Oh Brother, Where Art Thou?
A Real-Time SAR Team Tracking System

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Abstract

The Automatic Position Reporting System (APRS) has been used for nearly 10 years by amateur radio operators to track a variety of objects. APRS provides a protocol and method by which position reports from a handheld GPS can be transmitted via radio and plotted on an electronic map. APRS use in the SAR community has been sporadic, but there have been several attempts, and a number of actual implementations. There are commercial solutions available, but they cost more than many teams can afford. This work, funded by the Mountain Rescue Association, seeks to implement APRS in the SAR environment using off-the-shelf equipment, and to determine its efficacy with current hardware and software.

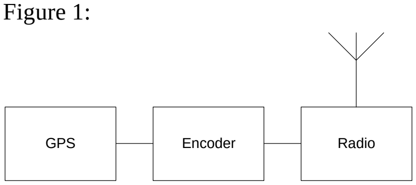
I. APRS Introduction

The Automatic Position Reporting System[1] (APRS) began as the brainchild of Bob Bruninga. For nearly 10 years amateur radio operators have been using APRS to track things such as high altitude balloons, parade floats, Olympic Torch runners, and approaching storms. APRS provides a means by which objects can be tracked in real-time, and their position plotted on an electronic map. There are three basic components to an effective field implementation of APRS. The stations in the field need to be able to send position reports, the command post needs to receive and plot these positions, and one or more digital repeaters, "digipeaters", may need to be deployed to facilitate the command post reception of the position reports.

A. Basic in-field tracker components

For a station to be tracked it requires three basic pieces of hardware. The station must have a GPS capable of being connected to a computer to give its position, a position encoder which receives the position information from the GPS and encodes it from transmission via a radio, and a radio transceiver to send the encoded position.

Figure 1:

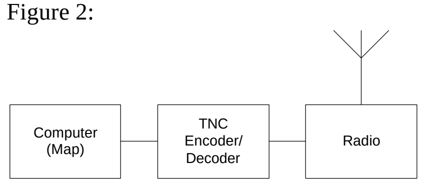


B. Basic receive station components

The base station (that station which is to receive the positions from the stations in the field) requires a similar suite of hardware components. The receive station requires a radio to receive the transmission of the station being tracked, a decoder to decode the encoded position report, and a computer with mapping software to plot the received position report. For a basic command post set-up, the radio does not have to have the ability to transmit, but it should be a good receiver with as big an antenna as is feasible.

The decoder at the base station is generally called a Terminal Node Controller (TNC), and has a more comprehensive feature set compared to that of the encoder. The TNC can also be used for the encoding function as well, however.

Figure 2:



C. Digipeater complement

In its simplest form a digipeater is a radio and TNC. The radio receives the position packets and the TNC forwards them along when the channel is free of RF traffic. That is, the TNC will cause the radio to retransmit the packet, thus aiding in its reception at the command post.

A computer is not required with the digipeater unless it is of interest to see the locations of signals that the digipeater is hearing. A minimum of one digipeater is required for most SAR applications. The terrain is the biggest factor when deciding the deployment of digipeaters.

D. Path settings

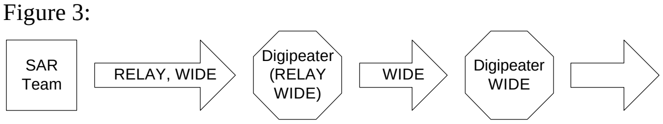
An APRS packet uses the unconnected protocol of packet radio. That is, a packet containing a position report is sent without addressing it to a specific station. A typical packet would be sent to a particular station, via a specific path. This unconnected protocol is one of the strengths of APRS in that a position report can seamlessly bounce through digipeaters,

1. APRS is a registered trademark of APRS Engineering LLC, which reserves all rights to its use for commercial products.

thereby increasing the range that it can be heard and decoded, without having to express a specific path. That being said, there are a number of standardized packet paths.

