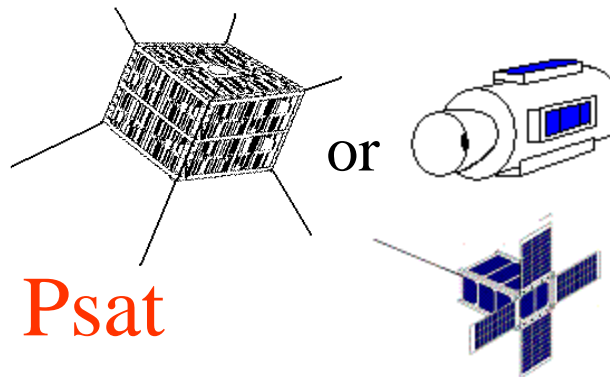
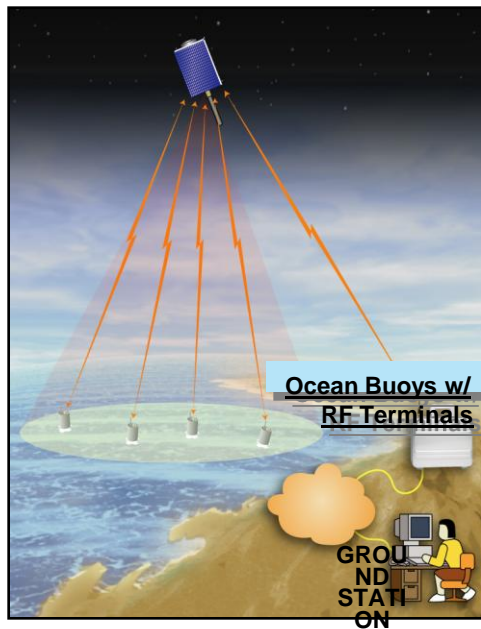


ParkinsonSAT

Remote Data Relay Transponder (Psat)

Presentation for CUBESAT Conference
AIAA/USU 9 Aug 2009



Bob Bruninga,

**Midshipmen: Ridge, Krumholz,
Shatz, Kobus, Brye, Healey, Leahey**

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



Data
Exfiltration

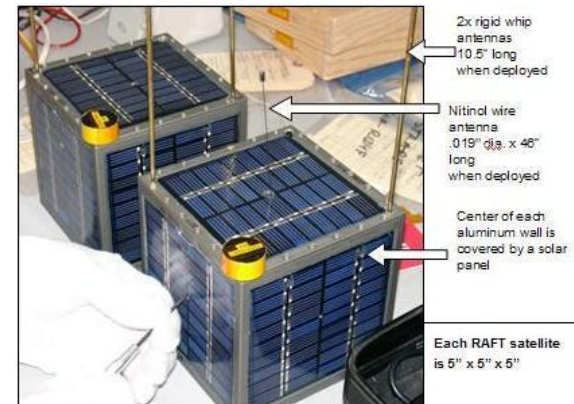
UNCLASS

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



2x rigid whip antennas
10.5" long
when deployed

Nitinol wire antenna
.019" dia. x 48"
long
when deployed

Center of each
aluminum wall is
covered by a solar
panel

Each RAFT satellite
is 5'' x 5'' x 5''

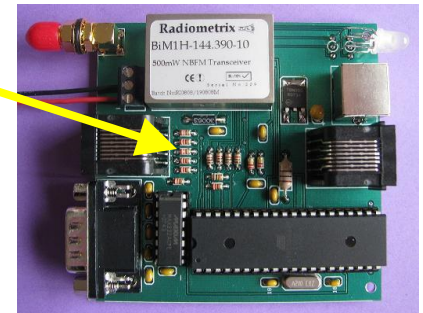
APRS space frequency is published as 145.825

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



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

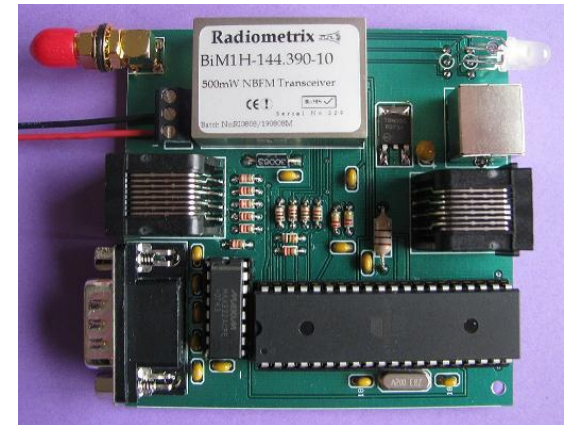
Size/Mass: < 10 cu.in (1 PCB 3.4" square), <0.1kg

Power: < 1W orbit average, 5 volts.

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

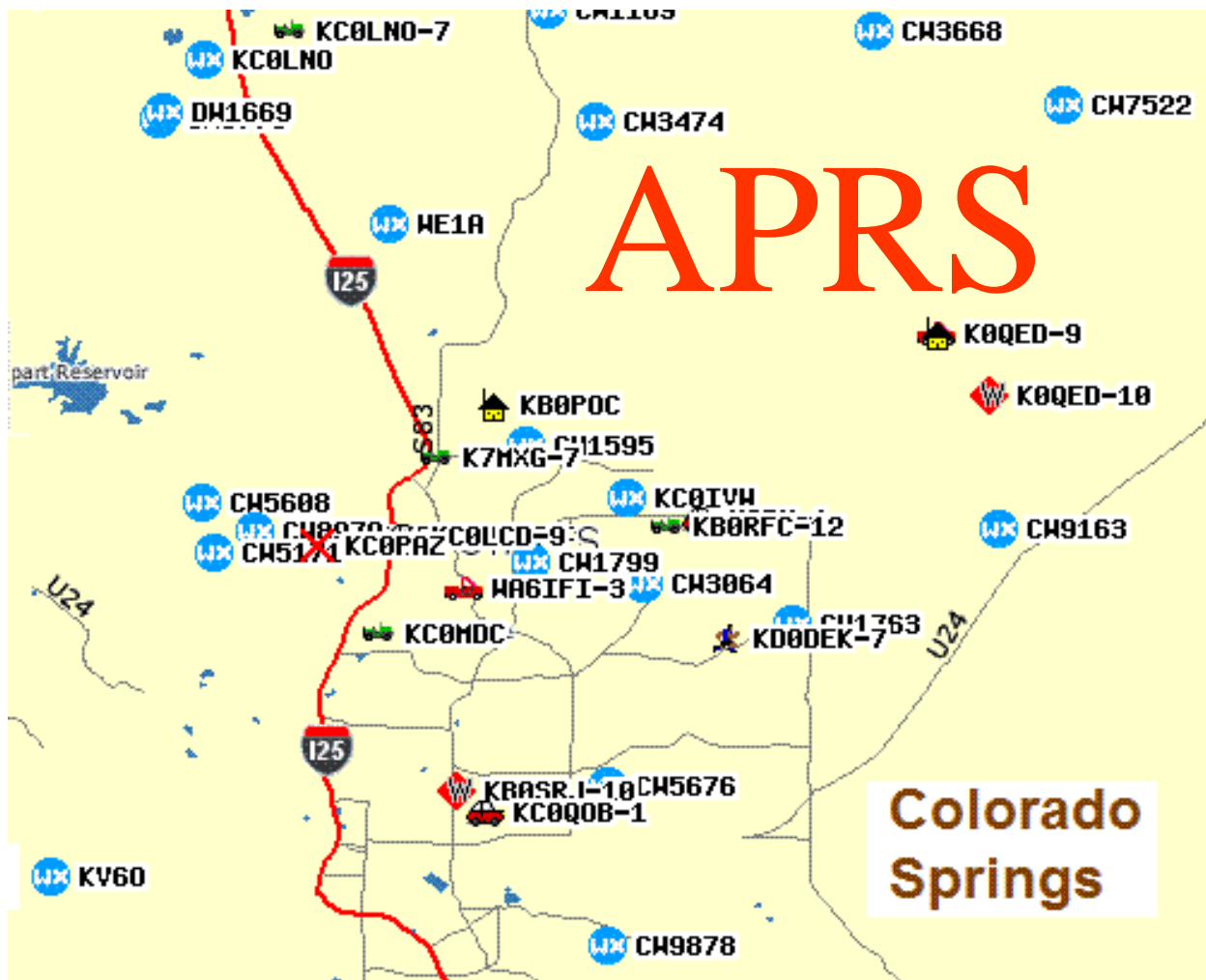
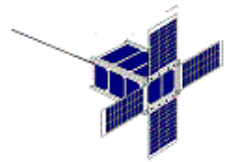
Structure Impact: Needs 19" thin wire whip antenna (1 cu.in)

Benefit to Spacecraft: High visibility 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 discrettes, backdoor reset capability. Worldwide Telemetry Beacon access via global station network.



Mission Background

Psat Xponder Mission (Remote Data Relay)



FOCUS:

“Network

Centric”

&

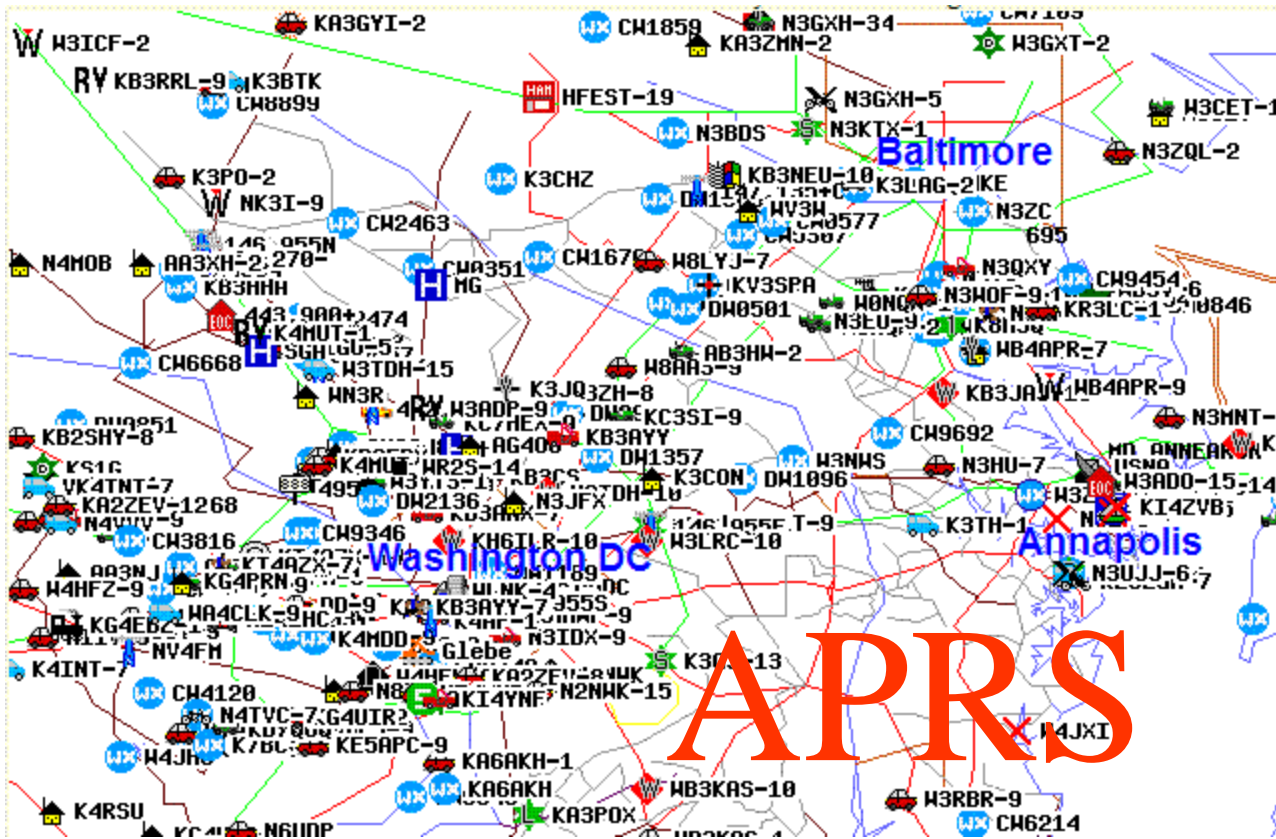
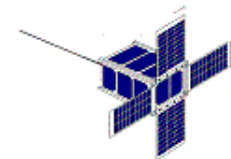
Remote Sensor
Experiments

