APRS Space Network

- APRS space frequency is **145.825 MHz**
- Also via GO-32 on 435.225 downlink, **145.85 MHz** up

Cubesat 2008
P-SAT Mission Concept

A transponder for the relay of remote environmental sensor and other low duty-cycle data.

3 Axis – Sun Pointing
ADCS Simulator

- **Structure**
  - PSat Dimensions - 1 cubic foot
  - 50% PSat Mass - 18 lbs

- **Hung from 16’ of 2x30lb fishing line**

- **2 Operational Magnetorquing Coils**
  - #30 wire 130 turns
  - 100 mA; approx. 55 ohms
  - Torque of 10E-4 N-m
  - Red LED coil indicators

- **Magnetorquing Coils in X and Z-Plane**

- **Solar Panel Configuration**
  - 6 Panels on the +Z face
  - 4.5 Panels on the -Z face
  - 4 Panels on X & Y faces

$50
ADCS Test

Results

- Lights too close!
- Re-test at 16 feet
- Results give max error of 9 degrees, within limits
Comms Satellites Benefit Others!

GO-32 APRS Igate System (potential)

Satellites for education need to provide access to other Student Projects

IE - Environmental sensors, WX stations, position/status reporting

APRS is a registered trademark Bob Bruninga, WB4APR
APRS Satellite Constellation

All on 145.825 MHz with *Generic* links

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

Generic Global Connectivity
8 Cubesats would provide 1 hour access 24/7/365 to handhelds
For mobiles, would provide 30 minute access
**APRS Space Applications**

- PCSAT-1 (Prototype Communications Satellite) is a US Naval Academy Aerospace student project.

ANDE and RAFT in Dec 2006-2007

- APRS space frequency is published as 145.825
APRS on ISS!

- ARISS supports APRS on 145.825 too!
- Use digipeater path VIA ARISS.
- PCSAT2 was also on ISS 2005-2006

PCSAT2, was the second APRS digipeater satellite.

See live downlink on www.ariss.net
Now GO-32 TECHSAT-1b

- GO-32 now supports APRS on its 435.225/145.85 packet system.
- APRS up on 145.85 (PC’s and messages)
- Mic-E up on 145.93 (D7 and D700’s)

9600 Baud!

See live downlink on www.ariss.net
Tracking is EASY! (AO51)

- No computer needed
- Two or more solid passes to handheld every day
Tracking ECHO (AO51) too!

- No computer needed
- Two or more solid passes to handheld every day
- Five or more uplink passes for mobiles, etc

Thurs, 14 August
GO32 -EZ - MOBILE Satellite Prediction and Tracking

This table is for Washington/Baltimore but works for all points north and south.

<table>
<thead>
<tr>
<th>01Aug</th>
<th>11Aug</th>
<th>21Aug</th>
<th>31Aug</th>
<th>10Sep</th>
<th>20Sep</th>
<th>30Sep</th>
<th>09Oct</th>
<th>19Oct</th>
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<tr>
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<td>1025</td>
<td>1005</td>
<td>0940</td>
<td>0920</td>
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<td>2005</td>
<td>2125</td>
<td>2100</td>
<td>2040</td>
<td>2135</td>
<td>2110</td>
<td></td>
</tr>
<tr>
<td>2210</td>
<td>2145</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tracking GO-32 in the mobile is easy, because the passes repeat every 10 days. Just prepare a table like the above and stick it on your mobile dashboard, and then any day, morning or evening, you will know when the next pass you can hear will be in range. For uplink there will be a pass 100 minutes before and 100 minutes after too.

- No computer needed
- Two or more solid TX/RX passes every day
- Two additional TX passes 100m before and after!

Thurs 14 Aug is shown
Tracking is EASY! (ISS)

No computer needed!

Similar Passes every other day.

22 minutes earlier each day???
LEO Pass Geometry

Low Earth Orbits

Typical pass times are 8 to 15 minutes.

