ParkinsonSAT Remote Data Relay (Psat)
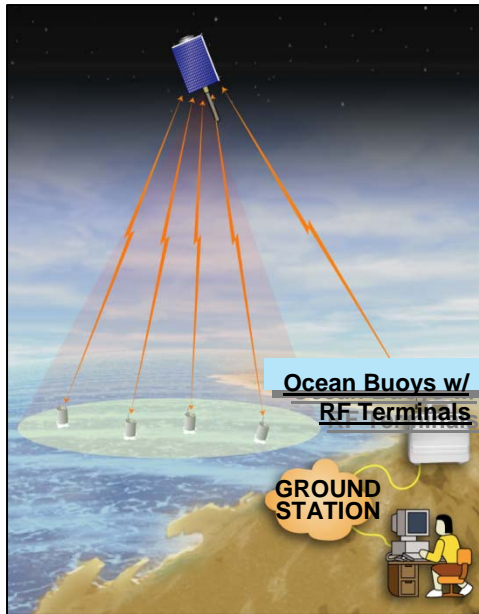
Cubesat Conference
August 2010

Psat

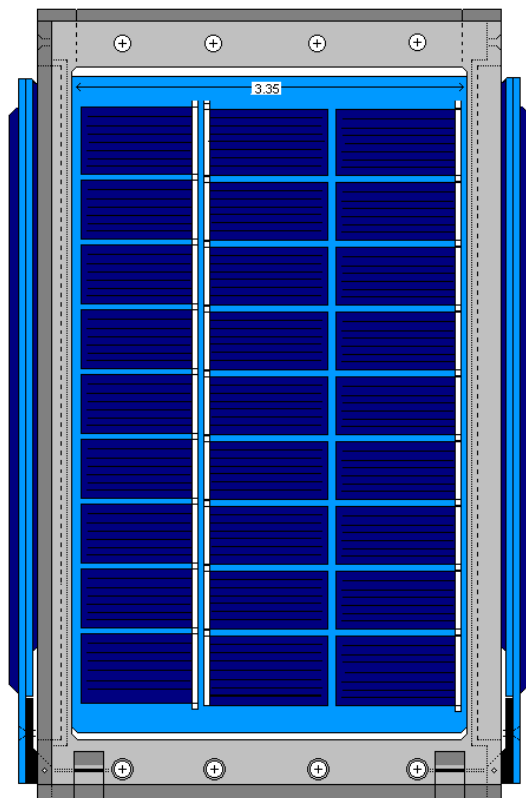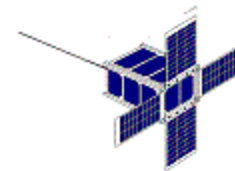Ocean Buoys w/ RF Terminals

GROUND STATION

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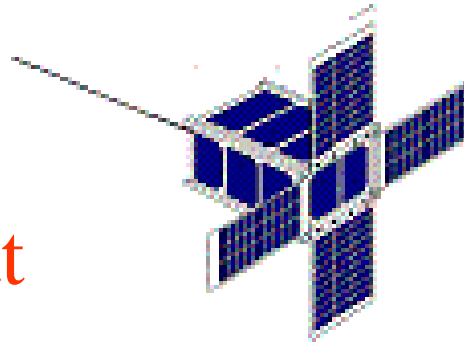
Bob Bruninga
Midns: Crawford, Guilfoyle,
Lumsden,Randall,Pollock,Schlottmann

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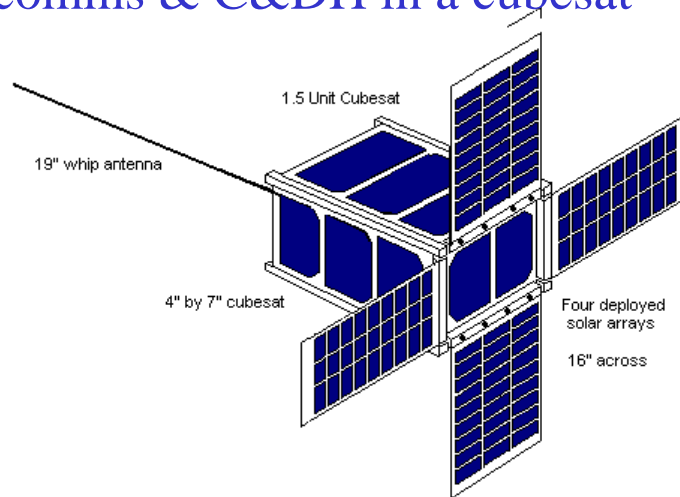*410-293-6417*
bruninga@usna.edu

RICKOVER HALL
FIRST FLOOR

UNCLASS

ParkinsonSAT 1.5u CUBESAT

Psat Xponder can also serve as complete comms & C&DH in a cubesat
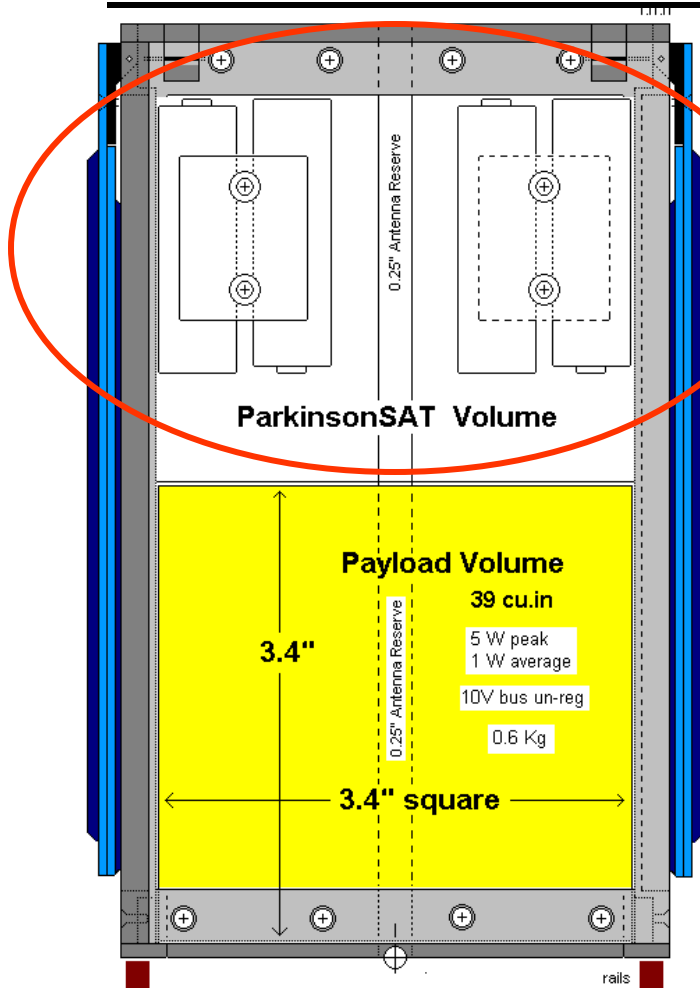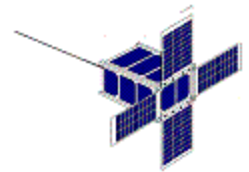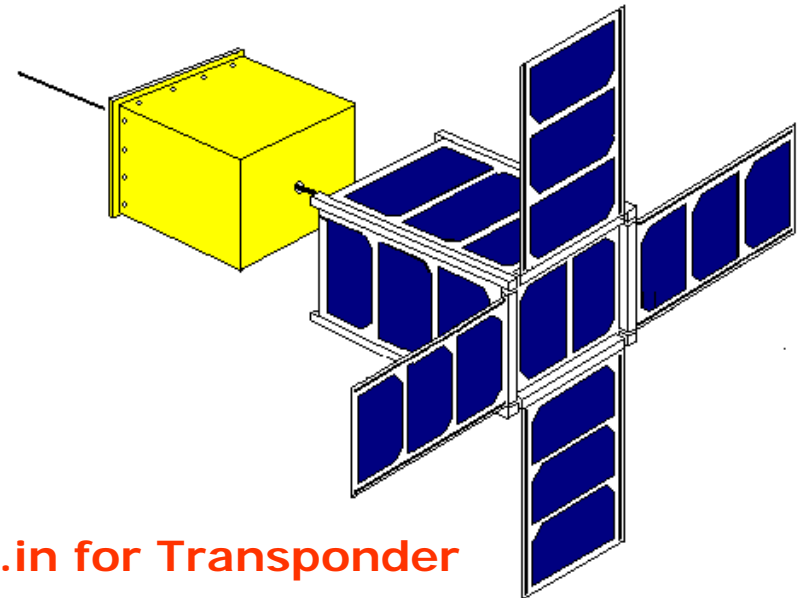
7"

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

2010 Navy SERB

Vandegriff

2

Psat Transponder   Aux Payload

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

0.25" Antenna Reserve

ParkinsonSAT Volume

Payload Volume

39 cu.in

5 W peak
1 W average

10V bus un-reg

0.6 Kg

3.4"

0.25" Antenna Reserve

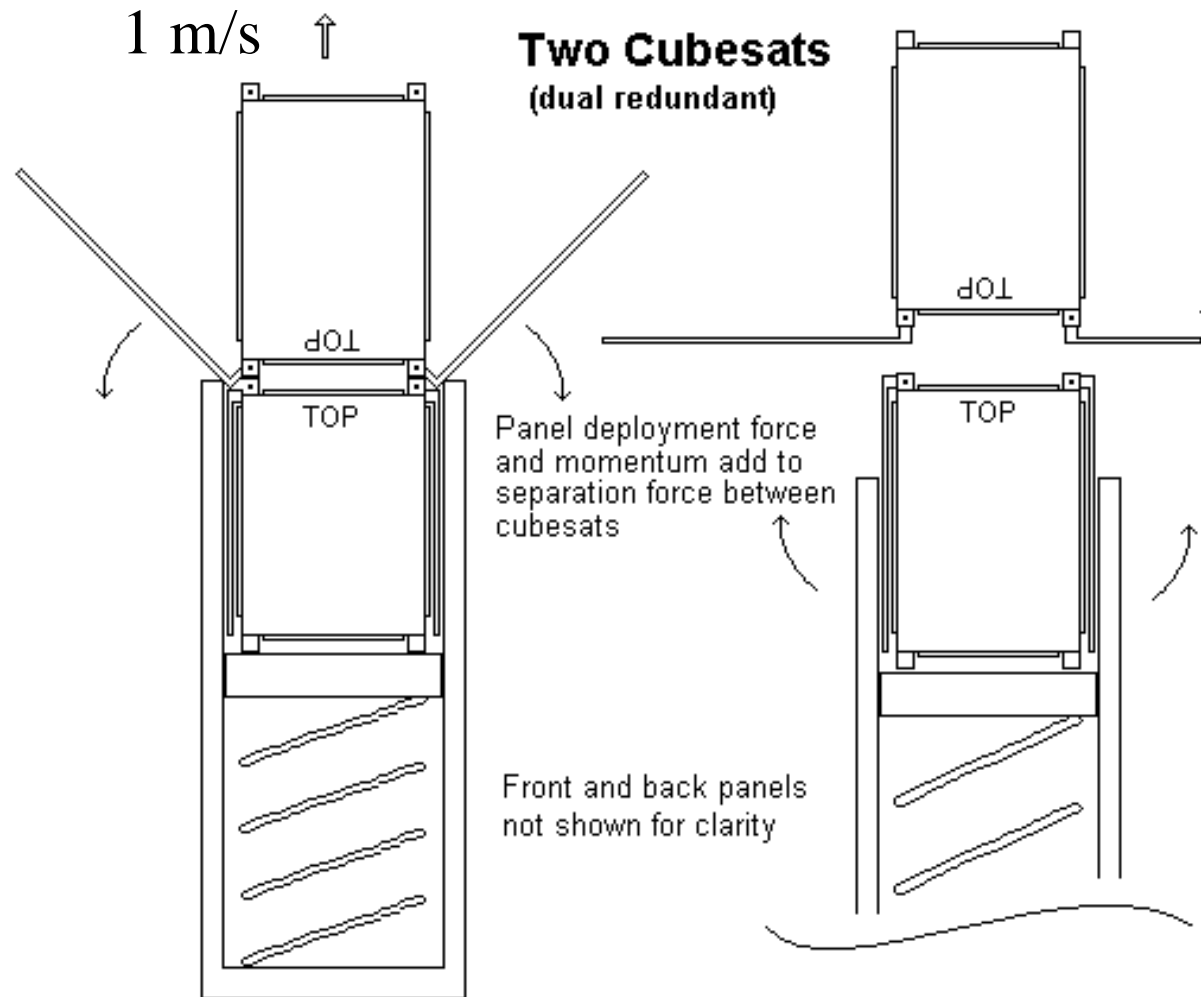**3.4" square**

rails

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

2010 Navy SERB

Vandegriff

Psat Structure

2010 Navy SERB

CUBESAT Deployment

1 m/s ⬆

Two Cubesats
(dual redundant)