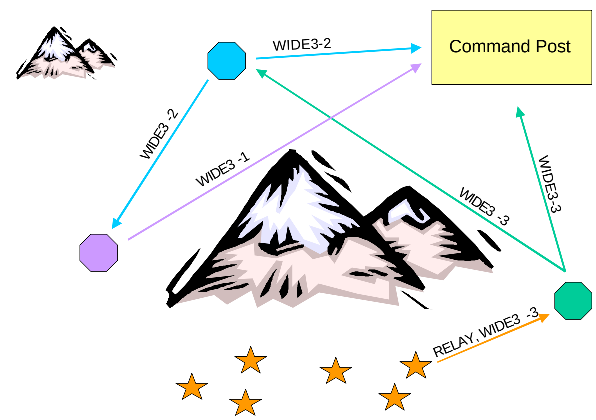
A common path is RELAY, WIDE. A packet addressed in this fashion will be repeated, first, by any digipeater configured to repeat packets with a path of RELAY in the first position of the path. Typically, the use of RELAY digipeaters is to fill in areas that cannot be heard by WIDE digipeaters. WIDE digipeaters are those that are high-level and can be heard by many stations. Upon being digipeated by the RELAY station the packet will be repeated by any station answering to WIDE. To expand the distance that a particular packet can be heard, one or more additional WIDE’s can be added, such as RELAY, WIDE, WIDE. This would add an additional hop in that after being repeated by the first WIDE digipeater, an additional WIDE digipeater would forward the packet as well. Unfortunately this type of addressing can cause much additional traffic (packet ping ponging) on your APRS network in that WIDEs may hear other WIDEs and re-digipeat a packet that it has already repeated. To combat this, the WIDEn-N protocol came to be.

Figure 3:



With the WIDEn-N path the number of times a packet will be digipeated will depend upon the value, “n”. For example, if a packet has a path of RELAY, WIDE2-2, then after being repeated by a station answering to RELAY it will be forwarded with a path of WIDE2-2. Any WIDE station that is configured for WIDEn-N routing would repeat this packet, but decrement the “2” to a “1”. This means that if this packet is heard by another WIDE, it will be repeated again, and the “1” will be decremented to “0”, and an additional WIDE would not repeat the packet. In addition, WIDEn-N digipeaters can be configured such that they won’t repeat a packet that they have already repeated within a certain time interval (a common interval is 30 s). See “WIDEn-N digipeater path.” on page 2. for a graphical depicition of WIDEn-N routing.

Figure 4:WIDEn-N digipeater path.



II. Project Components

A. In-Field Tracking Device

When designing the device that is to accompany rescuers in the field there are a number of requirements for effective SAR use. The device must be weatherproof to some degree, it must be relatively lightweight and not bulky; the device should not encumber the rescuer to such a degree that their ability to perform their primary function is compromised. Finally, the device should be “rescuer proof”. That is, there should be minimal maintenance required once deployed. The greater the number of buttons, and user intervention that is required, the greater the likelihood that the device will fail due to user error.

Radio

The radio used for the field unit is not brand or type dependent. Any radio that can be fit with a cable that connects to the microphone port will work. Typically these are VHF radios common to SAR applications. This work used Amateur Radio allocations for these activities, so the radio chosen was able to transmit legally in the spectrum of choice. Handitalkies (HT’s) are well adapted to this role, but they are not a requirement. In fact, for mobile stations a higher power mobile radio is better suited. Our study used Yaesu VX-150 HT’s.

Encoder

The stations in the field have minimal need to decode position packets. While this may be something to pursue, it complicates the in-field hardware and increase the likelihood of user error interfering with correct data collection.

To increase throughput and decrease the chances for packet collisions (two tracking devices transmitting at the same time such that neither packet is heard by the command post) the tracking device should monitor the radio receiver and not transmit when the frequency is in use.

The encoder can be purchased from a variety of manufacturers (See Figure 1). Each of these listed are adequate for SAR field use. Some are better adapted than others for particular applications, however. There are even kits that can be assembled. Each device has a particular form factor with the TinyTrak and TigerTrak having the smallest volume. The TigerTrak and TinyTrak are encode-only devices.

Table 1: Encoders

TinyTrak[a]	www.byonics.com
TigerTrak	www.gpstracker.com
KPC-3+	www.kantronics.com
PicoPacket[b]	www.paccomm.com

a. This is available as a kit.
b. Paccomm produce a number of products that are suitable.

Figure 5:Front and rear view of Kantronics KPC-3+

Figure 6:PacComm PicoPacket

Figure 7:TigerTronics TigerTrak

Figure 8:TinyTrak II

We originally budgeted for and purchased six TinyTrakII encoders. After assembling 2 of these boards it was determined that RF was causing the encoder to actuate the radio's PTT continuously. We attempted remediation after consulting with the manufacturer of the kit, but we could not eradicate the interference. Most of the trouble was the result of the close proximity of the radio and encoder, which was unavoidable. To replace the TinyTraks we purchased six TigerTrak TM-1 encoders.

