

Position Reporting with APRS

You can run, but you can't hide

Richard Parry, P.E., W9IF

email address:

rparry@qualcomm.com

Home Web Page:

<http://www.qualcomm.com/~rparry>

AX.25 wireless packet address:

W9IF @ K6JCC.#SOCAL.CA.USA.NA

ABSTRACT

The Automatic Packet Reporting System (APRS) allows amateur radio operators to broadcast information from simple position reports containing heading and velocity measurements, to weather reports, and more. This paper is intended as an introduction for the beginner, but special attention is given to address a few of the more esoteric topics of APRS that should be of interest to all users. It provides information on how to set up several types of APRS stations ranging from a simple listen only station to a mobile broadcasting system. Particular attention is given to the APRS network protocol which can be confusing even to the advanced user. Included is an extensive source for obtaining shareware software, and a comprehensive list of APRS related web sites.

February, 1997

INTRODUCTION

I remember being handed a small Global Positioning System (GPS) unit a few years ago and being told that this little device would tell me where I was located anywhere on earth. I could not believe my eyes or ears, and was not prepared to be sucked into this canard. How could this device, barely the size of a cellular phone, tell me where I was located within a hundred feet. It just couldn't be, this had to be a hoax. Upon further discussion and a demonstration I was hooked, I knew I had to have one, but wasn't sure why. It took a few years to come up with an excuse, but I finally did, thanks to the pioneering work of Bob Bruninga, WB4APR, and his Automatic Packet Reporting Systemⁱ (APRS™).

Before the final purchase I spent two years playing armchair quarterback watching my fellow amateur radio operators move around the country on a map of the U.S. on my computer screen. Watching these dots reminded me of my childhood ant farm in which I could see ants build their colony. With APRS I could see my fellow amateur radio operators going to and from work, and see their weekend trips to the local ham store. Seeing my fellow club members coming and going to the Palomar Amateur Radio Club (PARC) meeting once a month was particularly interesting. Watching real-time special events including balloon expeditions, parades, satellites, boats, and marathons was fascinating.

APRS has many serious applications besides entertainment. In this article I'll concentrate on what I learned along the way while installing an APRS station. Although APRS is conceptually easy to grasp, the network protocol can be a little enigmatic, even for the advanced user. Setting TNC parameters can also be a little tricky. Therefore special attention will be devoted to this topic and the supporting reasons to allow the user to customize his or her system to assure good channel usage.

There are several ways that you can start with APRS, ranging from literally no amateur radio equipment, to a mobile APRS system replete with TNC, GPS, and transceiver.

GETTING STARTED

If you have a packet station (TNC, transceiver, and computer), you have all the hardware you need to start monitoring APRS activity in your area. All that remains is to obtain an appropriate version of the APRS software. There are currently three versions: Apple Macintosh, DOS, and Windows. By the time you read this, there might even be an X Windows version to run on Sun and Linux workstations.

Any of the web pages listed in this article will direct you to the latest version of the software. The software is offered as shareware, which means you may freely download the software and try it. The Macintosh and Windows programs are full working versions, only the ability to save settings has been removed. If you decide to continue to use it, the authors should be sent the requested registration fee. This entitles you to future updates and great support. The software comes with installation instructions, but if you need help, there is the aprssig@tapr.org mailing list where you will typically get an answer within hours, if not from the authors, by thousands of "Elmers" ready, willing, and able to help you.

ⁱ APRS is a Trademark of Bob Bruninga, WB4APR

Where to listen is the next piece of information one needs. There are presently two main frequencies dedicated to APRS work. On HF, it is 10.151 MHz and 145.79 MHz on VHF in most areas. For northern California it is 145.01 and 144.39 MHz in Canada. Monitoring the HF band will show activity across the U.S. due to the propagation characteristics of 30 meters. The VHF band provides a picture of activity predominately in your local area. However, as we shall see, even when monitoring 2 meters, which is limited to line-of-sight communication, you will find activity in many places throughout the US.