50 stations
In 25 miles

Find any station - http://map.findu.com/CW5608*

Mission Background

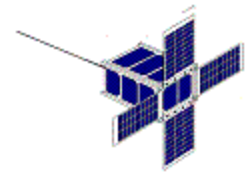
Psat Xponder Mission (Remote Data Relay)



FOCUS:
“Network
Centric”
&
Remote Sensor
Experiments

300 stations
In 35 miles

Find any station - http://map.findu.com/WB4APR*



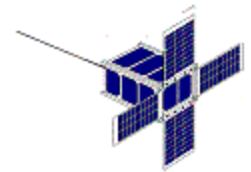
- Psat Xponder can draw from 30,000+ volunteer/student experimenters

APRS

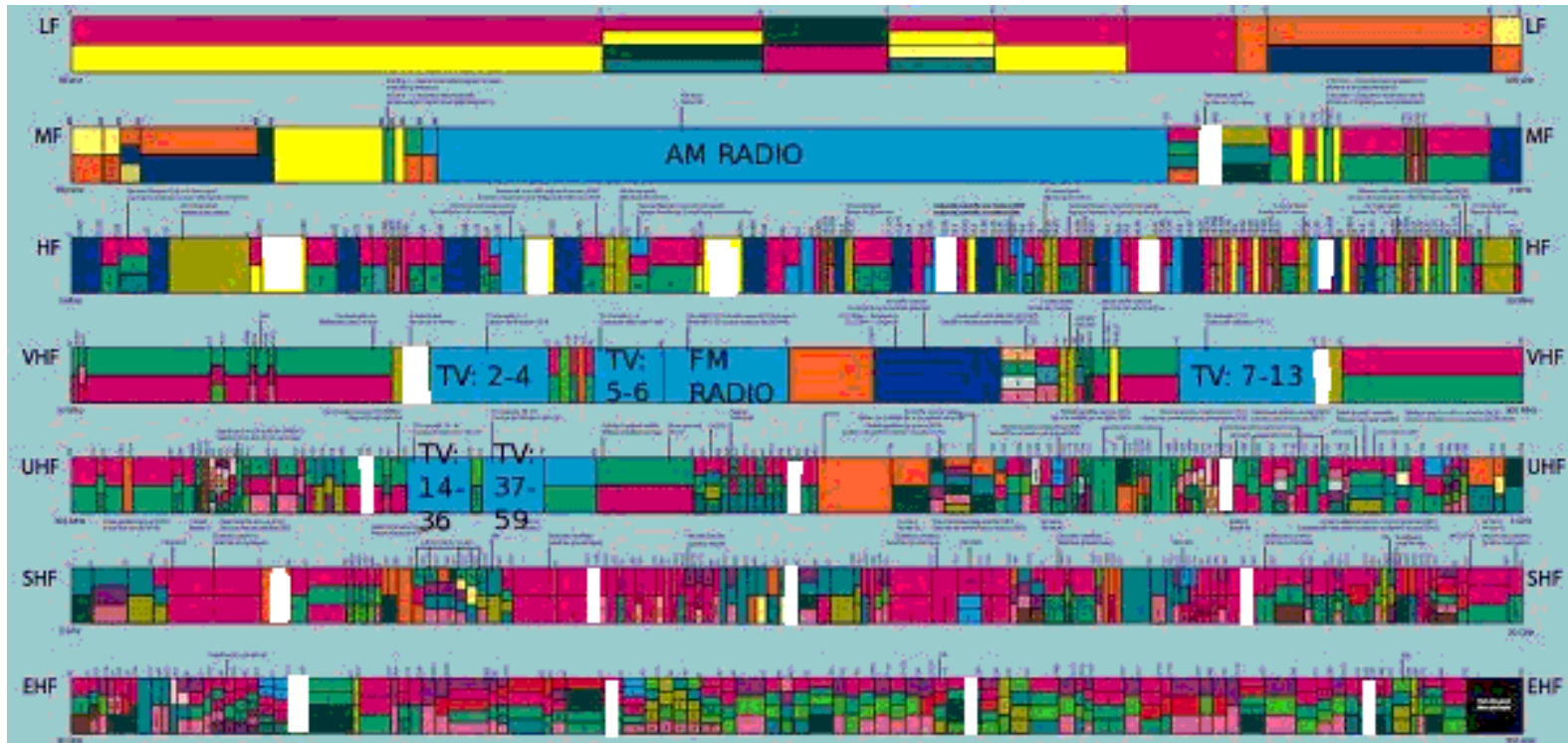
FREQS: 3000 !

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

- Not only sensors and users exist, but the global volunteer infrastructure also exists from our previous USNA satellites and ISS



- Psat Xponder can draw from 30,000+ volunteer/student experimenters
- But that is only 5% of the Licensed Operators **FREQS: 3000 !**



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	-76.56288	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 **A**utomatic **P**acket **R**eporting **S**ystem

Example Situational Awareness (in SLC Utah)

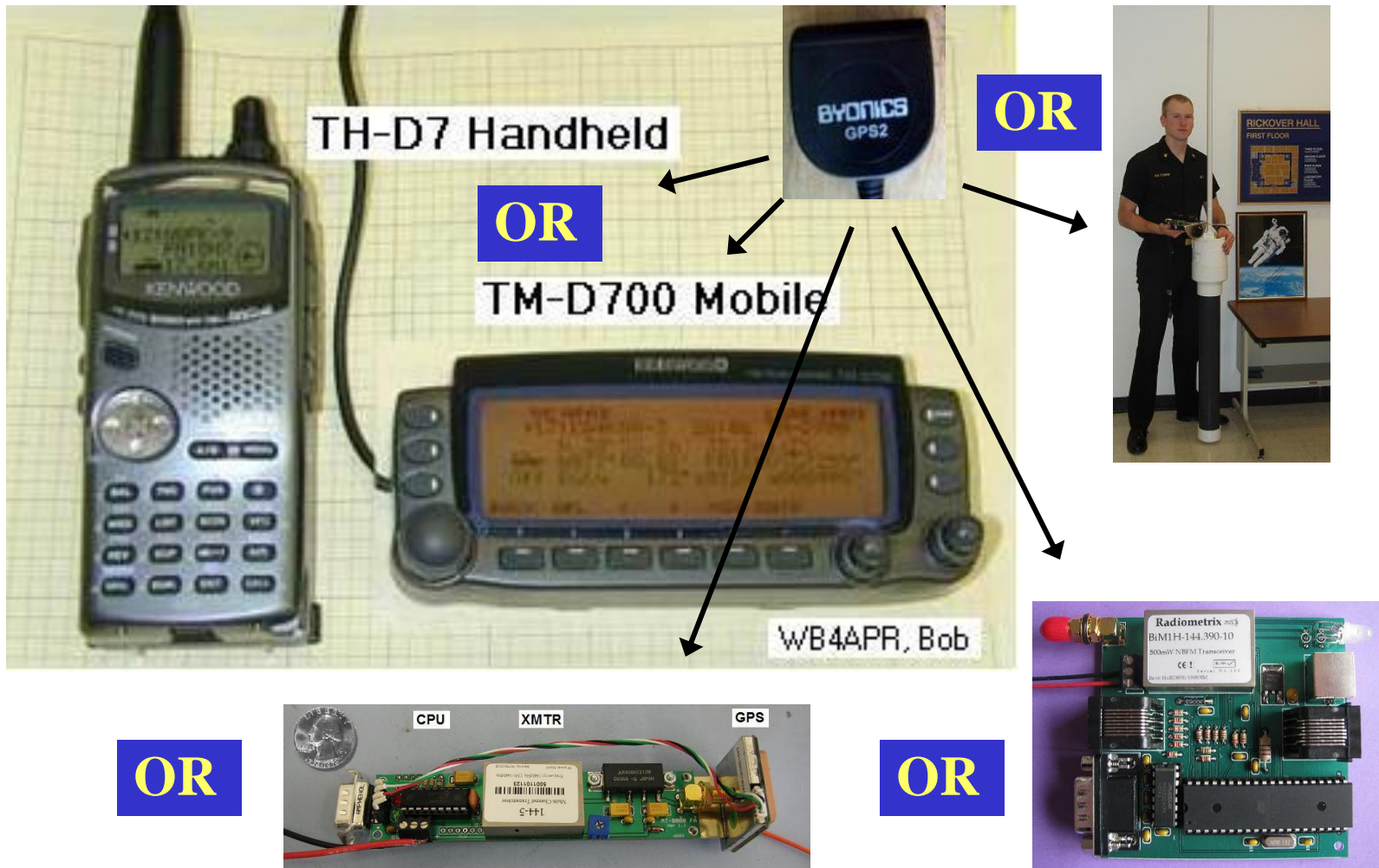
27 users in S.L.C

map.findu.com/N7RKB*



Ground Terminal Applications Focus

Supports Student Experimenters world wide



Ground Terminal Applications Focus

**Supports Student Experimenters
School missions/movements
And Emergency Comms**

and



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

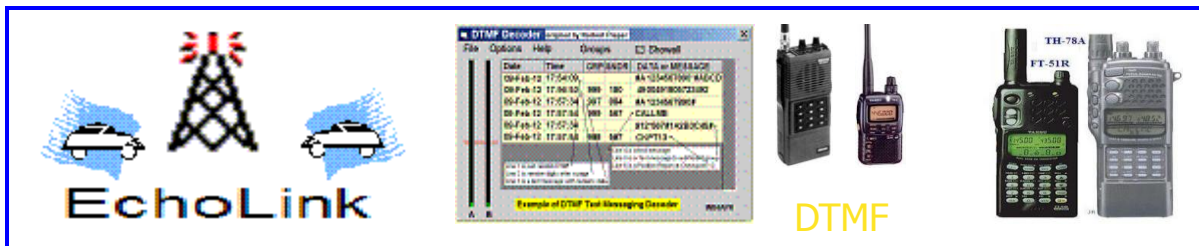


The Yard Patrol Craft

Universal Ham Radio Text Messaging Initiative



APRS



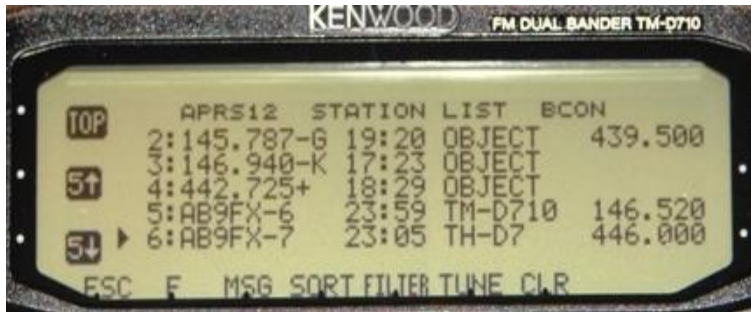
Send/RX anytime, anywhere, any device by callsign

26 separate systems!

