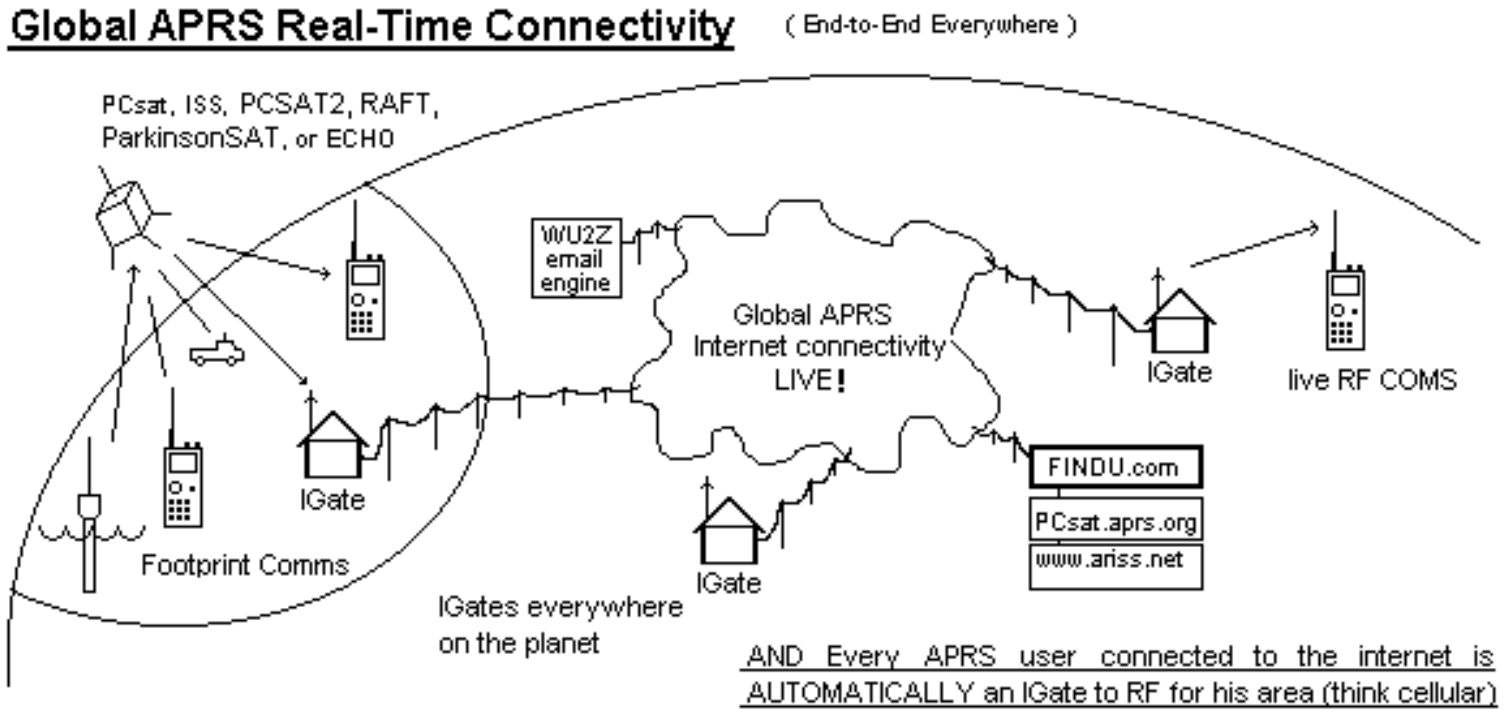




- ❖ Multiple transponders on smaller picosats can form a constellation for greater coverage and reduced latency.

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

APRS Global Internet linked Comms Network



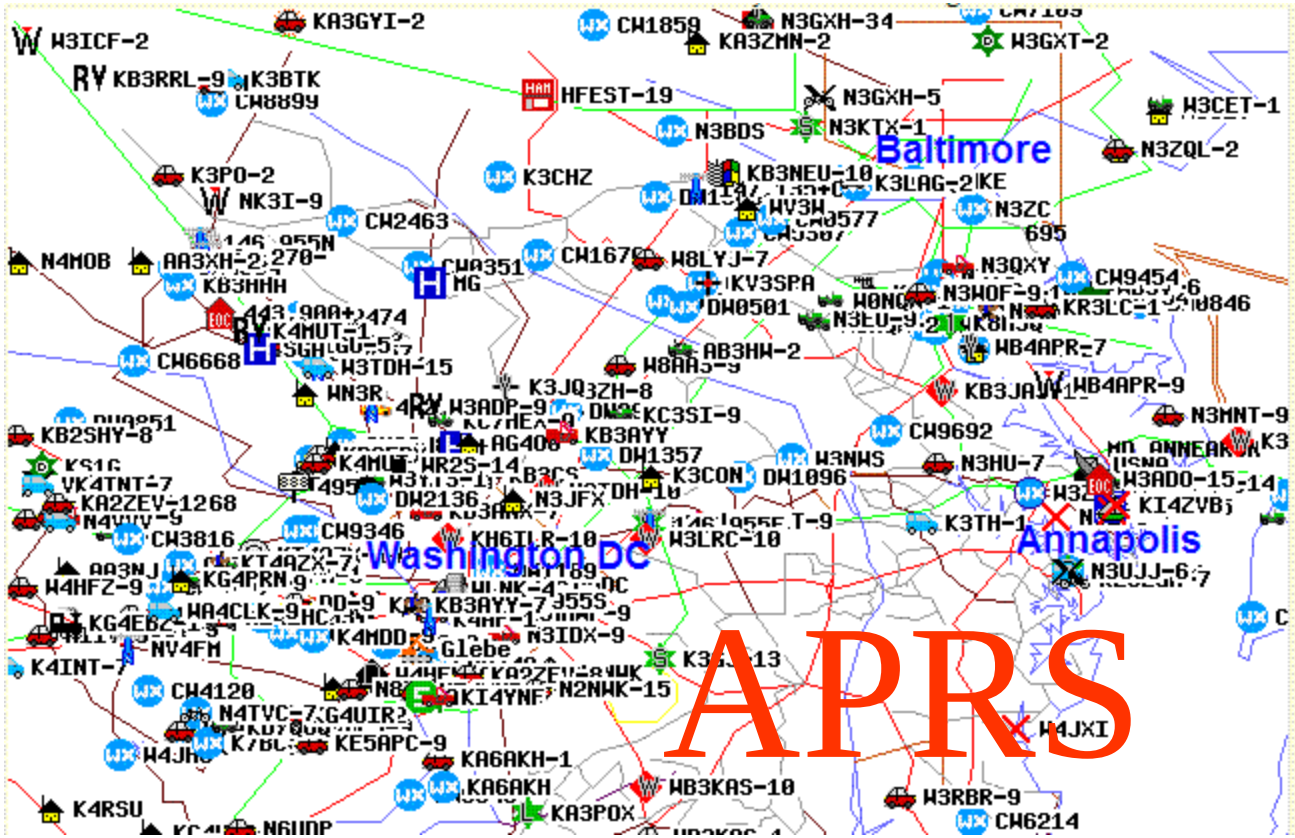
APRS Global Packet Radio Network

Internet Linked for live Communications

Automatic Packet Reporting System

Mission Background

APRS is everywhere * (Remote Data Relay)



FOCUS:

"Network Centric" & Remote Sensor Experiments

300 stations
In 35 miles

Find any station, Any map, Anywhere- http://aprs.fi

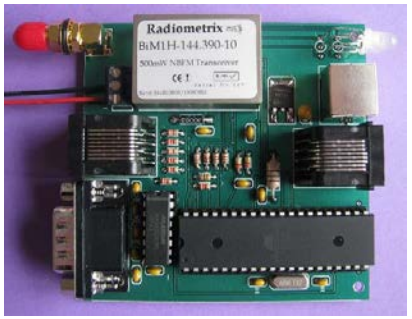
Ground Terminal Applications Focus

Supports Student Experimenters world wide

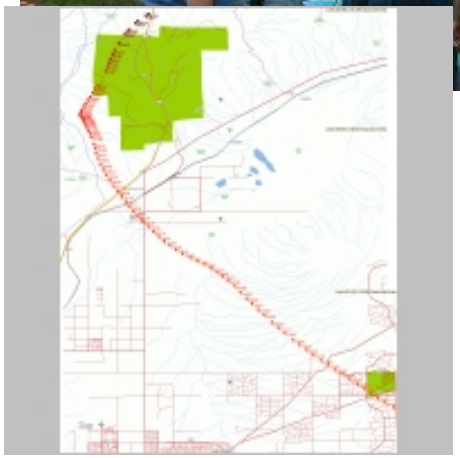
OR

OR

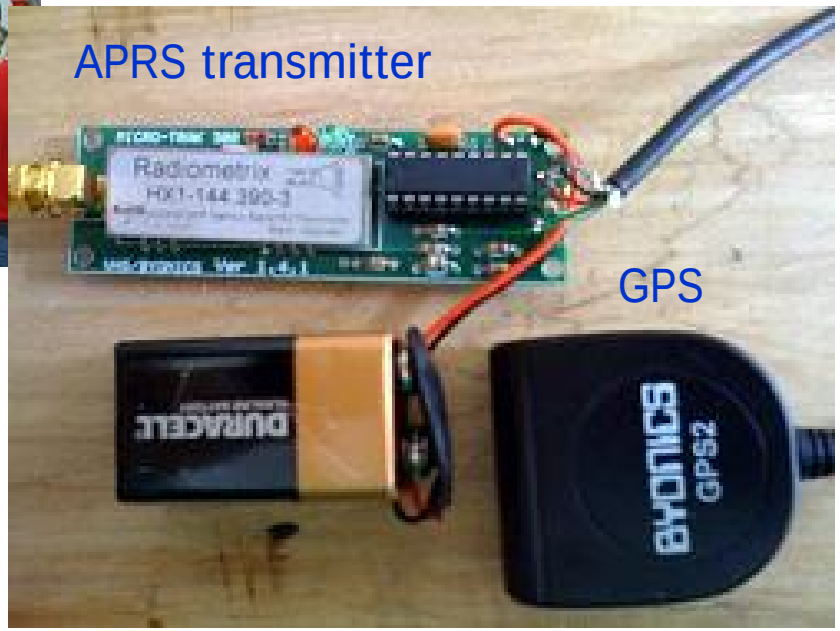
OR



Example Remote Sensors using APRS Protocol



Very Simple



Based on the USNA Automatic Packet Reporting System

Synergy with Educational Experimenters

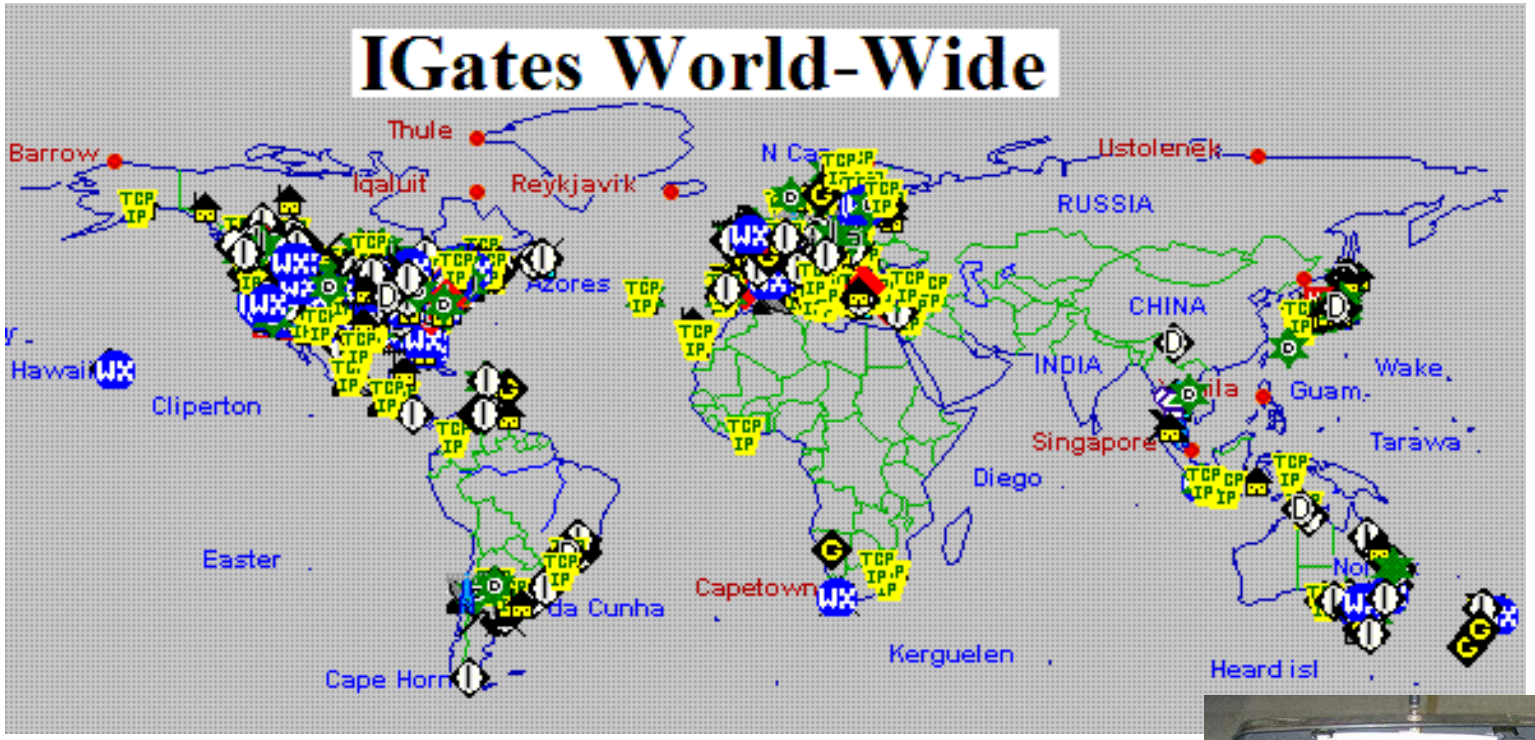
Based on the Automatic Packet Reporting System

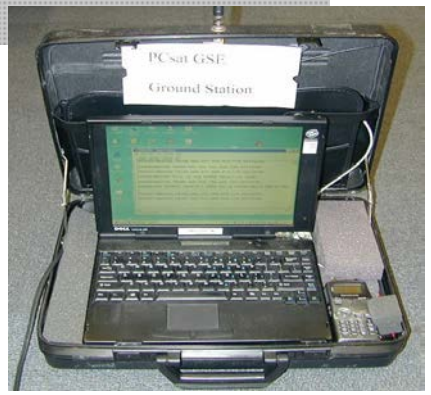
“Purple Force” Tracking

Map.findu.com/w3ado*

Tactical situational awareness

Psat APRS Network Architecture





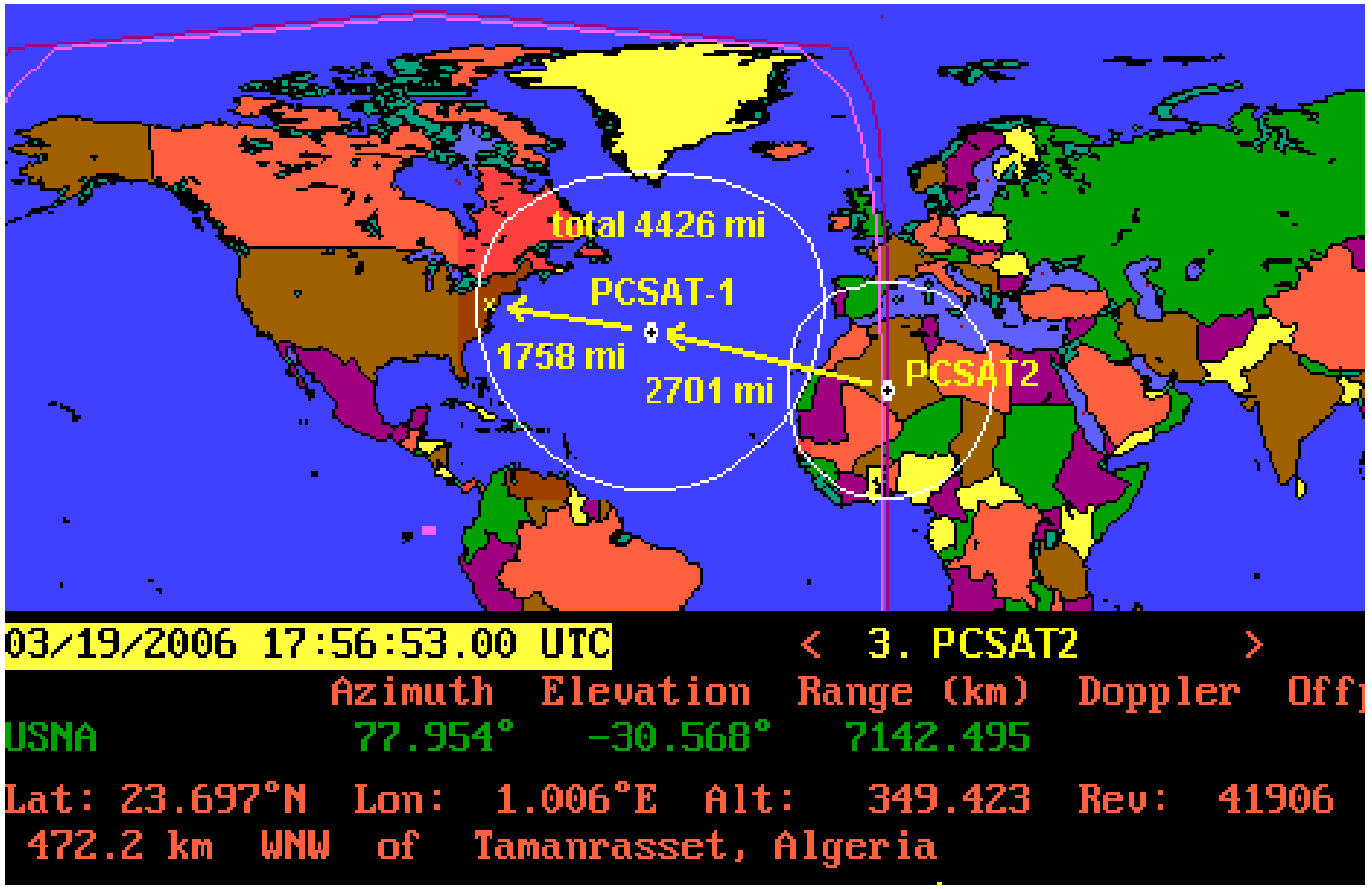
Global Volunteer Ground Station Network

Internet Linked for live Telemetry

Global Volunteer Groundstations

feed live downlink into Internet

Dual Hop Operations with PCSAT-1 and PCSAT2:



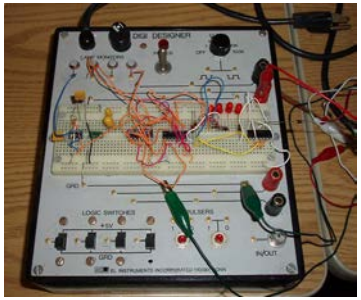
During the March 2006 joint PC1<=>PC2 operations period, numerous dual hop elemetry and user packets were observed. This telemetry packet from PCSAT2 is just about as far as we can get with satellite-to-satellite-to USNA. Notice how few European or USA users were in the footprint making it more probable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

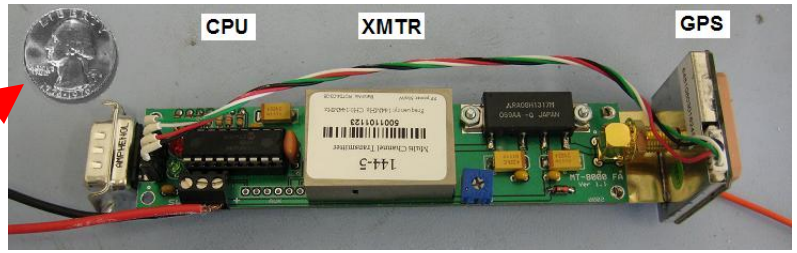
Sensor Buoy Baseline (prototype)

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

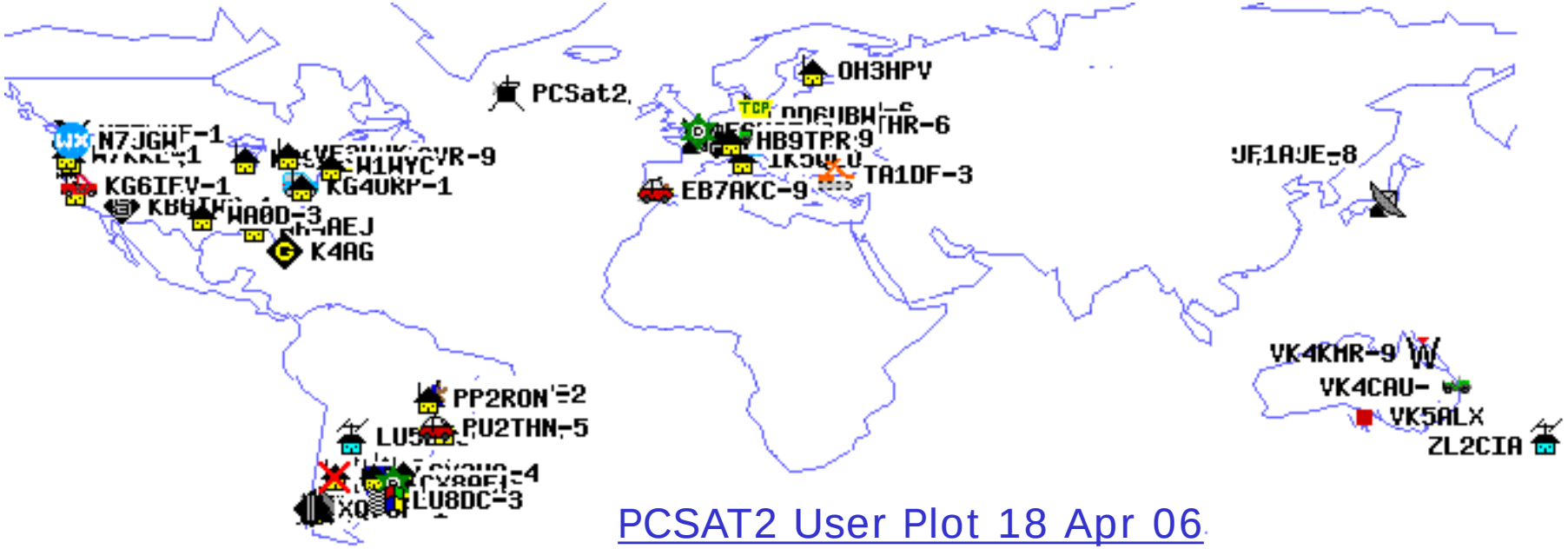




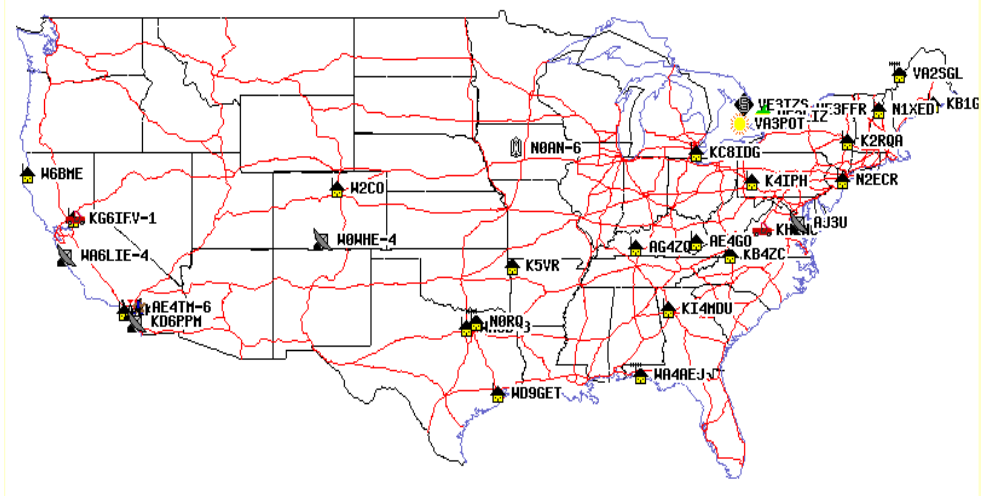
See Buoy Location and Telemetry at
http://www.ew.unsa.edu/~bruninga/buoy4.html