Although I have indicated there are only two APRS frequencies, that is changing and varies around the country. It is for this reason that the web pages for the major metropolitan areas provide excellent frequency coordination tools. There is APRS activity on HF bands from 40 to 6 meters. You will even find APRS activity on multiple frequencies on 2 meters.

With the standard packet station equipment and software, tune to one of the frequencies indicated and watch the activity. However, it will not be too long before you will want to put yourself on the map, literally. So let's see what it takes to broadcast APRS packets.

PUTTING YOURSELF ON THE MAP

The APRS protocol relies on Unnumbered Information (UI) frames to broadcast location information. If you have previously used packet radio, you have used UI frames when you called CQ or Beacons your station. For APRS work, all that is required is changing your *beacon text*, *beacon rate*, and *path*. On most TNCs these parameters are: BTEXT, BEACON, and UNPROTO respectively. In practice there may be a few other parameters needing initialization, but these three are particularly important. In fact, APRS is becoming so popular, virtually all TNC manufacturers advertise APRS compatible TNCs which provide additional functionality specifically designed for APRS work. These features include the ability to easily interface with an external GPS unit, and have parameters and buffers dedicated to APRS use. In those cases, the standard parameters (BTEXT, BEACON, UNPROTO) remain the same and you specify APRS specific parameters. For example, one manufacturer of an APRS friendly TNC has a Location Text (LTEXT) parameter where you specify your position and therefore leave BTEXT unchanged. This discussion assumes a TNC is to be used as a stand-alone configuration (no computer control). When a computer with APRS software is used to control the TNC, you specify the parameters with simple "fill in the blank" boxes and the computer system controls initialization. However, for simplicity and clarity, let's assume that you have a standard TNC and it will be broadcasting position reports independent of a computer.

Setting the beacon rate requires a little understanding of the APRS network. Technically, there is no reason why one could not transmit a location as often as one liked. In practice, however, fixed stations (e.g., home stations), should not transmit more frequently than every 30 minutes. There is a good reason for this, remember APRS is an *unconnected broadcast protocol*. This means there is no acknowledgment between stations when a packet has been received. Therefore, if packets collide, there is no re-transmission and the information is lost. This is significantly different than the normal AX.25 *connected protocol* that assures error free transmission. Therefore, to reduce collisions, the rate between transmissions should be extended to assure a high probability that the channel is available. Since a fixed APRS station by definition is not moving, updating its position more often than every 30 minutes is superfluous and counterproductive, so every 30 to 60 minutes is a reasonable interval. Some versions of the APRS software set rates to 20 minutes and others to 30, however, the user may

set the rate as desired. For our current fixed location application set your beacon rate to 30 minutes or BEACON 180 on most TNCs (180 = 1800 seconds = 30 minutes).

The beacon text is the second important parameter that needs to be initialized. Since we are currently limiting our discussion to a fixed APRS station, there is no need for a GPS device. All you need to know is your location. It should not be too hard to find a fellow amateur radio operator to borrow a GPS from to find your exact latitude and longitude. With that information, you can initialize BTEXT. For example, BTEXT for my fixed station is:

```
/120800z3300.28N/11702.39W-PHG2230/Rick in Poway, CA
```

In the event you don't know your latitude and longitude, or perhaps you don't want to tell the world your exact location, the standard is to use 6 letter grid squares which provide accuracy to within a few miles. For example, here is an alternate beacon text for my location:

```
/120800z[DM13la]-PHG2230/Rick in Poway, CA
```

