

# APRS via the ISS – A Quick Tutorial



# Sending APRS Packets via the ISS

## Concept:

- To have the International Space Station “*digipeat*” digitally repeat your transmitted APRS packet(s) to any ground-based Internet-linked station (called *SGate*)
- Verify that your ISS digipeated message was recorded by APRS tracking websites

## Purpose:

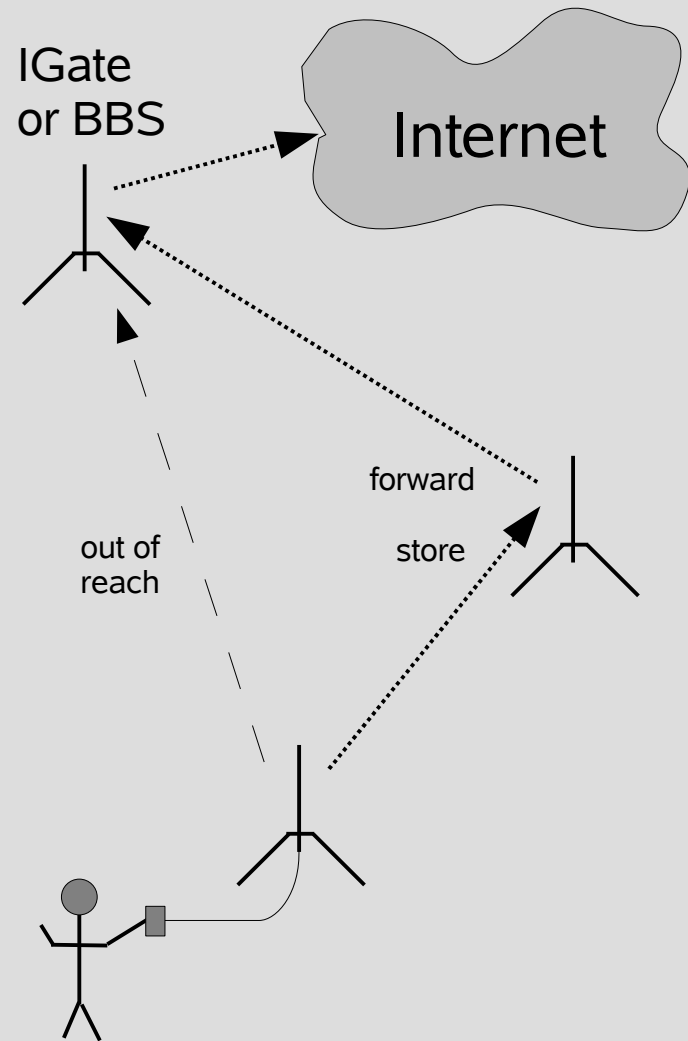
- For fun – and possibly for sending emergency messages out-of-area (although unreliable)

# What is APRS<sup>®</sup>?

- **Automatic Packet Reporting System<sup>®</sup>**
- A digital (non-voice) method of transmitting messages, status, and position – using specially formatted AX.25 packet messages
- TNC (Terminal Node Controller), similar to a computer dial-up modem, transmits packets and APRS data over the airwaves
- APRS is normally operated terrestrially – for 2m VHF in USA: 144.390 Mhz FM simplex
- Created by, and is a registered trademark of, Bob Bruninga WB4APR ([www.aprs.org](http://www.aprs.org))

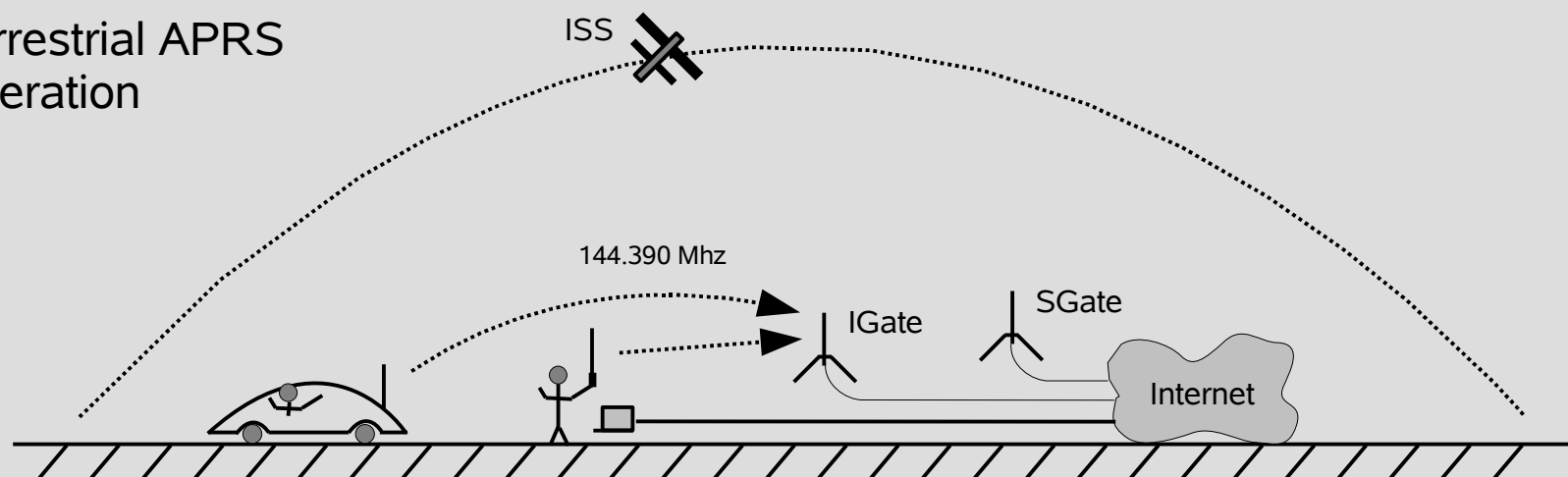
# Packet Digipeating Concept

- Digitally repeating an AX.25 packet on simplex frequency using a *store-and-forward* method, e.g. like a children's Telephone Game (Chinese Whisper)
- Allows packets to travel farther using intermediate hops



