Proposal: An AMSAT Mobile TRAKNET

by Bob Bruninga, **WB4APR,**
wb4apr@amsat.org

Commercially, there are two distinct advantages of the global nature of satellites which cannot be easily met with terrestrial systems: wide-bandwidth point-to-point and mobile applications. With the availability of telephone, cable, and the Internet to link amateurs at fixed sites to each other routinely, we are wasting a lot of potential of our very valuable Amateur Radio satellite resources by ignoring mobile applications.

Ham radio is on the move. Any survey will likely show that many amateurs only have time to play radio while mobile, and similarly, whenever a ham contemplates a long trip, his ham radio is high on the packing list. Although many dream of taking along an I-IF mobile to play with and to report their progress back home, the $1000 to $2000 investment is just too much of a risk. Two meters is fun, and can bring emergency aid, but it just doesn't provide the nationwide coverage that is needed for the mobile ham traveler far from home, the offshore boater, or first-response teams arriving in a disaster area. In many cases, just a brief position/status report is all that is needed to assure the health and welfare of the traveler or to summon assistance or alert other communications channels.

Many hams have put together impressive mobile satellite stations, but the performance is poor and takes a major investment in dollars, size and weight. The reason is that they are essentially duplicating a typical weak-signal home satellite station on wheels. What we need is a new perspective which takes advantage of some very unique capabilities to exploit a small portion of our satellite on-orbit capacity to the mobile requirement. Fortunately, there are several Amateur Radio satellites that are ***very*** easy to transmit to from the mobile using only a 2 meter 25 watt FM mobile radio - the ubiquitous radio that everyone has.

Uplink

Lets look at the 1200 baud Pacsat uplinks. These uplinks are unique for several reasons that make them ideal for the mobile environment:

- The 2-meter uplink from a mobile omni antenna has a 9 dB advantage over a similar 435 MHz link due to the three times larger antenna aperture.
- There is no tuning or tracking required on the uplink since the Doppler on 2-meter is less than 3 kHz.
- Any 25 watt mobile 2-meter FM rig can be used as the transmitter.
- Any TAPR-2 compatible TNC can be modified for the uplink for $2.
- World-wide coverage.
- No software or hardware on-orbit modifications to the satellite.

Reportedly, stations running as low as seven watts into an indoor omni antenna have reported success with the 1200 baud PACSATS. This means that even backpackers with an HT and handheld gain antenna could get emergency or priority traffic into a Pacsat from anywhere on Earth! Figure 1 shows the results of the SPRE experiment during STS-72 when there was a digipeater on the Shuttle for station position/status reporting.

Downlink

OK, so the 2-meter ***uplink*** is easy and anyone can do it, so what about the downlink? This is not so easy. The path loss omni-to-omni is 9 dB worse, the satellite is only transmitting a watt or so for another 13 dB worse performance, plus it ***requires*** Doppler tuning, a $250 PACSAT modem and a $1000 all mode UHF receiver! In most cases, all successful Pacsat stations use high gain antennas and automatic tracking to make up for the more than 22 dB performance difference on the downlink. This is not something that most operators will want to add to their mobile. But what if the mobile application did not need to receive data, but only send it?

Traknet

The combination of easy uplinks, ***minimum*** downlinks, and an application that often only needs a one way exchange of data, such as the mobile position/status report is the whole idea behind Traknet. Only a few automated downlinks are needed every 1000 miles or so to receive the mobile data and to provide it into a nationwide system of linked ground stations. These ground stations relay the mobile position/status reports onto local mobile vehicle tracking channels and onto the Internet. Anyone may access these data live on VHF, HF or via the Internet. Traknet is not just a future idea, it can be implemented immediately with existing equipment and satellites. Yes, even the