Ground Terminal Applications Focus

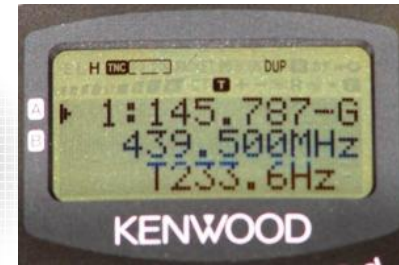
Tactical Situational Awareness and Text Messaging

Last 100 stations!



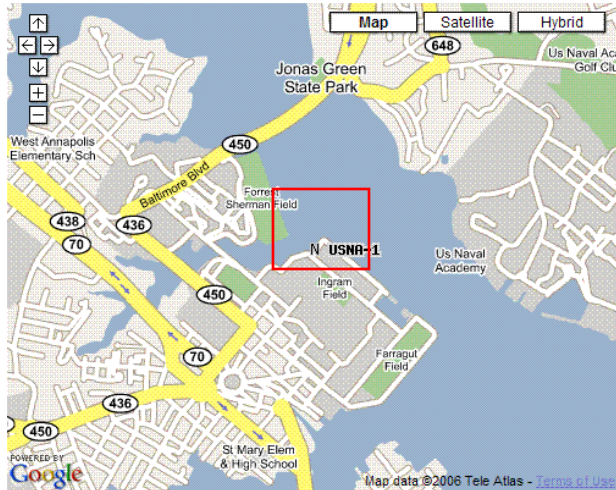
Direction & Distance

Frequency and Tone



“Purple Force” Tracking

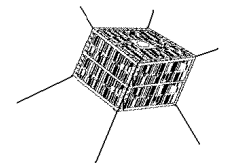
Map.findu.com/wb4apr*



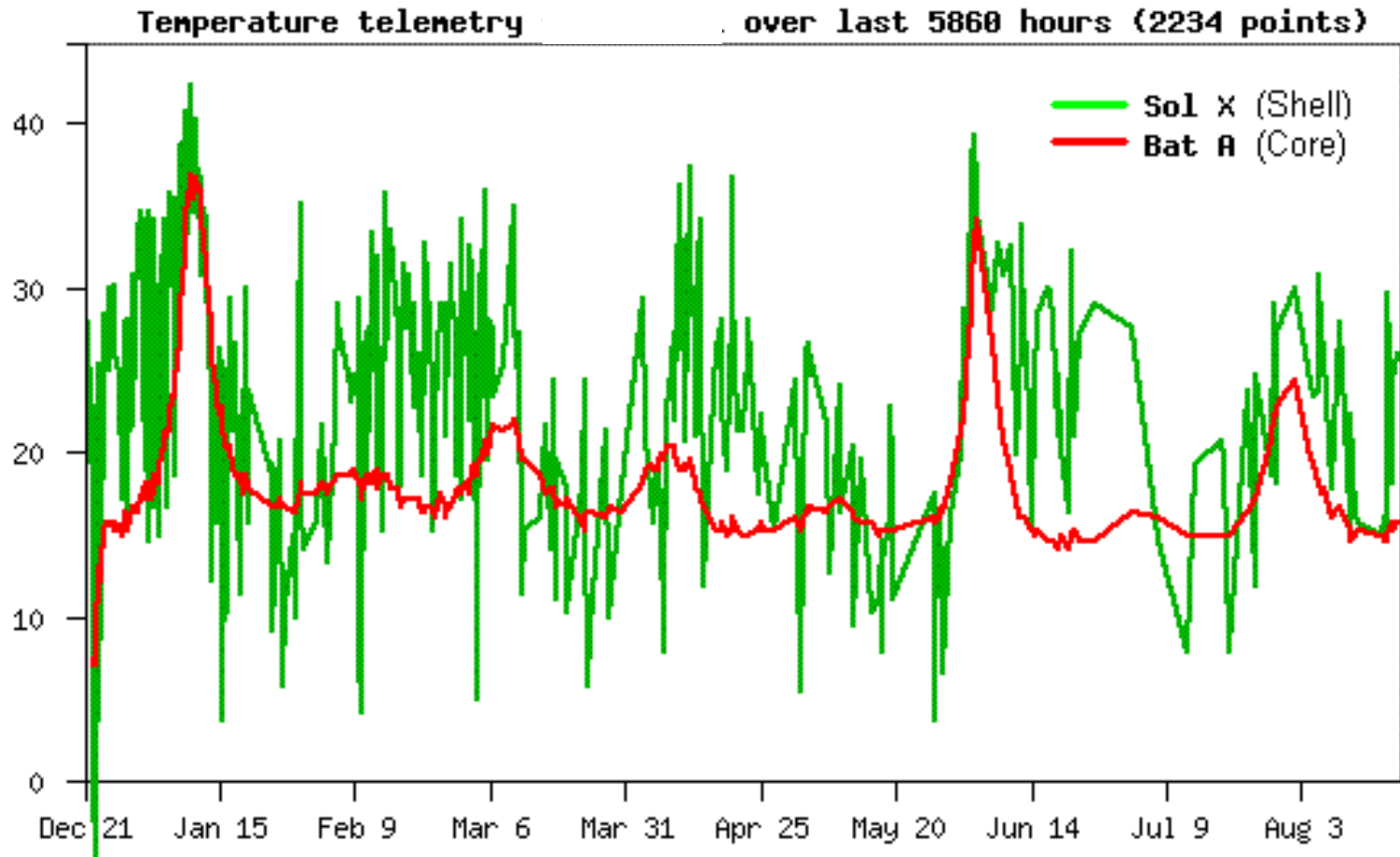
Tactical situational awareness



Findu.com Telemetry Plots



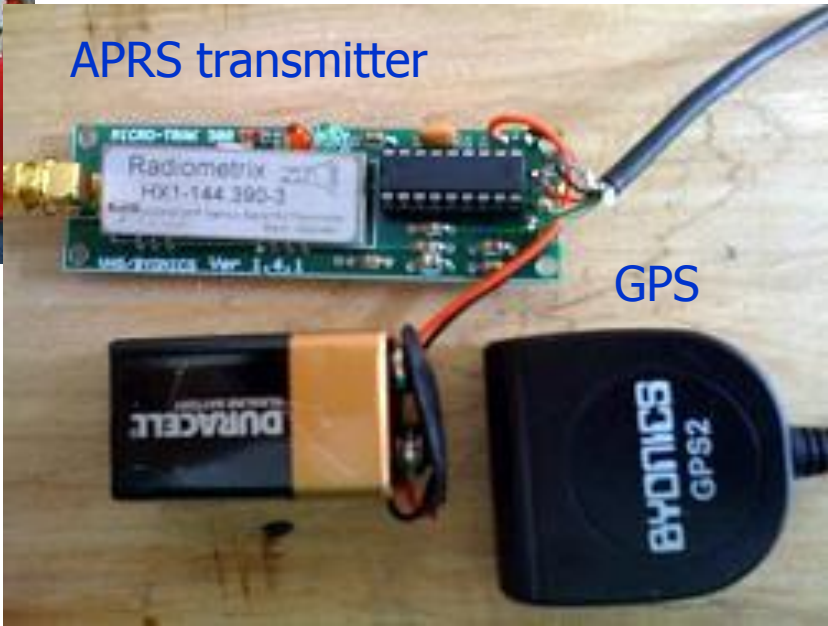
Live Example: www.aprs.org/wb4apr-15.html



Example Remote Sensors using **APRS** Protocol



Very Simple

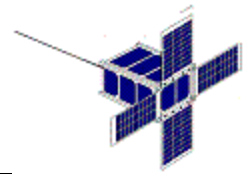


APRS transmitter

GPS

Based on the **USNA Automatic Packet Reporting System**

Sensor Buoy Baseline (prototype)



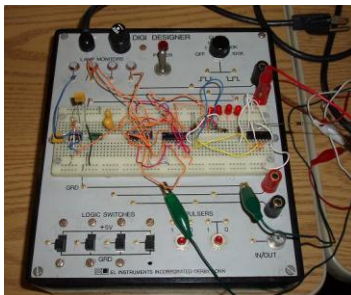
Naval Academy Student Project

- * 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.usna.edu/~bruninga/buoy4.html>