TOP

TOP

TOP

TOP

Panel deployment force and momentum add to separation force between cubesats

Front and back panels not shown for clarity

2010 Navy SERB

Vandegriff
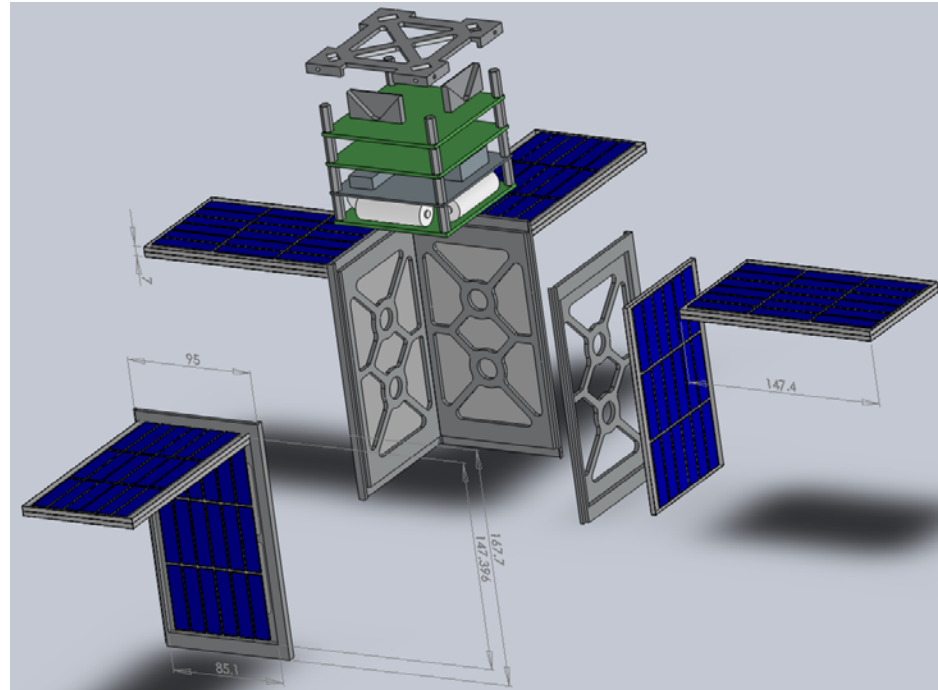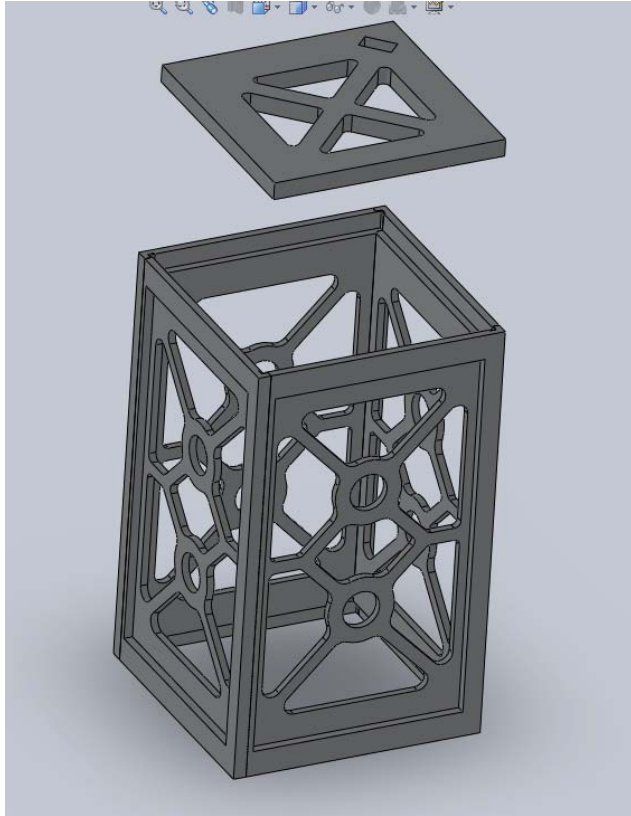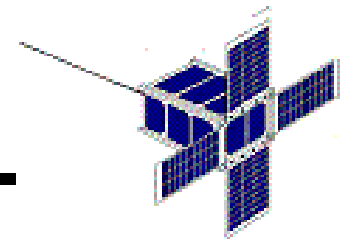
Sun Pointing Attitude Control System

Sensors/ Magneto | http://www.sparkfun.com/commerce/product_info.php?products_id=244
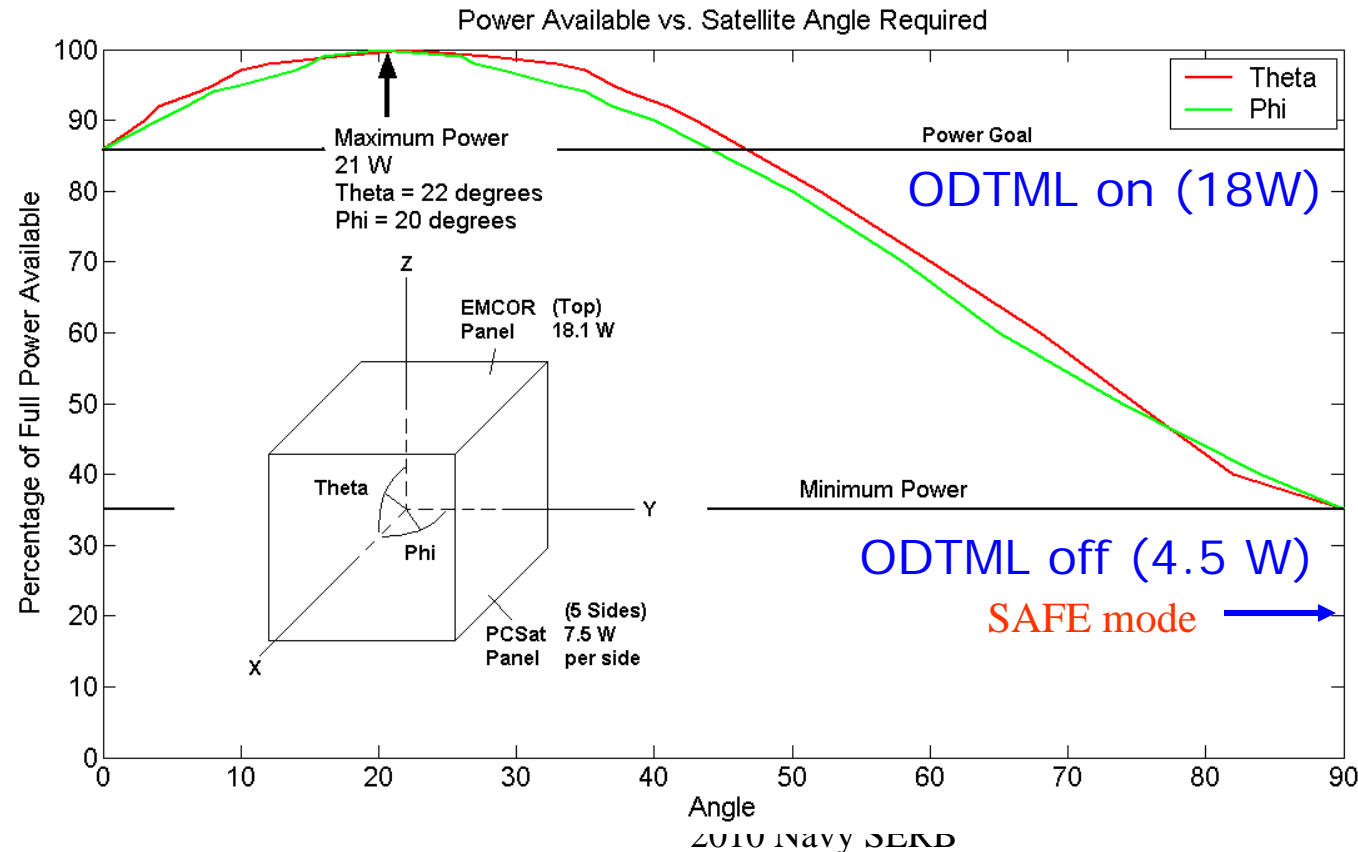
MicroMag 3-Axis Magnetometer
SKU#: Sense-Mag3   Price: $54.95

Description: PNI Corp's 3-axis magnetometer.
Ready for the big time? Low noise, large resolution
magnetic field sensing all packed into a user-
friendly DIP module at your disposal. Stable over a
wide temperature range, the MicroMag3 is a must
have for orientation sensing and navigation.

Features:
- 500uA @ 3.3V DC
- Field measurement range +/-1100uT
- Resolution as low as 0.015uT
- SPI interface - no additional circuitry needed

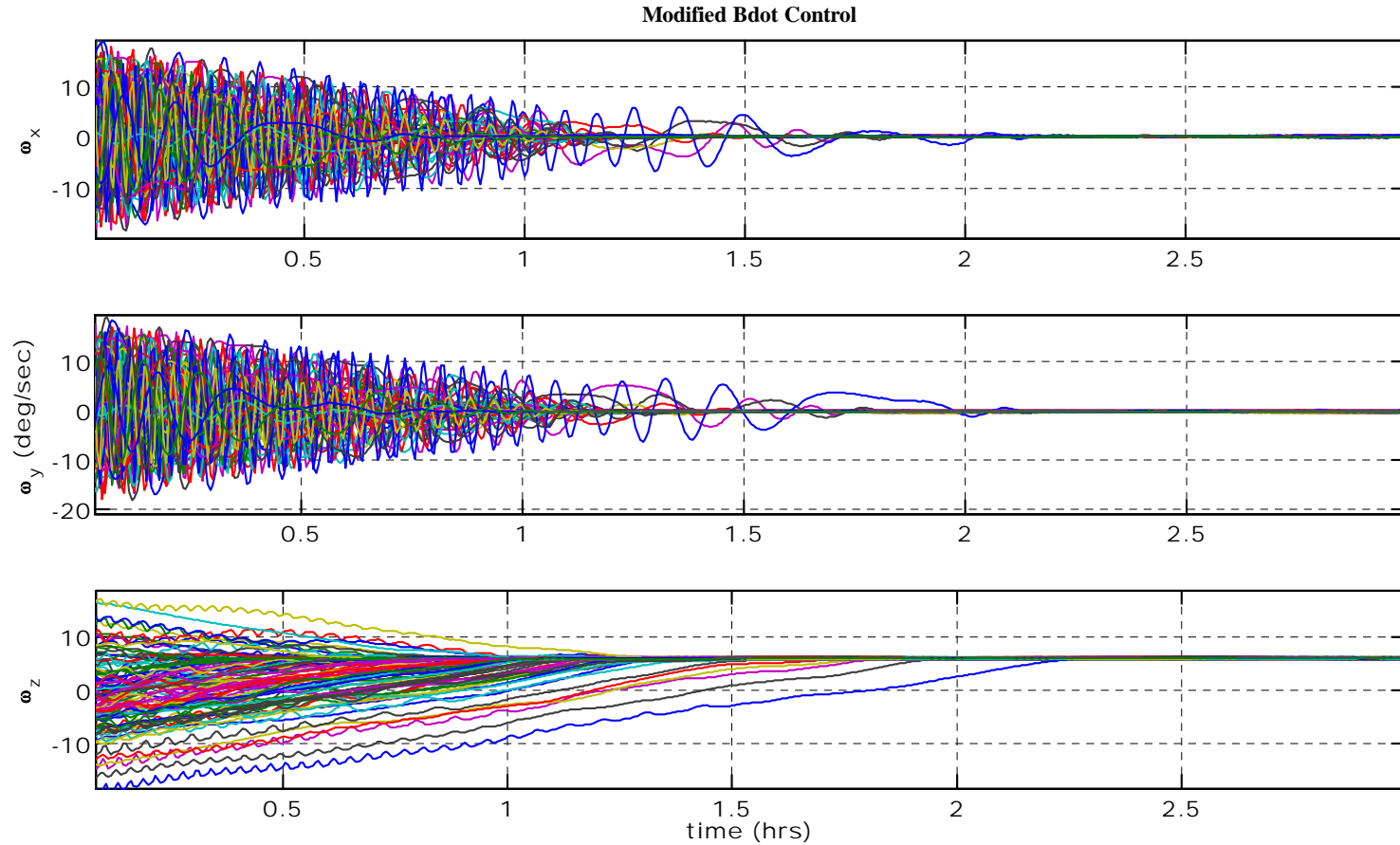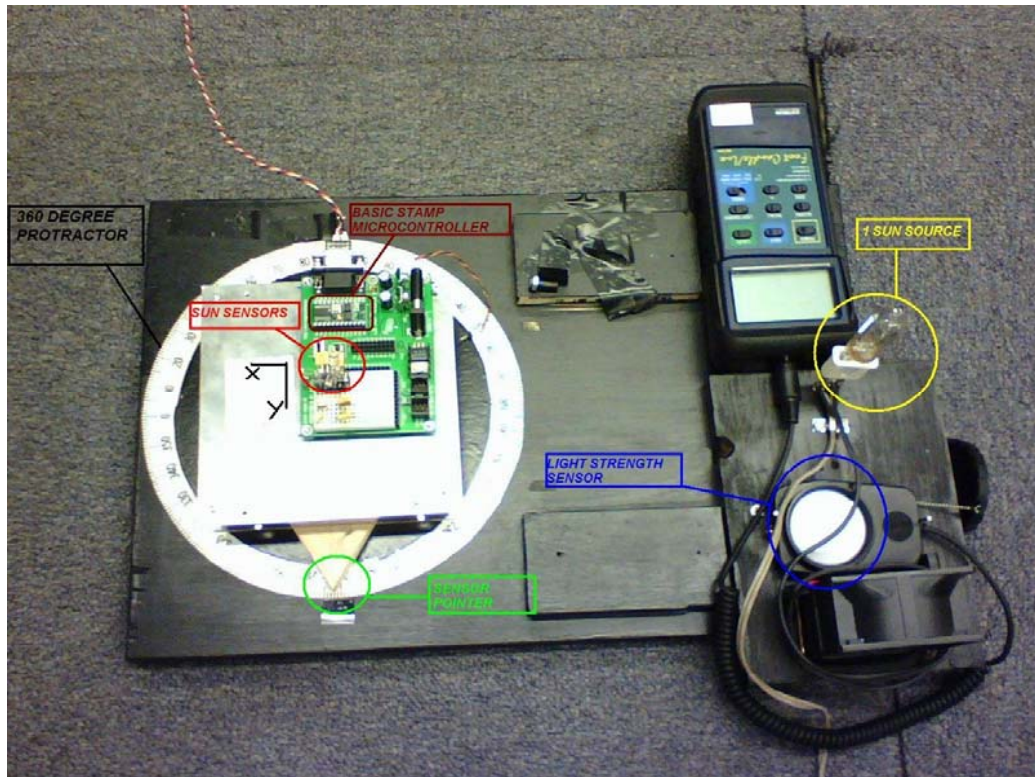✓ Pointing requirements are relaxed +/- 40 deg