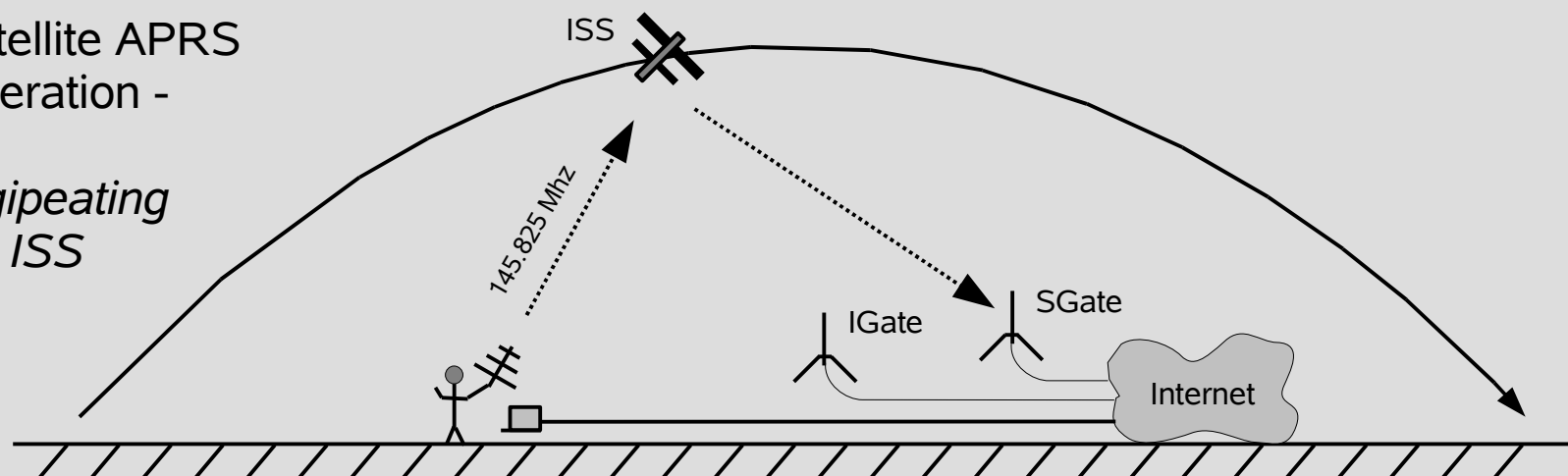
# APRS – Terrestrial vs. Satellite

## Terrestrial APRS Operation



## Satellite APRS Operation -

*Digipeating via ISS*



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# ISS Pass Opportunity

- Window of opportunity for transmitting to ISS
  - Each ISS orbit period is about 90 minutes
  - 5 to 10 minute window per orbit pass
  - Groups of consecutive passes about twice a day, roughly 12 hours apart
- Number of usable consecutive passes
  - Depends on your latitude, e.g.
    - 1 pass near equatorial latitudes
    - Up to 7 passes near the 50° latitude
    - But typically at other latitudes:
      - 1 to 2 usable passes within an 1 ½ hour period
      - Rarely: 3 usable passes in a 3 hour period

# ISS Pass Prediction

- Pass prediction websites
  - <http://www.issfanclub.com>
  - [http://space.cweb.nl/space3d\\_iss.html](http://space.cweb.nl/space3d_iss.html)
  - <http://www.n2yo.com/?s=25544>
  - <http://www.amsat.org/amsat-new/tools/predict/>
- Pass prediction computer freeware
  - <http://www.amsat.org/amsat-new/tools/software.php>
  - Windows:
    - SatScape
    - Orbitron
    - WXtrack
  - Unix:
    - predict with gsat client
    - gpredict
    - ktrack

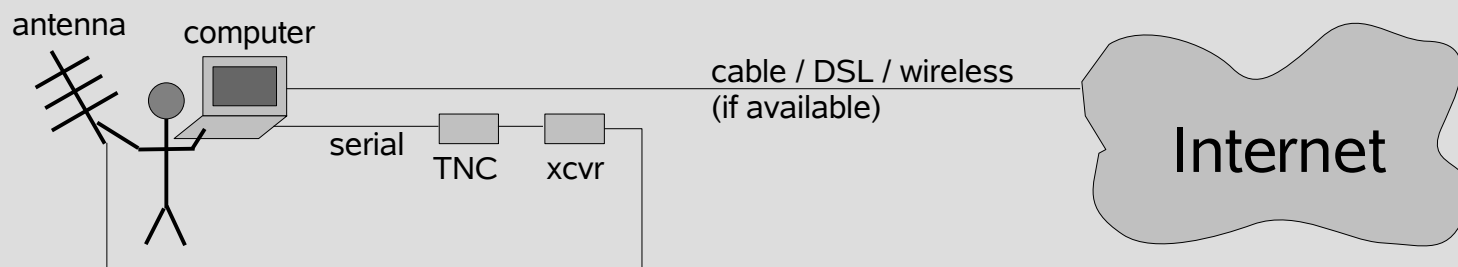
# ISS Station Operation

- ISS universal callsign alias: ARISS
  - Other callsigns: NA1ISS, RS0ISS, DP0ISS, etc.
- Kenwood TM-D700, etc. on-board the ISS
- Packet digipeating operations
  - 145.825 Mhz simplex FM
    - since September 2007 – hopefully it will be permanent
  - ISS digipeater callsign: ARISS
- ISS beacon message:  
RS0ISS-4>CQ,SGATE:  
>ARISS - International Space Station (BBS/APRS on)
- More details at:  
<http://spaceflight.nasa.gov/station/reference/radio/>  
<http://www.rac.ca/ariss/oindex.htm>

# Ground Station Equipment Required

- Any Tech / Gen / Extra class amateur license
- 2 meter VHF transceiver
  - No PL tone required (i.e. old equipment OK)
  - 5 watt power with Log-Periodic or Yagi antenna
  - 10 to 25 watt power with ground-plane antenna
- 1200 baud packet TNC and/or software – plus transceiver model-specific TNC cable
- Antenna: beam, ground-plane, eggbeater
- Computer with serial port and Internet access
- Satellite / ISS tracking software or website
- Orientation / compass, and local / UTC clock

# Ground Station Equipment Setup



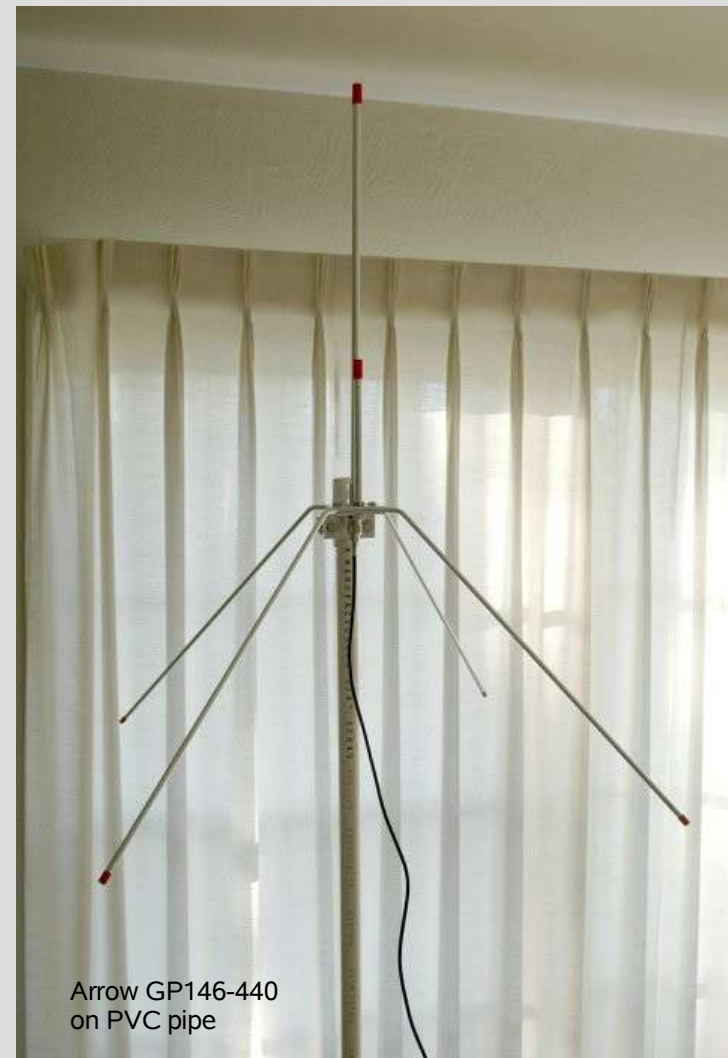
- Internet access might be unavailable in disaster and remote areas or mobile ops
- No transceiver pre-amp normally required
- Transceiver mic and speaker connections are dedicated to the TNC – voice ops unavailable
- Some TNCs accept a GPS connection for APRS beacon operation (don't use with ISS)