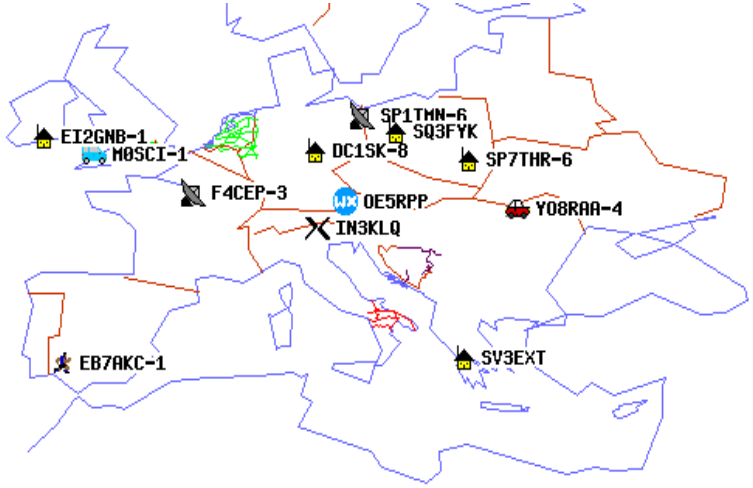
Sensor Buoy Baseline

PCSAT validates our links

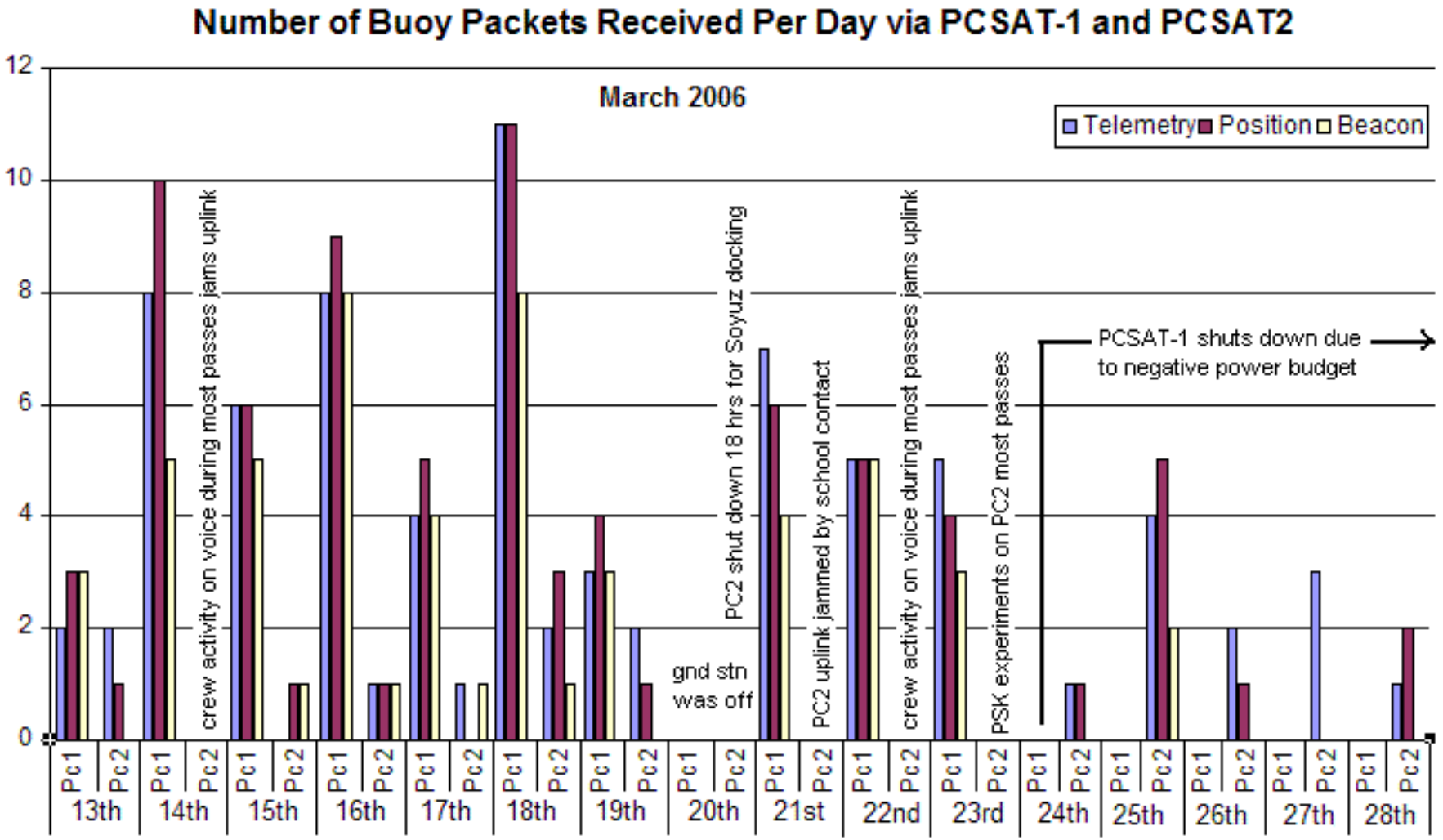


PCSAT2 User Plot 18 Apr 06

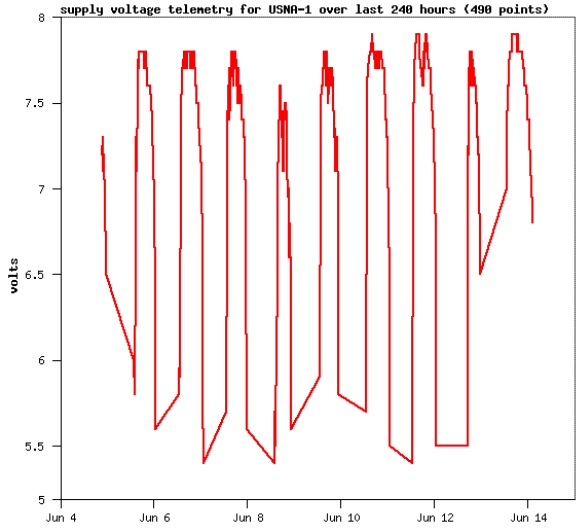


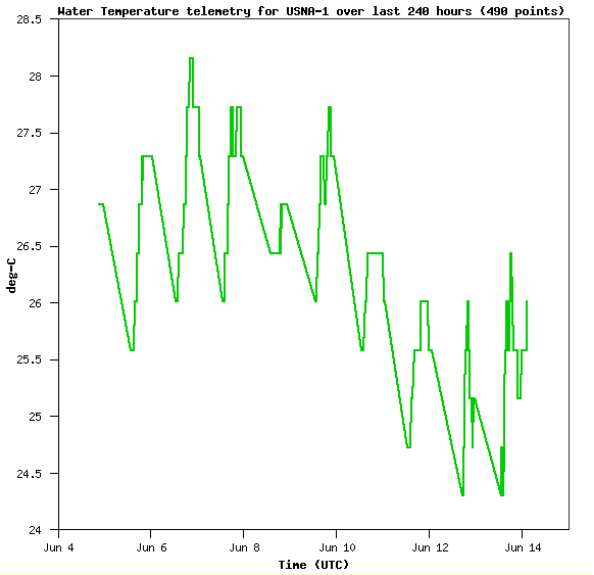


Sensor Buoy Baseline Test



Prototype Buoy Data



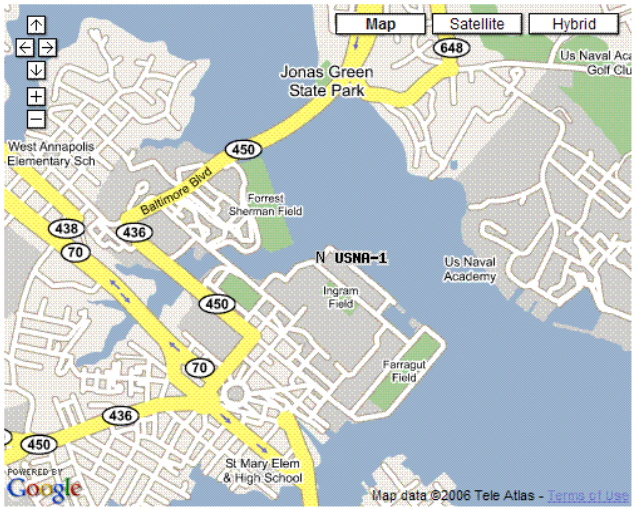


Google for

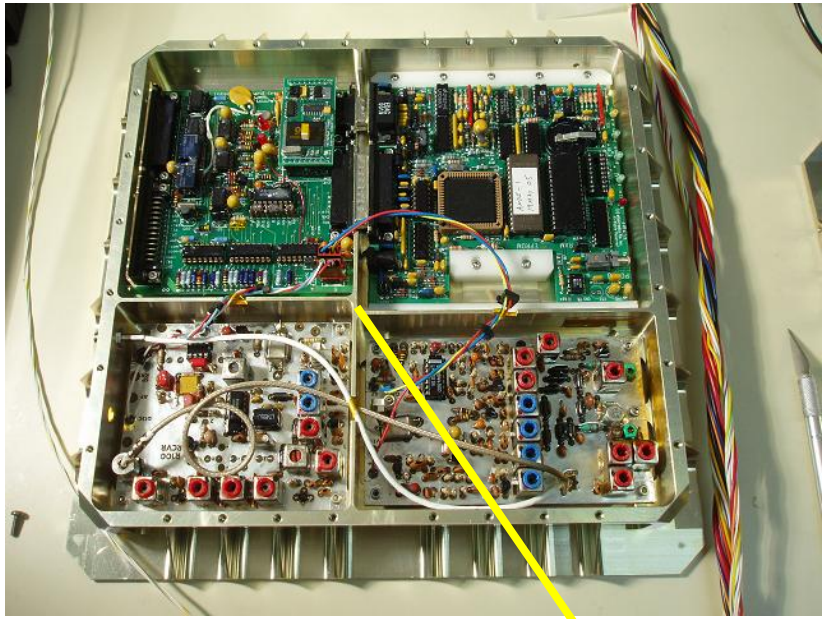
"USNA Buoy"

Select USNA-1

(or Buoy4)

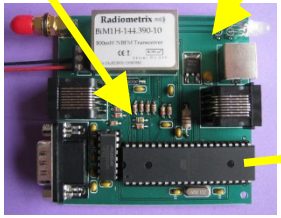


Huge reduction from transponders on PCSAT's 1,2, ANDE and RAFT missions

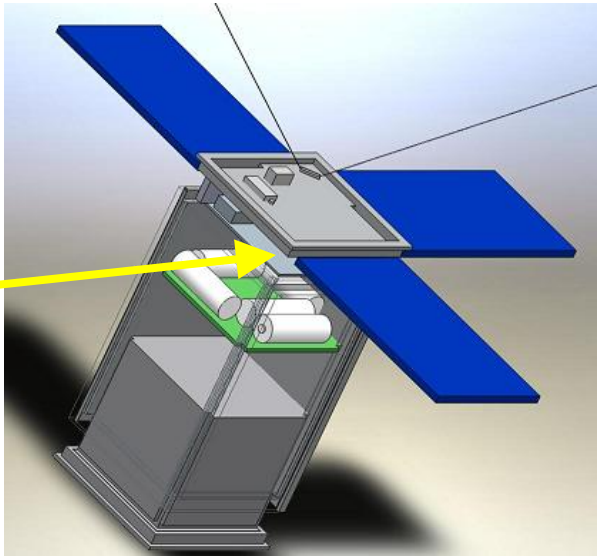


Earlier reductions to 5" cubesat on RAFT (2006)

4:1



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



AX.25

New slide (post presentation)

One-Page Summary for Psat

145.825 MHz

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

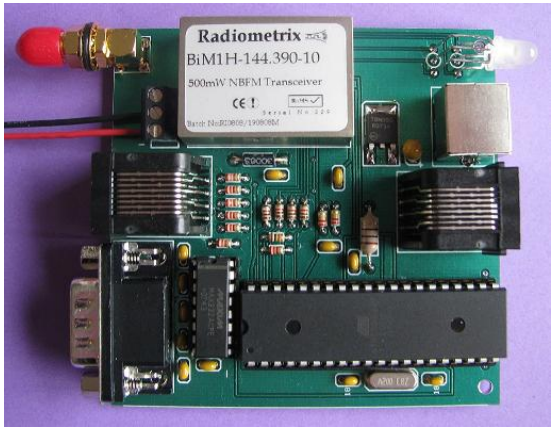
Benefit: Support Space Education on the ground through space applications and student experimental access

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.

