PSAT-2 Remote Data & Comms Transponder

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A satellite relay channel for Amateur Satellite User data anywhere on earth. PSAT
Quicker Student involvement using a Ground Terminal Operational Concept

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

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

Education Force Multiplier!
Solution: Ground Terminal Applications Focus

Supports Student Experimenters world wide
APRS Local & Global Internet linked Data Network

Global APRS Real-Time Connectivity

APRS Global Packet Radio Network
Internet Linked for live Communications

Automatic Packet Reporting System
Arctic Buoy Student Experiment

- USNA Arctic Buoy deployed March 2012

The APRS piece
Example Remote Sensors using **APRS** Protocol

Very Simple

APRS transmitter

GPS
Why We Need Psat Satellite Transponders

- Transatlantic APRS balloon launched and tracked through terrestrial network
- Lost comms over Atlantic Ocean
- It could have been picked up by our Psat/Pcsat transponder or the ISS
Global Wilderness Areas (90% of Earth)

M0XER-3, 4 and 6

- Live Global APRS Balloon Tracking Web Page

http://habitat.habhub.org/mobile-tracker/
Hand-Held Satcom via APRS & Psat

Ground Terminal is Walkie-Talkie, and Palm Pilot

“When you have no comms, 1200 baud text/data is great!”

CAPT Chas Richard
MAREA* Rover Projects (ARRL)

- STEM School projects
- Excite kids with Robotics
- Drive anywhere on Earth!
- Via APRS links

*http://www.arrl.org/marea-ham-radio-robotics
Psat  APRS Network Architecture

Global Volunteer Ground Station Network
Internet Linked for live Telemetry
Remote Buoy Baseline Test – Success of 1 min Xmit rate

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

March 2006

- Telemetry
- Position
- Beacon

PCSAT-1 shuts down due to negative power budget
Tracking (on Google Earth)

http://aprs.fi

Tactical situational awareness
Findu.com Telemetry Plots

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

APRS Global data network
All on 145.825 MHz

APRS Data Relay Satellites since 2001

- Common VHFA/HF, 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

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

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

Earlier reductions to 5" cubesat on RAFT (2006)

APRS Global data network
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 discretes, backdoor reset capability. Worldwide Telemetry Beacon access via global station network.

APRS Global data network
AX.25  A single 3” Square card  145.825 MHz

$5000
New Board Layout –
Standard Comm board

$250
Psat-1 Transponder & Aux Payload

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

- 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

Vandegriff
PSAT-1 Unique Power Attitude and spin

- Uses only one Z coil for attitude Control
  - Fires only within +/- 20 deg of Equator
  - Solar Panel angle better than 95% power
  - Higher reliability
  - Passive Spin maintenance

Differential Radiation Spin
Plenty of Room for more cards

- For Maximum MOI about Z
- Batteries to outside for MOI & Shielding
- Stainless steel belt around everything
PSAT BS2 CPU telemetry – spin analysis

S#033814, 0z290, qhDqhEqhFqhHqhIqhIpiJpiKpiLphLphMphM

sun vector triplets: xyz xyz xyz xyz xyz xyz xyz xyz xyz xyz

0z200 -> WOD=2 -> 12 samples every 5 sec

values A-Z = +1 to +26, a-z = -1 to -26

DK3WN

APRS Global data network
• When we find the time we are really looking forward to understanding our Solar Radiative Spin system.
PSAT: Aux PSK31 Transponder Payload

- Flew on PCSAT2 on ISS but astronaut broke off HF antenna
- Flew on RAFT but took 1 kW uplink and negative power budget
- Now Operational since May 2015 launch of PSAT and BRICsat
- Both transponders built at Brno Univ, Czech Republic.
PSAT Nitinol Wire Whip Antennas
Wrapping Antennas to one Burn Resistor

2 Orthogonal UHF whips
One VHF whip
One 6’ HF whip
3rd Enable Switch
APRS Ground Station Network

IGates World-Wide

Global Volunteer Ground Station Network
Internet Linked for live Telemetry
APRS iGate

APRS IGate with Raspberry Pi and DVB-T stick

DK3WN

http://www.kubonweb.de/?p=130
http://www.mstewart.net/super8/aprs/RASP/index.htm
http://n5dux.com/ham/raspberrypi/igate.php

Raspberry PI iGate APRX with soundmodem
https://www.youtube.com/watch?v=MtUnuJn_70o
Communications 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
APRS Terrestrial Data Relay Network

- Supports over 20,000+ terrestrial users and experimenters.

- But stops at the shoreline and has huge holes in the wilderness.
There are terrestrial network holes everywhere

Just like cell coverage,

Maybe 70% of USA users are actually out of range of the terrestrial network in rural areas

And the terrestrial user does not know when the next APRS satellite is in view…