# Typical Interfaces for TNC Hardware



# Ground-Plane Antenna

- No aiming required
  - Omnidirectional
  - Stationary
  - Works indoors too →
- Unity gain ( $\frac{1}{4}$  wave)
  - More transmit power required than Log-Periodic or Yagi
  - 10 to 25 watts (to ISS)
- Radiation pattern
  - Low takeoff angle
  - Null at zenith



# Other Antennas for Satellite Use

## Beam: Yagi / Log-Periodic

- Aiming required
  - Directional radiation
- High gain
  - Less transmit power required than ground-plane antenna
  - 5 watts sufficient
- Better suited for outdoor use with handheld operation, weather permitting

## EggBeater

- No aiming required
  - Omnidirectional
  - Stationary
- Unity gain
  - More transmit power required than Log-Periodic or Yagi
- Radiation pattern
  - Circular polarization
  - No null at zenith
- Expensive to buy, cheaper to build

# Ground Station Operation Overview

- Setup
  - Verify your setup with terrestrial APRS operation
  - Pre-program transceiver with Doppler frequencies
  - Set TNC parameters (in TNC Command mode)
  - Update TLE, track & predict ISS orbit passover
- Operation
  - Check websites for recent ISS packet activity
  - Adjust transceiver for Doppler shift, if necessary
  - Transmit APRS packet (in TNC Convers mode)
  - If ISS digipeated packet is not received by your TNC, then check at APRS tracking websites
  - If nothing logged, retry transmission in 1 minute

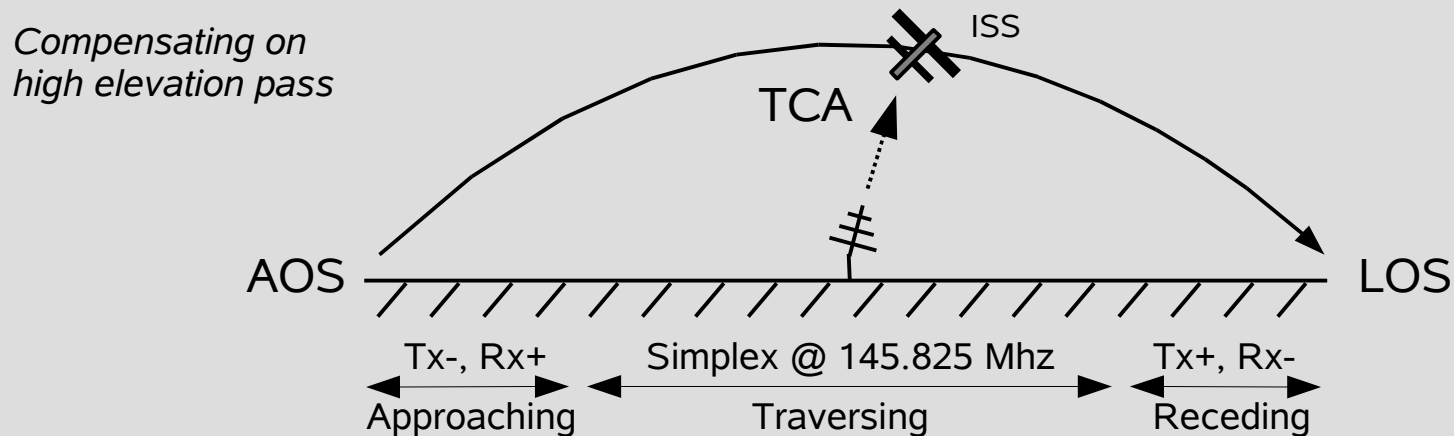
# Compensating for Doppler Effect

- *Doppler Effect* frequency shift is a factor when the ISS is approaching and receding
  - ISS travels roughly 214 statute miles (344 Km) above the earth @ 17,500 mph (28,000 Kph)
  - Ground station transceiver should frequency compensate when the ISS is near AOS<sup>1</sup> and LOS<sup>2</sup>
  - Only compensate on high elevation passes
  - Compensation might not be required on 2m VHF, since Doppler shift is less than 3 Khz

<sup>1</sup> AOS – Acquisition of Signal, i.e. ISS rising above the horizon

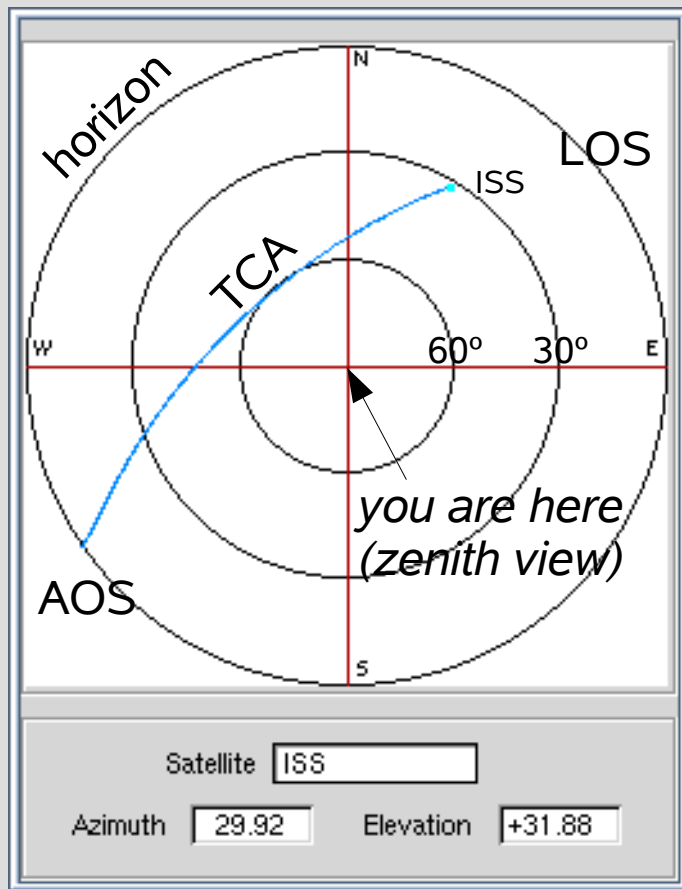
<sup>2</sup> LOS – Loss of Signal, i.e. ISS dropping below the horizon