The TigerTrak encoders did not suffer any affects of RF interference, and are marginally larger than the TinyTrak.

Encoder settings

The encoder can be set to transmit a position report at a user-defined interval. In addition a comment can be sent, and a call sign must be sent. Since APRS software, by default, displays the call sign of the reporting station we decided to use a tactical call sign for the call sign, and use the comment field for the amateur radio call sign. In this manner we could keep the transmissions legal, yet have a meaningful team descriptor appear on the map (SAR01, SAR02, SAR03, etc...).

The reporting interval used was 1 minute. This is much more resolution than a typical SAR mission requires, but because of terrain all teams cannot be heard all the time. A higher rate of position reporting helps to maximize the chance that a particular team's position report is heard in any given longer time interval.

The path used for the field encoder is RELAY, WIDE3-3. The decision to use RELAY surrounded the fact that we were using amateur spectrum, and there is a good chance that in the event that our roving digipeater or command post didn't hear the packet, an amateur station in the area would repeat it and greatly increase the likelihood that it was heard by our digipeater or command post. The digipeater was set up to respond to RELAY and WIDEn-N in this event. We did not see, in our field tests, any instance were a neighboring station RELAY'ed a packet to our digipeater or command post. We did, however, see much repeating by WIDE digipeaters.

GPS receiver

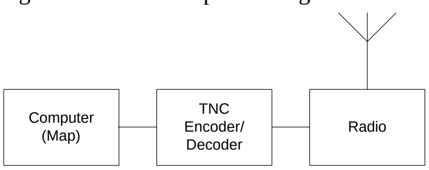
Any GPS receiver that can be connected to a serial port, and will pass NMEA position sentences can be used in an APRS tracker. We used the Garmin eTrex as this is the GPS in our team cache.

Figure 9:Garmin eTrex

B. Command Post Receive Station

As mentioned previously, the command post requires a radio, computer and encoder/decoder (TNC).

Figure 10:Command post configuration



Possibly the biggest challenge in designing the command post station is designing it in such a fashion that the software and hardware can be set-up quickly with minimal tinkering. This means that an effective station will have a dedicated computer, TNC, and radio so that from mission to mission the station does not have to be reassembled. Placing this hardware in some sort of command post vehicle is ideal, but not a requirement. The user should be able to apply power to the computer, TNC, and radio, make appropriate antenna connections, and begin plotting positions with minimal fuss. After field testing, we found that the command post station is the most labor intensive to operate. It requires somebody who is computer savvy, and very familiar with APRS.

Radio

Any radio that is capable of being connected to a terminal node controller (TNC) will work as the command post receive station. This radio only needs to receive, and our study used a Yaesu FT-50R HT. The key to effective reception is to use the largest antenna feasible, and to place it as high as possible. All position reports need to be heard by this station. Most field stations are heard by the digipeater(s), so it is important that the command post can hear the digipeater at all times. Also, be wary about using a HT for a receiver. Often, when connected to a “real” antenna (not the rubber duck that is commonly used) the front-end on the receiver can overload and disable effective packet reception. We have not found that to be a problem in our configuration, however.

Encoder/Decoder (TNC)

The requirement for the TNC is that it can connect to your radio, and that it is compatible with whatever software you choose to use. Virtually all TNC’s sold today will work with available APRS software, so the compatibility issues are not great. The feature set, and robustness of these devices is important, however. Due to its track record, our project uses a Kantronics KPC-3+ for the base station. The TNC need not be configured to repeat any packets; in the most basic application this device only decodes incoming position reports. There is text messaging available as part of APRS, and if this is to be used with the command post, then the TNC must be configured to transmit, and appropriate settings configured.

Computer/Software

The computing requirements are not great; most current computer hardware is more than sufficient for APRS use. The computer must be able to display maps effectively, however. Any computer that will work for common mapping programs such as DeLorme, Mappoint, MapTech, or TOPO! should work fine. Having a dedicated computer is best so that configuration settings do not change from mission to mission.

The software has been the biggest issue with respect to APRS use in SAR. In search and rescue we require topographical maps. At this point only one software title, Xastir, is able to display position reports on a topographical map. XASTIR uses the USGS DRG maps which are available at a variety of web sites. XASTIR, however, runs under X Window and LINUX, making it not well suited for the command post of most SAR teams. WinAPRS has some topo support, but it is not completely implemented at this time. Some APRS titles will work with external mapping software. APRS+SA works with DeLorme StreetAtlas products, APRSPoint uses Microsoft’s MapPoint, and WinAPRS works with Precision Mapping Streets. All of these software titles, however, are street map based.[1] Also, all of these maps use NAD83 or WGS84 as the map datum. This means that the in-field GPS’s must be configured to use one of these datums if the positions are to be plot correctly.