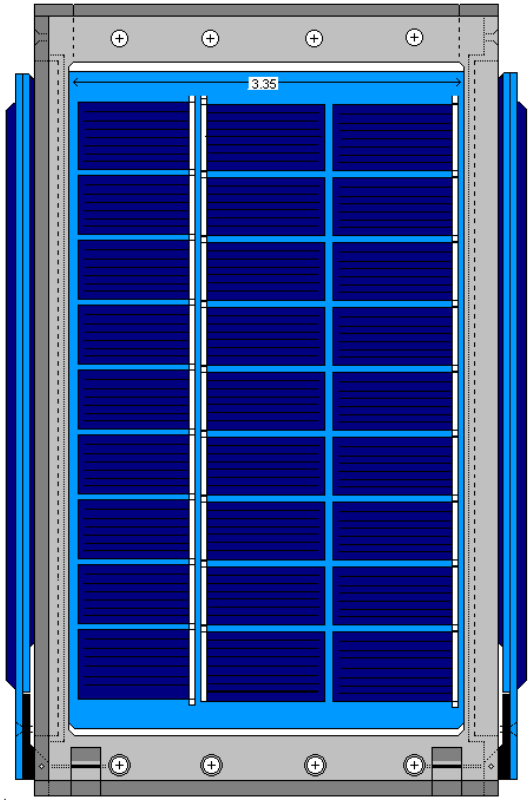
Integration Requirement: Simply, on/off (or *)



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

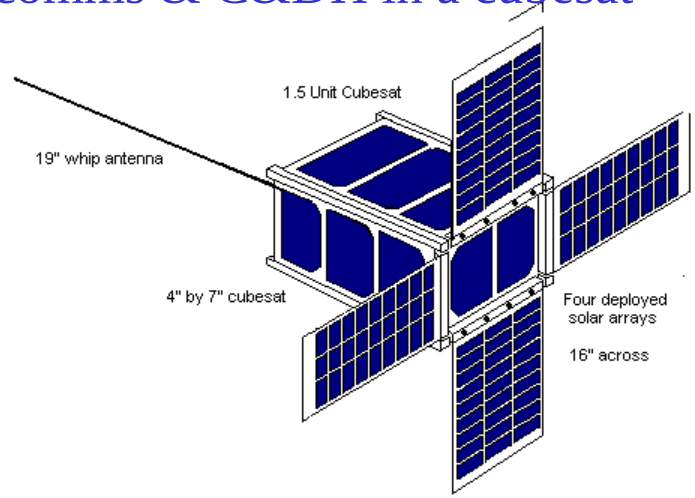
Benefit to Spacecraft: High visibilty to worldwide educational institutions, fosters collaboration, orders of magnitude greater student experimental access to space systems (ground segment). * Independent back-up telemetry command/ control channel, RS232 serial data, 16 on/off discretes, backdoor reset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

PSAT 1.5u CUBESAT



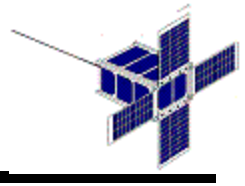
7”

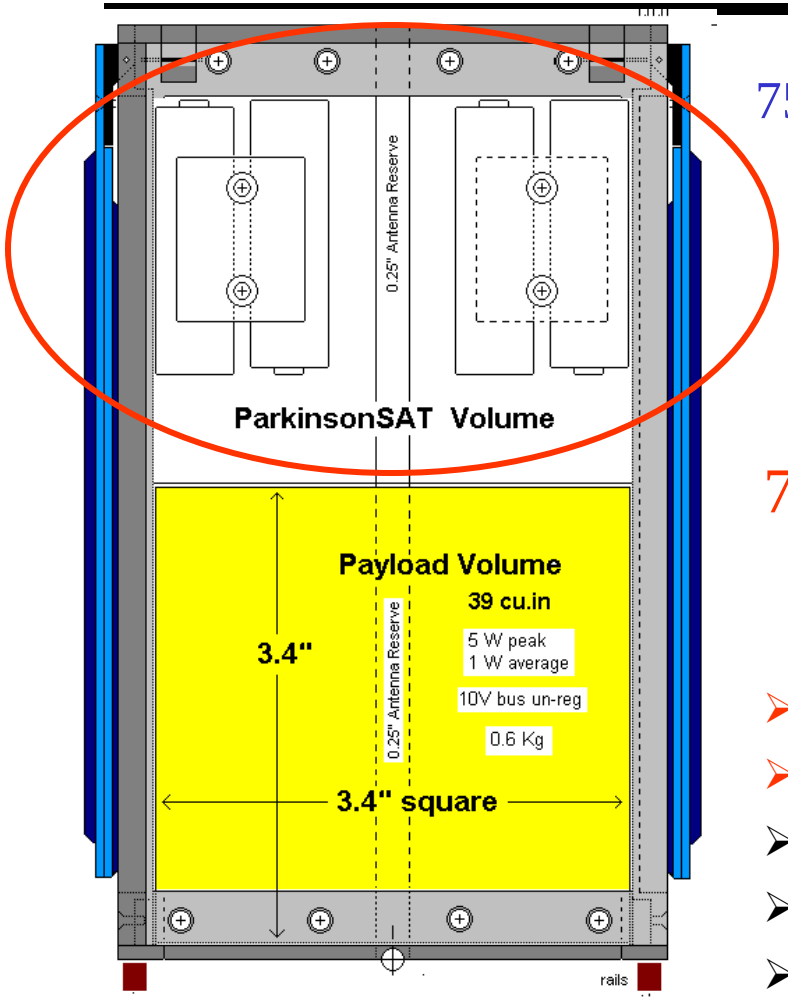
Psat Xponder can also serve as complete comms & C&DH in a cubesat



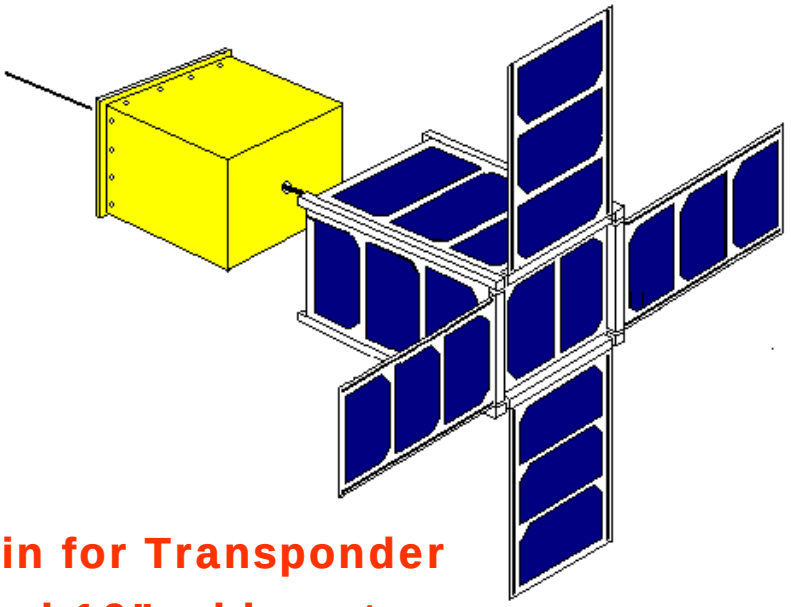
- New tiny 5W RF Xponder
- Simple Sun Pointing ADCS **$50** Magnetometer
- Can support other SERB Payloads
- COTS solar panels **$360 / ($15,000)**