The strings may seem a little like gibberish, so let's examine them in a little more detail. The first field consisting of the single slash character (/) indicates you are a fixed station with no APRS messaging capability. The second field uses the format, DDHHMM to indicate the date and time. Normally this field contains the current time and date based on real-time GPS information, but since we don't have a connected GPS for this system or a real time clock embedded in the TNC, the accepted practice is to specify the date that you started your APRS. In our example, 120800z, indicates the system was started on the 12th day of the month at 0800 Zulu. The next two fields contain the latitude (3300.28N) and longitude (11702.39W) or a single field for the 6 letter grid square (DM13LA). Next comes the dash character (-) which indicates to those listening that you are a fixed station at your home QTH. There are nearly 200 symbols (characters) available ranging from ambulance to airplane to provide receiving stations with information about your use of APRS. The Power Height Gain (PHG) field contains 4 digits that represent the power of the transmitter, the height, gain and radiating pattern of the antenna. For our example, 2230 represents a transmitting power of 4 watts, the antenna is 40 feet high with 3db gain, and an omnidirectional radiating pattern. The development of the 4 digit code to represent this information comes from a table that is provided with the APRS documentation (see PROTOCOL.TXT). One might ask why we include this apparently meaningless PHG information, however, when we discuss the efficient use of the APRS network, we will revisit this important topic. After the PHG field you append a comment. This is typically your city and state, name and perhaps a short salutation.

The only other major TNC parameter that must be set is UNPROTO (unprotocol). Like the PHG parameter, we will cover this in more detail when we discuss networks, but for the present, a good starting path for a fixed stations is:

```
APRS VIA WIDE, WIDE
```

That's all there is to it. Slight variations may be required depending on your TNC, however, in general it is as easy as setting BTEXT, BEACON, UNPROTO and tuning to 145.79 MHz. At this point you are able to see APRS activity and transmit your location to others. Now let's hit the road.

TAKING IT ON THE ROAD

For a mobile APRS station you will need a GPS since your position is constantly changing. Fortunately, prices have dropped drastically. For a mobile system, there are a few more system dependent variations which require the user to know a little bit about the GPS protocol to assure compatibility. Connecting the GPS to the TNC also requires a little more knowledge.

However, GPS units use standard protocols and hardware interfaces. For example, most GPS devices provide 4800 baud RS-232 compatible signals in a standard string format that GPS friendly TNC's can parse easily. Connectors vary but are typically standard and prefabricated cables are often available.

For mobile use, we are still typically concerned with three parameters: BTEXT, BEACON, and UNPROTO. If the TNC is configured properly, the TNC will take the information provided by the GPS (latitude, longitude, time) and automatically use that as the beacon text. Some TNCs provide similar text strings for GPS work, but the idea is the same. The beacon rate, as we previously mentioned, should be set to one minute intervals since we are now moving and need to update our position more frequently. Lastly, the UNPROTO path must be set. In our fixed station example, the UNPROTO path was set to APRS VIA WIDE, WIDE. For mobile applications it is common practice to add the digipeater RELAY so that our final path is:

```
APRS VIA RELAY, WIDE, WIDE
```

The exact application, TNC, and propagation characters all play a role in setting these parameters. However, the key parameters listed and a little Elmering (help from your friends) will get you going.

THE APRS NETWORK

After spending a lot of time looking at moving dots, I started to examine the frames to see what exactly was being transmitted. I had been in packet radio a few years, but seeing frames with a digipeater path of RELAY, WIDE, WIDE, or WIDE, WIDE, GATE, and virtually every other combination imaginable, I was lost. In this section I will show examples of digipeating paths and explain why they are used. However, first a quick AX.25 refresher course.

APRS uses the AX.25 protocol, a wireless point-to-point protocol based on the international standard X.25 protocol. Enhancements to the X.25 protocol were necessary to accommodate the unique requirements of wireless communication and the amateur radio environment in particular. X.25 is a connection oriented protocol. This means that it assumes that two stations will connect to each other and handshake before any information is passed between them. However, this would mean that amateur radio operators could never call CQ. Remember by definition a CQ is a one way broadcast to an unknown destination. For this reason, UI (unnumbered information) frames are provided in AX.25. This is important since all APRS information uses UI frames so that a single packet can be heard by everyone. When an APRS station broadcasts its location it has no idea if it is being heard, nor does it expect a response (acknowledgment) that the packet has been received. This means that the packet is operating on an unreliable channel. However, it is only a matter of a few minutes before the information is repeated again, so a lost packet for APRS is not as critical as a lost packet in normal packet communication.