DOD Synergy with Educational Experimenters

Based on the USNA Automatic Packet Reporting System

APRS Data Experiment in F-16 Aircraft



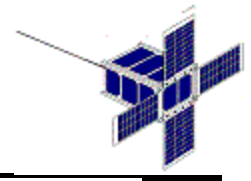
“Purple Force” Tracking

Map.findu.com/w3ado*

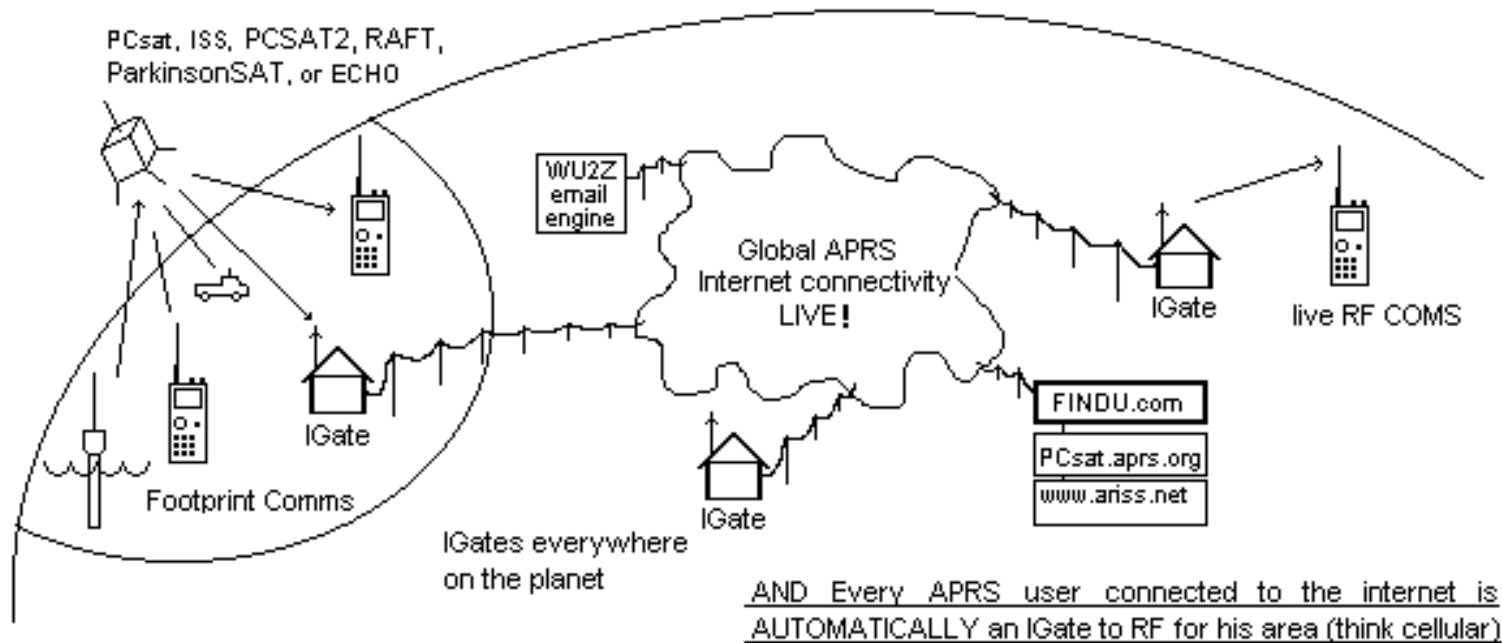
Tactical situational awareness



Psat Global Internet linked Comms Network



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

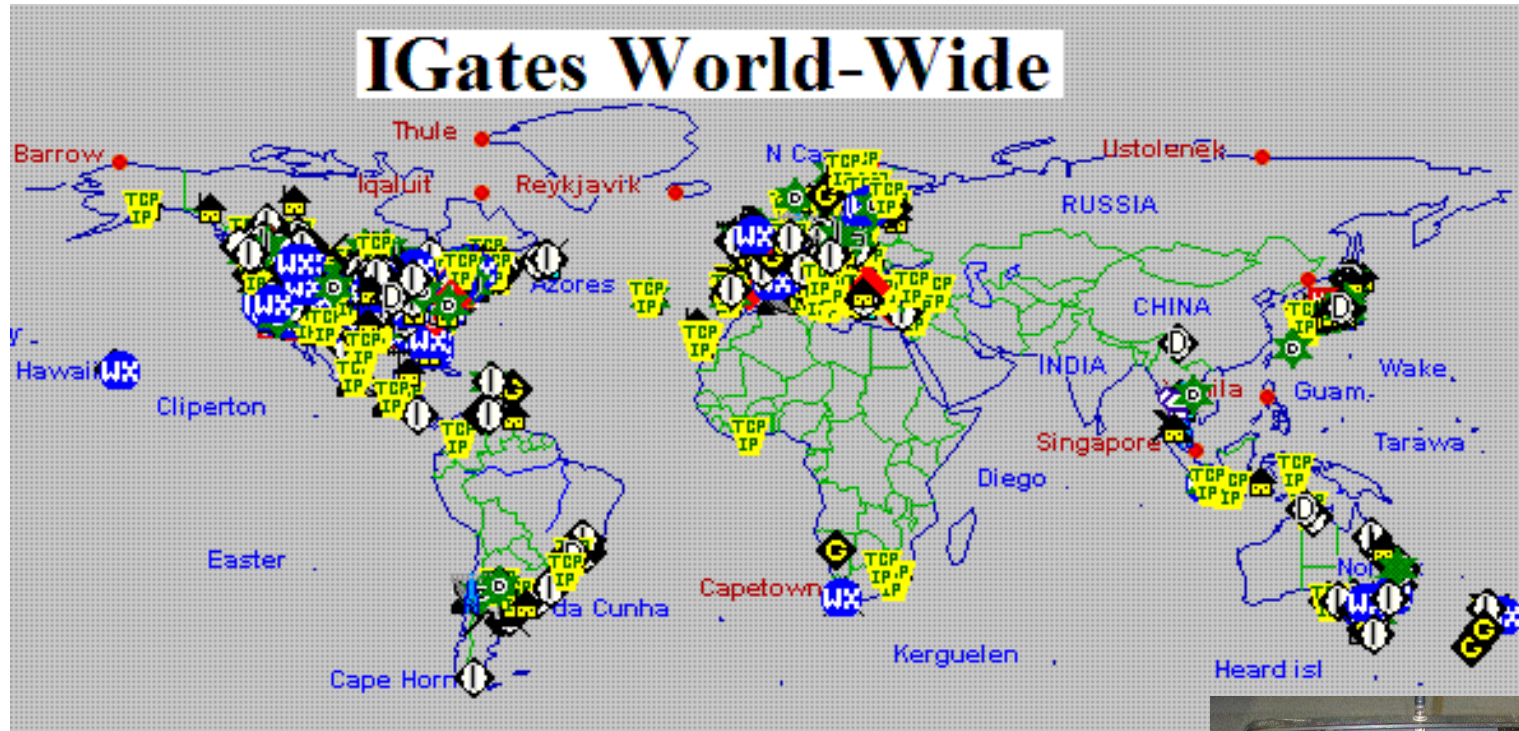
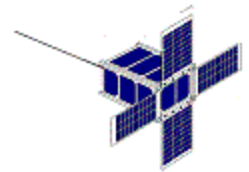


APRS Global Packet Radio Network

Internet Linked for live Communications

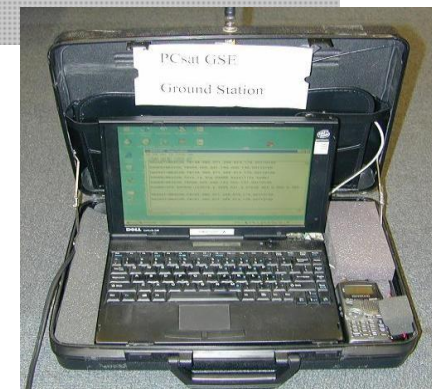
Automatic Packet Reporting System

Psat APRS Network Architecture

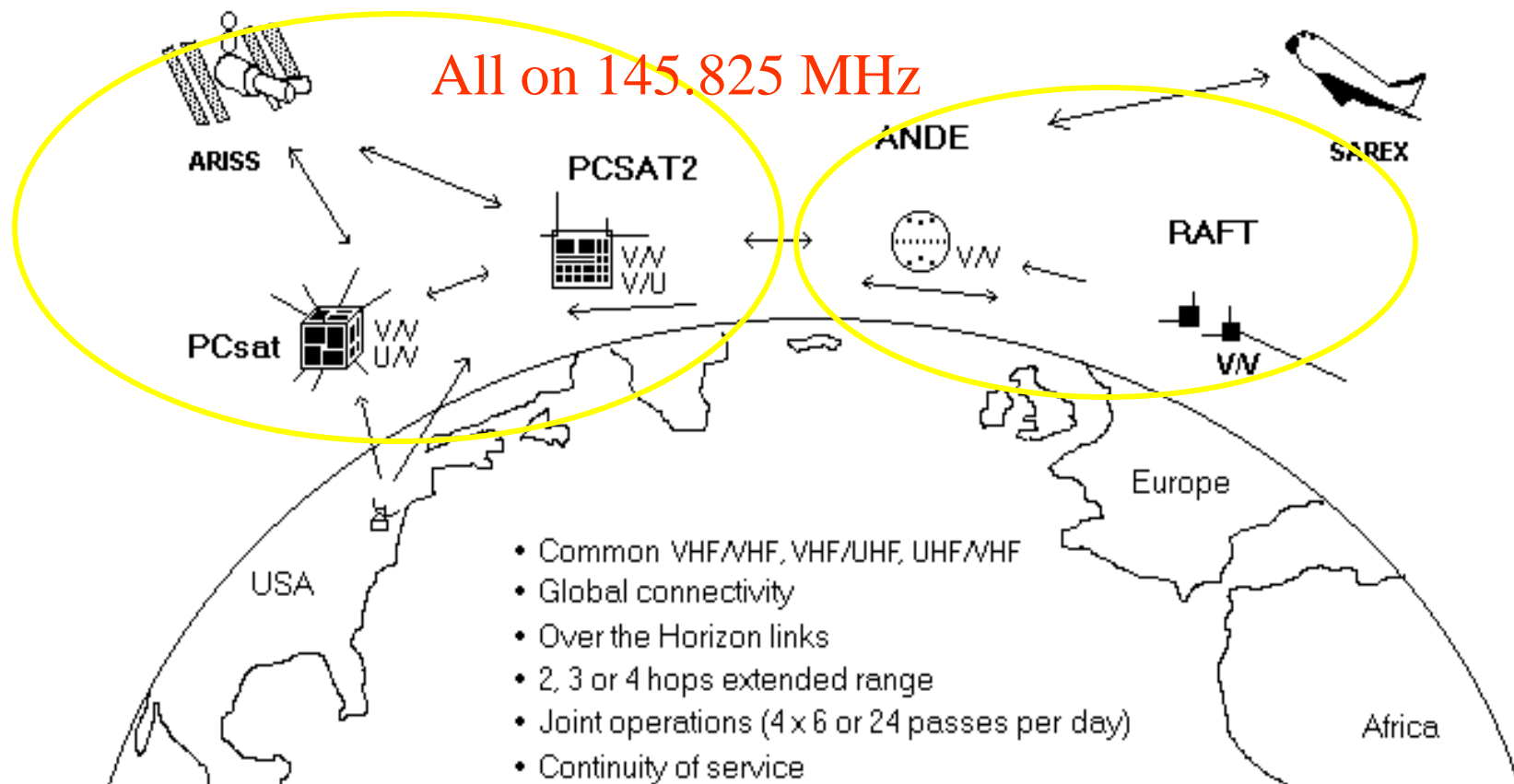


Global Volunteer Ground Station
Network

Internet Linked for live Telemetry



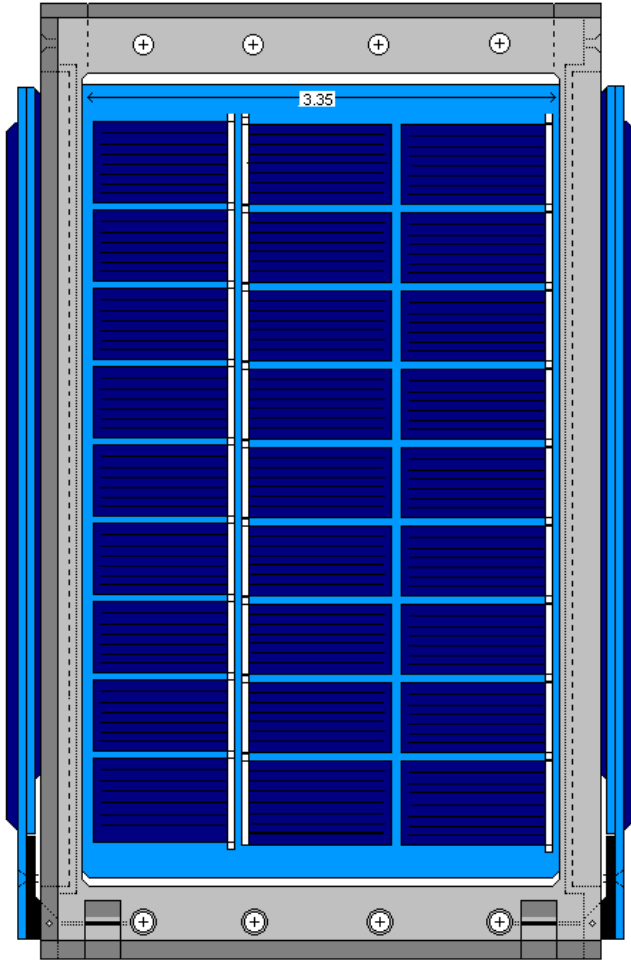
Constellation Operation of USNA Satellites