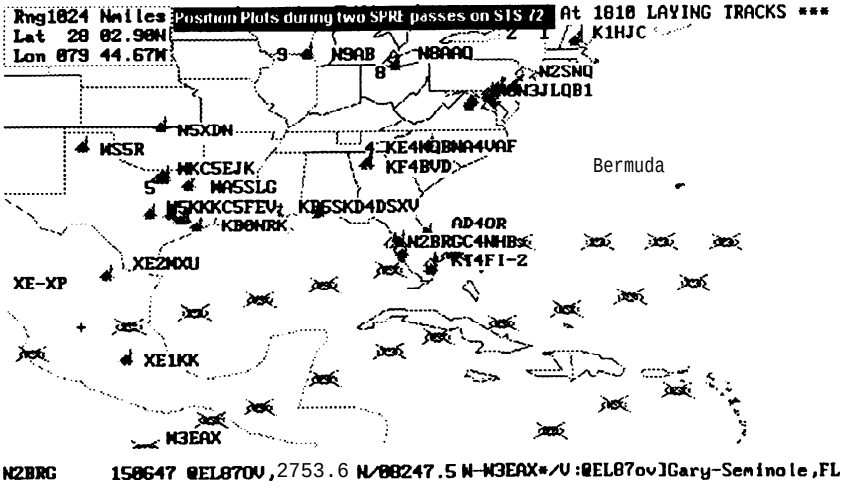

Figure 1. This figure shows the display of stations in the US that successfully digipeated their positions and status via the SPRE experiment on STS-72. A similar experiment was conducted via SAREX on STS-78.

Internet ground stations exist. Already there are six Traknet-type stations on the World-Wide-Web. Just link to any of the following sites and you will see *LIVE* (or nearly live) fixed and mobile amateur radio position/status reports.

- ATLANTA: *http://www.wadsy.radio.org/aprs/index. html*
- CALIFORNIA: *http://sboyle.slip.netcorn. com/LIDSAPRS. html*
- CHICAGO: *http://tbcnet.com/~jleonard/noiltest. html*
- MIAMI: *http://www.bridge.net/~sdimse/javAPRS.html*
- ONTARIO, CANADA: *http://www.peel. com/javAPRS. Html*
- WASHINGTON, DC: *http://web.usna.navy.mil/~bruninga/aprs.html*

You only need to access one, since most of them have links to each other, and more are coming on line monthly. Some of these sites are already listening to many such status/position reporting channels. But the problem is that none of these sites is yet listening to the Pacsats mostly because setting up an automatic Pacsat ground station is not trivial and the guys who play with the Web all day are not the same guys that are necessarily fully invested in Pacsat hardware. All we need are probably eight stations scattered over the continental USA to implement a reasonable Traknet system as shown in Figure 2.

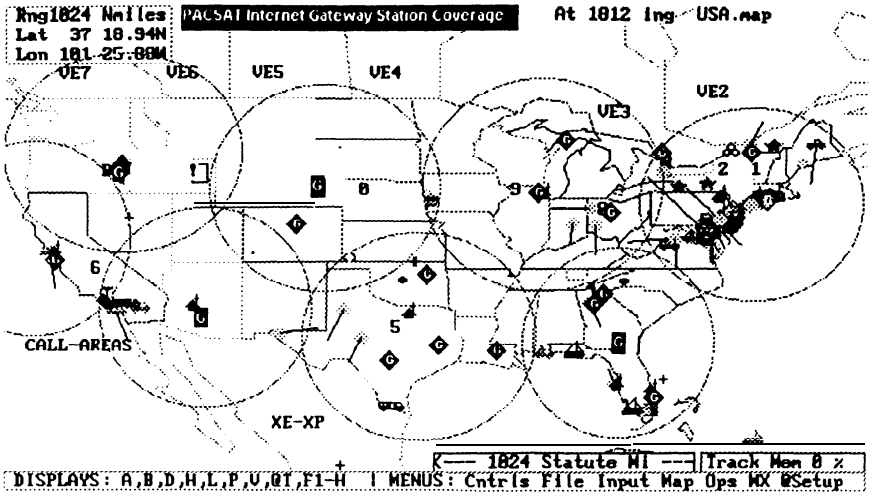

Figure 2. This figure shows how eight reasonably located PACSAT Internet Gateway stations could provide nationwide coverage for mobile travelers. These range circles are a very conservative 600 mile radius or less. Two hundred or more mobiles could be accommodated per footprint per pass.