Table 2: APRS Software

APRS+SA	www.tapr.org/~kh2z/aprsplus/
WinAPRS	aprs.rutgers.edu/
APRSdos	web.usna.navy.mil/~bruninga/aprs.html
APRSPoint	www.aprspoint.com
PocketAPRS	www.pocketaprs.com
APRSCE	www.tapr.org/~aprsce/
UI-View	uiview.app.aprs-is.net/
XASTIR	www.xastir.org

Most of these map products show many smaller roads, but they do not show any features or trails. While this is useful for seeing the relative locations of these teams, it is not the optimal display. See “The Field Tests” on page 6. for more information on this issue that surfaced as a result of our field tests.

Another useful feature is the ability to translate coordinate systems and datums. Since most SAR operations use USGS topographical maps, the NAD27 datum is used, and the UTM coordinate system is used to plot location. Most aircraft, how-

1. APRS+SA won’t work with the topo maps distributed by DeLorme.

ever, will use latitude and longitude for positions, and they will often use NAD83 or WGS84. For this reason it is helpful to be able to move between these as the need arises. APRS+SA has the ability to do this. While the information is not plotted on the map, there is a utility that will take a position report and convert it between datums or coordinate systems. Since APRS uses NMEA position strings, all of the position reports are in latitude and longitude, so the APRS+SA conversion utility is helpful to convert those to UTM and NAD27.

Products such as MapTech and National Geographic Topo Maps (Formerly TOPO!) have the best feature set for SAR use. However, when asked, neither of these companies said they would be adding APRS support to their products in the future. The MapTech representative said that they were thinking about it, but they had no immediate plans. The National Geographic representative said that they had no plans for implementation. Unfortunately, either of these products with the APRS features would serve as an excellent SAR APRS platform.

After our field tests we have decided that, absent any topo map support by any other product, that APRS+SA is the best software title for SAR work. While APRSPoint is more integrated into its map product (MS MapPoint), and therefore more user friendly, the ability of APRS+SA to convert between datums and coordinate systems is *very* useful.

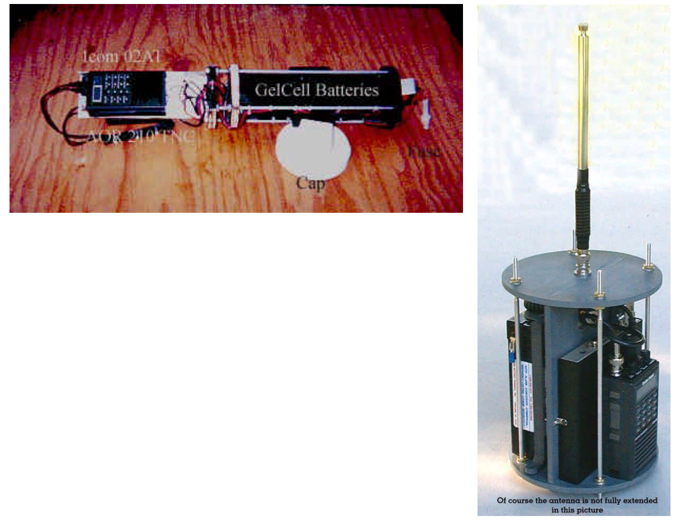
C. Roving Digipeater

To effectively deploy APRS in wilderness regions it is important to field one or more digipeaters. These devices, as mentioned previously, serve to extend the range of position reports. The simplest configuration of a digipeater requires a radio and TNC; no computer is required. A digipeater could be taken into the field and placed in a fixed position, or it can exist in a mobile (roving) platform. Two versions of portable digipeaters to be placed in PVC pipe are shown in Figure 11. Small, portable digipeaters usually use low-power radios since the weight of batteries with enough capacity to power a high-power mobile radio does not lend itself to easy carry in the wilderness. These portable digipeaters could be deployed in regions throughout a search area and forward packets to the command post.

Our study used a roving digipeater, where a high-power mobile radio is connected to a TNC and the digipeater moves throughout the search area or is driven to a location that has wide radio coverage of the search area.

Connecting a GPS to the digipeater is helpful, but not required. It is helpful for the command post to be able to “see” (appear on the map) the digipeater so as to be able to position it throughout a mission if needed.