Psat Transponder Aux Payload





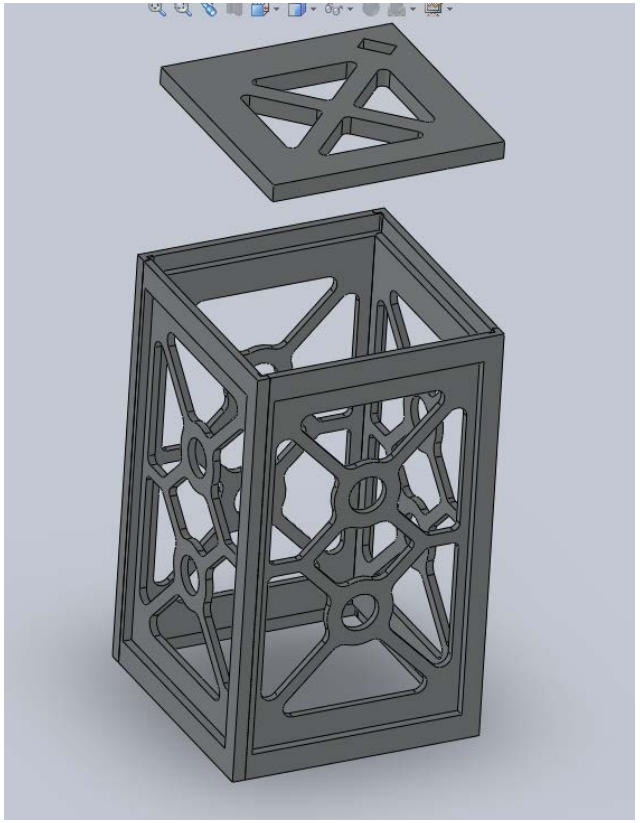
75% Payload Space Available! (only 50% shown here)

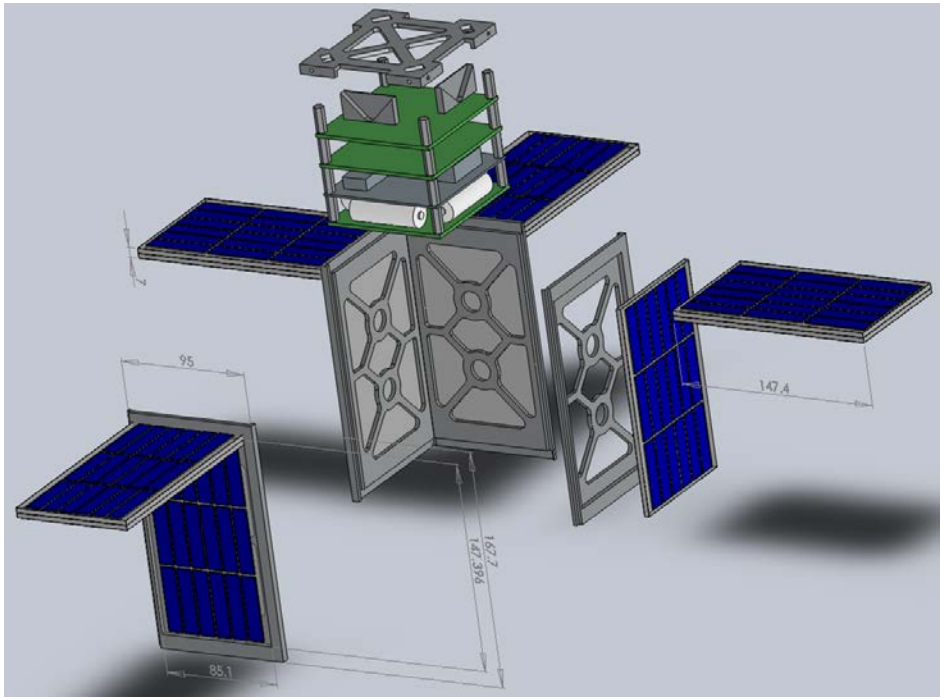


7”

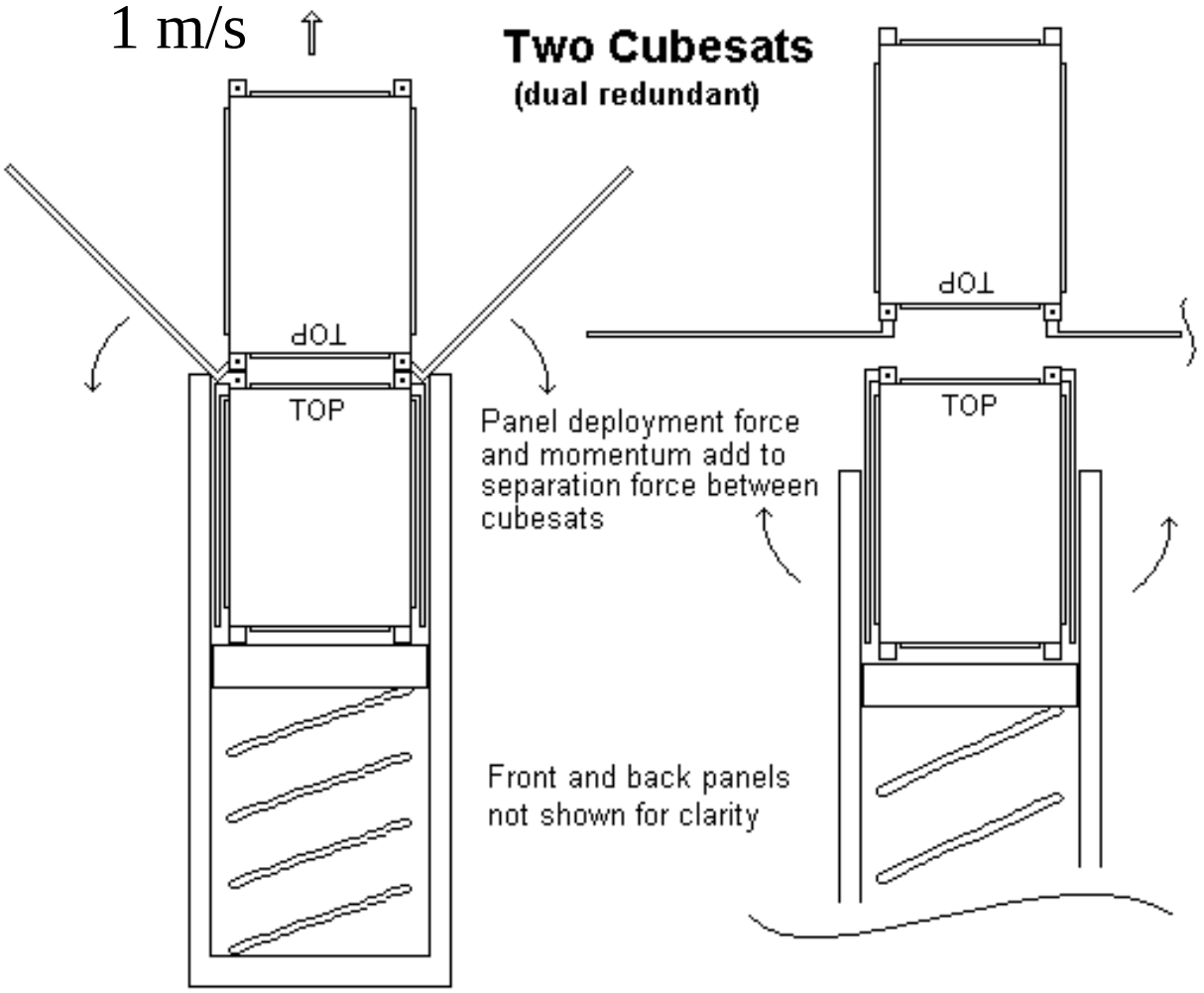
- **18 cu.in for Transponder**
- **External 19” whip antenna**
- 68 cu.in for Aux Payload (SPMS?)
- Aux payload gets 4” external panel
- Aug payload gets .5 kg – self contained
- 1 to 3W average power for aux payload