# Transceiver Setup for Doppler Shift



- Pre-program AOS and LOS shift frequencies into the transceiver – using *odd-split* offsets
  - Most 2m transceivers have 5 Khz step minimum
  - AOS: Tx 145.820 Mhz, Rx 145.830 Mhz FM
  - LOS: Tx 145.830 Mhz, Rx 145.820 Mhz FM
  - TCA: 145.825 Mhz FM simplex (Tx = Rx)
  - TCA - Time of Closest Approach, i.e. maximum elevation*

# AOS / TCA / LOS Frequency Adjust



Azimuth / Elevation chart for  
ISS orbit pass (in light blue)  
*annotated predict / gsat chart*

AOS (approaching)

Tx 145.820 Mhz

Rx 145.830 Mhz

TCA (traversing)

145.825 Mhz simplex

(Tx = Rx)

LOS (receding)

Tx 145.830 Mhz

Rx 145.820 Mhz

# TNC Settings (via terminal session)

- TNC has two modes: Command and Convers
- Recommended settings in Command mode:

```
mycall <your_callsign-ssid>  
passall on, monitor on, mcon on, flow on,  
paclen 70
```

```
axdelay plus txdelay >= 3
```

then set the unproto path string to:

```
unproto aprs via ariss
```

*whereas for terrestrial operation the unproto path string  
would be something like:* unproto aprs via wide2-1

and turn beacon(ing) off

- Switch into Convers mode by typing:  
k or convers

# APRS Type / Syntax (Convers mode)

- There are 3 main APRS types: message, status, position (designated by the first character of the Convers mode string)
- In TNC Convers mode, these types can be specified as follows (maximum 64 bytes):

## *Position*

[GG##gg]...message...

*where GG##gg is the Maidenhead grid square, e.g. cm87xi*

## *Status (>)*

>...comments...

>GG##gg/-...comments...

## *Message (:)*

:<9 character TOCALL>:...message...

# APRS Position Type – Lat / Long

An example of specifying an APRS position type with latitude / longitude coordinates

```
!3720.00N/12205.00Wx/A=000100/Happy trails ISS !
```

!	no timestamp, no APRS messaging capability
3720.00N	37.2000° N latitude
/	symbol table to use for displaying map icon
12205.00W	122.0500° W longitude
x	display a X Windows icon on the APRS map
/A=000100	altitude @ 100 feet (optional field)
/	comment delimiter

## APRS map symbol / icon info:

<http://eng.usna.navy.mil/~bruninga/iss-aprs/issicons.html>

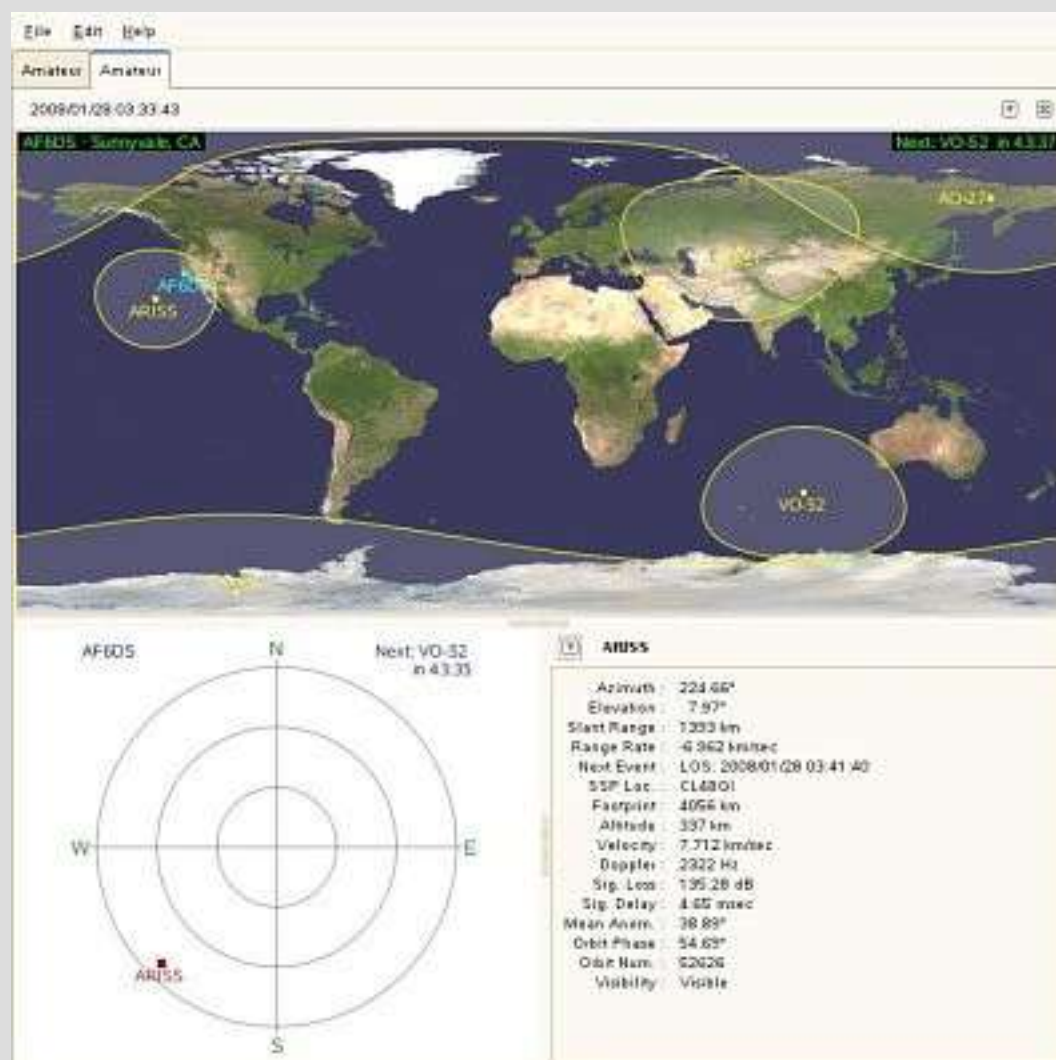
<http://eng.usna.navy.mil/~bruninga/aprs/symbolsX.txt>

# Orbital Description of Satellites

- A satellite's orbit can be mathematically described by Keplerian Elements – encoded in a format called Two-Line Element (TLE)
- TLE format:  
ISS  

```
1 25544U 98067A   08022.20136510   .00020651   00000-0   12618-3 0   7634  
2 25544   51.6401   54.3302 0005382 315.0141 127.5080 15.77334577525339
```
- Satellite tracking software accepts TLE data
  - Make sure the orbital data is up-to-date, since the ISS orbit may be boosted by visiting US Space Shuttle or Russian Progress spacecraft
- Obtain the latest TLE data from:  
<http://www.celestrak.com/NORAD/elements/stations.txt>