Figure 11: Digipeaters for portable operation



Radio

We used a radio in one of our team vehicles, a Kenwood 742A. This radio is well adapted to APRS use in that it is a dual band (2 m and 70 cm) that has the capability of listening on two VHF frequencies at the same time. In this manner we could have one frequency always tuned to the APRS frequency, and the other listening to the principle mission frequency. This proved to of significant advantage. An additional feature of this particular radio is that the data port is on the front of the radio rather than on the back. This makes it much easier to connect the TNC to the radio. For a roving digipeater, a high-power mobile works best.

TNC

Any TNC that supports smart digipeating is useful for the digipeater. That is, it should support WIDEn-N addressing, and, if possible, remote access. An additional requirement is that it operate from low voltage (12V or less) DC. It is not convenient to power these devices with AC in the field. We used the same model TNC as that used for the base station, a Kantronics KPC-3+. The KPC-3+ has a long track record with use as a digipeater.

The TNC can be configured prior to deployment, and should retain these settings when powered off. This removes the requirement of a computer for TNC operation. To operate the TNC, and digipeater, the user must connect the device to the radio, turn it on, and make sure the radio is tuned to the correct frequency.

We did use a Handspring VISOR running PocketAPRS to plot positions in the digipeater. This device helped find reliable locations for the digipeater, but it also greatly increased the skill level required to operate the station, as the software would occasionally seize, and at times change the configuration of the TNC. At this time, if PocketAPRS is to be used in a digipeater, it is very important for the operator to be familiar with the TNC commands and APRS.

III. The Field Tests

After a few months of building and research we were able to field our six tracking devices, base station, and a roving digipeater on three different occasions.

A. Mountain Terrain with Rolling Hills

The first operation was part of a San Bernardino County Sheriff's West Valley SAR Team search scenario in the local San Bernardino Mountains.

The plan was the "overdue hiker scenario" where the team rolls on site, interviews the reporting person, sketches any shoe prints, makes team assignments, and searches for the lost person. Mark Kinsey (KG6JZX), a fellow Cave Team member, and I were to attach our tracking devices to one member of each of the six search teams, set up a base station for map display, and deploy our roving digipeater if necessary. The search scenario occurred in Holcomb Valley which is well-suited for a first-time test. For the most part, radio coverage is not greatly complicated by the terrain, but as with any search, communication can always be problematic.

Mark Kinsey and I were prepared to operate out of the front seat of a vehicle, but Bill Maclay (KD6HFY) member of both the San Bernardino County Sheriff's Search Dog Team and Communications Team, showed up with his nifty trailer with well-appointed radio/computer workspace. This freed our team vehicle for use as the roving digipeater. We maintained a position lock on every team throughout the duration of the eight hour scenario. When we began to not get position reports from teams at each two-minute interval, the roving digipeater was deployed to fill the gaps. This digipeater was the Cave Rescue Team truck with a TNC attached to its VHF radio (Kenwood TM-733A). I drove the roads in the area finding a high spot, and coordinated with Mark back at the command post to confirm that he was getting position reports. When the teams moved to an area no longer covered by the digipeater, I moved along as well. A few times we "lost" teams for 10 or 15 minutes, but this could have been due to poor GPS coverage, as the encoder will not send a packet unless the GPS has a position lock. In one case it was due to a team member's pack covering the GPS during a lunch break.

Since this was new technology, the APRS information was not relied upon heavily early in the search. One of the issues was the location of the mapping display with respect to the master search map. It would be more effective if they were right next to each other. Also, one of the current difficulties with SAR use is that the maps provided with the APRS software are street-level maps, and not topographic maps. We could see relative locations and locations with respect to roads, but not directly on a topographic map.

At one point three teams were waiting for instructions at a road intersection when one of the teams "caught sign" and began tracking. Right away their departure from the area was noticed on the APRS plot and the command post called to ask why they were leaving, and why the command post wasn't notified. As it turned out, one of the other teams at the intersection had suggested to the tracking team that they should notify the command post of their departure, and the tracking team was about to do that when the command post called. This same day we were able to notify two teams that they were actually following each other, and to spread out to make a more effective search.