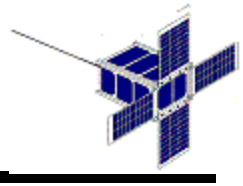
Psat Structure



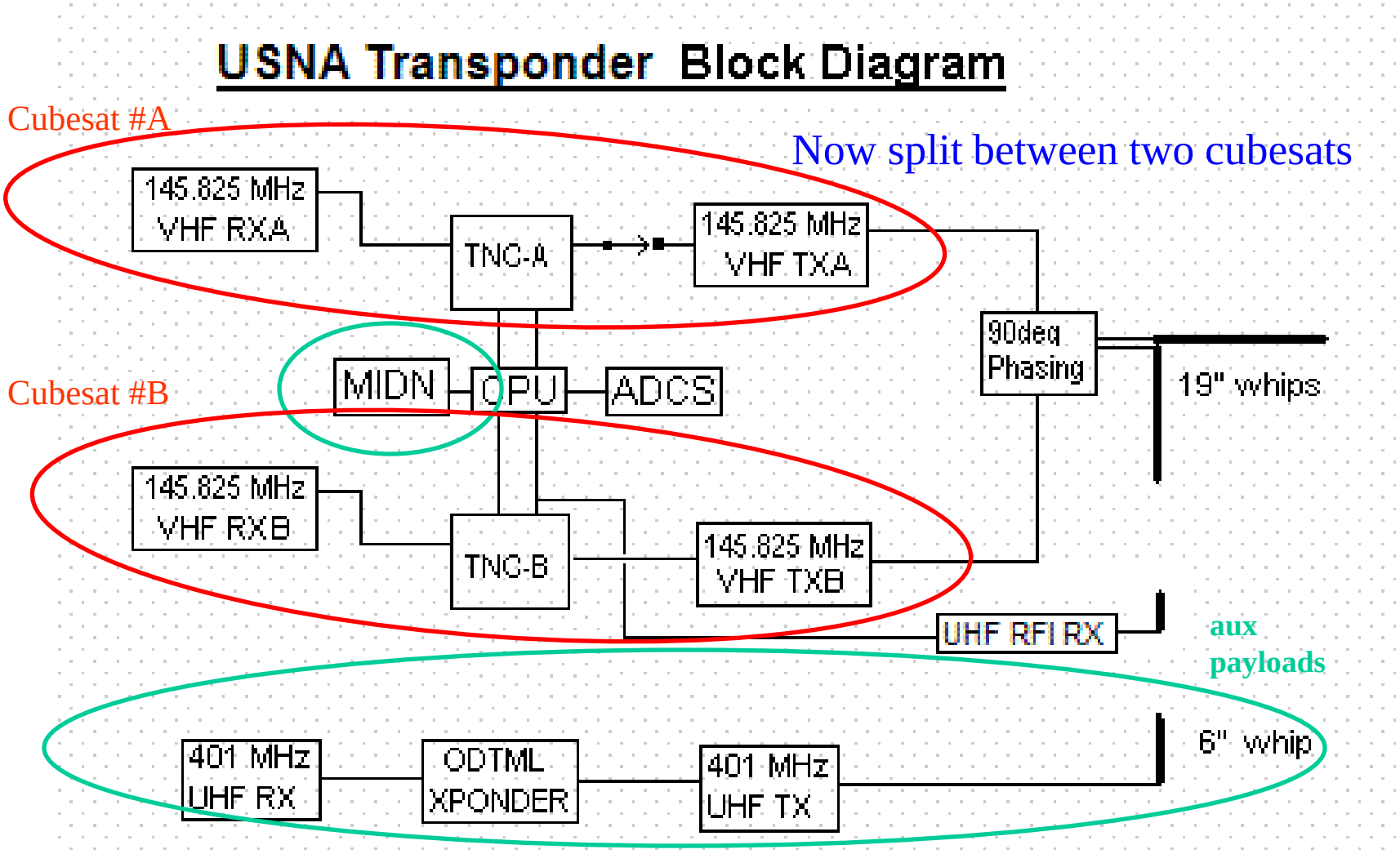


CUBESAT Deployment



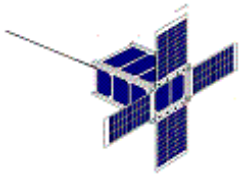


USNA Transponder Block Diagram

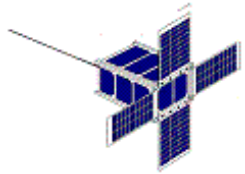


Psat Operational Concept Graphic

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

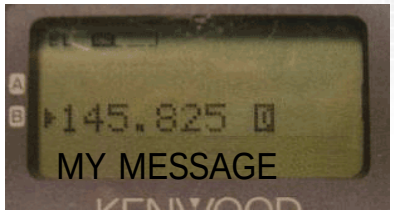
Force

Multiplier!

Ground Terminal Applications Focus

Direction & Distance

Text Messaging

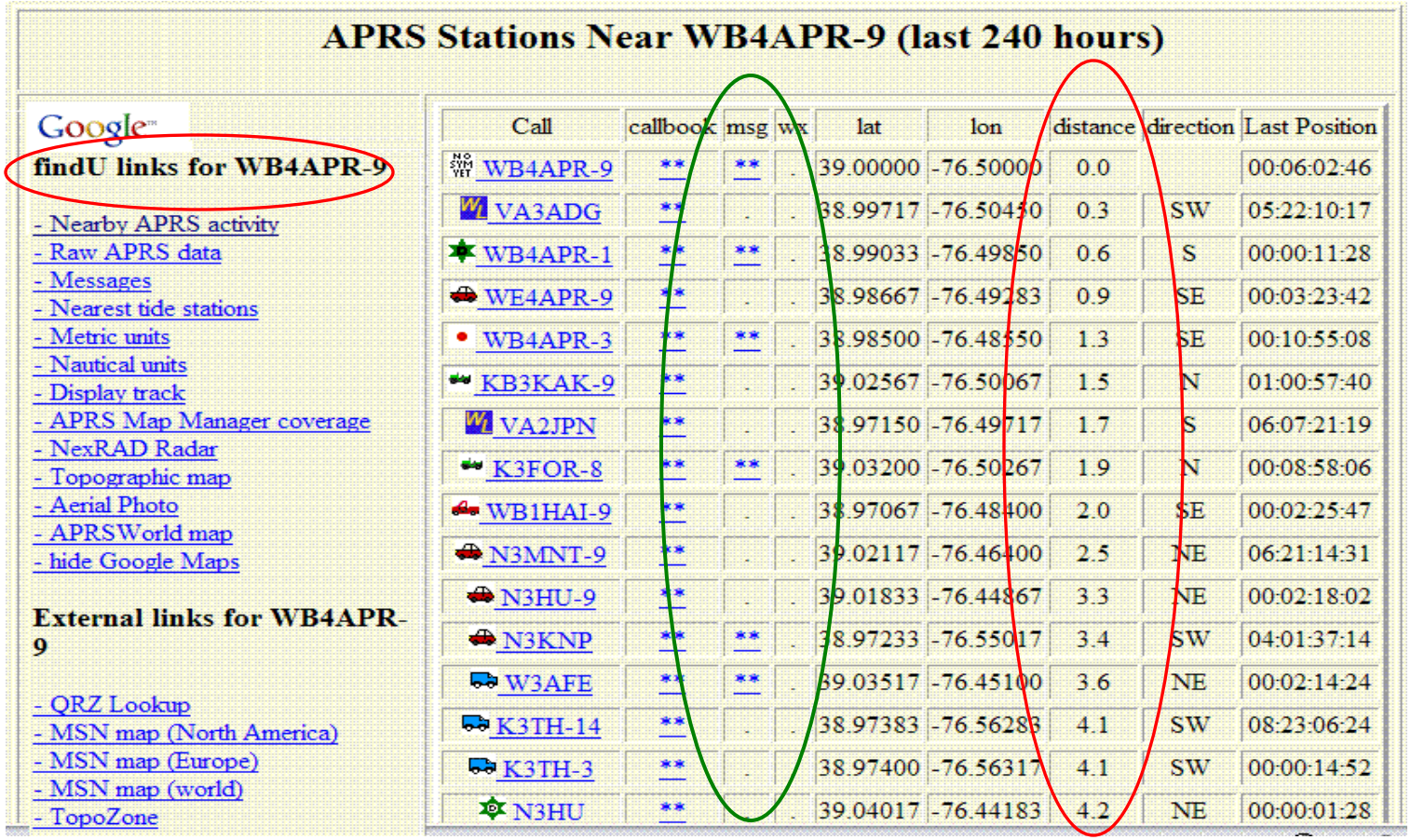


Small Platform Minimum Satcom (SPMS)

Ground Terminal is Walkie-Talkie, and Palm Pilot

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

Universal Ham Radio Text Messaging Initiative

TH-D7

TM-D700

DJ-135

HAMHUD

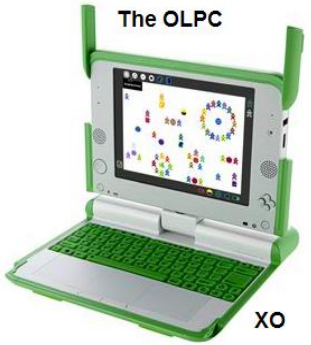
TM-D710

VX-8R

APRS

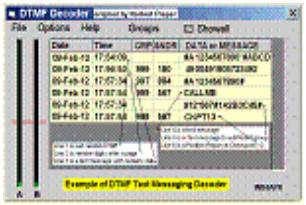
cell

wireless



XO

EchoLink



DTMF

Send/RX anytime, anywhere, any device by callsign

26 separate systems!

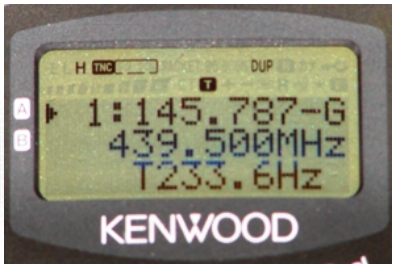
Ground Terminal Applications Focus

Tactical Situational Awareness and Text Messaging

Last 100 stations!