✓ High precision attitude control not required

Power Available vs. Satellite Angle Required

Cubesat

3.5W

1.5W

ODTML on (18W)

ODTML off (4.5 W)

SAFE mode

Maximum Power
21 W
Theta = 22 degrees
Phi = 20 degrees

EMCOR (Top)
Panel   18.1 W

PCSat 7.5 W
Panel per side
(5 Sides)

Power Goal

Minimum Power

Theta

Phi

Matlab Simulation of Modified B*dot

2010 Navy SERB

Sun Sensor & ADCSTesting

16' string
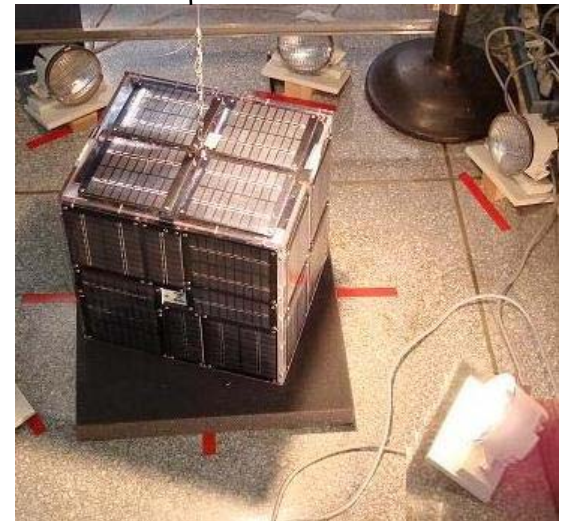
2010 Navy SERB
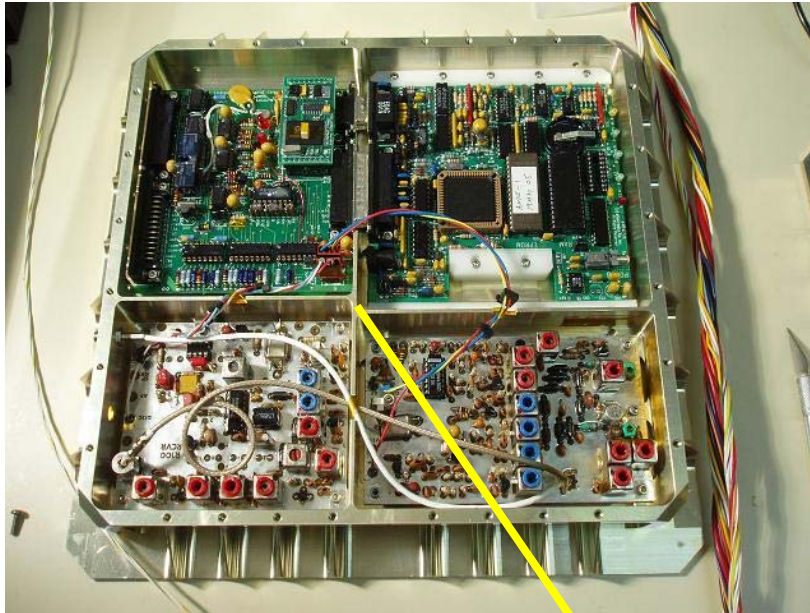
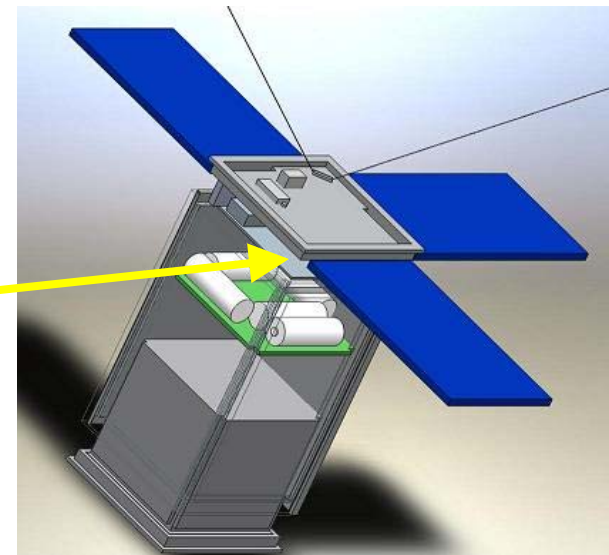# Huge reduction from transponders on PCSAT's 1,2, ANDE and RAFT missions
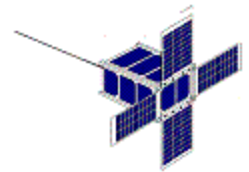

Earlier reductions to 5" cubesat on RAFT (2006)

4:1

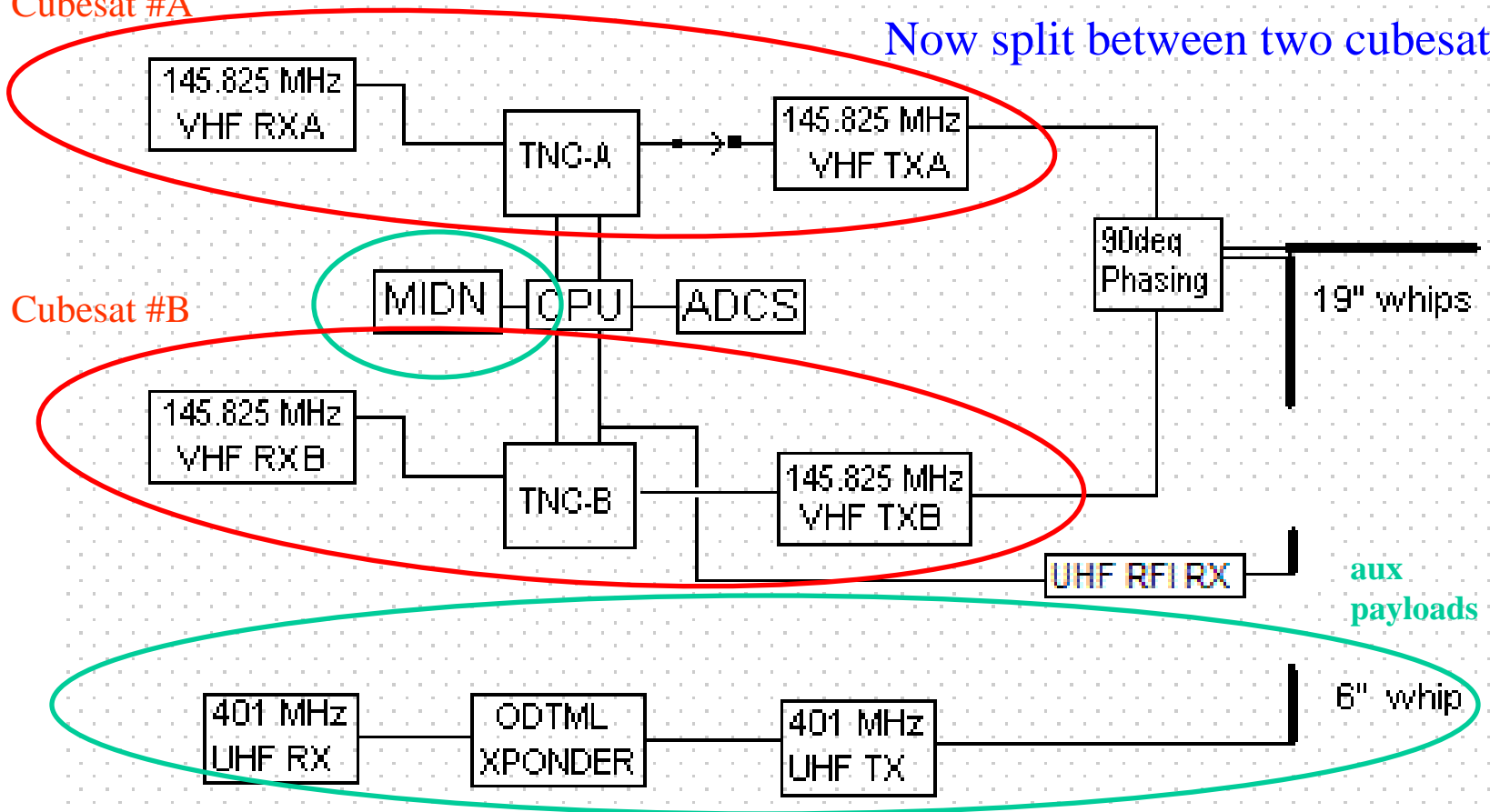Now reduced 18:1 in volume/mass for 4" cubesat 2009

2010 Navy SERB

USNA Transponder Block Diagram

Cubesat #A

Now split between two cubesats

Cubesat #B

| 145.825 MHz VHF RXA |
| TNC-A |
| 145.825 MHz VHF TXA |
| MIDN | CPU | ADCS |
| 90deg Phasing |
| 19" whips |
| 145.825 MHz VHF RXB |
| TNC-B |
| 145.825 MHz VHF TXB |
| UHF RFI RX |

aux payloads

6" whip

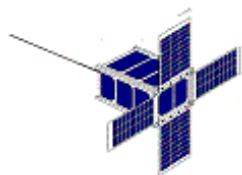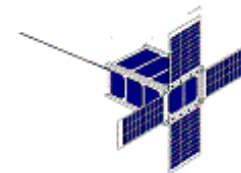| 401 MHz UHF RX | ODTML XPONDER | 401 MHz UHF TX |

2010 Navy SERB

Psat (USNA-0601)
Operational Concept Graphic (OV-1)

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

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

30 Nov 2001   de WB4APR

Education

Force

Multiplier!

