ParkinsonSAT Remote Data Relay (Psat)

Cubesat Conference
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Psat

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

- New tiny 5W RF Xponder
- Simple Sun Pointing ADCS
- Can support other SERB Payloads
- COTS solar panels

Psat USNA-0601

7”

MicroMag 3-Axis Magnetometer

Price $54

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Psat 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
- Aux payload gets .5 kg – self contained
- 1 to 3W average power for aux payload

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Vandegriff
Psat Structure
CUBESAT Deployment

1 m/s ↑

Two Cubesats
(dual redundant)

Panel deployment force and momentum add to separation force between cubesats

Front and back panels not shown for clarity

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Sun Pointing Attitude Control System

- Pointing requirements are relaxed +/- 40 deg
- High precision attitude control not required

Power Available vs. Satellite Angle Required

- Maximum Power: 21 W, Theta = 22 degrees, Phi = 20 degrees
- Power Goal
- Minimum Power: 6.5 W per side

ODTML on (18W)
ODTML off (4.5 W)
SAFE mode

Cubesat
3.5W

Psat
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Paquette
Matlab Simulation of Modified B*dot

Modified Bdot Control

\[ \dot{\omega}_x \]

\[ \dot{\omega}_y \] (deg/sec)

\[ \dot{\omega}_z \]

time (hrs)
Sun Sensor & ADCS Testing

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

Earlier reductions to 5” cubesat on RAFT (2006)

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

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Cubesat #A

Cubesat #B

Now split between two cubesats

aux payloads

19" whips
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!
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*
Example Situational Awareness (in SLC Utah)

27 users in S.L.C

map.findu.com/N7RKB*
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.
Ground Terminal Applications Focus

Supports Student Experimenters world wide
Small Platform Minimum Satcom (SPMS) Background

Ground Terminal is Walkie-Talkie, and Palm Pilot

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

CAPT Chas Richard
APRS Experiment Data Access (via internet)

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

* Click to see all stations on map

Based on the USNA Automatic Packet Reporting System
Universal Ham Radio Text Messaging Initiative

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

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.unsa.edu/~bruninga/buoy4.html
DOD Synergy with Educational Experimenters

Based on the USNA Automatic Packet Reporting System

APRS Data Experiment in F-16 Aircraft

Rome Air Development Center

• Typical Low Cost Experiment
“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

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

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Psat Global Internet linked Comms Network

Global APRS Real-Time Connectivity

(End-to-End Everywhere)

Global APRS Internet connectivity LIVE!

Footprint Comms

I.Gate

WU2Z email engine

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

I.Gate everywhere on the planet

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

APRS Global Packet Radio Network

Internet Linked for live Communications

Automatic Packet Reporting System

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Psat APRS Network Architecture

IGates World-Wide

Global Volunteer Ground Station Network
Internet Linked for live Telemetry
Constellation Operation of USNA Satellites

All on 145.825 MHz

- Common VHF/UHF, VHF/UHF, UHF/UHF
- 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

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
Dual Satellite 2-hop links
Global Volunteer Groundstations
feed live downlink into Internet
Sensor Buoy Baseline  PCSAT validates our links

Psat USNA-0601

PCSAT2 User Plot 18 Apr 06

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2010 Navy SERB  Vandegriff
Sensor Buoy Baseline Test

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

Crew activity on voice during most passes jams uplink
PC2 shut down 18 hrs for Soyuz docking
PC2 uplink jammed by school contact
Crew activity on voice during most passes jams uplink
PSK experiments on PC2 most passes

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Prototype Buoy Data

Google for
“USNA Buoy”
Select USNA-1
(or Buoy4)
Questions?

2001-2007
USNA Comms Compatible Spacecraft

2006

2007

2009

Psat USNA-0601

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