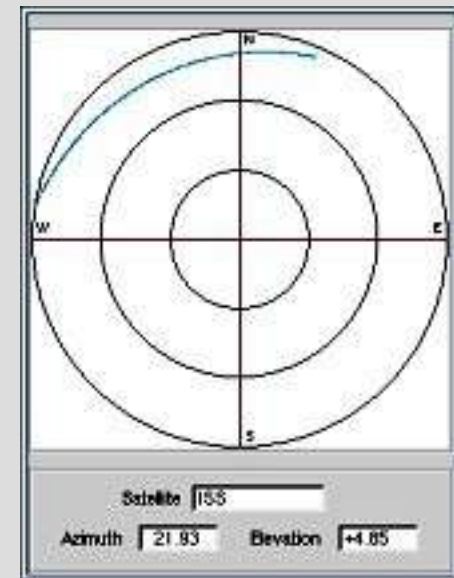
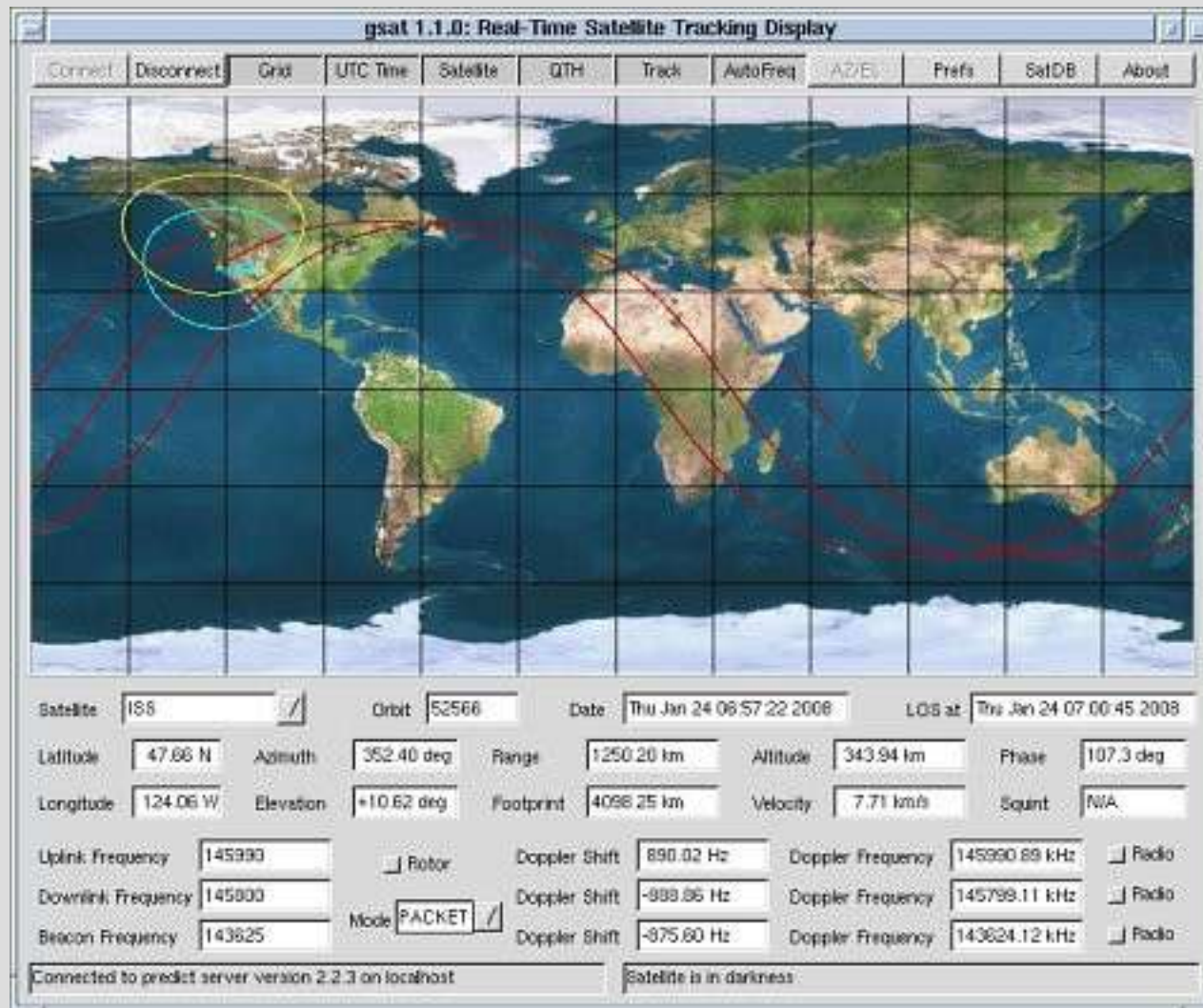
# Prediction SW – gpredict (Linux)



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- World map
- Your location
- Satellites & orbits
- Az / El chart
- Future pass prediction
  - Time to AOS
- Doppler shift frequencies
- TLE updates

# Prediction SW – predict / gsat



# Prediction Website – issfanclub.com



Click on **select your city**  
for pass prediction info

Click on **read more...**  
for activity reports

# Sending the ISS Digipeated Packet

What you type in TNC Convers mode to send, e.g.:

```
[cm87xi]Happy trails ISS !<Enter>
```

What your TNC transmits (and what you see):

```
AF6DS>APRS,ARISS:
```

```
[cm87xi]Happy trails ISS !
```

What the ISS digipeats (and what you might see):

```
AF6DS>APRS,RS0ISS-4*:          ARISS digipeated as RS0ISS-4
```

```
[cm87xi]Happy trails ISS !
```

Note: you will see your callsign instead of AF6DS

- Digipeating station inserts an asterisk (\*) after its own callsign in the packet string
- Packets with an asterisk (\*) marked ISS callsigns are logged by SGate stations








# ISS APRS Tracking Confirmation

Amateur Radio Stations heard via ISS - Mozilla Firefox

y Bookmarks Tools Help

U http://www.ariss.net/

**Station List** Click here to see times in absolute UTC

Call	Messages	lat	lon	Age (dd:hh:mm:ss)
 <a href="#">ISS</a>	* —	48.00930	-123.15490	00:00:00:03
RS0ISS-4	* —	.	.	00:00:00:03
 <a href="#">ISS-10</a>	* —	47.11828	-65.72127	00:00:00:03
 <a href="#">ISS-5</a>	* —	51.62430	-94.15305	00:00:00:03
 <a href="#">AF6DS</a>	* —	37.36667	-122.16667	00:00:00:04
 <a href="#">W6MSU</a>	* —	38.05350	-121.36033	00:00:00:13
KD7YPG	* —	.	.	00:00:00:19
 <a href="#">N7OFW</a>	* —	45.80233	-122.70150	00:00:01:30
 <a href="#">W7KKE 1</a>	*	45.01100	-124.00583	00:00:02:05

station  
near top  
of list  
→  
click on  
link to  
see data  
(see next  
slide)

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# ISS APRS Tracking Confirmation

AF6DS Location - Mozilla Firefox

View History Bookmarks Tools Help

http://www2.findu.com/cgi-bin/find.cgi?AF6DS

Position of AF6DS --- 3.6 miles southwest of Mountain View, CA --- Report received 10 seconds ago

Status: cm87xjtesting aprs formats

Raw packet: AF6DS>APRS,RS0ISS-4\*,qAO,KK5MV-12:[cm87xi]Happy trails ISS !