Since most APRS activity is on 2 meters, transmission is limited to line-of-site. Add the limitation of mobile communication where the power transmitted is low (typically a few watts) and the antenna system is limited (a whip), it would appear that a mobile APRS station has little or no chance of being heard outside a radius of a few miles. This obstacle is overcome with a little help from your friends. Other local, fixed APRS stations with more power and better antenna systems serve as strategically placed digipeaters. It is through the use of these digipeaters that a mobile can broadcast its location to a large metropolitan area and beyond.

Let's look at a standard packet station example, since a firm grasp of digipeating and how it is used is necessary to assure good channel utilization.

C KK5SU via WA3ZFE, KC5PVL

In this example, we are sending a packet to KK5SU through stations WA3ZFE and KC5PVL. A packet user does this digipeating when the desired station cannot be contacted directly. WA3ZFE receives the packet first and rebroadcasts it to KC5PVL, who repeats it again, sending it to its final destination, KK5SU. This is “old hat” to the packet user, but its importance cannot be overemphasized in APRS work. Digipeating is a powerful tool and forms the building blocks for APRS networks. This digipeating technique allows the APRS user to extend its range far beyond the line-of-sight.

For standard packet station communication, we know the names of the digipeating stations (WA3ZFE and KC5PVL). The same cannot be said for APRS. So how do you digipeat through a station when you don't know its name. The answer can be found in the APRS network standard protocol. The protocol requires a few standard “alias” names. Therefore if everyone uses the same alias, then you can digipeat by specifying that name and assume that someone listening can hear you and repeat your packet.

Commonly used aliases are: RELAY, WIDE, and GATE. Each alias denotes a very different type of station. A RELAY station is one with a limited range (a few miles). Clearly mobile stations and some fixed stations fall into this category. A WIDE station is usually a dedicated station with a range over a metropolitan area (20+ mile radius). The GATE has a very wide coverage area (500+ mile radius). Most, if not all GATE stations are really gateways from 2 meters to 30 meters. Although there may be exceptions, these working definitions provide a basis for discussion and an understanding of a relatively complex digipeating method. It may not sound like a robust communications network, but it works, and it works surprising well.

We are now prepared to return to the topic of the PHG (power, height, gain) parameter. As every amateur radio operator knows, the line-of-sight range of a station is primarily a function of PHG. Therefore, if we look at the coverage circles of local APRS stations, we are in a good position to develop digipeating paths that are customized to our particular location. Figure 2 shows coverage circles for southern California. If by examining these displays we know that we cannot hit a WIDE digipeater, then we would be justified in adding RELAY as the first hop of our digipeating path even though we may be a fixed station (recall that RELAY is usually suggested only for mobile stations). In a similar way, if we know that we can hit two WIDE digipeaters, we may wish to use a digipeater path that specifies the “callsign” of the digipeater rather than using the generic WIDE. In this way, we bring up only one WIDE station and help reduce channel congestion.

There is a great deal more that can be said regarding the APRS network protocol. However, that is often best learned through on the air trial-and-error and a little experimenting with your particular system.

CONCLUSION

A lot has happened to APRS since its humble beginnings. I think even Bob Bruninga would be surprised what has become of his idea. New applications and uses are being developed constantly. Imagine the next fox hunt you go on being from the comfort of your car with a laptop, graphical display of a map, and no guessing. Imagine the ability of the amateur radio community to provide the National Weather Service with a hundred thousand data points around the country. Imagine the ease and accuracy of tracking during expeditions or emergencies. Imagine no more, it is here now; come and join the fun.

APRS ON THE WEB

For those with no packet radio equipment, you can still marvel at the APRS information that is available through the Internet. If you have a web browser and Internet access, you can see live data of amateur radio operators around the country and even satellites circling the globe. You may also playback recorded journeys of balloons, cars, and sailboats from history files. The following are a few of the many web sites devoted to APRS that are both entertaining and informative.