2010 Navy SERB

Psat Xponder Mission (Remote Data Relay)
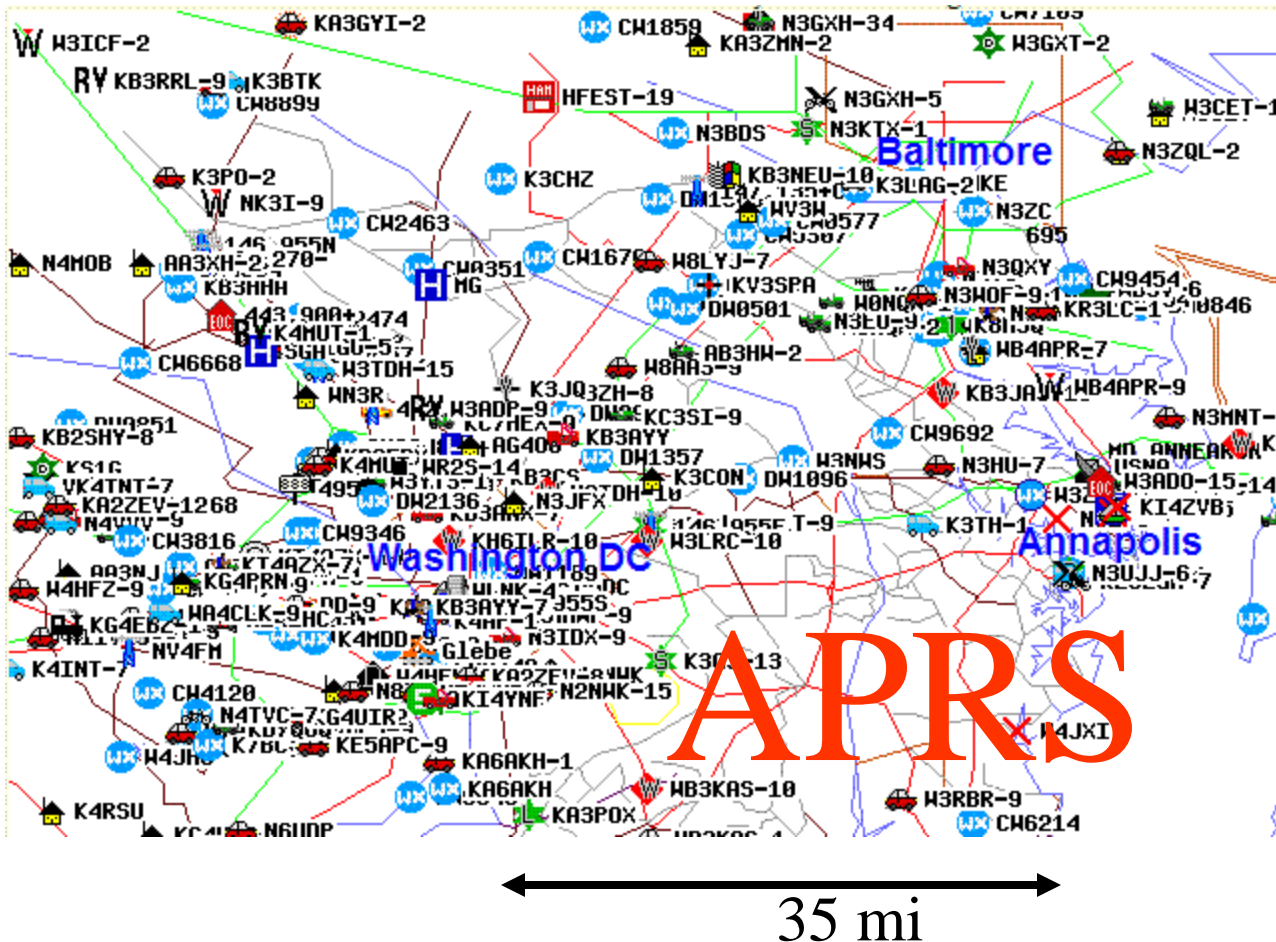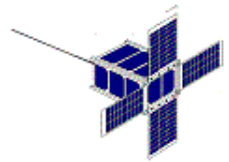
FOCUS:

"Network

Centric"

&

Remote Sensor Experiments

300 stations
In 35 miles

35 mi

APRS

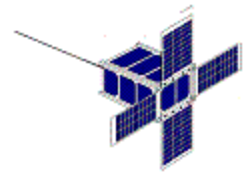**Find any station - http://map.findu.com/WB4APR***

Example Situational Awareness (in SLC Utah)

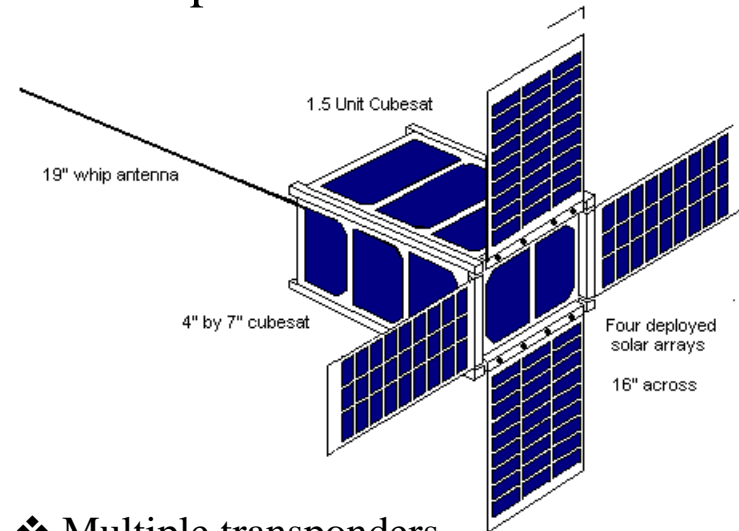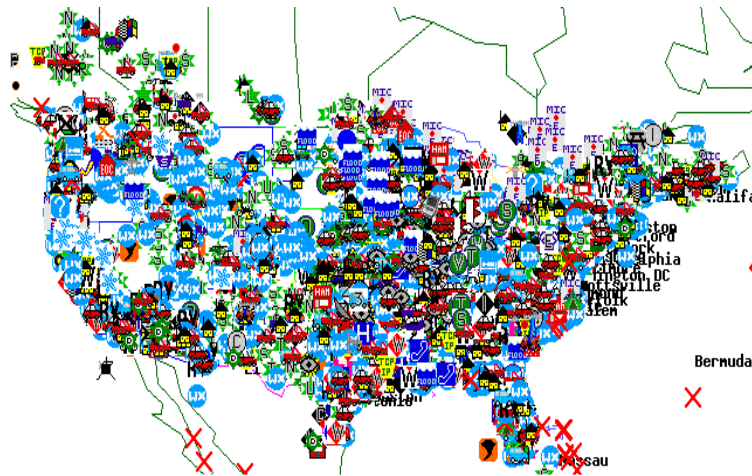**27 users in S.L.C**

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.

THE MARS SOCIETY

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

1.5 Unit Cubesat

19" whip antenna
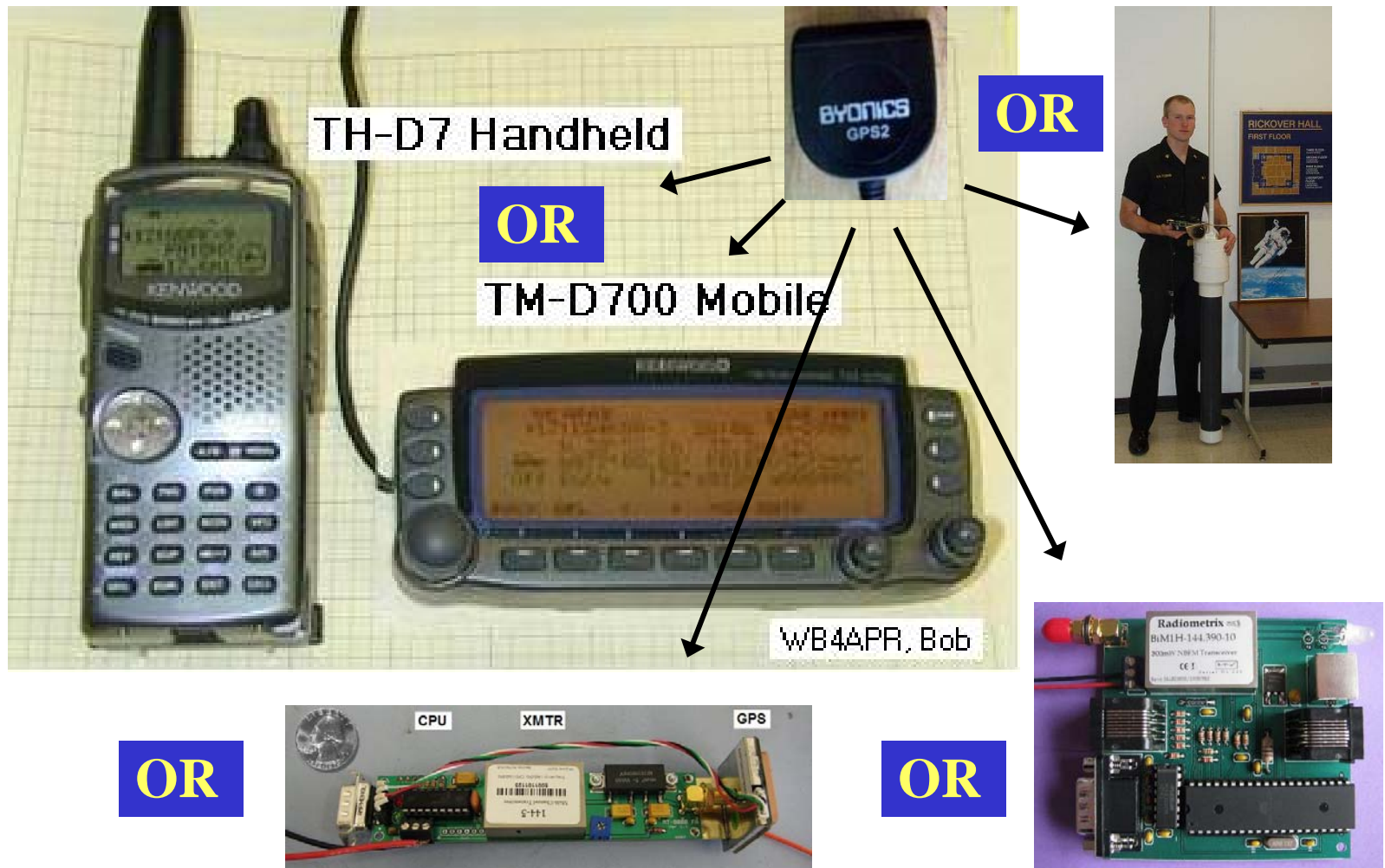
4" by 7" cubesat

Four deployed
solar arrays

16" across

❖ 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.

2010 Navy SERB

Ground Terminal Applications Focus

Supports Student Experimenters world wide

TH-D7 Handheld

OR

OR

TM-D700 Mobile

WB4APR, Bob

CPU   XMTR   GPS

OR

OR

Small Platform Minimum Satcom (SPMS) Background

Ground Terminal is Walkie-Talkie, and Palm Pilot

PCsat Afloat Operations Test

CDR	Chas Richards	W4HFZ (CO)
LTjg	Brian Young	KC5KLE
ETCS	Curtis Mathews	N1FDW
ENS	Brian Scrabek	PCsat design team

TH-D7 APRS HT

PalmPilot Satellite Tracking

"When you have *no comms*, 1200 baud text/data is great!"