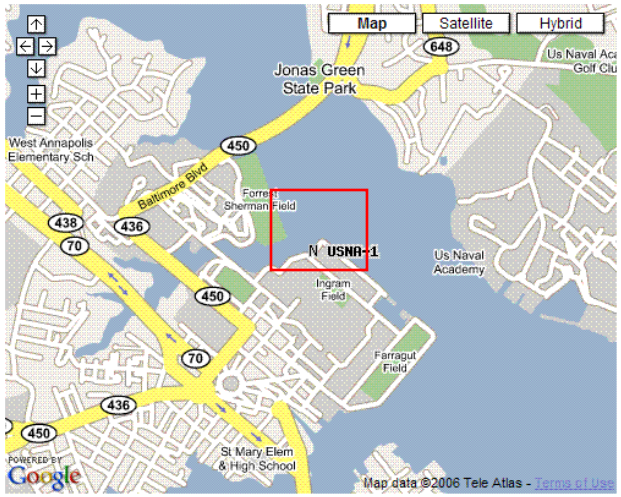
Direction & Distance

Frequency and Tone

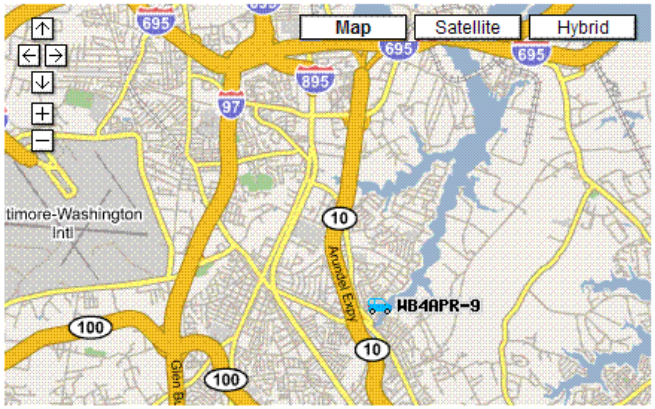


Tracking (on Google Earth)

http://aprs.fi

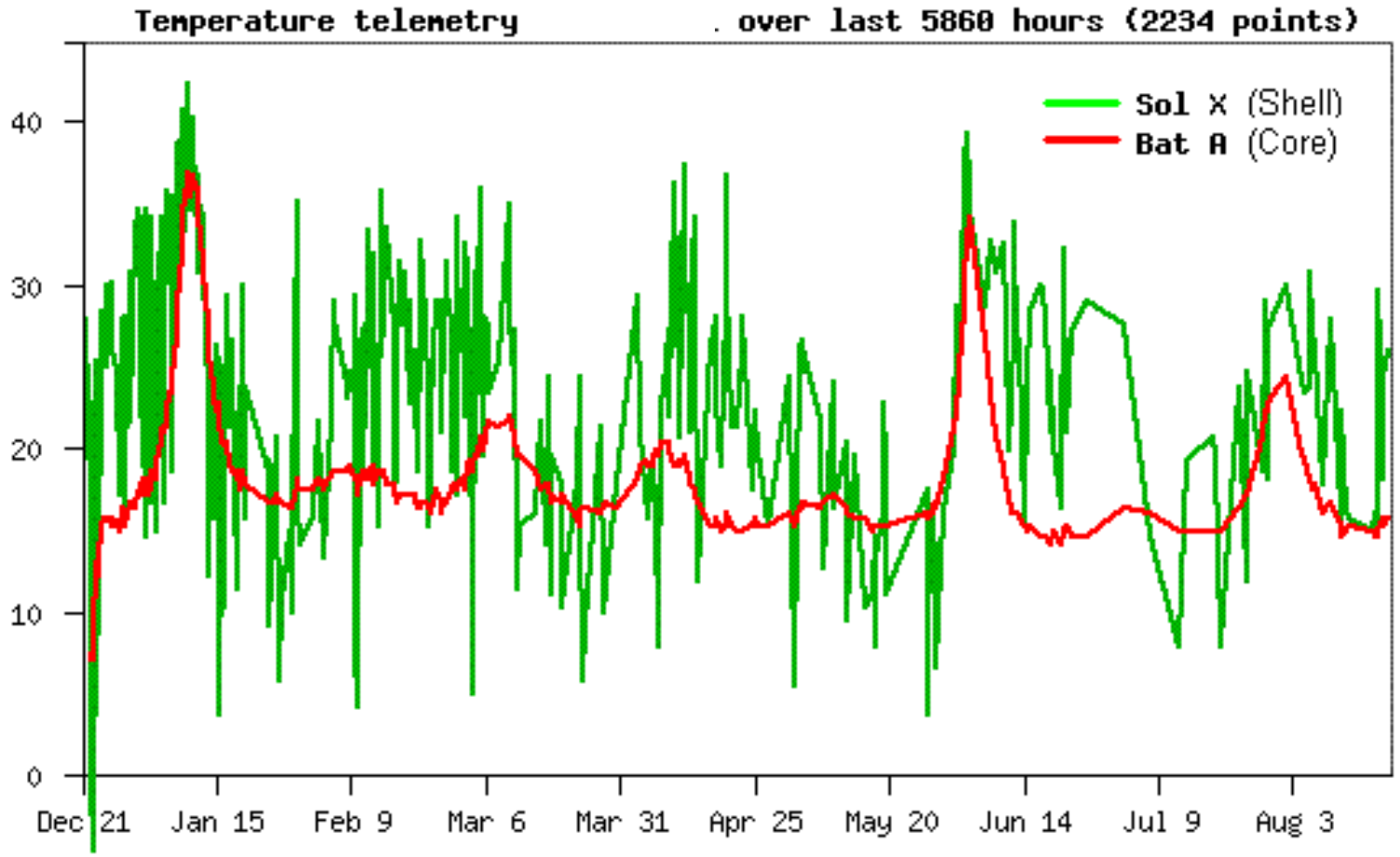


Tactical situational awareness

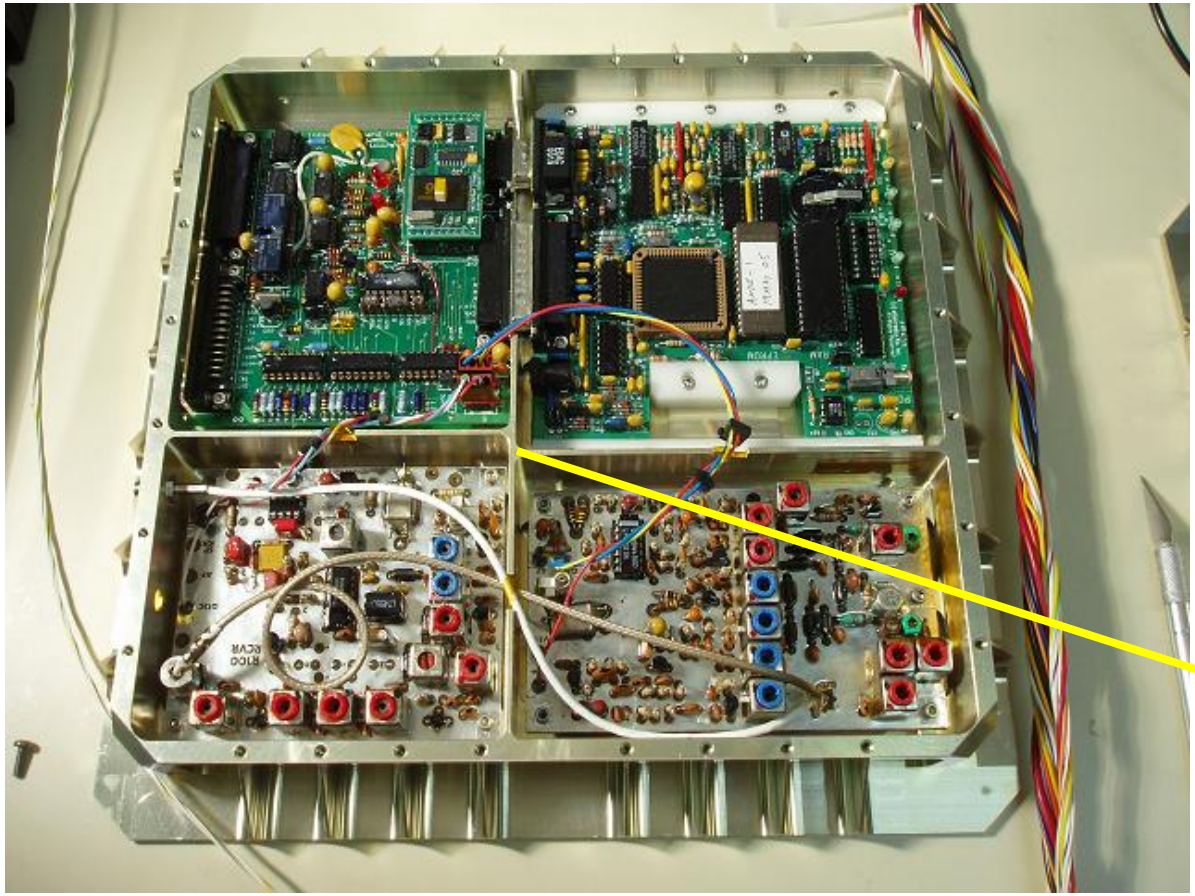


Findu.com Telemetry Plots

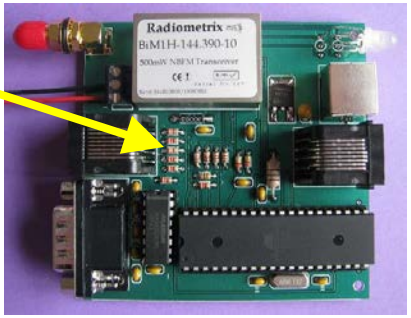
Live Example: www.aprs.org/wb4apr-15.html



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



Now reduced 18:1 in volume/mass



If it flies, it should have an APRS transponder on it

- If it is off the ground we want a TRANSPONDER on it!
- Range at 5000’ = 100 miles