The Kansas City APRS Working Group offers an excellent page at <http://www.kcaprs.org/>. Of particular importance is the link to *Recommended Operating Practices* for APRS users in the Kansas City LAN (Local Area Network). This is a great idea. It aids users in developing efficient networks which is particularly important for APRS. Also provided is a section on the Kansas City digipeaters with vital statistics. This page can serve as a model for APRS work since it not only provides information, it is an excellent coordination tool for the amateur radio operators in the area using APRS.

Java, the computer language developed by Sun Microsystems, has been available for many years. However, it was not until the advent and widespread use of the Internet, that Java has become particularly popular. Amateur radio operators, and Steve Dimse, K4HG, in particular, were quick to see the potential of using Java to enhance APRS and disseminate information. JavAPRS allows Java savvy web browsers to display in graphical form live, animated APRS traffic. For the Miami, Florida area, point your web browser to <http://www.bridge.net/~sdimse/javAPRS.html>. There you will find links to many APRS web sites and the ability to playback previous APRS expeditions such as Steve's 8,730 mile journey from Miami, FL to Seattle, WA and back. With javAPRS you can even control the display. You can zoom in and out, up or down, change the center of your viewing area, scroll the map, change colors and more. If this doesn't get you excited, check your pulse.

No amount of surfing of APRS web sites would be complete without a visit to the homepage of Bob Bruninga, WB4APR, the father of APRS. At <http://web.usna.navy.mil/~bruninga/aprs.html> you will not only find the position of live VHF and HF APRS channels but also the location of GPS satellites. Terrestrial links are provided to boats, aircraft, and more. This page is an impressive resource and an excellent source for a quick overview of just how pervasive and powerful APRS has become. Of particular importance is a link to <http://web.usna.navy.mil/~bruninga/digis.html> which shows all known APRS digipeaters nationwide, a *must see* sight for all newcomers. It is a live display that will let you see the activity in your area.

The Atlanta Area APRS Home Page at <http://www.mindspring.com/~rwf/aprs1.html> provides an excellent description of APRS, the activities of the Atlanta APRS group, and links to other APRS web sites. Again a good example of how the Internet can help coordinate and disseminate information.

The authors of the Apple Macintosh and Windows version of APRS software, Keith Sproul, WU2Z, and Mark Sproul, KB2ICI, provide excellent web pages at <http://aprs.rutgers.edu/index.html>. and <http://msproul.rutgers.edu/APRS/MacAPRS.htm>. There you can download all three versions of APRS software (Mac, Windows, and DOS). Also provided are a large number of detailed maps and documentation on virtually any APRS subject.

For information on northern Illinois APRS activity visit <http://tbcnet.com/~jleonard/n9vjq.htm>. There you will find links to other sites along with a JavaAPRS real time display. Of particular interest are two links that show the path taken by a balloon flight. The 3D view is particularly interesting.

For northern California, Bob Wilkins, N6FRI, provides an excellent APRS page at <http://www.ccnet.com/~rwilkins/aprs.html>. There you will find links to numerous other APRS web pages around the country. You will also have a good starting point for finding information on the Global Positioning System (GPS). To aid APRS frequency coordination, a list of the digipeaters in the area is also provided.

Our neighbors to the north in Ontario, Canada are no strangers to APRS. Take a trip to <http://www.peel.com/javAPRS.html> There you will find real time APRS traffic (within past 15 minutes) as well as the ability to view traffic in previous periods (i.e., 15 minutes to 24 hours).

The future of APRS is constantly expanding. For example, take a trip to <http://web.usna.navy.mil/~bruninga/aprs.html> to find how you can have GPS on any radio using the MIM or MIC-EAPR. Pictures and further information on this unique technology can be found there.

The Tucson Amateur Packet Radio (TAPR) is the home and central point for virtually all amateur radio digital communication. Go to the APRS special interest group page at <http://www.tapr.org/tapr/html/sigs.html>. From there you will find a wealth of APRS information and resources.