CAPT Chas Richard

USS Parche   SSN-683

2010 Navy SERB

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

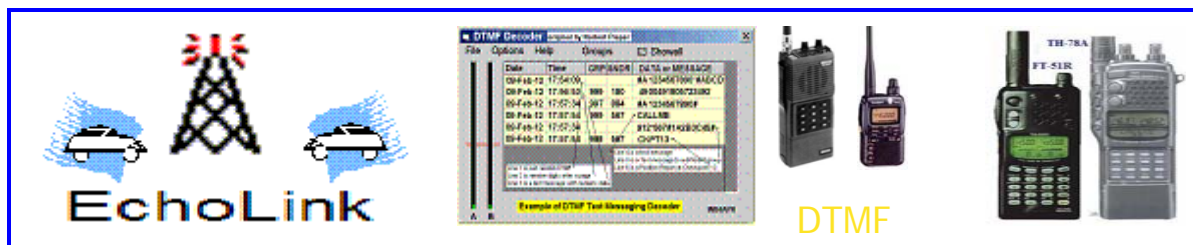| Call	callbook	msg	wx	lat	lon	distance	direction	Last Position
WB4APR-9	**	**		39.00000	-76.50000	0.0		00:06:02:46
VA3ADG	**	.	.	38.99717	-76.50450	0.3	SW	05:22:10:17
WB4APR-1	**	**	.	38.99033	-76.49850	0.6	S	00:00:11:28
WE4APR-9	**	.	.	38.98667	-76.49283	0.9	SE	00:03:23:42
WB4APR-3	**	**	.	38.98500	-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

cell

wireless

APRS

TM-D700

DJ-135

TH-D7

HAMHUD

TM-D710

VX-8R

The OLPC

XO

EchoLink
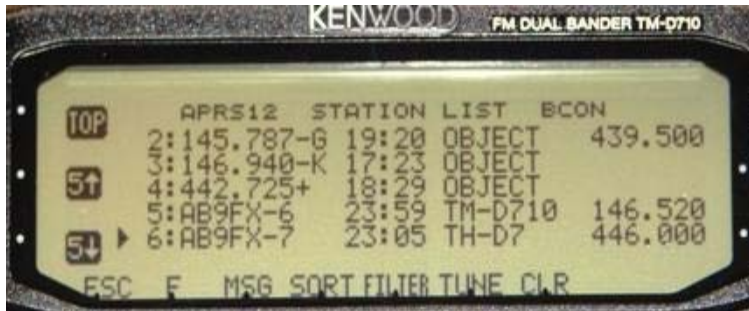
DTMF

WINLINK 2000
Global Radio Email System

Send/RX anytime, anywhere, any device by callsign

26 separate systems!
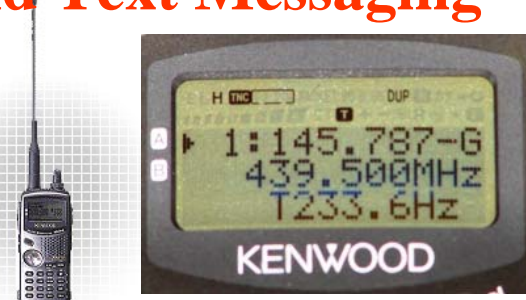
Ground Terminal Applications Focus

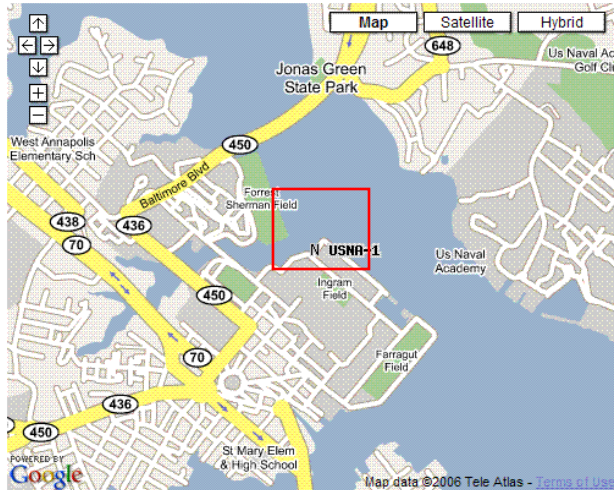## Tactical Situational Awareness and Text Messaging

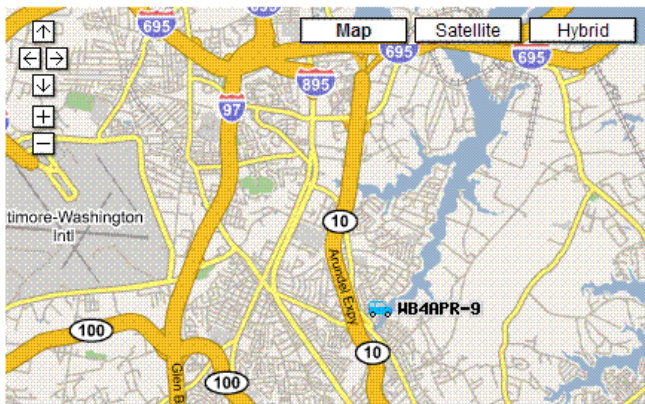Last 100 stations!

Direction & Distance

Frequency and Tone

"Purple Force" Tracking

Map.findu.com/wb4apr*
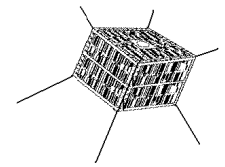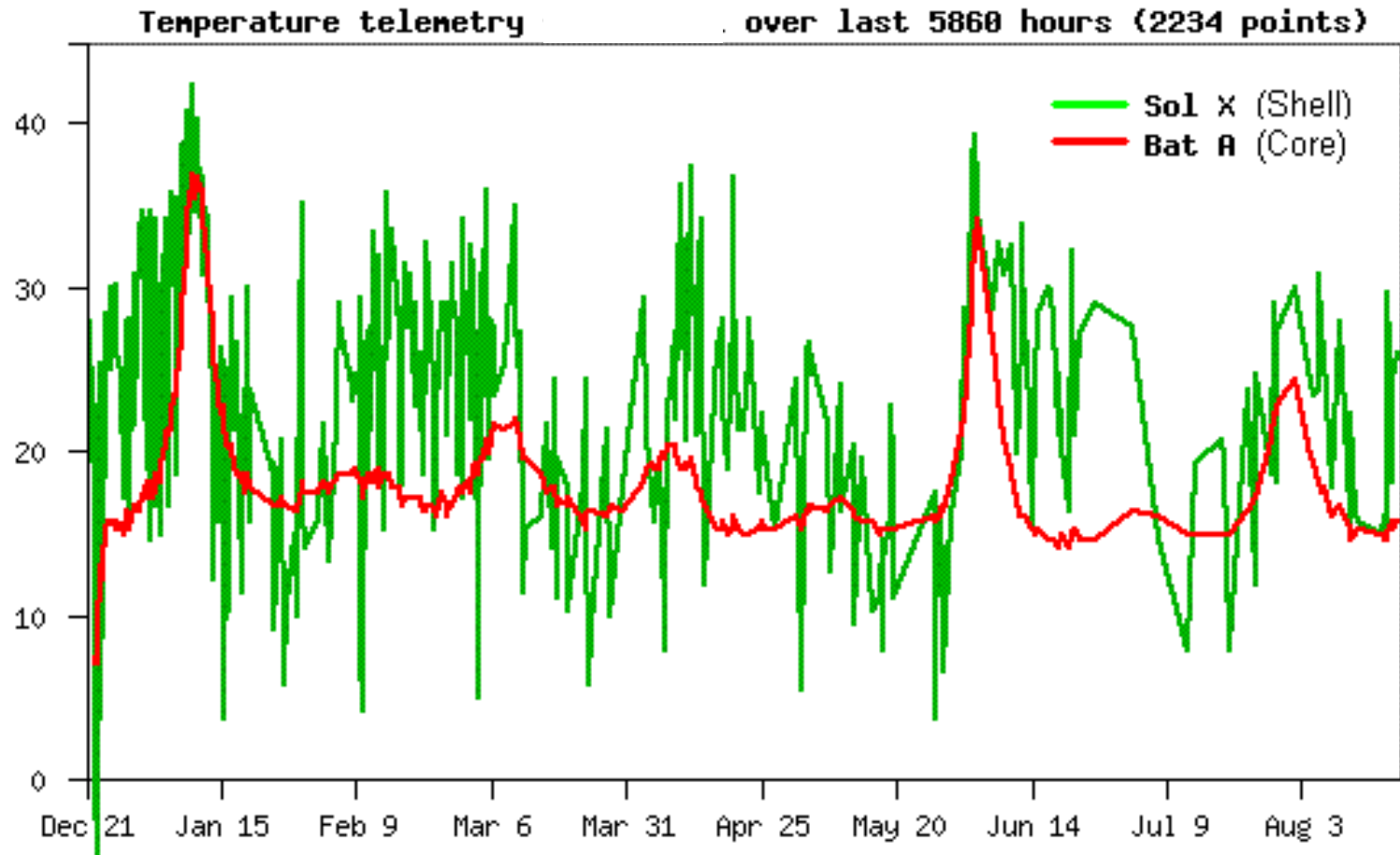
Map.findu.com/wb4apr*

Tactical situational awareness
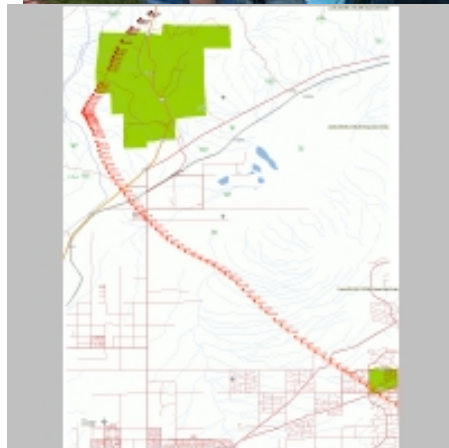
Findu.com Telemetry Plots

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

Example Remote Sensors using APRS Protocol

Very Simple

APRS transmitter

GPS
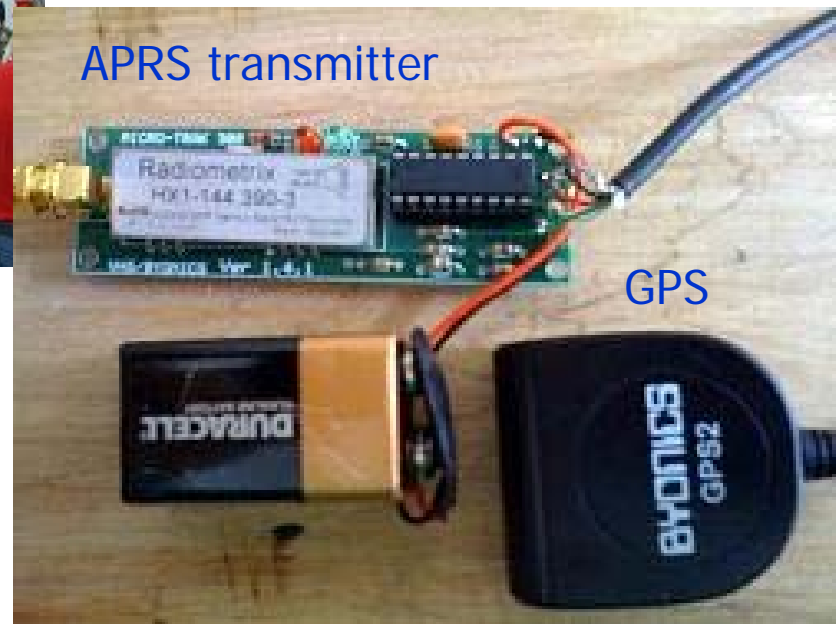
Based on the USNA Automatic Packet Reporting System

Sensor Buoy Baseline (prototype)
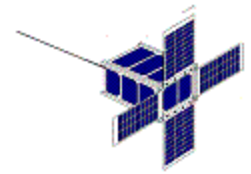
Naval Academy Student Project

* 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

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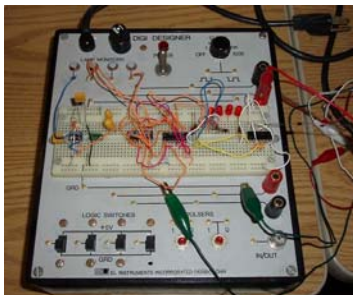
See Buoy Location and Telemetry at
http://www.ew.unsa.edu/~bruninga/buoy4.html