Most of the time LEO satellites are in view, they are below 20 degrees elevation. Rarely do they pass directly overhead. Only 2% of the time are they above 60 deg.

Only Azimuth Tracking is needed!

- 10 dB gain Horizon-to-horizon
- 98% of all in-view times
- Using $75 TV rotator only
Omni Antenna Gain 7 dBi!

¾ wave vertical

1%

30%

70%

SATgate!

3/4 and 1/4 Wave Omnis at 435 MHz

APRS is a registered trademark Bob Brunings, WB4APR
Combined Omni Gain
Path Gain + Antenna Gain!

SATgate!
**Omni SatGates**

Get about 3 minutes of data (each)

![Graph showing elevation angle and packet reception](image)

This plot shows the total packets per minute received by my TM-D700 APRS mobile radio using a mag-mount 1.9' whip on the roof of my car. In this case I was tracking Doppler, starting at 435.230, then 435.225, and ending at 435.220 MHz. Since the satellite is too far away at any elevation below about 25 degrees, only the central frequencies are useful.

**Promoting Student Ground Station Involvement worldwide!**

APRS is a registered trademark Bob Brunings, WB4APR
Omni SatGates (Alogger)

Any APRS client can be a SatGate
APRS Satellite
Msgs/Email

Send/Receive messages or email
Anywhere on the planet via APRS satellite
AMSAT Operating Areas

AMSAT Global Operating Areas

OA/I0 - Isolated, Open
OA/A - Areas Regional
OA/B - Border Congested
OA/C - Congested

IA Interference Area

Areas shown are for low LEO's such as ISS.
Areas are larger for higher LEO's such as AO51.

APRS is a registered trademark Bob Brunings, WB4APR
What is APRS?

- **APRS** = Automatic **Packet** Reporting System

- **APRS** was developed in the early 1990's for local **tactical digital communications**, situational awareness and **TWO-WAY information exchange** using Amateur radio.

- **Not just Vehicle Tracking!**
What is APRS all about?

- Immediate local digital and graphical information exchange between all participants in a local area or event. This includes:
  - Positions of all stations and objects
  - Status of all stations
  - Messages, Bulletins and Announcements
  - Weather data and telemetry
  - DF bearings and signal strengths for quick transmitter hunting
  - RF Connectivity plots of all stations
  - Local OBJ ECTS on a common map display for all users
  - Local Freqs, Nets, Meetings

- Typical applications are:
  - Routine local awareness of all ham radio events and assets around you
  - Marathons, races, events and public service
  - Search and rescue
  - Family communications and tracking and one-line emails
  - Mobile-to-mobile global messaging
  - Weather data exchange and display
  - Efficient multi-user Satellite communications
Scope of APRS

- APRS consists of a very large land based wireless network. Almost 30,000 users around the world.
- This network works via RELAYS every 20-30 miles called “digipeaters.” And Globally via IGates to the internet.
- APRS is also used via some of the Amateur Satellites.
- It is also used to monitor telemetry values of weather stations for the National Weather Service (NWS)
- APRS has the capability to quickly relay telemetry values to research centers without the Internet.

But, only 10% try Satellites
Only 0.1% on any given orbit...
Peak User Transponder Load is < 4%

30,000 experimenters to draw from

APRS is a registered trademark Bob Bruninga, WB4APR
APRS MisConceptions!