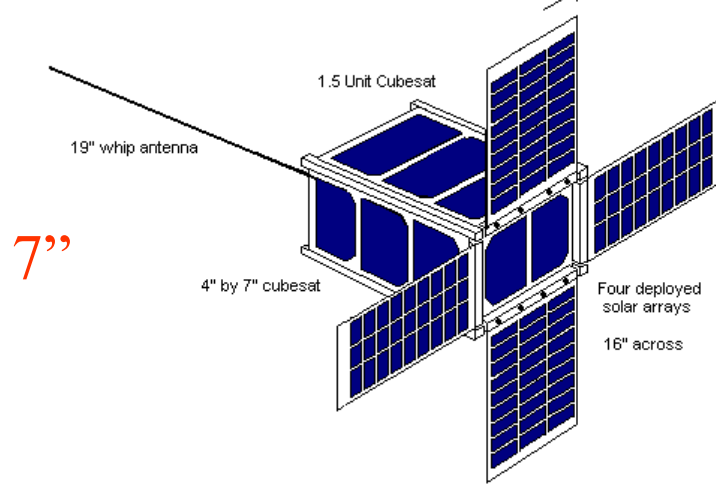
WB4APR

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

2008 ParkinsonSAT CUBESAT

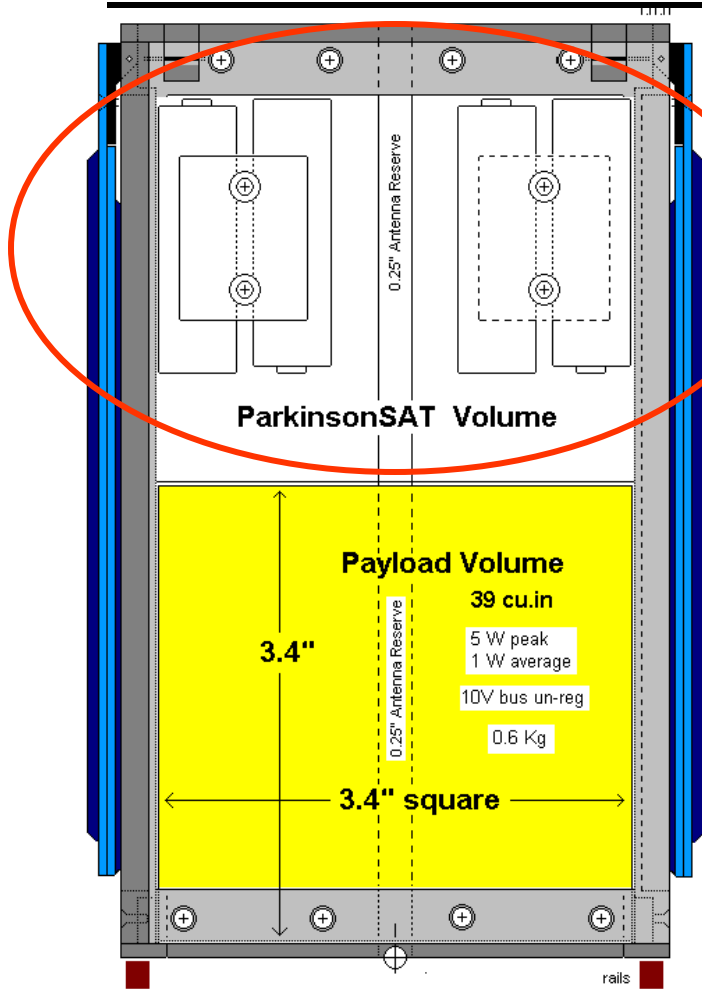


Psat Xponder can also serve as complete comms & C&DH in a cubesat

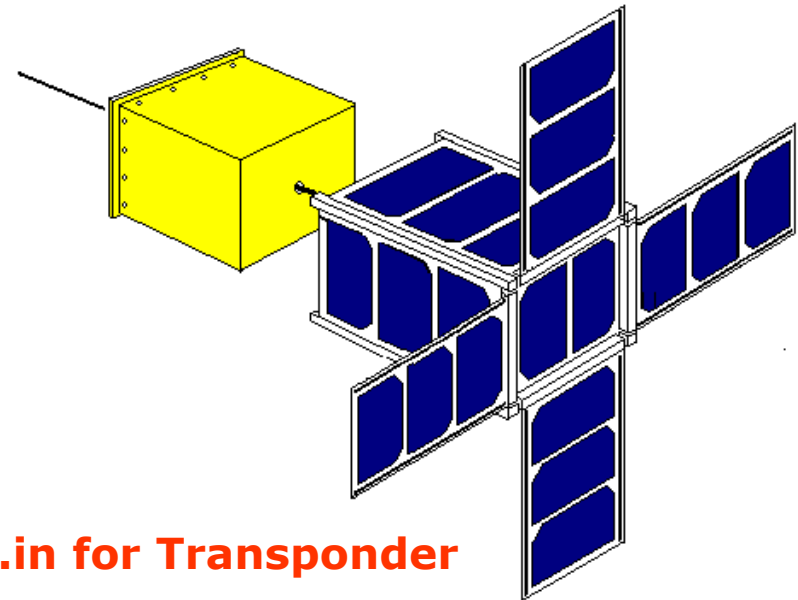


- New tiny 5W RF Xponder
- Simple Sun Pointing ADCS **\$50** Magnetometer
- Other SERB Payloads
- COTS solar panels **\$360 / (\$25,000)**

Psat Transponder Requirements



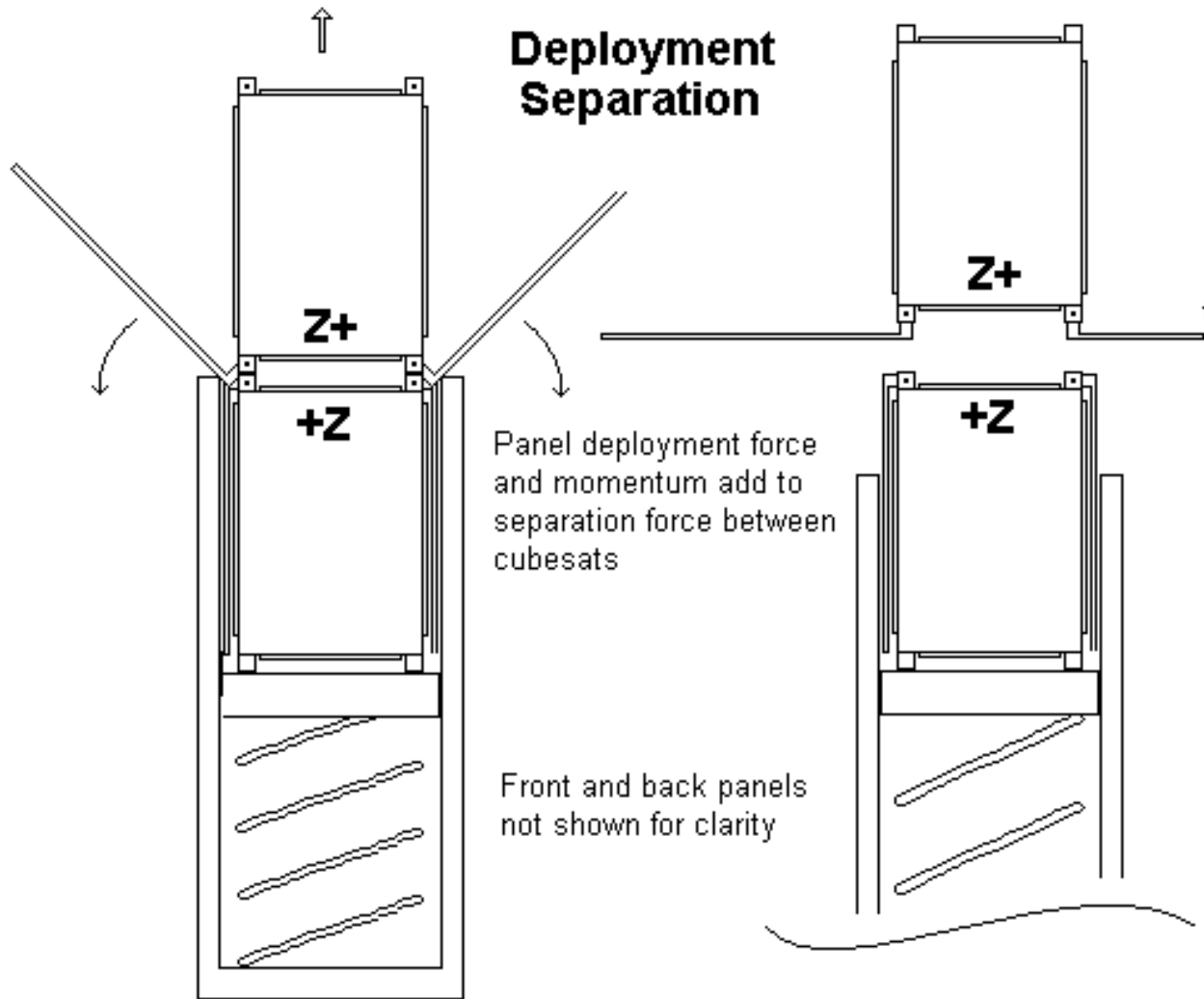
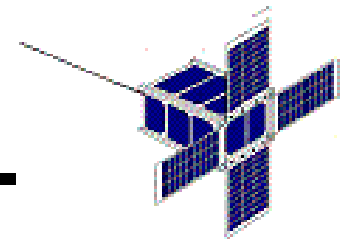
75% Payload Space Available! (only 50% shown here)



7"

- **10 cu.in for Transponder**
- **External 19" whip antenna**
- 68 cu.in for Aux Payload(s)
- Aux payload gets 4" external panel
- Aux payload gets 2 kg – self contained
- 1 to 5W average power for aux payload

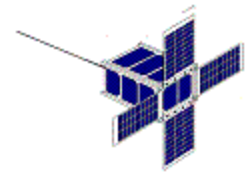
Psat and Array Deployment



Dual Launch
Potential.
Using
common bus.
Constellation

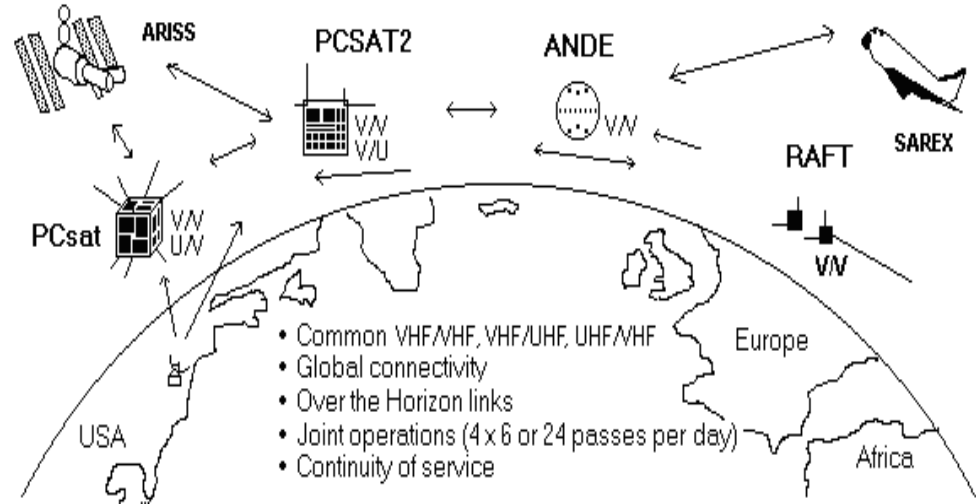


Psat (USNA-0601) Flight Requirements



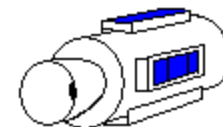
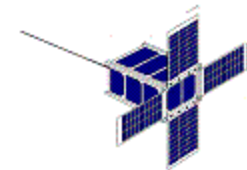
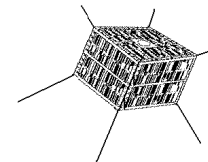
Need for Spaceflight: **Medium is the message**

- Future Officer Aerospace Education – space cadre
- Remote Data Relay requires Comms orbit.
- Space Performance of COTS required