For those with lots of questions, point your browser to <http://home.sprynet.com/sprynet/ku0g/APRSFAQ.HTM> to examine the APRS FAQ (Frequently Asked Questions). Gary Wells, N3HCP, has developed a page specifically for the newcomer at <http://users.nb.net/~gwells>. If you need more help, join the APRS mailing list by sending email to listserv@tapr.org with **subscribe aprssig FirstName LastName** in the body of the message. When you ask a question, your message is sent to thousands worldwide and an answer often arrives within minutes.

APRS OPERATING GUIDELINES

The APRS networking protocol requires users to cooperate to assure efficient use of the spectrum. A good digipeating path for one station may be bad for another, therefore this list is intended only as a guideline. Factors such as your location and the amount of traffic in your area will play a major role in determining what works for you.

1. Always use the MINIMUM digipath necessary to maintain communications to minimize channel loading and QRM. Remember, the APRS protocol uses UI frames which does not assure reliable delivery of packets.
2. Fixed stations (e.g., home APRS stations) should not beacon very frequently. Intervals from 20 to 60 minutes are common.
3. Fixed stations which broadcast weather related information may transmit at frequent intervals. The present standard is every 9 minutes.
4. Mobile stations (e.g., moving APRS vehicles) may beacon as frequently as once per minute for special events or 3 to 5 minutes for routine mobile operation. Care should be exercised with local network conditions taken into account.
5. When a mobile station changes to a fixed station, such as when the station arrives at its destination, the beacon should be stopped or the rate adjusted to meet the new designation as a fixed station.
6. Use APRS VIA WIDE for your path if you are in a metropolitan area where you can hear a WIDE. Better yet, if possible, specify a unique digi (callsign).
7. Use APRS VIA WIDE, WIDE for regional coverage. In a metropolitan area with an active APRS community, you should get coverage up to 100 miles. Better yet, specify a fixed callsign in place of the second WIDE to get better coverage.
8. Fixed stations may set a path of APRS VIA RELAY, WIDE if the WIDE cannot be reached directly. Then when you find out who your local RELAY is, you should specify a unique callsign for the first digi.
9. If you have information for a national audience, use APRS VIA WIDE, GATE to reach an HF gateway. However, this is for rare occasions. The 300 baud HF data rate limits the number of mobiles nationwide to approximately 20. This path may also be used by long distance travelers with emergency or priority traffic that are near a GATEway.
10. Never use APRS VIA WIDE, WIDE, WIDE since it has the potential to totally saturate a channel with 27 copies of each packet. If you are in a remote area, this may be your only option, so the "never" may be changed to "seldom". Again, use a fixed callsign as the first digi if possible.
11. Although APRS supports keyboard to keyboard contacts, extended use of this communication technique is discouraged, especially on the HF where the information rate is 300 baud.
12. All fixed stations should set the TNC's MYALIAS to RELAY. This will vary between various manufacturer's TNCs, but some form of an alias should be set to RELAY. This is true even for mobile stations.
13. Mobile stations should use RELAY, WIDE or RELAY, WIDE, WIDE as a digipeating path for city wide coverage.
14. Do not enable the GATEWAY function of your TNC unless you are the only GATEWAY near your local WIDE. Before setting the GATEWAY function, local coordination with

other GATEWAYS is encouraged. This is especially true when an existing GATE already serves your network.

15. Never digipeat on HF unless both stations attempting to pass data cannot hear each other but are known to be on-line. If you must digipeat on HF, use only one hop. This is typically for emergency or priority traffic only.
16. Whenever possible, use a direct path to chat.
17. If a direct path is not practical, use a specific digipeater callsign in lieu of a generic path such as RELAY or WIDE.
18. When events, information, or data are intended for a specific area, utilize a specific path by designating the exact callsigns of the digipeaters necessary for reliable communication.
19. As APRS popularity continues to grow, the potential for long-range VHF coverage is possible. Ask yourself if your information is of interest to someone a hundred miles away. If not, restrict the path.
20. Consult local experts or experiment to find the best route for your application. Remember these are guidelines and numerous exceptions exist.