See APRS-tactical.html

- That APRS is just Vehicle Tracking instead of a **Real-Time Information Distribution System**.
- That APRS is dependent on GPS for its value (**GPS is not needed. See Objects**).
- Using APRS clients that only do maps and ignored **APRS Comms fundamentals**.
- Failure to understand the importance of OBJECTS: . See **Objects 101**
- Failure to use real-time messaging: . See **Messages 101** and **Message Operations**
- Failure to implement the original APRS Centralized **Common Bulletin Board**
- Not understanding the APRS operator’s role of **Data Input** (Objects, Bulletins and Messages)
- Not realizing the importance of **Voice Operating frequencies** in APRS.
That APRS is dependent on GPS for its value

(GPS is not required to put things on maps)
APRS is a registered trademark Bob Bruninga, WB4APR

**APRSstt (Touchtone)** or any other source (Dstar)

See [aprstt.html](https://aprstt.html)

- Simple DTMF memory - One button puts you in APRS (Position, Frequency and Status)!
  - DTMF on voice freq translated to packet on APRS channel (or direct to APRS-IS)
  - Position is 10 mile ambiguity using repeater posit (or 60 mile ambiguity out west)
  - Frequency in packet is Frequency of Repeater
  - If Echolink or IRLP, APRS packet includes node number!

&DSTAR users!
APRS is a registered trademark Bob Bruninga, WB4APR

DTMF Report shows on APRS!
- CALLSIGN with date and time
- Position in vicinity of repeater or APRStt entry point
- Voice Operating Frequency, Tone and other info
- Node number if Echolink or IRLP, or reverse patch number if Repeater

147.105MHz T107 R30m
Various APRS Stations (two-way)

APRS is a Network intended for real-time Tactical INFORMATION exchange. This means 2-WAY.

And Satellite
One-way APRS is not normally recommended. APRS is a Network. We want good communications among all participants for maximum utility.

But for some very remote applications, APRS is a great way to communicate small data packets from remote locations…

Satellite APRS
On 145.825 MHz

TX APRS on 144.39
RX Voice on XXX.XX
Global Mobile and Portable Satcom

GO-32 APRS IGate System (potential)

GO-32

IGate

IGate every­where on the planet

Footprint Comms

Global APRS internet connectivity LIVE!

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)
Mobile/ Portable Satellite Terminals

Kenwood TM-D700A

- Dual band 144/440 MHz 50/35 Watts
- Built-in 1200/9600 bps TNC including digipeater
- Built-in screen display of other APRS stations and front-panel send/receive messaging.
- Other APRS station locations are sent to the attached GPS map for display.

TM-D710

- Adds operation Freq to every posit!
- Auto tunes to others with Freq!
- Shows local Voice Repeaters!

Kenwood TH-D7A(G)
Alinco DR-135T/EJ -41U

- Basic 2 M Radio with optional TNC.
  (Opentrack makes a drop in tracker module)
- Allows direct input from any standard GPS.
- Basic 1200/9600 bps TNC
- Unlike the Kenwood radios, it requires a PC to set it up, and there is no APRS display directly on the radio.
Yeasu VX-8R

- “APRS” announced at Dayton?
- Optional GPS in spkr-mic
- Features of D7
APRS Voice Alert! *(For all mobiles!)

- Voice Alert is effectively 3rd Radio channel for the D7 and D700 APRS radios

- By setting the APRS Band, A, to PL-100, but keeping the volume turned up:
  - You won't hear any packets on 144.39 *
  - But you will hear a voice call using PL-100 on 144.39
  - And you will hear* an occasional Ping packet if another D700 comes in line-of-site to you, like a proximity radar alerting you to local presence.

- Great for long haul traveling and meeting other APRS users.
APRS – IS - Local Info/Data!

Last 100 stations!

Direction & Distance
Frequency and Tone

Mobiles and HT are 100% compatible

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The APRS Network

Satellite

Digipeaters

And to the Internet Gateway

Multiple Hops

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This data is plotted from Steve's FINDU data for 10 days and plotted on APRSSdos shows the user density in the USA in Feb 05. Although it appears that most of the USA is low density, remember that a WIDE5-5 launched anywhere in the remotest area will still get to the closer cities and add to the QRM there. And there are 100 times more low density users surrounding these cities hitting them from all sides that really adds up to heavy QRM. We recommend WIDE2-2 in red and surrounding areas.