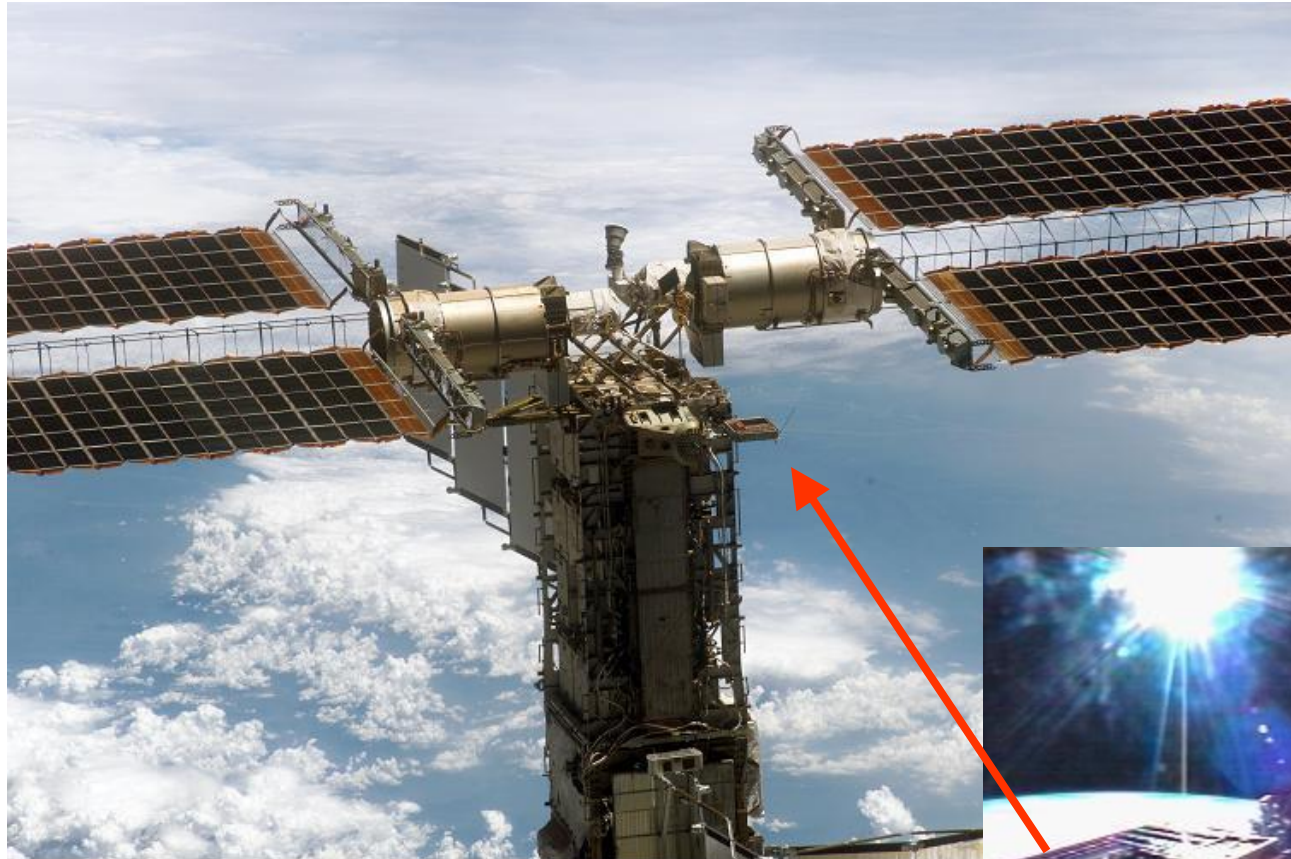
Any Orbit, Any Attitude:

- Free-Flyer or Piggy-back or **cubesat**
- Apogee/Perigee: 400 to 800 km (>5 yr life)
- Inclination: 20 to 98 deg (lower, if higher)
- Physical Data: 10 cu.in, 0.1 kg, nominal 1 W



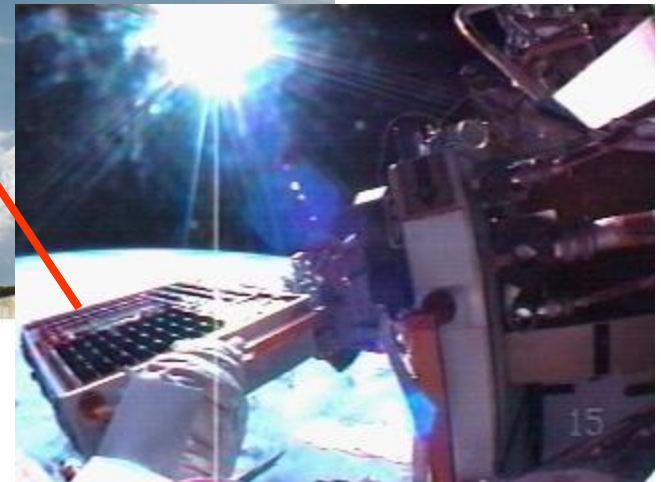
Prior APRS Transponder Experience (PCSAT2)

But only 1 year on ISS before return



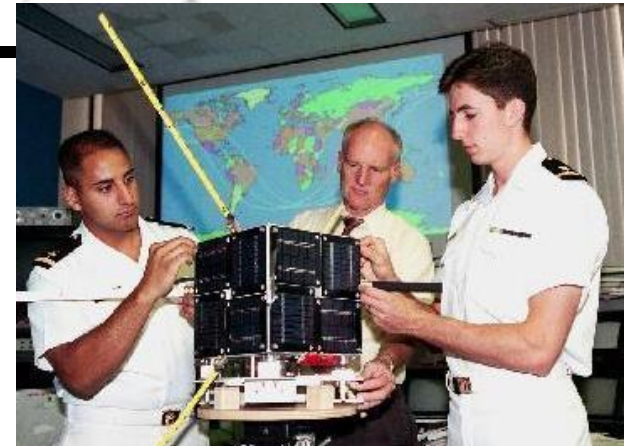
S114E7235

PCSAT2
on
MISSE5

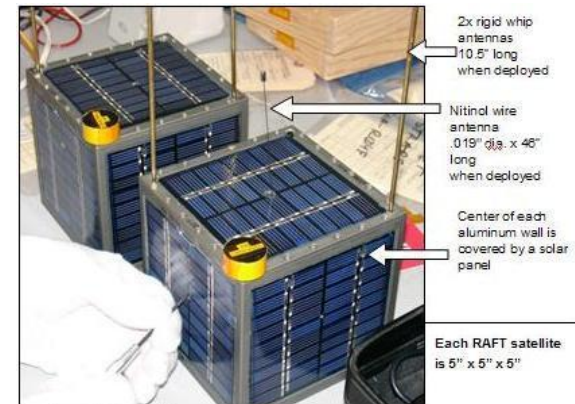


APRS (Psat Transponders) in Space

- 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



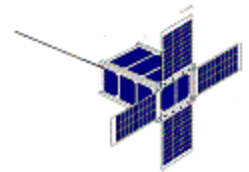
Experimenters need a continuous Transponder in Space



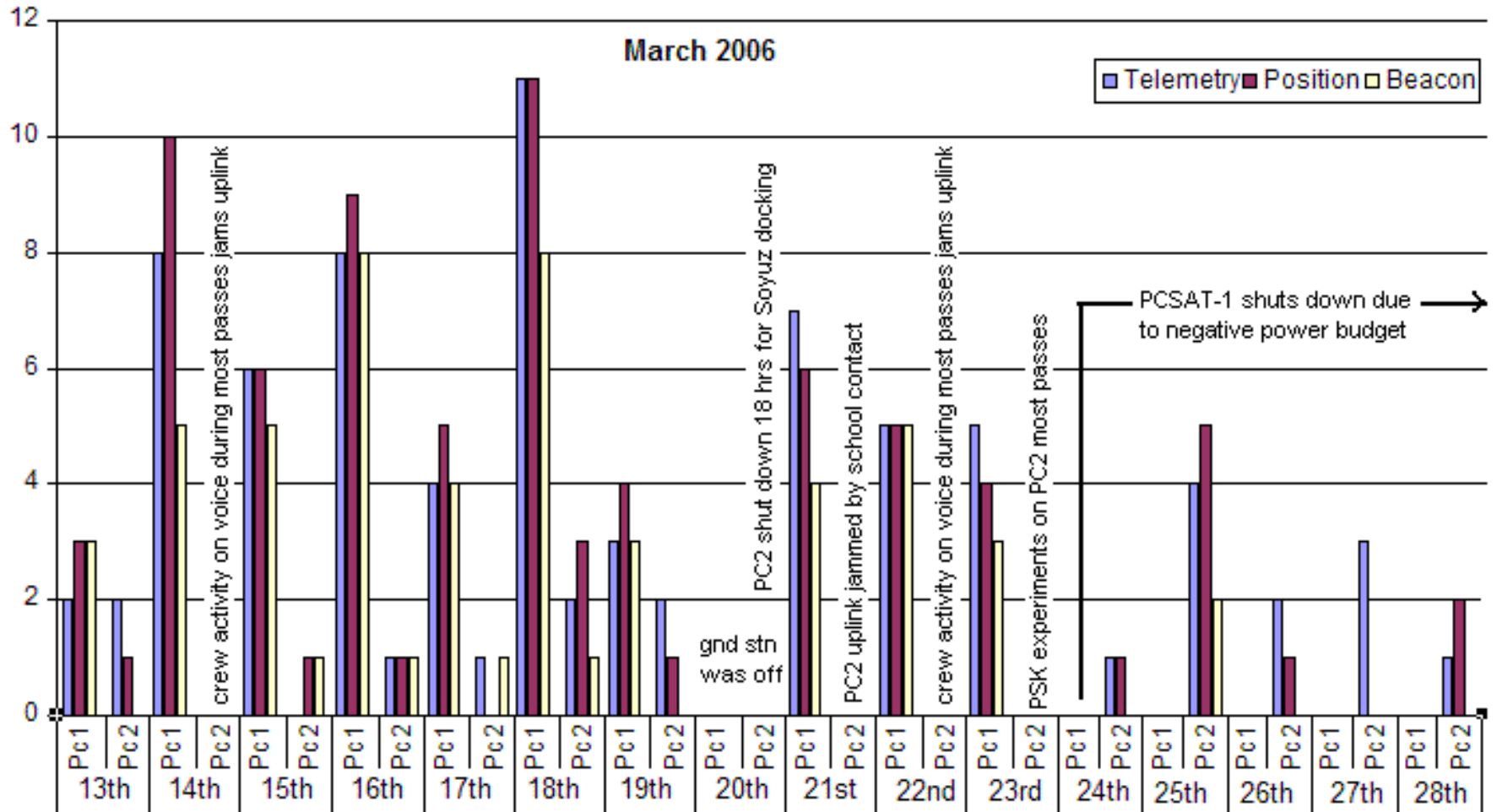
APRS space frequency is published as 145.825