Piggrem

DOD Synergy with Educational Experimenters

Based on the USNA Automatic Packet Reporting System

APRS Data Experiment in F-16 Aircraft

GPS antenna

Palm Pilot APRS display running PalmAPRS

Rome Air Development Center

•Typical Low Cost Experiment

"Purple Force" Tracking

Map.findu.com/w3ado*

Tactical situational awareness

Photo by Dave Dobbins K7GPS

15-22 May 2004
Track of Allan's Ercoupe and the
USNA's W3ADO-11 APRS tracker
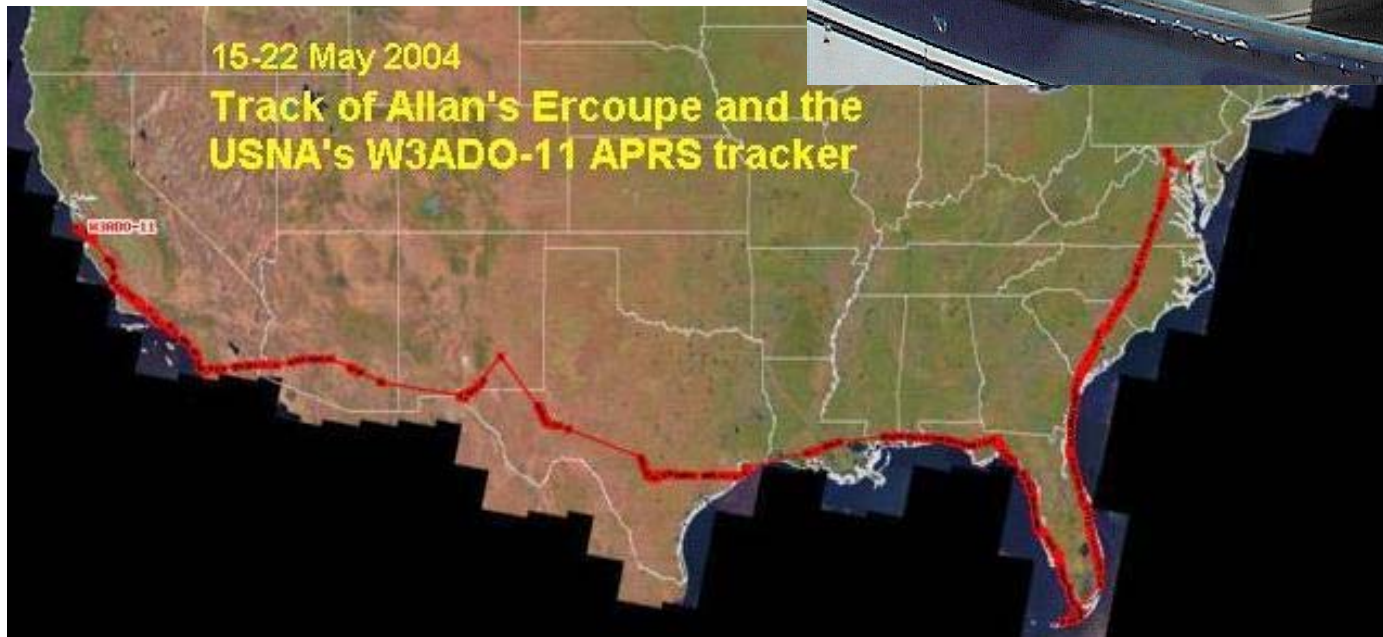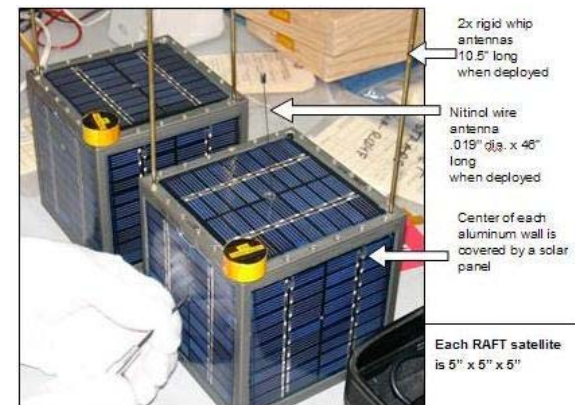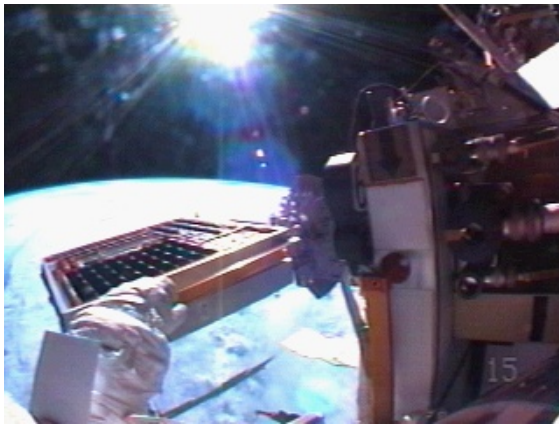
APRS (Psat Transponders) in Space

- 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

Obj# 29664

2x rigid whip antennas 10.5" long when deployed

Nitinol wire antenna .019" dia. x 46" 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
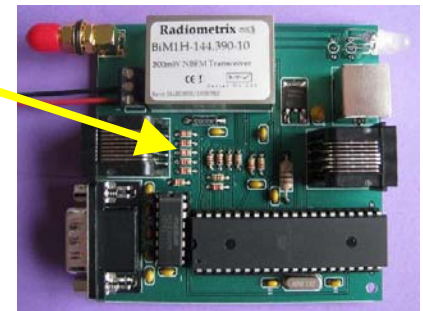
Mission: Remote Data Relay, Data Exfiltration, Remote Sensor Relay

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

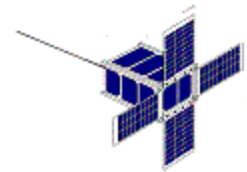**Power:** < 1W orbit average, 5 volts.

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

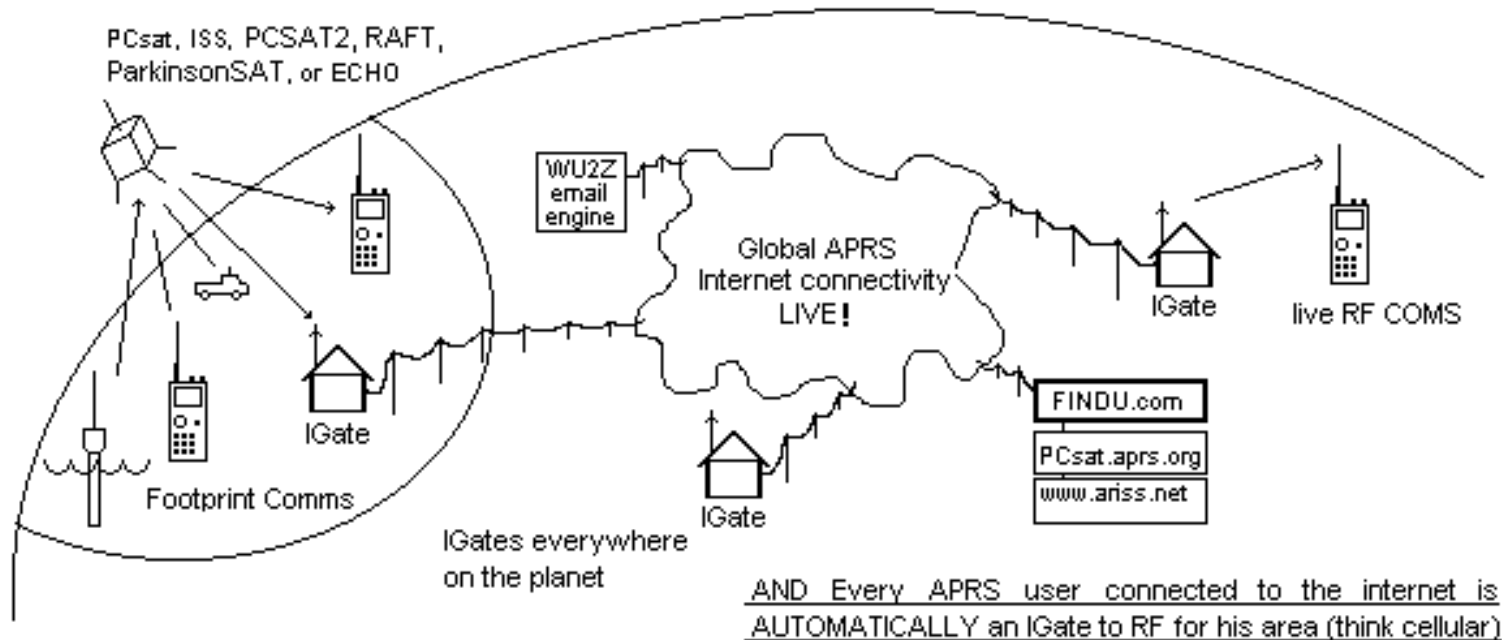**Structure Impact:** Needs 19" thin wire whip antenna (1 cu.in)

Benefit to Spacecraft: High 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.

2010 Navy SERB
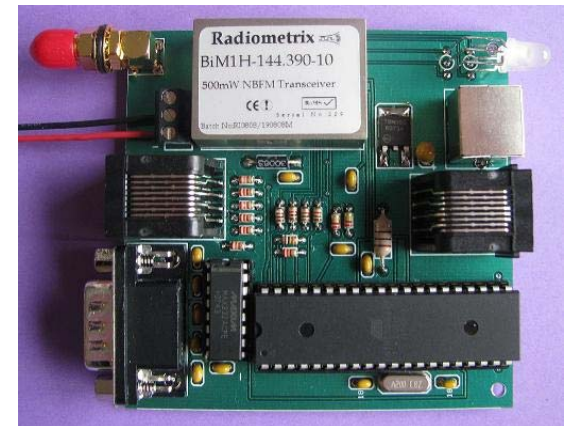
Psat Global Internet linked Comms Network

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

PCsat, ISS, PCSAT2, RAFT, ParkinsonSAT, or ECHO

WU2Z email engine

Global APRS Internet connectivity LIVE!

IGate

live RF COMS

IGate

Footprint Comms

IGates everywhere on the planet

IGate

FINDU.com
PCsat.aprs.org
www.ariss.net

AND Every APRS user connected to the internet is AUTOMATICALLY an IGate to RF for his area (think cellular)

APRS Global Packet Radio Network

Internet Linked for live Communications

Automatic Packet Reporting System

2010 Navy SERB

Psat APRS Network Architecture

IGates World-Wide

Global Volunteer Ground Station Network

Internet Linked for live Telemetry

2010 Navy SERB

Constellation Operation of USNA Satellites

All on 145.825 MHz

ARISS

PCSAT2

ANDE

SAREX

RAFT

V/V
V/U

PCsat

V/V
U/V

V/V

V/V

Europe

USA

- Common VHF/VHF, VHF/UHF, UHF/VHF
- Global connectivity
- Over the Horizon links
- 2, 3 or 4 hops extended range
- Joint operations (4 x 6 or 24 passes per day)
- Continuity of service