BIBLIOGRAPHY

1. Bruninga, Bob, "*Automatic Packet Reporting System (APRS)*," 73, December 1996, pp. 10-19.
2. Dimse, Steve, "*javAPRS: Implementation of the APRS Protocols in Java*," ARRL and TAPR 15th Digital Communications Conference Proceedings, Seattle, Washington, September 1996, pp. 9-14.
3. Horzepa, Stan, "*APRS Tracks: RELAY, WIDE, and Other Paths*," Packet Status Register, Fall 1996 - Issue #64, pp. 30-31.
4. Horzepa, Stan, "*APRS Tracks: Alias Envy*," Packet Status Register, Summer 1996 - Issue #63, pp. 25-26.
5. Horzepa, Stan, "*APRS Tracks*," Packet Status Register, Spring 1996 - Issue #62, pp. 16-17.
6. Horzepa, Stan, "*Getting On Track with APRS*," American Radio Relay League, Newington, CT.
7. Wilson, Mark, "*QST Compares: GPS-Compatible TNCs*," QST, October 1995, pp. 68-71.

AUTHOR VITA

Richard Parry, W9IF, was originally licensed in New York City as WN2BIJ. Amateur radio interests include packet radio, satellite communication, Linux, and of course, APRS. He comes from an amateur radio family consisting of WB2ILP (father), KC5PVL (wife), and KK5SU (son).