The grid size is 30 miles and each is averaged with all 8 of its surrounding adjacent grids. The file is over 11,000 stations.

But the great news is that the New n-N Paradigm is the right approach. It encourages WIDEen-N everywhere while letting the high density areas trap large values of N to prevent overload in their areas only.

WB4APR

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APRS (ALOHA circle and digipeater hops)

[Your ALOHA circle is your 100% saturated channel range]

MAPS-PLOT-HOPS display shows snapshot of number of hops from each digipeater to my station in Baltimore (at center of my ALOHA circle). Data is plotted from last-packet-received, so needs to be observed several times to average out circuitous packets and lucky shots.
APRS (Solo DF Fade Circle Technique)

Fade Circle Omni DF-ing

Technique was driving E/W on 214, then back to center and N/S on PaxRvrRd.

First fade-circle based on loss of signal.

Second fade-circle based on full-scale.

Notice river valley skewed the big circle.

- Fox was 100 mW HT with rubber band
APRS (Solo DF Fade Circle Technique)

First tried North side of 4 lane, but signal began to weaken.

Original detections along this highway not shown.

Then went South and signal strengthened before weakening.

Again, ignore BLOON-2 at this point. Still no clue where TX was.

APRS is a registered trademark Bob Bruninga, WB4APR
This was hard going. The signals were getting stronger in the corn, but travel was painful and difficult. I decided to just head along the rows to the other side and then got another cross track where it was easier to walk. I couldn't even see the trees until out of the corn!

I could not see the payload until I was 6 feet away!

I have changed color scale down on this view, since I was now much closer than previous views. On previous views, RED showed places where signals were beginning to sometimes hit S8 full scale on my D7 HT. On this view, however, red shows where it was SOLID S9 with no dropouts. White shows where I could begin to hear signals without the HT antenna.

Aprs is a registered trademark Bob Bruninga, WB4APR
We knew Balloon was headed north at last posit, so I walked along North edge of field where Murphey's law would predict it would land in the thin tree line. Then headed south and sigs got stronger. In this field I was using short 3/4'' antenna on my HT. White shows where I removed antenna completely. Blue is where I first could see package in summer crops.
APRS has a 3D map display mode. The vertical scale can be separately set from the normal Range Scale depending on the altitude of objects. This is a typical APRS balloon track.
APRS Event Data Entry

Score Message Sent

Score Data Received
An IGATE is a local APRS station that utilizes the APRS-Internet network to pass all packets heard on their local RF back to the Internet. (Gives global views to local activity.

Also act as two-way gateways for ALL APRS MESSAGES worldwide (Internet ⇨ RF).

APRS is a registered trademark Bob Bruninga, WB4APR
Findu.com mapping

Internet tracking developed by
Steve Demise – K4HG

APRS is a registered trademark Bob Bruninga, WB4APR
APRS-Internet (APRS-IS)

Situational awareness

This data is LIVE
http://Pcsat.aprs.org

* Nearby APRS activity
**APRS-IS (FINDU – Near Range)**

APRS Stations Near WB4APR-9 (last 240 hours)