Mobile Station

A mobile station consists of nothing more than a typical 2-meter FM radio and a modified TAPR-2 compatible TNC as shown in Figure 3. Optional accessories are a GPS for moving position reports, and a laptop for entering messages. Most modem TNCs will accept the GPS data directly and will transmit the data in a timed packet burst. There is even a tiny handheld TNCs called the APRS Mic-Encoder that includes front panel switches for selecting 1 of 7 pre-canned status messages without needing a laptop to change the status report. The modifications to the TAPR-2 TNC are to simply ***exclusive*** or the transmit data with its 1200 Hz clock and to filter the result to the Mic input of the radio. The following circuit will do this with nothing but an 89 cent standard 7400 quad 2 input NAND gate connected as an XOR gate to the two points shown.

The pin numbers shown in Figure 4 are for a PacComm TINY-2.

Traknet Protocol

The problem with any Amateur Radio satellite is the very low bandwidth available compared to the very large worldwide Amateur Radio population. At first glance, the prospect of increasing the number of users on a Pacsat channel by a hundred fold raises lots of red flags in the minds of those stations who already find ten minutes of a satellite pass to be too short for any meaningful dialog. But what if each of these hundreds of new users was limited to only a few seconds per orbit? Then as many as 200 stations per footprint could be tracked. That is the only objective of the Traknet protocol, to allow everyone to transmit a few single l second position/status reports during the closest point of approach over their location. If only one channel is designated for Traknet,

Figure 3. This photo shows a typical PACSAT mobile status/position reporting station. It consists of a 2 meter FM radio, a GPS unit and a slightly modified TAPR-2 compatible TNC.

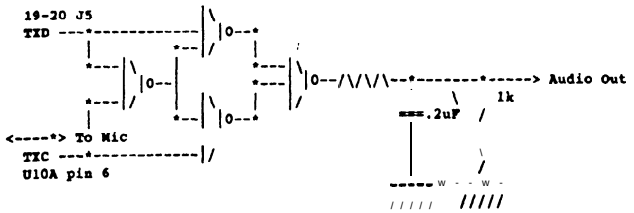

Figure 4. Pin numbers for a PacComm *TINY* 2.

then the other 3 channels are free for normal Pacsat use and no amount of congestion on the Traknet channel can interfere with existing users on the other three.

Traknet Satellites

There are currently five 1200 baud Pacsats on orbit. One, WO- 18 has actively invited UI frame digipeating and leaves DIGIPEAT on most of the time. The problem is that the WO-18 downlink is difficult to receive unattended due to a spur tone in the middle of the data which makes receiver lock a difficult and manual process. AO- 16 has had its digipeater ON for the last six months. Other Pacsats occasionally have DIGIPEAT turned on, but there is no formal policy. The purpose of this article is to encourage the designation of one good channel as a gathering point for Traknet experiments, and then progress can be made and the potential of Traknet can be evaluated. Here are the frequency plans of the existing Pacsats:

Digipeater	Uplink (MHz)	Downlink (MHz)
AO-16	145.860, 145.900, 145.920, 145.940	437.051
LU-19	145.840, 145.860, 145.880, 145.900	437.153
WO-18	145 .900	437.104
IO-26	145.875, 145.900, 145.925, 145.950	435.822

Advanced Mobiles

While the preceding was written to emphasize the ease of using the Pacsats by anyone for emergency or priority status/position reporting, there is certainly no reason why a full two way Pacsat communications system cannot be added to most mobiles. Omni Pacsat downlinks are possible and the addition of only a modest gain antenna will certainly help. Advantages are the small size of a 6 dB two element UHF antenna and the SHORT cable run found in a mobile. Rather than a $1000 SSB rig, a $90 QRP HF rig and a UHF downconverter could do just as well.

Conclusion

The advent of the handheld GPS unit for under $199 has brought thousands of mobile amateur radio operators into the world of mobile data. For years, the growth of amateur GPS applications have been growing at phenomenal rates. At this writing there are mobile map packages available which ***include*** the GPS unit for under $150 total! Similarly, the state-of-the-art in automatic Pacsat ground station technology has been improving with many recent software packages to make un-attended automatic ground station operation quite easy. The problem is that these two communities of expertise have so far had little cross-interests. It seems that the time is now to merge these technologies into a new amateur application that takes advantage of the unique capabilities of each and fuels the development of an Amateur Radio Mobile Satellite System. Traknet is the opportunity to not only merge these interests into a common purpose, but also to demonstrate Amateur Radio's continuing progress in communications technology. ■