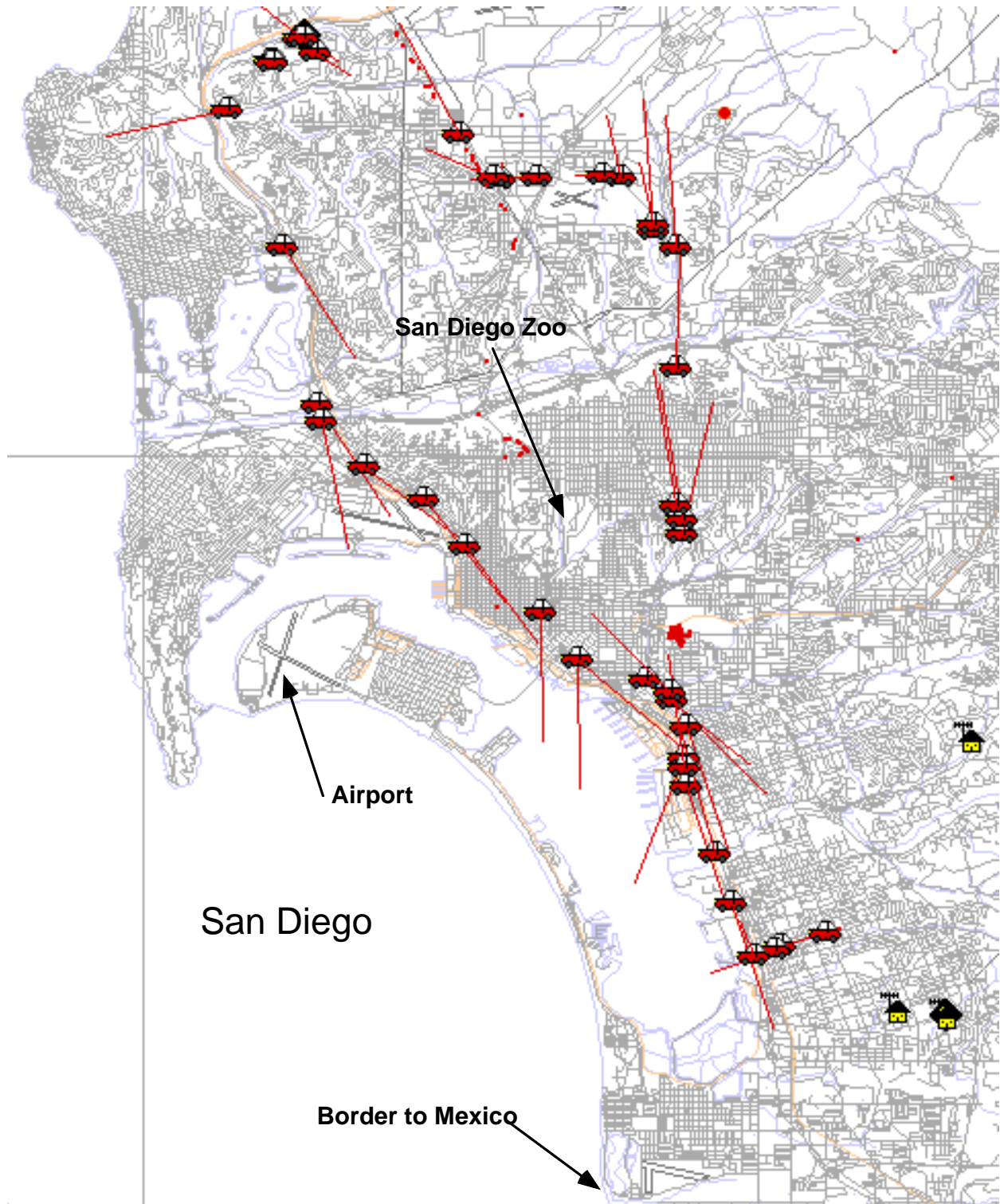


FIGURE 1

Here is a street level map of San Diego showing the daily commute of the local APRS group. The area displayed is approximately 18 by 15 miles. The vector lines show vehicle direction. Callsigns of stations are not shown for clarity and to protect the innocent.

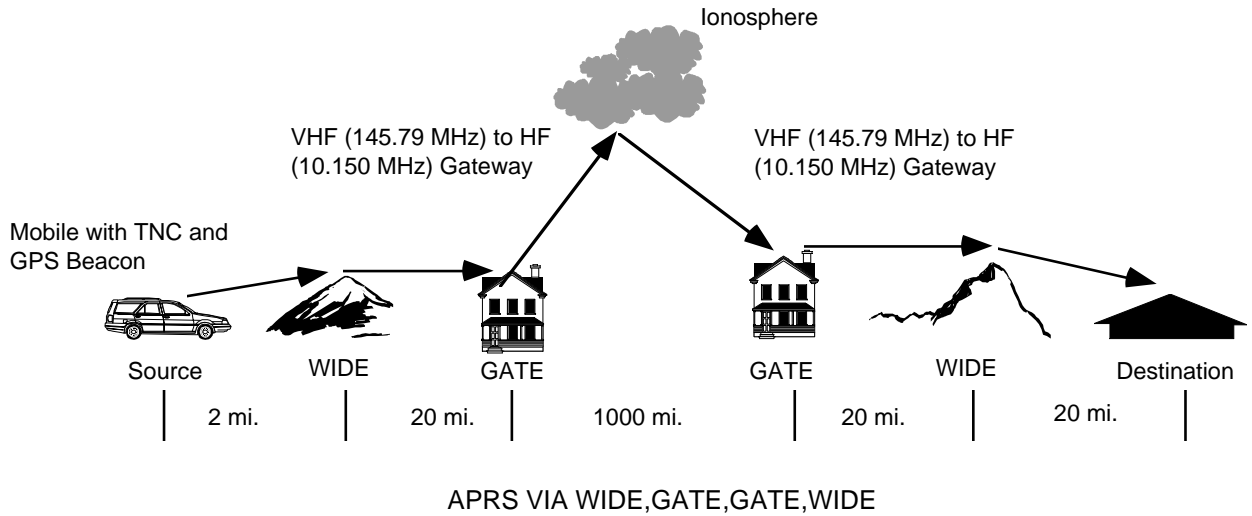


FIGURE 3

Ever wonder how a 2 watt 2 meter mobile station can broadcast its location to the world. With the digipeater path shown, the mobile extension can hop from one station to the next to reach almost anywhere. However, this is not an efficient path and is displayed here to show a concept rather than to propose an efficient use of the APRS network.