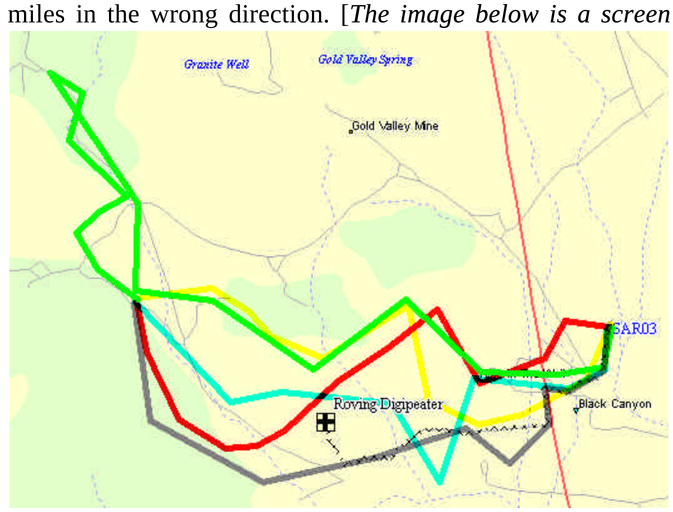
B. Desert Terrain

The following month Mark Kern (KE6QXF) and I were able to accompany West Valley SAR on their annual land navigation exercise. This exercise covers a very large area in the East Mojave Desert that presents some interesting challenges with respect to RF propagation. This particular exercise placed the command post a few miles from the operation in a low spot with a very large hill (mountain for you Easterners) between it and most of the teams. Again, all six trackers were deployed, but there were 11 teams. Therefore, not all teams were tracked throughout the exercise.

Each team was given a series of locations on a map for which they were to travel to and report what they found. They were not allowed to use a GPS and had to rely on their ability to read a topographical map and compass.

The roving digipeater was crucial in that the command post could not hear any stations due to the hill and low position. Also, the terrain allowed for the digipeater to stay in one location throughout the operation.

The APRS triumph of the day occurred relatively early when the command post notified the operations leader that a team was heading in the wrong direction, out of the navigation course area. The position was converted to the correct datum and UTM coordinate system and reported to the ops leader so that he could plot it on a topo map. He couldn't believe that this team was in the position reported by the APRS report and didn't worry about them until the team was no longer within communications range (a portable voice comm repeater was used by the team, so out of commo range meant a long way away). Again our command post showed them a couple of miles in the wrong direction. [*The image below is a screen*



shot of the APRS tracks of these groups, with the green track being the errant team]. We continued to get position reports eventhough they were no longer within voice comm range. We relayed their last position to the ops leader as he left to try to find them. Lo and behold, they were right where we said they were, and were promptly returned to their original start location so that they could begin again.

During this operation we used an additional item in the roving digipeater. We used a Handspring Visor Deluxe running PocketAPRS to monitor the position reports in the roving digi. This proved to be very helpful in placing the digipeater as the operator can see for him/herself whether reports are being received. This reduces radio traffic in that the command post does not have to tell the digi when and where to move. It was also helpful in making the case that there was a team off-track that needed some guidance. One thing is certain, however. The operator of the digipeater must be intimately familiar with TNC operation since PocketAPRS, depending upon configuration, may change a few TNC settings upon start-up. If a computing device is to be connected to the TNC used as the digipeater, then there must be an experienced operator nearby to tend it, as an inexperienced operator could change the TNC configuration rendering it useless for the task at hand.

C. Steep Alpine Canyons

West Valley SAR agreed for a third test as part of another of their monthly trainings, and Mark Kinsey, Tad Gallistel, and I headed for the mountains for a simulated search and subsequent litter evacuation. The scenario was different from the others in that the team was not told ahead of time where the activity was to be. They were told that they would be paged as they are in an actual call-out, so to play along the APRS team was told to be in a certain metropolitan area and tune to a coordinating radio frequency. Around 6pm the page was sent and team members began coming up on the requested frequency and coordinating their activities. At that time we, the APRS team, were notified of the location and began heading in that direction.

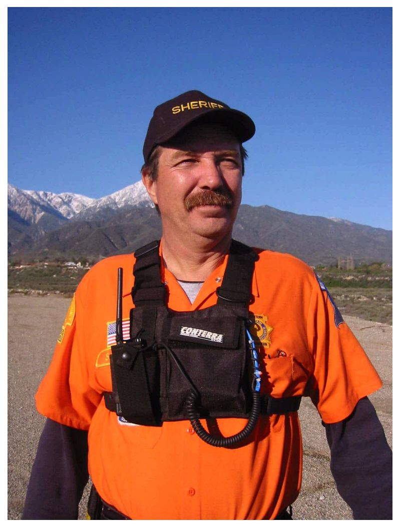
Arriving on scene we found the terrain to be steep canyons with no place to operate a roving digipeater. We issued our tracking packages to the first team out, the hasty team, and the next two teams. Fortunately we had good reception of the teams in the field and didn't need to deploy the digipeater early in the exercise. Also to our relief the lost subject was located within the first hour or so of the operation, and he was within 1.5 miles of the command post. What ensued was a several hour evacuation down a talus slope on a cold evening in November.