Africa
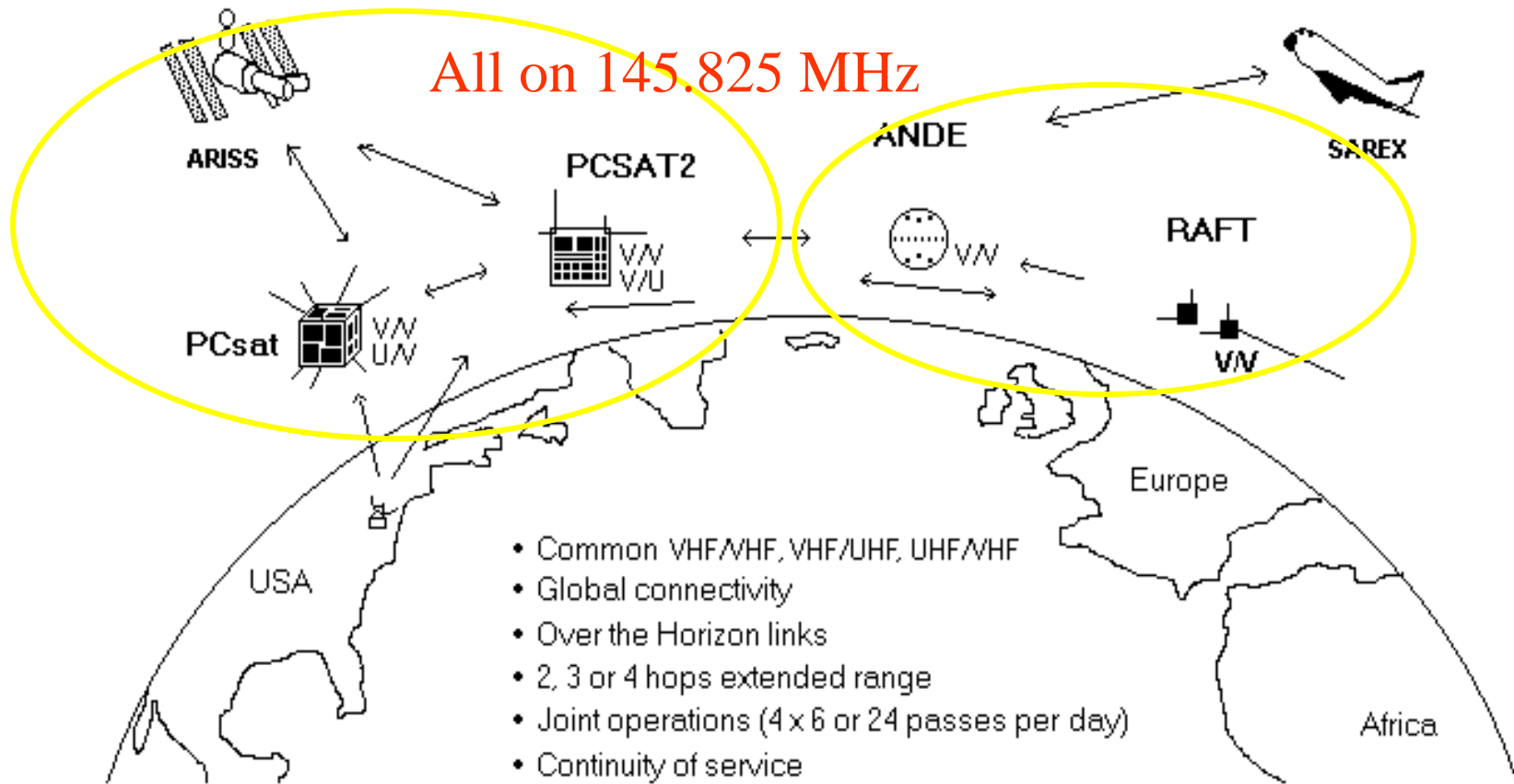
WB4APR

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

2010 Navy SERB

Dual Hop Operations with PCSAT-1 and PCSAT2:
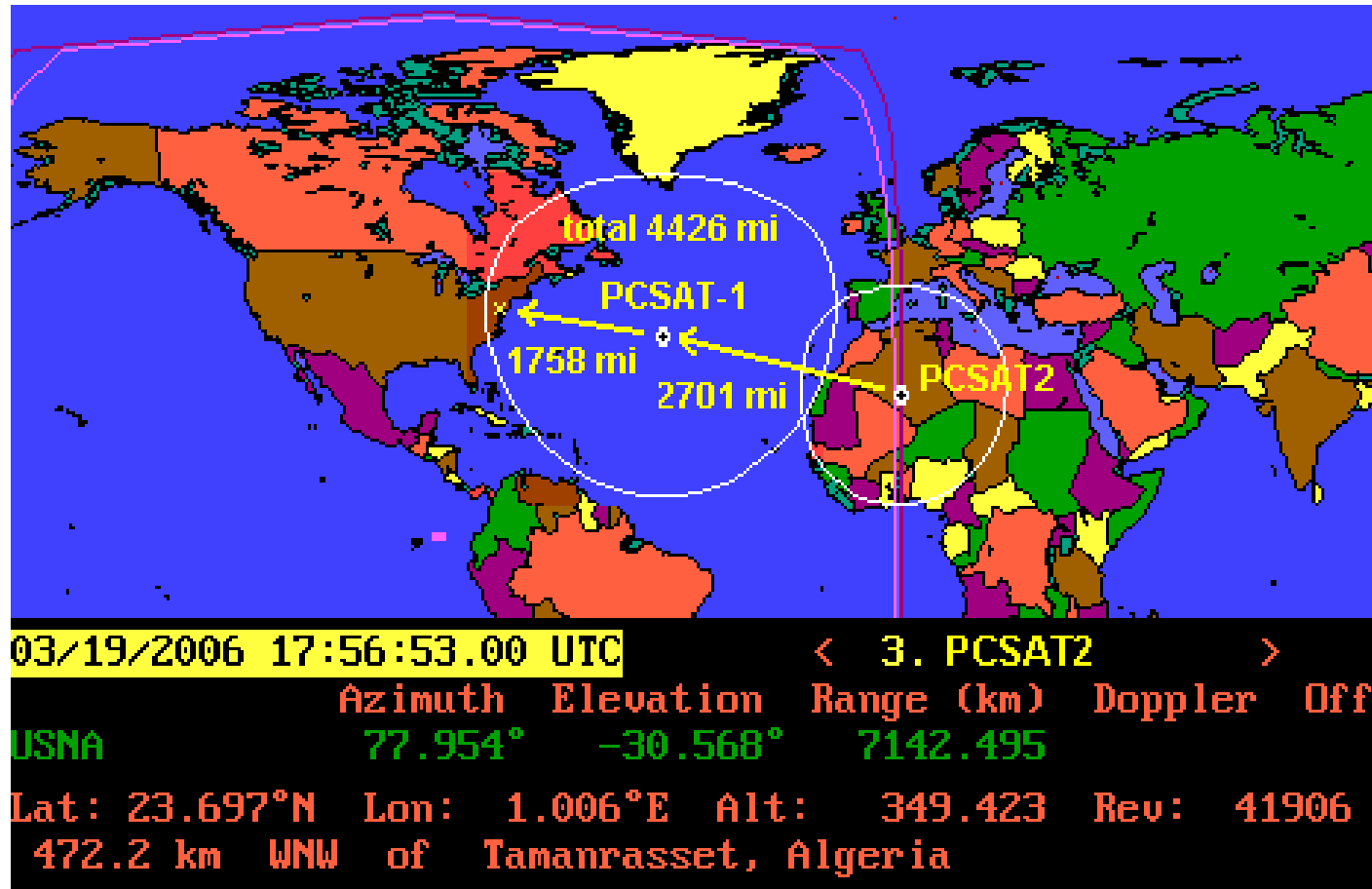
During the March 2006 joint PC1<=>PC2 operations period, numerous dual hop elemetry and user packets were observed. This telemetry packet from PCSAT2 is just about as far as we can get with satellite-to-satellite-to USNA. Notice how few European or USA users were in the footprint making it more probable that PCSAT-1 could hear PCSAT2's signal.   WB4APR
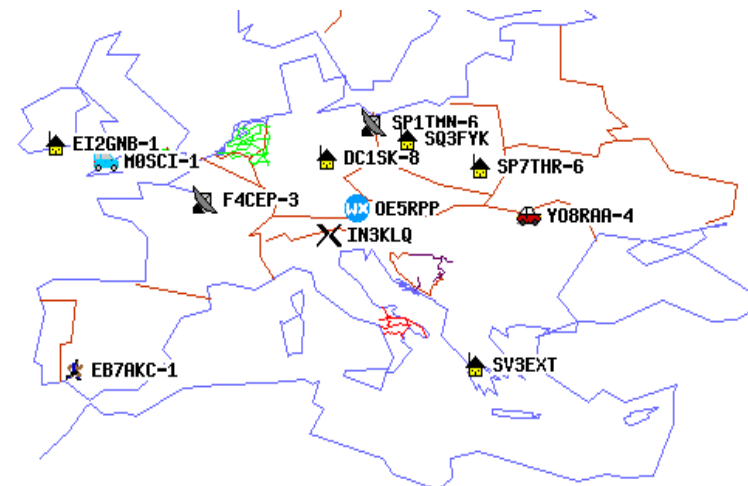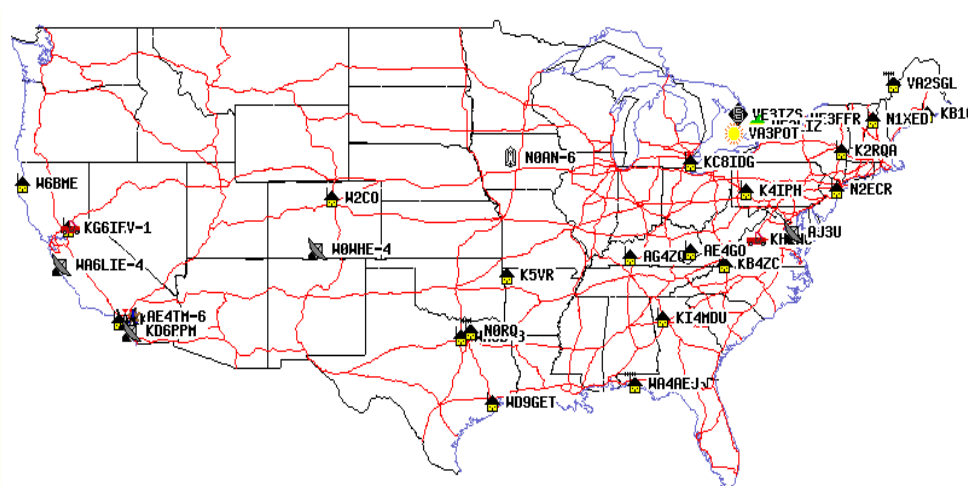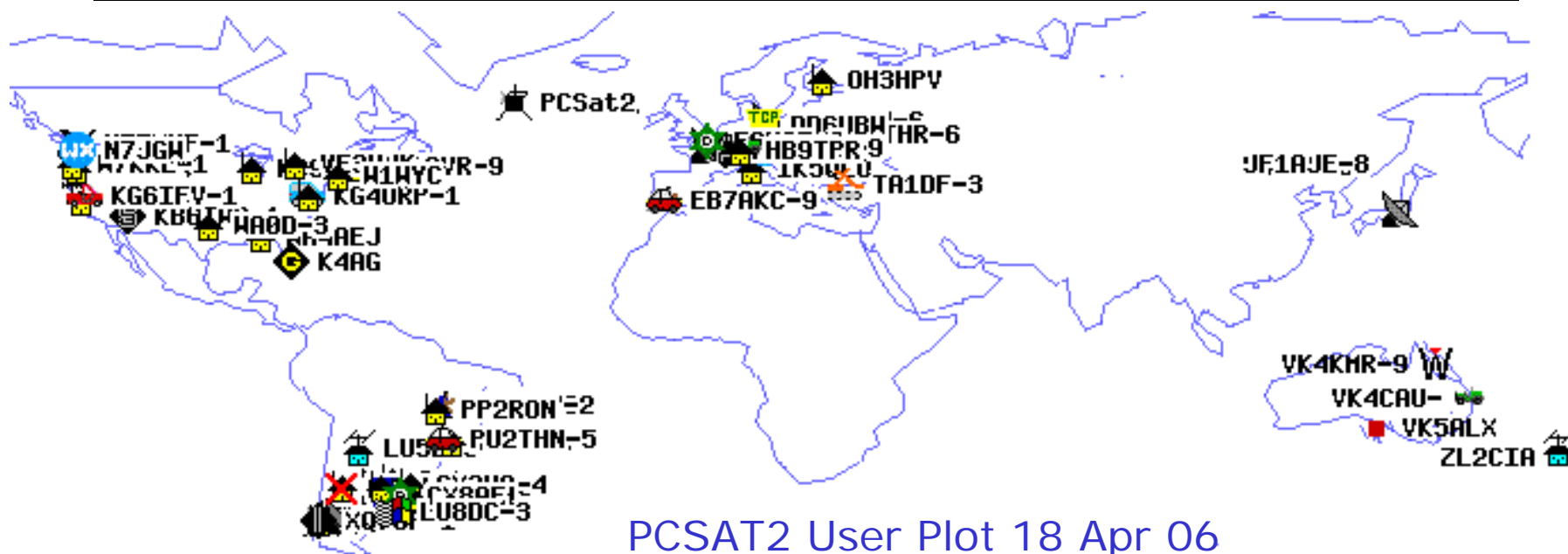
2010 Navy SERB