<table>
<thead>
<tr>
<th>Call</th>
<th>callbox</th>
<th>msg</th>
<th>wx</th>
<th>lat</th>
<th>lon</th>
<th>distance</th>
<th>direction</th>
<th>Last Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB4APR-9</td>
<td>**</td>
<td>**</td>
<td></td>
<td>39.00000</td>
<td>-76.50000</td>
<td>0.0</td>
<td></td>
<td>00:06:02:46</td>
</tr>
<tr>
<td>VA3ADG</td>
<td>**</td>
<td></td>
<td></td>
<td>38.99717</td>
<td>-76.50450</td>
<td>0.3</td>
<td>SW</td>
<td>05:22:10:17</td>
</tr>
<tr>
<td>WB4APR-1</td>
<td>**</td>
<td>**</td>
<td></td>
<td>38.99033</td>
<td>-76.49850</td>
<td>0.6</td>
<td>S</td>
<td>00:00:11:28</td>
</tr>
<tr>
<td>WE4APR-9</td>
<td>**</td>
<td></td>
<td></td>
<td>38.98667</td>
<td>-76.49283</td>
<td>0.9</td>
<td>SE</td>
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<tr>
<td>WB4APR-3</td>
<td>**</td>
<td>**</td>
<td></td>
<td>38.98500</td>
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<td>KB3KAK-9</td>
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<td>39.02567</td>
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<td>1.5</td>
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<td></td>
<td>38.97150</td>
<td>-76.49717</td>
<td>1.7</td>
<td>S</td>
<td>06:07:21:19</td>
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<td>K3FOR-8</td>
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<td>**</td>
<td></td>
<td>39.03200</td>
<td>-76.50677</td>
<td>1.9</td>
<td>N</td>
<td>00:08:58:06</td>
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<td>**</td>
<td></td>
<td></td>
<td>39.97067</td>
<td>-76.48400</td>
<td>2.0</td>
<td>SE</td>
<td>00:02:25:47</td>
</tr>
<tr>
<td>N3MNT-9</td>
<td>**</td>
<td></td>
<td></td>
<td>39.02117</td>
<td>-76.46800</td>
<td>2.5</td>
<td>NE</td>
<td>06:21:14:31</td>
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<td>N3HU-9</td>
<td>**</td>
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<td></td>
<td>39.01833</td>
<td>-76.44567</td>
<td>3.3</td>
<td>NE</td>
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<tr>
<td>N3KNP</td>
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<td>**</td>
<td></td>
<td>38.97233</td>
<td>-76.55017</td>
<td>3.4</td>
<td>SW</td>
<td>04:01:37:14</td>
</tr>
<tr>
<td>W3AFL</td>
<td>**</td>
<td>**</td>
<td></td>
<td>39.03517</td>
<td>-76.45100</td>
<td>3.6</td>
<td>NE</td>
<td>00:02:14:24</td>
</tr>
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<td></td>
<td>38.97383</td>
<td>-76.56283</td>
<td>4.1</td>
<td>SW</td>
<td>08:23:06:24</td>
</tr>
<tr>
<td>K3TH-3</td>
<td>**</td>
<td></td>
<td></td>
<td>38.97400</td>
<td>-76.56317</td>
<td>4.1</td>
<td>SW</td>
<td>00:00:14:52</td>
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<tr>
<td>N3HU</td>
<td>**</td>
<td></td>
<td></td>
<td>39.04017</td>
<td>-76.44183</td>
<td>4.2</td>
<td>NE</td>
<td>00:00:01:28</td>
</tr>
</tbody>
</table>