While this was a good test of the operation in steep alpine canyons, the search area was relatively well-defined by the terrain, and teams did not get spread out too far such that management of resources was an issue. One helpful aspect to the operation was managing and planning additional resources. For example, once the patient was located and it was determined that a litter and additional equipment was necessary for a safe evacuation, a team waiting in reserve was sent with the needed equipment. They received a tracker and it was helpful to monitor their progress to relay to the teams waiting for the materiel. It was dark, so they could not see each other except for the occasional flash of a headlamp.

IV. Results and Recommendations

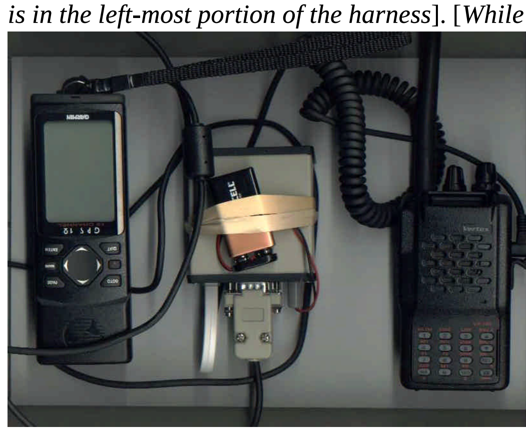
A. In-Field Tracking Package

For our tests, one member from each team was designated the beacon mule, and a radio harness and tracker complement was entrusted to their care for the duration of the event. Periodically they checked on the GPS and radio to make sure that they were still powered up. The TigerTrak will not report a position if the GPS does not have a lock, so it is important to make sure that the GPS is receiving a sufficient number of satellites. One handy thing with the use of APRS in SAR is that the whole set-up does not have to be in operation when teams enter the field; the teams can be issued trackers, but the command post station and any digipeaters can be set-up later in the operation.



There have been a number of interesting and clever packaging ideas for APRS trackers presented in *QST* and other locations. We found, however, that the best packaging for a system that uses off-the-shelf radios and GPS's is the standard radio harness. The antenna stays in the correct orientation and the radio and encoder are out of the way of the rescuer. This set-up could also be placed on a pack, and this configuration was also used.

[*In the image, Steve Elliott, KG6OPJ, is wearing a Conterra radio chest harness. The TigerTrak encoder box and GPS are in the large pocket in the center-right, and the radio is in the left-most portion of the harness*]. [*While we didn't use*



the Garmin GPS 12 in our work, it is shown in the image above for scale].

Tracker Configuration

The TigerTrak is configured via the serial port on a PC. A number of sets of settings are available with the TigerTrak. In this manner one can select a different icon or path for each mode (setting). The call sign and any comments are the same regardless of the mode. The comment can be disabled or enabled between modes, however. Also, the TM-1 can operate in continuous or Mic-E modes. To change modes the mode button is pressed a number of times corresponding to the mode number. For instance, if you would like to use mode 6 then you would press the mode button 6 times in succession and an LED would blink 6 times confirming your change to mode 6. The other button on the TM-1 is the power button; it is a toggle where a press of the button toggles between on and off.

One of my teammates, Tad KG6ANQ, summed it up best when he stated that the TigerTrak has two too many buttons (it only has two buttons.). The configuration program allows for the disabling of both the power and mode buttons, and this is a requirement when sending these devices into the field. The push-button switch is easily bumped which could turn the unit off or change modes inadvertently. This could effectively render the tracker unusable while in the field. A helpful remedy would be some sort of heavily detented switch that shows the mode number easily and is not easily actuated with rough handling. This would allow the user to actually make use of the different modes. For us, the mode feature is unusable since it is not practical to make continuous changes in the field.

Our configuration of the TM-1 used a path of RELAY, WIDE3-3 and we used the call sign field for a tactical call sign (SAR01-SAR06). In this manner the tactical call sign appears on the map which is much more useful than an amateur radio call sign. A piece of tape with the tactical call sign enables quick identification of each encoder so that it can go with the correct team. To keep things legal we identified our stations by putting the amateur radio call sign in the “comment” of the APRS report. Our reporting interval was once per minute. While this is far more resolution than is required for SAR work, where folks are travelling relatively slowly in difficult terrain, it was determined to be optimum since the GPS regularly looses lock, and the terrain limits RF communication, making a higher reporting interval necessary to increase the likelihood that a position report will be heard by the command post.