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

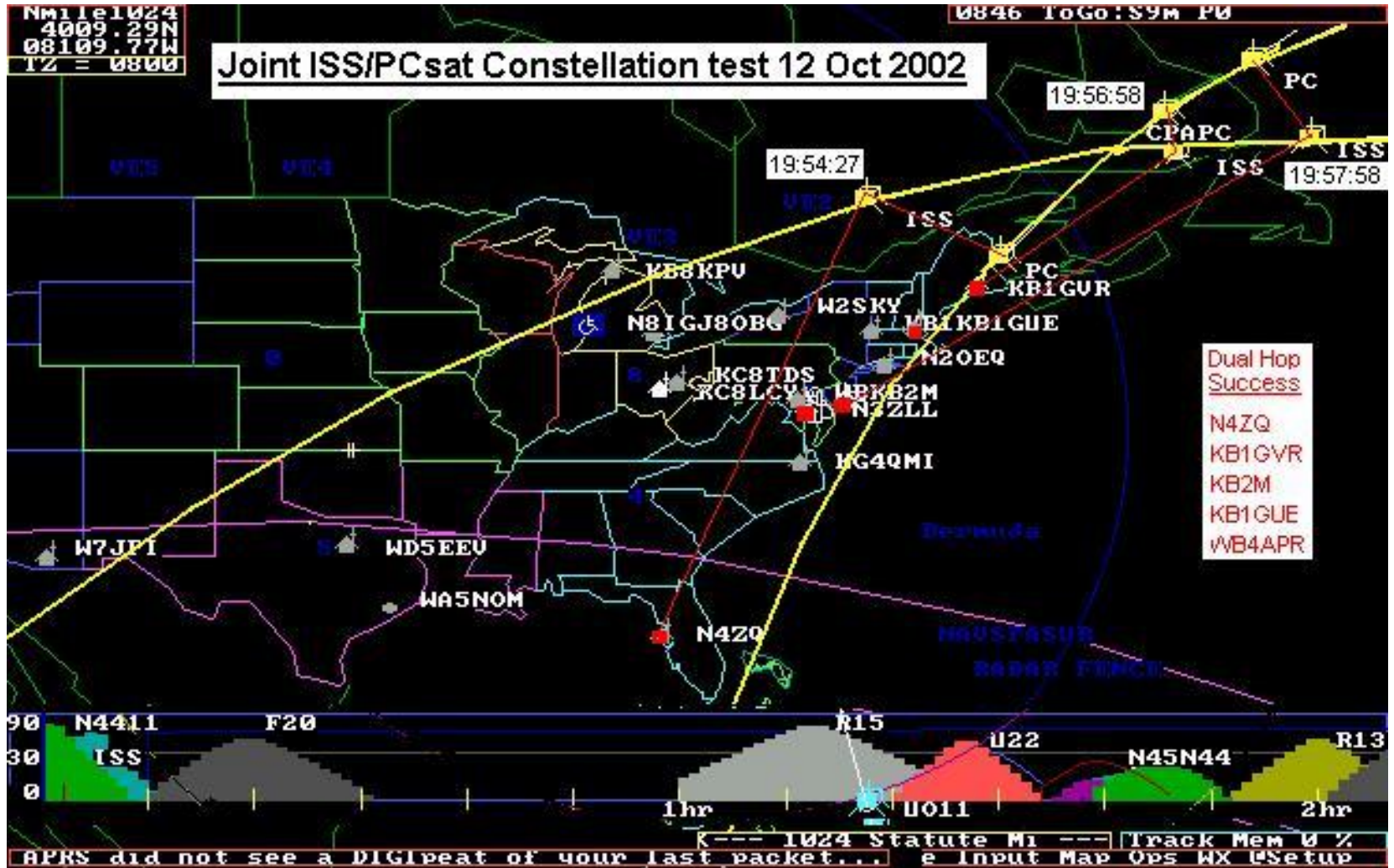
Buoy Link Verification Test



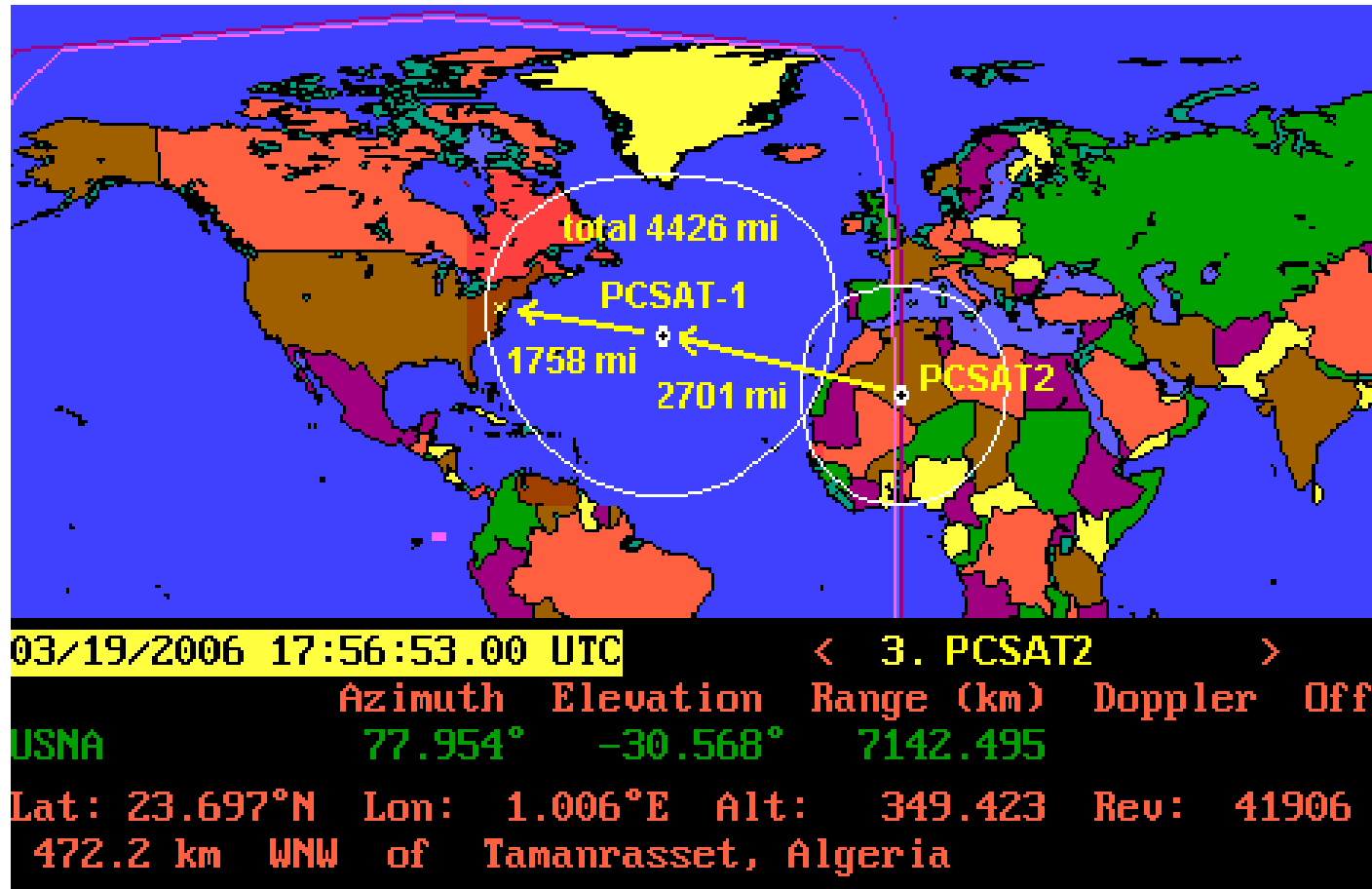
Number of Buoy Packets Received Per Day via PCSAT-1 and PCSAT2



Dual Satellite 2-hop links

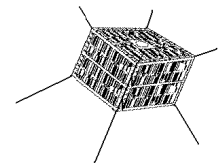


Dual Hop Operations with PCSAT-1 and PCSAT2:

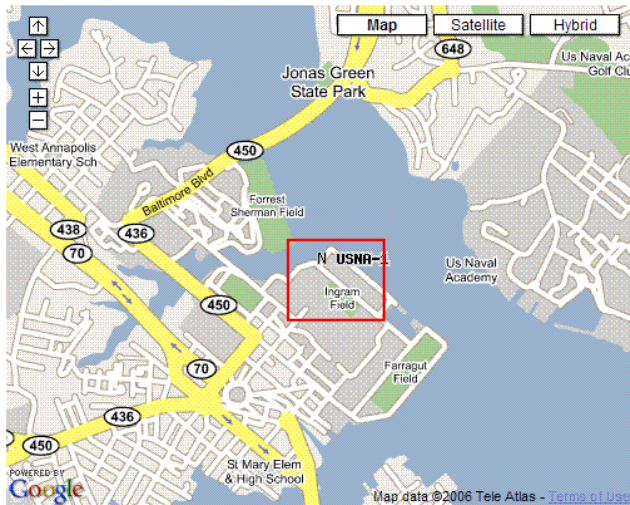


During the March 2006 joint PC1<=>PC2 operations period, numerous dual hop telemetry and user packets were observed. This telemetry packet from PCSAT2 is just about as far as we can get with satellite-to-satellite-to USNA. Notice how few European or USA users were in the footprint making it more probable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

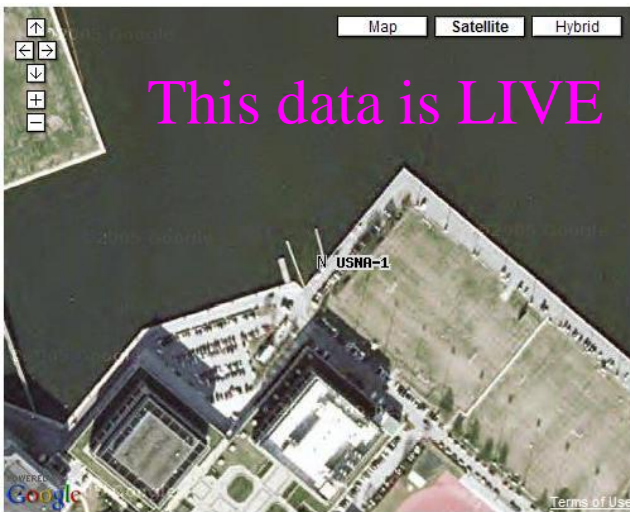
Prototype Psat Buoy Data



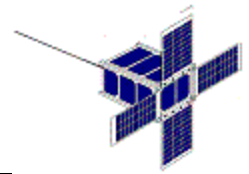
Google for "USNA Buoy" Select USNA-1



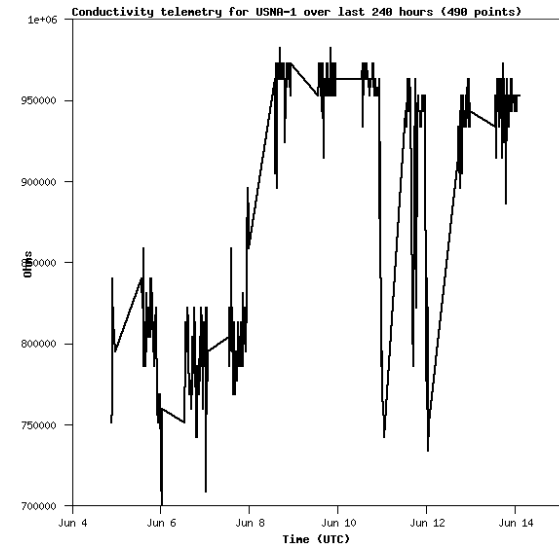
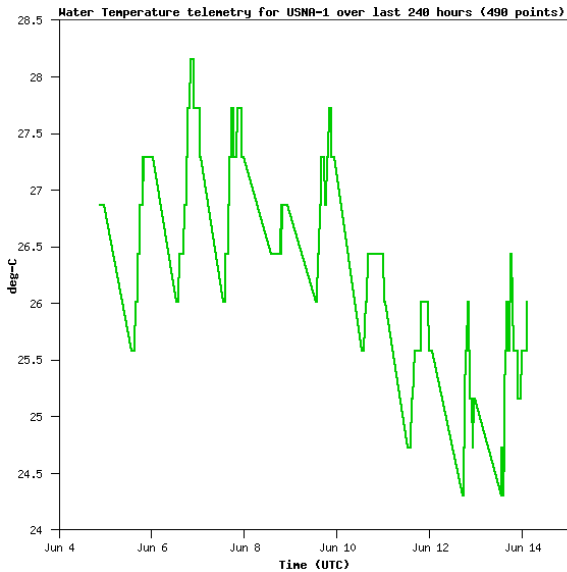
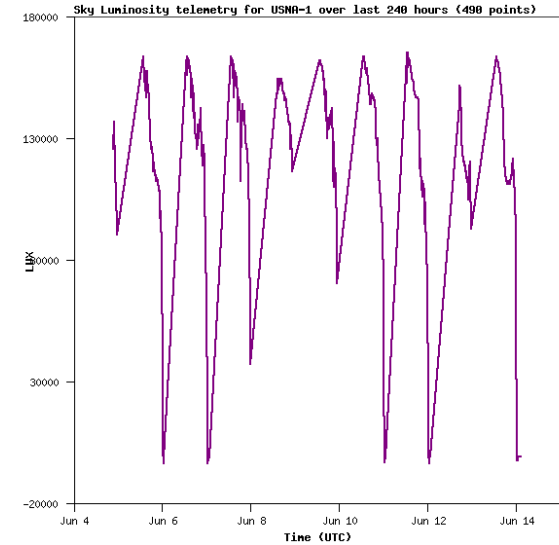
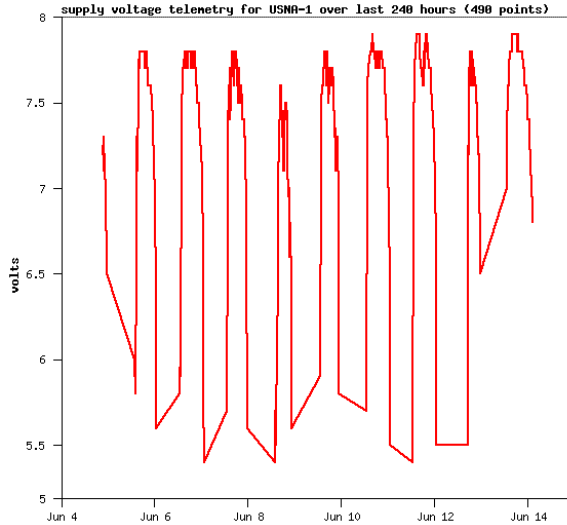
Buoy-4 came "home"