[GPS Vehicle Tracking](#)  
Affordable GPS tracking direct to you - saving you time & money.  
www.gpsdirectonline.com

[Vehicle Tracking](#)  
Vehicle Tracking listings Find  
Vehicle Tracking  
EasyDailyDeals.com


[GPS Vehicle Tracking](#)  
Discounted Gps Vehicle Tracking  
Gps Vehicle Tracking Offers!  
Ideascube.com

[Vehicle Tracking](#)  
Find Providers of Vehicle  
Tracking Solutions on  
Business.com.  
www.business.com

Ads by Google

Support findU!  
Make A Donation

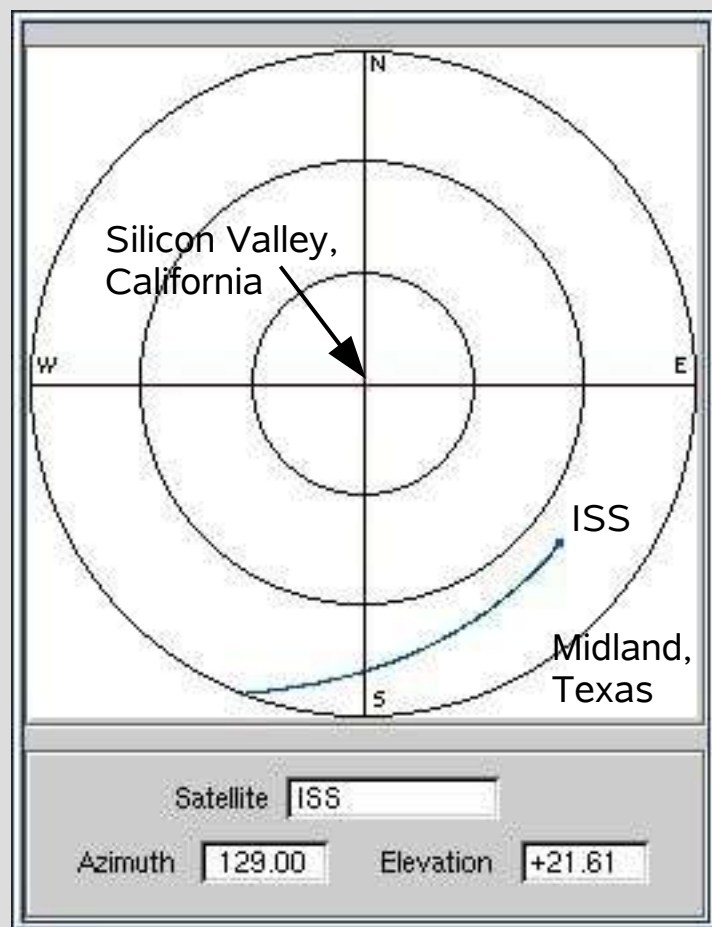
Links for AF6DS  
[APRS activity](#)  
[APRS data](#)



(see next slide)

# Anatomy of an ISS Digipeated Packet

Raw packet: **AF6DS>APRS,RS0ISS-4\*,qAO,KK5MV-12:[cm87xi]Happy trails ISS !**



January 25, 2008 04:07 UTC

- KK5MV (w/SSID of 12) is the SGate for this packet – QTH in Texas
- From Silicon Valley → ISS → Midland, Texas → Internet !
- 1200 mile city-to-city single-hop digipeat
- Thanks ISS and SGate stations like KK5MV !

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# Emergency Welfare Message via ISS

- During a major disaster (or for remote area operation), digipeat your APRS messages outside the region (via the ISS)
  - Infrastructure outage: power, phones, Internet, repeaters, or HF operation is unavailable / busy
  - Your operation needs to be totally self-sufficient
  - Digipeating 1000+ miles is possible via the ISS
- **Unreliable!** - no means to verify if your message reached APRS tracking websites
- Pre-arrange with concerned parties where to look for your status when a disaster occurs

# Improving Your Chances for Success

- Verify packet / TNC setup terrestrially first
- Check for recent packet activity:
  - <http://www.ariss.net>
  - <http://www.issfanclub.com>
  - ISS digipeating available 24 hours/day, but might be off during: docking, EVA (spacewalks), etc.
- Check for and use the latest orbital data
  - <http://www.celestrak.com/NORAD/elements/>
  - <http://www.issfanclub.com> – website tracking orbital data may get out-of-date occasionally
- Distant ground or ISS packet collisions are often not detected by your TNC – so retry

# Other Things to Note

- Cost:
  - TNC: ~ \$200+ USD
  - Antenna: GP ~ \$35+ USD, Eggbeater ~ \$300 USD
  - Software: freeware / open source available
- Turn off *Rx Save* (power management) mode in HTs, to allow proper decoding of received packets by the TNC – quicker battery drain!
- APRS CQ and ISS packet BBS usage also possible, but maybe difficult in heavy traffic

# Glossary

AOS – Acquisition of Signal (rise above horizon)  
APRS – Automatic Packet Reporting System  
AX.25 – X.25 packet protocol for Amateur radio  
Digipeat(ing) – Digitally repeating packets  
IGate / SGate – Internet / satellite gateway  
ISS – International Space Station  
Keplerian Elements / TLE – orbital description  
Log-Periodic / Yagi – directional beam antenna  
LOS – Loss of Signal (drop below horizon)  
Packet – digital form of data transmission  
TNC – Terminal Node Controller

# Tracking Websites and Data

## Satellite Tracking

<http://www.issfanclub.com>

<http://www.ariss.net>

<http://www.amsat.org/amsat-new/tools/predict/>

[http://space.cweb.nl/space3d\\_iss.html](http://space.cweb.nl/space3d_iss.html)

<http://www.n2yo.com> **Or** <http://www.n2yo.com/?s=25544>

<http://www.heavens-above.com>

## Keplerian Elements

<http://www.celestrak.com/NORAD/elements/>

<http://www.amsat.org/amsat/ftp/keps/current/nasa.all>

# APRS Tracking and Map Symbols

## APRS Tracking

[http://map.findu.com/<your\\_callsign-ssid>](http://map.findu.com/<your_callsign-ssid>)  
[http://map.findu.com/<your\\_callsign>\\*](http://map.findu.com/<your_callsign>*)  
[http://aprs.fi/info/<your\\_callsign>](http://aprs.fi/info/<your_callsign>)  
<http://www.aprsworld.net>  
<http://www.jfindu.net>  
[http://wx.findu.com/<your\\_callsign>](http://wx.findu.com/<your_callsign>)