In addition to the settings listed above we also used the “To Call” of “SAR” so that we could more easily filter the reports back at the command post.

The following are a number of suggestions for improving the TigerTrak TM-1 for use in SAR:

- Use a detented dial for mode changes.
- Use a more positive button for power such that it cannot be easily switched off with rough handling. The fact that the power switch can be disabled is a big help, however.
- Allow different comments and call signs for each mode. This way the trackers can be more easily repurposed in the field (change icons and tactical call signs).
- Provide some sort of battery “fuel gauge” so that battery condition can be readily assessed in the field without a voltmeter.
- Build a case that will accommodate a 9V battery.
- Have the ability to cycle through the modes alternating with each position report. In this manner different paths can be used without having to reconfigure the tracker if paths are an issue.
- Offer pre-built cables for a number of popular radios. The cables provided are handy, and so is the modular connector, but making the cable and providing sufficient strain relief for those tiny wires is not a trivial exercise.

B. Command Post Station

The biggest issue with the command post station is the software. As discussed earlier APRS+SA was deemed the favorite due to its ability to translate datums and coordinate systems. An interesting finding of our tests, however, was the realization that having topographic software was not an absolute requirement. Often when running an operation the incident commander and command staff will discuss the situation over the hood of a car or in a makeshift command post. It is difficult for many folks to hover over a relatively small computer screen. For this reason, a regularly updated table with the current position of each team that can be translated into any datum or coordinate system is of great utility. With this position data the operations leader can quickly locate each team on a master map, and those positions are easily viewed by everybody around the table. While APRS+SA can do these transformations, it must be done for each team and for each position report. It would be nice to have a table that will toggle all positions between datums and coordinate systems. In fact, PocketAPRS is well-adapted to this since its ability to display high resolution maps is limited, and PalmOS PDA’s can be obtained for small amounts of money compared to a full-fledged PC. The author of PocketAPRS has been contacted in this regard, and he is working on adding these features. If this author had to choose between topographic map support and the ability to express position reports in different datums and coordinate systems, I would choose the latter. Granted both are the best situation, however.

C. Roving Digipeater

The roving digipeater has proved to be invaluable in SAR APRS work. The complex terrain requires relay devices, and a mobile radio and TNC provide a great platform for this device. We were continually amazed at the comprehensive coverage of existing amateur APRS networks. Even in the middle of the Mojave Desert we were bouncing in to digipeaters that would forward our positions to the Internet. After each operation we were able to view the locations of all of our teams using findu (www.findu.com). This has tremendous possibilities in resource management.

We set the digipeater to respond to both RELAY and WIDEn-N paths. The reasoning behind this was to accommodate a packet from one of our teams that may have relayed from a nearby amateur station, but was not heard by our digipeater. In practice, however, this concern was not realized.

The use of a PDA and PocketAPRS was a big help in the roving digipeater. Running this software enabled the driver to accurately position the vehicle as well as keep tabs on the teams in the field. In our desert scenario it was nice to be able to show the screen with the relative location of all the teams to the ops leader to show him that there was one team way out of bounds. There is nothing like a picture to get your point across. This did, however, introduce additional training that would be required of the operator. In its simplest form, the digipeater is very easy to operate. Nothing is required as long as the TNC is correctly configured. The operator must only make sure that the digipeater is in a good location.

D. Closing Comments

APRS use in SAR is a perfect fit. We are not the first to have deployed APRS trackers with SAR teams, and we hope that many will continue to refine the packaging and software to better serve those involved in volunteer search and rescue.

I would like to offer a special thanks to my teammates Tad Gallistel, Mark Kern, and Mark Kinsey who are building hardware and working with software as part of this effort. Also, thanks to the Mountain Rescue Association and the San Bernardino County Sheriff's Cave Rescue Team for helping to purchase equipment to make this project a success. We are continuing our efforts, and if you have any questions, comments, or suggestions, we'd enjoy hearing from you at aprs@caverescue.net.

Additional Resources

Additional information about this project including vendor lists and wiring diagrams can be found at www.sbsar.org/aprs.

Figure 12: APRS Project Team (left to right) Tad Gallistel, Jeff Lehman, Mark Kinsey, and Mark Kern (standing)