Dual Satellite 2-hop links

2010 Navy SERB
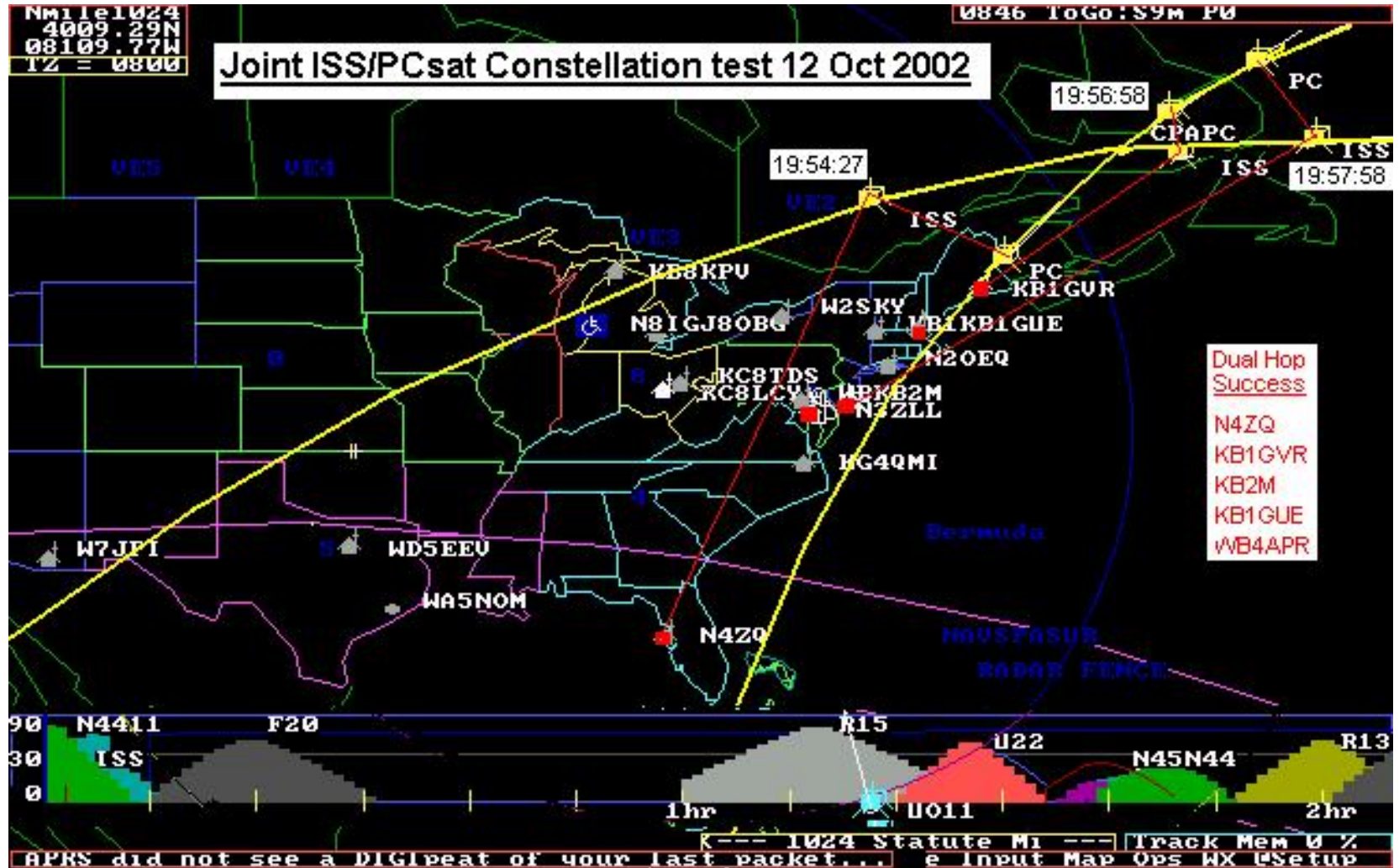
Global Volunteer Groundstations

feed live downlink into Internet
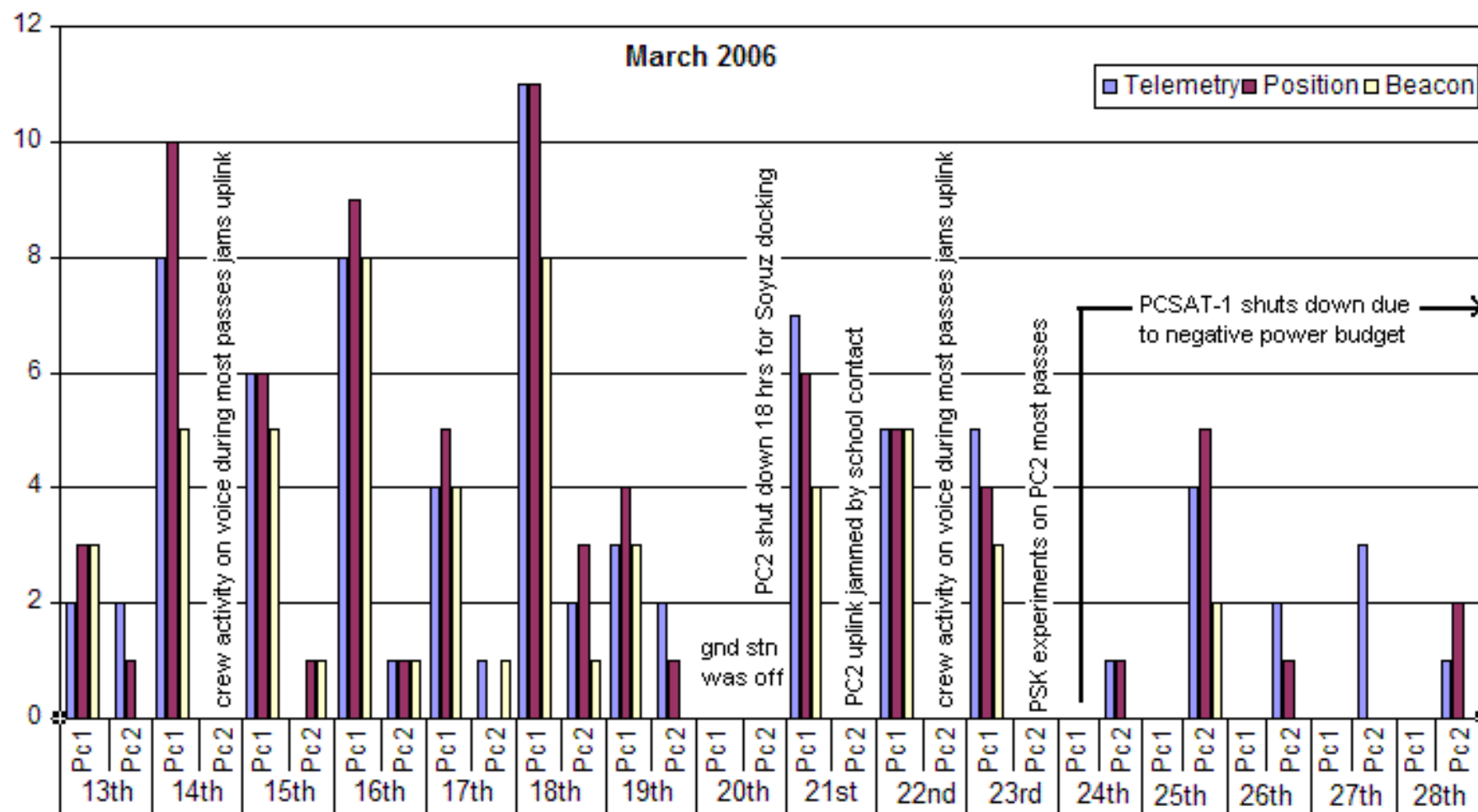

DK3WN Germany

W7KKE Oregon

PA3GUO Ground Station
RAFT/ANDE
Netherlands

2010 Navy SERB

Sensor Buoy Baseline PCSAT validates our links
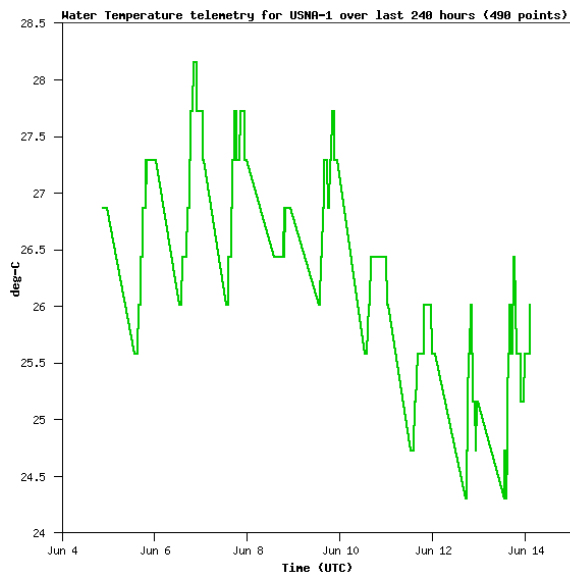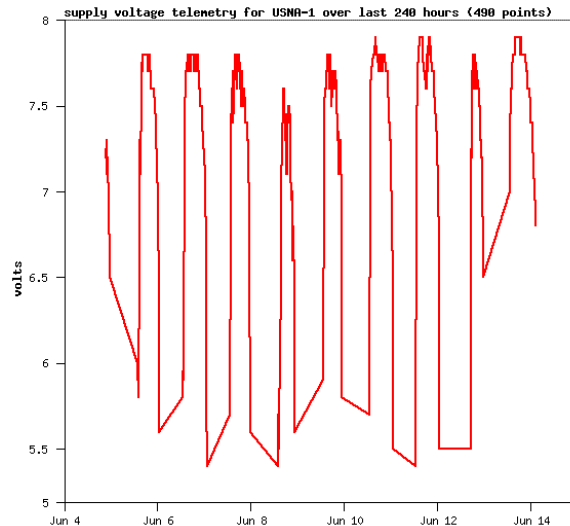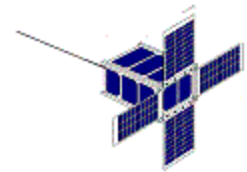

PCSAT2 User Plot 18 Apr 06

2010 Navy SERB

Sensor Buoy Baseline Test
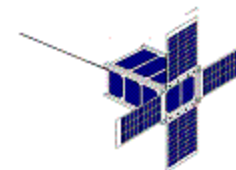
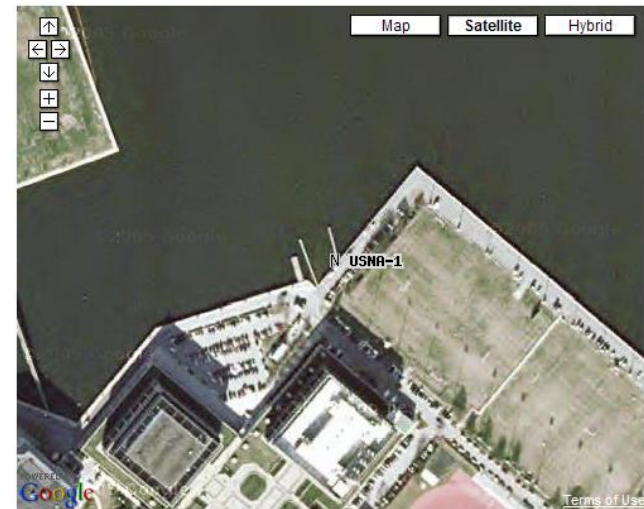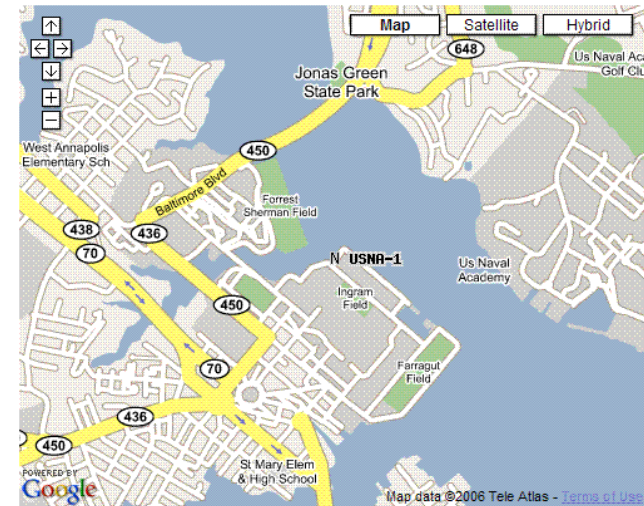**Number of Buoy Packets Received Per Day via PCSAT-1 and PCSAT2**

Prototype Buoy Data

Google for

"USNA Buoy"

Select USNA-1

(or Buoy4)

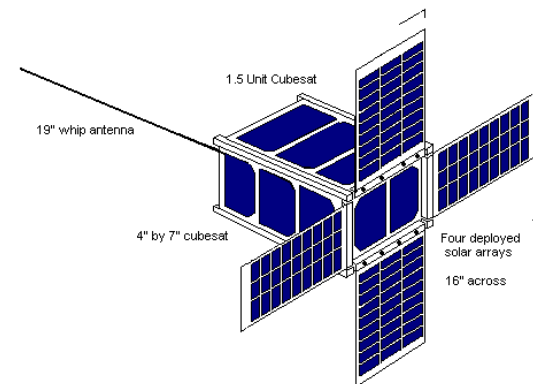2010 Navy SERB

Questions?

2001-2007

USNA Comms Compatible Spacecraft

2009

2006

2007

2010 Navy SERB