## APRS Map Symbols and Icons

<http://eng.usna.navy.mil/~bruninga/iss-aprs/issicons.html>  
<http://eng.usna.navy.mil/~bruninga/aprs/symbolsX.txt>  
[http://www.kc2hwb.com/APRS\\_symbols.htm](http://www.kc2hwb.com/APRS_symbols.htm)  
[http://wa8lmf.net/aprs/APRS\\_symbols.htm](http://wa8lmf.net/aprs/APRS_symbols.htm)

# References

<http://spaceflight.nasa.gov/station/reference/radio/>  
<http://www.amsat.org/amsat-new/ariss/#freqs>  
<http://web.usna.navy.mil/~bruninga/iss-faq.html>  
<http://web.usna.navy.mil/~bruninga/astars.html>  
<http://www.marexmg.org/fileshtml/isspacketmanual.html>  
<http://www.rac.ca/ariss/oindex.htm>  
<http://ronhashiro.htohanenet.com/am-radio/spacecomm/getting-started-iss.html>  
<http://ronhashiro.htohanenet.com/am-radio/spacecomm/doppler-and-the-iss.html>  
[http://www.amsat.org/amsat-new/information/faqs/Intro\\_sats.pdf](http://www.amsat.org/amsat-new/information/faqs/Intro_sats.pdf)  
<http://www.arrl.org/tis/info/HTML/aprs/pos-reporting.html>  
<ftp://ftp.tapr.org/aprssid/aprssid/spec/spec/aprs101/APRS101.pdf>  
<http://www.users.cloud9.net/~alan/ham/aprs/aprs.pdf>

# Questions / Comments? and Thanks!

Any and all errors, omissions, misconceptions,  
and cheesy graphics are solely mine

[af6ds@yahoo.com](mailto:af6ds@yahoo.com)

And many thanks to the following who reviewed  
this presentation and provided comments:  
KE6AFE, N5VHO

# PCSat Digipeating

# PCSat Digipeating Setup

- General info:

<http://eng.usna.navy.mil/~bruninga/pcsat.html>

- PCSat operational again on Feb. 8, 2008
- Operational only during mid-day sun?
- Set the `unproto` path string to:  
`unproto aprs via w3ado-1` (`w3ado-1` is default callsign)
- Same FM simplex frequency of 145.825 Mhz
- PCSat Satellite Tracking:
  - Software – same as for tracking the ISS
  - Website: <http://www.n2yo.com/?s=26931>
- APRS tracking website URL:

<http://pcsat.aprs.org> **or** <http://pcsat.findu.com>

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# TNC Operation with PCSat

- PCSat beacon message received by the TNC:

```
W3ADO-1>ID,SGATE:
```

```
W3ADO-1/R XBAUD/G MAIL-1/B
```

```
W3ADO-1>BEACON,SGATE:
```

```
T#714,132,138,145,142,214,00111111,0001,1
```




- An example of a TNC Convers mode send string:

```
[cm87xi]APRS via PCSAT test<Enter>
```



# PCSat APRS Tracking Confirmation

Amateur Radio Stations heard via PCSat, ANDE and RAFT - Mozilla Firefox

ry Bookmarks Tools Help

 <http://www.findu.com/cgi-bin/pcsat.cgi>  <http://pcsat.aprs.org>  

**Station List** [Click here to see times in absolute UTC](#)

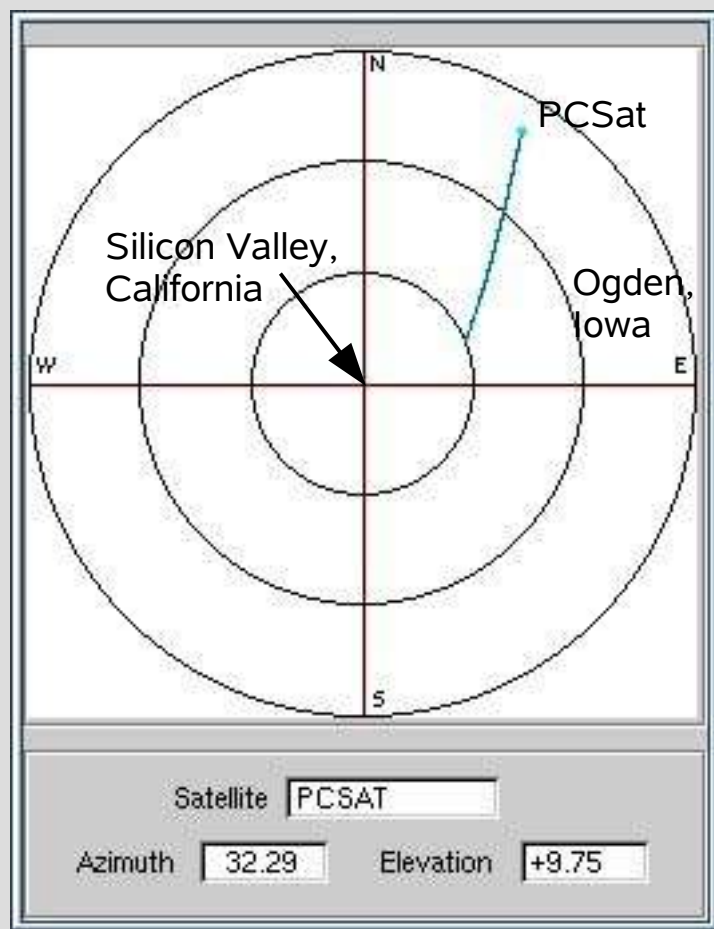
Call	Messages	lat	lon	Age (dd:hh:mm:ss)
 <a href="#">ANDE-10</a>	* —	30.25554	-78.63674	00:00:00:04
 <a href="#">PCSat</a>	* —	44.25515	-113.42513	00:00:00:04
 <a href="#">PCSat-5</a>	* —	58.04181	-96.31146	00:00:00:04
 <a href="#">ANDE-5</a>	* —	15.74077	-91.96631	00:00:00:04
 <a href="#">PCSAT-10</a>	* —	66.53775	-63.02673	00:00:00:04
 <a href="#">ANDE</a>	* —	0.38764	-103.27485	00:00:00:04
 <a href="#">AF6DS</a>	* —	37.33333	-122.08333	00:00:00:06
 <a href="#">KC9XG-4</a>	* —	41.57167	-88.05500	00:00:00:09

station near top of list  
→  
click on link to see data

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# Anatomy of a PCSat Packet Digipeat

Raw packet: **AF6DS>APRS,W3ADO-1\*,qAo,N0AN:[cm87xi]APRS via PCSAT test**



February 15, 2008 15:33 UTC

- N0AN is the SGate for this packet – QTH in Iowa
- From Silicon Valley → PCSat → Odgen, Iowa → Internet !
- 1500 mile city-to-city single-hop digipeat
- Thanks PCSat and SGate station N0AN !