Prototype Buoy Data



Telemetry captured
decoded and displayed
automatically on line!



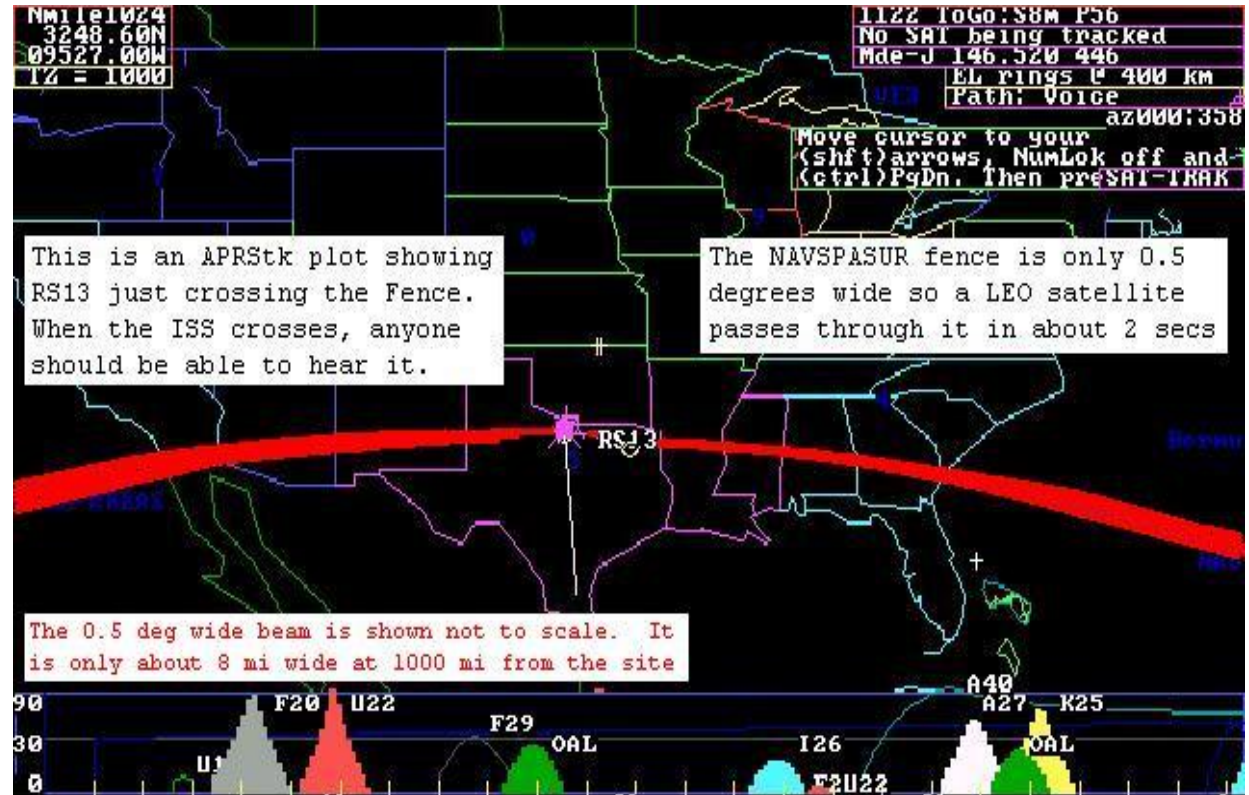
Global Volunteer

Groundstations

feed live downlink into Internet



Other Aux Payload? - NSSS Radar Fence Detector



Flew in 2007 on USNA RAFT cubesat

XP-217 Radar Fence Detector

- On Orbit - Self locating – receiver
- A very small receiver for detecting the NSSS Radar Fence
- 4 cm x 6 cm x 0.5 cm (12 cu.cm)
- 8 milliwatts

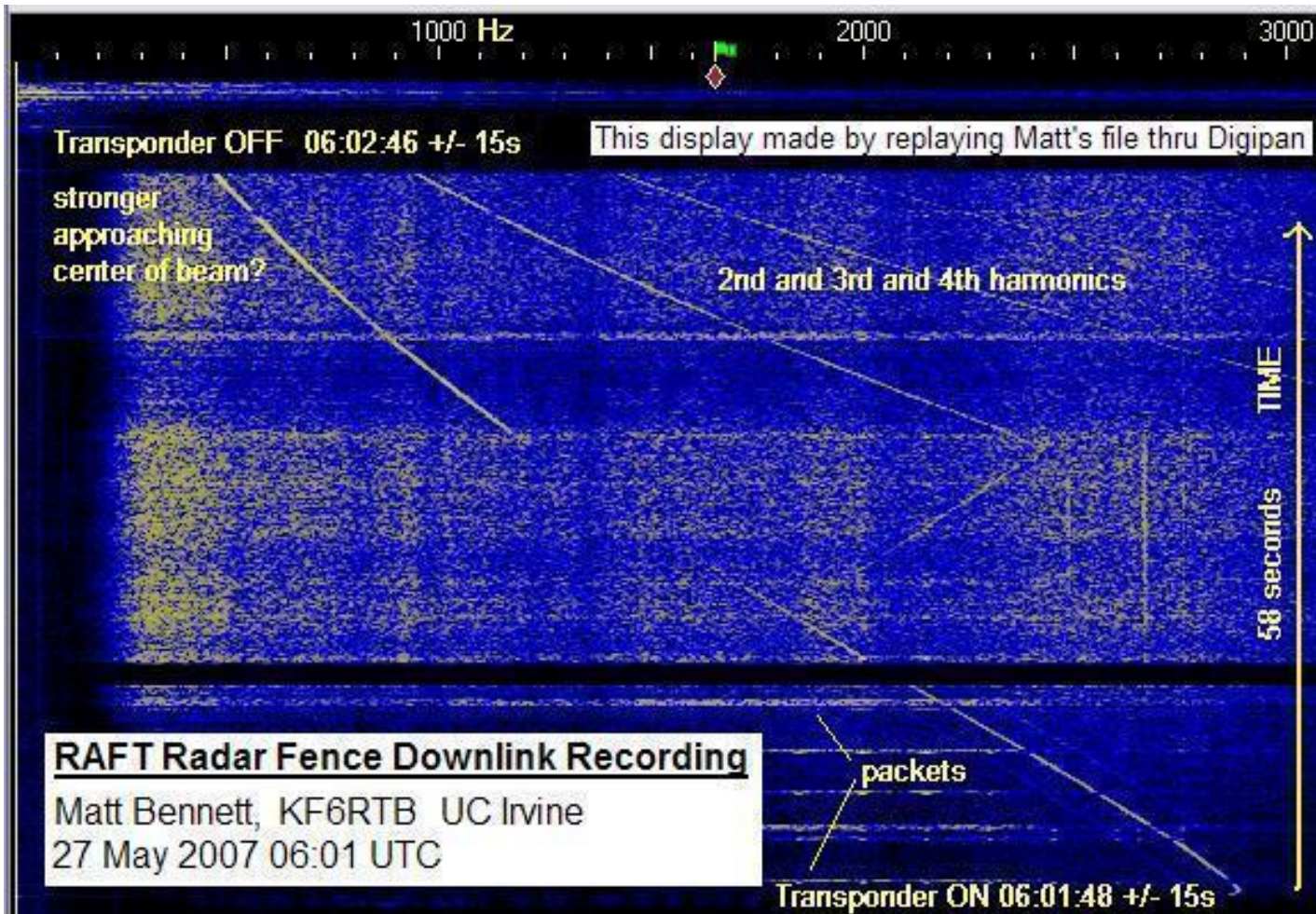


Small Size! Could help locate Falconsat



SPASUR Fence Detection

- RAFT designed to detect the Fence ([Doppler tracking](#))
- Report radar Doppler and fence crossing to ground



Other Aux Payload? UHF Military Affiliate Radio System

Make Satellite match assets rather than \$\$\$ satcom for each



The Yard Patrol Craft

105' length
Crew of about 25
Quantity 20



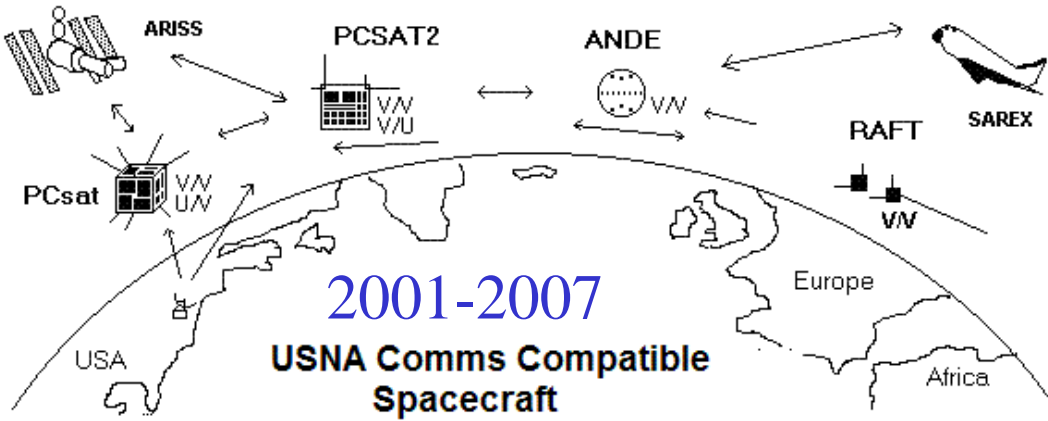
YP COMMS EQUIPMENT

- Tactical UHF (uplink)
- Harris HF Xcvr (downlink)

Unique UHF AM Uplink and HF SSB downlink

Can be used by any existing military vehicle

Questions?



2006



2007

2008