* Click to see all stations on map

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APRS-1S (FINDU – Near Map)
<table>
<thead>
<tr>
<th>from</th>
<th>to</th>
<th>time</th>
<th>message</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB4APR-9</td>
<td>JA1RBY-4</td>
<td>10/25 00:07:04z</td>
<td>no msg list?{44}</td>
</tr>
<tr>
<td>WB4APR-9</td>
<td></td>
<td>10/25 00:02:47z</td>
<td>qsl! {43}</td>
</tr>
<tr>
<td>JA1RBY-9</td>
<td>WB4APR-9</td>
<td>10/24 23:59:59z</td>
<td>hello{15}</td>
</tr>
<tr>
<td>N3HEV-1</td>
<td>WB4APR-9</td>
<td>10/14 14:09:06z</td>
<td>GM lve a grt day! 73! {0}</td>
</tr>
<tr>
<td>WB4APR-9</td>
<td>ALL</td>
<td>10/14 13:53:03z</td>
<td>in d700... ignore that msg. It was 4 satellite. {42}</td>
</tr>
<tr>
<td>WB4APR-9</td>
<td>ALL</td>
<td>10/14 13:50:24z</td>
<td>in d700 {41}</td>
</tr>
<tr>
<td>WB4APR-9</td>
<td>ALL</td>
<td>10/14 13:49:07z</td>
<td>in d700 use ptt mode to TX while RXing{40}</td>
</tr>
<tr>
<td>KE4NYV-15</td>
<td>WB4APR-9</td>
<td>09/30 21:55:30z</td>
<td>S1, if that{7}</td>
</tr>
<tr>
<td>KE4NYV-15</td>
<td>WB4APR-9</td>
<td>09/30 21:51:01z</td>
<td>noisy{6}</td>
</tr>
<tr>
<td>WB4APR-9</td>
<td>KE4NYV-15</td>
<td>09/30 21:50:32z</td>
<td>6.85?{38}</td>
</tr>
<tr>
<td>KE4NYV-15</td>
<td>WB4APR-9</td>
<td>09/30 21:49:45z</td>
<td>noisy{5}</td>
</tr>
<tr>
<td>N8PK</td>
<td>WB4APR-9</td>
<td>09/30 21:12:16z</td>
<td>Try again on 6.835 {003}</td>
</tr>
<tr>
<td>WB4APR-9</td>
<td>KE4NYV-15</td>
<td>09/30 20:48:11z</td>
<td>52?{37}</td>
</tr>
<tr>
<td>N1TI</td>
<td>WB4APR-9</td>
<td>09/29 02:47:14z</td>
<td>Good luck @ DCC {82}</td>
</tr>
<tr>
<td>N3IDX-1</td>
<td>WB4APR-9</td>
<td>09/28 02:06:44z</td>
<td>Greetings from Huntingtown, Md{2b}</td>
</tr>
<tr>
<td>KD8ATF-2</td>
<td>WB4APR-9</td>
<td>09/28 01:55:17z</td>
<td>r u going to be on the next pass of go-32 bob?{26}</td>
</tr>
<tr>
<td>WB4APR-9</td>
<td>ALL</td>
<td>09/28 01:51:40z</td>
<td>ck in!{35}</td>
</tr>
<tr>
<td>N1TVZ</td>
<td>WB4APR-9</td>
<td>09/28 01:45:12z</td>
<td>%private line{M}</td>
</tr>
<tr>
<td>WB4APR-9</td>
<td>ALL</td>
<td>09/28 01:43:14z</td>
<td>what is pl?{34}</td>
</tr>
<tr>
<td>N8PK</td>
<td>WB4APR-9</td>
<td>09/28 01:40:41z</td>
<td>Gud 2 C U on the CARA last night! -Pat {000}</td>
</tr>
</tbody>
</table>

APRS is a registered trademark Bob Bruninga, WB4APR
APRS for Special Uses

- Bicycle rallies, races
- Walk-a-thons, Parades
- Skywarn
- Weather Nets
- Crime prevention patrols
- Damage assessment
- Direction Finding – Foxhunts
- Voice for communications, APRS for visual mapping
- Now integrating into APRN (Automatic Picture Relay Network)
**Sensor Buoy Prototype**

See Buoy Location and Telemetry at

http://www.ew.unsa.edu/~bruninga/buoy.html

*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.

APRS is a registered trademark Bob Bruninga, WB4APR

Piggrem
Findu.com Telemetry Plots

Temperature telemetry for ANDE-1 over last 5860 hours (2234 points)

Sol X (Shell) | Bat A (Core)
APRS Emergency Power

200W Solar Power
- Continuous

10 kW gas Generator 220 VDC
- Auto-runs as needed
- lightweight wires

Low Cost
APRS in Space.
Comms, not just tracking!

GO-32 APRS IGate System (potential)

End-to-End Everywhere

Global APRS internet connectivity LIVE!

Footprint Comms

IGates everywhere on the planet

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