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# Sending APRS Email via PCSat

- Service provided by WU2Z in New Jersey
- In TNC Convers mode, send the following string:

`:EMAIL :email_address message<Enter>`

where

- callsign field is 9 characters between the colons(:), hence `EMAIL` is followed by 4 spaces
  - `email_address` and `message` is 64 bytes (chars) max, and separated by a space
- An example:  
`:EMAIL :af6ds@yahoo.com testing email via pcsat`  
(see next slide)

# Anatomy of a PCSat Email Digipeat

Raw packet (from [www.findu.com](http://www.findu.com)):

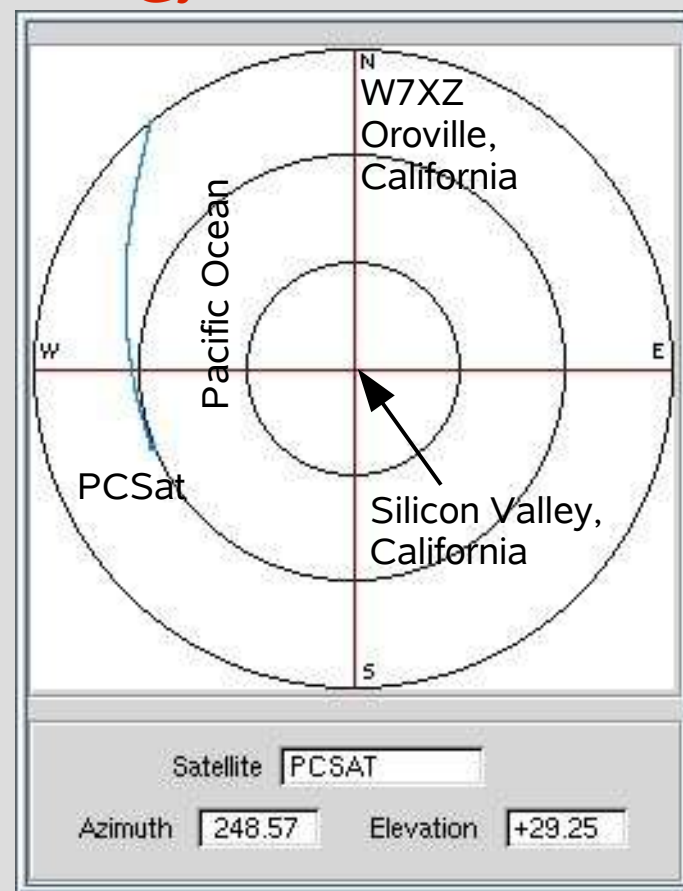
**AF6DS>APRS,W3ADO-1\*,qAO,W7XZ-6::EMAIL :af6ds@yahoo.com  
testing email via pcsat**

Received email:

<b>Date:</b>	Fri, 15 Feb 2008 21:02:05 -0500 (EST)
<b>Date:</b>	Date header was inserted by mta4.srv.hcvlny.cv.net
<b>From:</b>	ksproul@rci.rutgers.edu <a href="#">Add Mobile Alert</a>
<b>Subject:</b>	APRS Message from AF6DS
<b>To:</b>	af6ds@yahoo.com

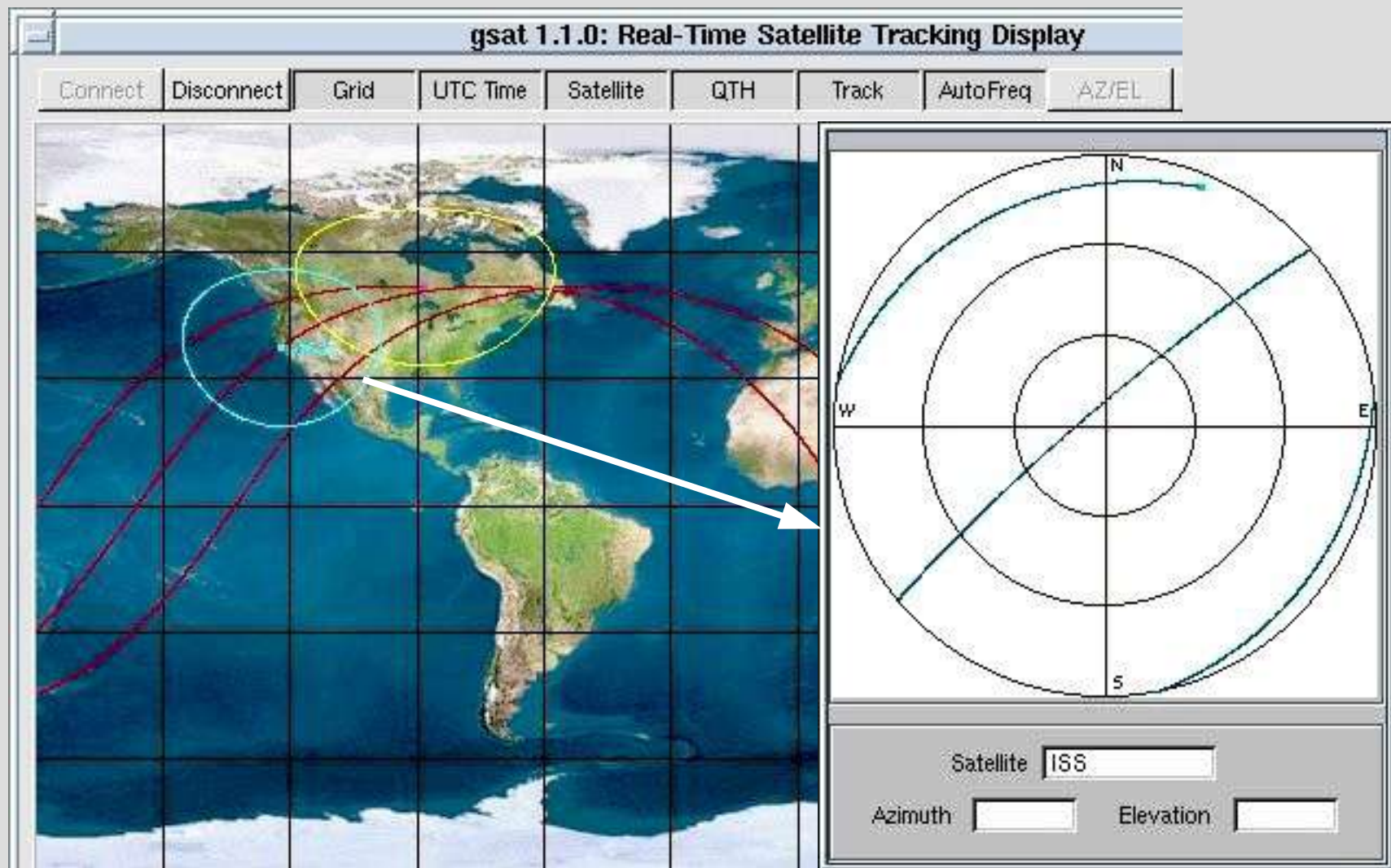
testing email via pcsat

.....  
Message received by MacAPRS IGate station WU2Z  
Located in NO BRUNSWICK, NJ  
APRS path = AF6DS>APRS,W3ADO-1\*,qAO,W7XZ-6



# Backup Slides / Info

# 3 Usable Consecutive Passes in 3 Hrs



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