An Automated, Real-Time, Search and Rescue Team Tracking System

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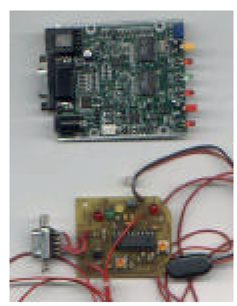
A three-month progress report to the Mountain Rescue Association grant program.

Summary of Progress

The project is fully underway. Six trackers have been built using existing team radios and GPS equipment. A base station consisting of a TNC, computer, radio, and antenna has been assembled as well as a portable digipeater. Three software titles are currently being investigated, with the authors of two of the titles pursuing our suggestions for the inclusion of "SAR friendly" features. We have completed one field test in hilly terrain with an overdue hiker search scenario that lasted more than eight hours. This tracking system will work in SAR environments with minimal end-user involvement.

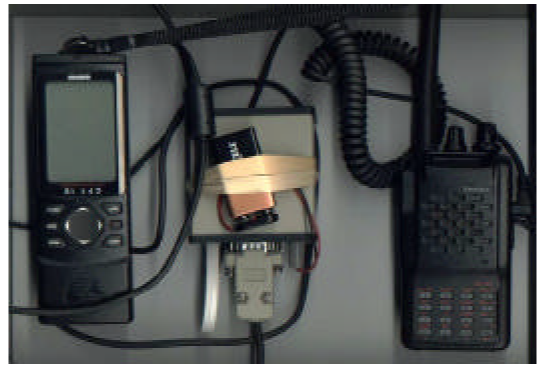
Hardware

The original proposal stated that we would build six trackers from TinyTrakII kits. Six of these kits were purchased and two were assembled. After assembly and testing it was determined that the necessary close proximity of the radio to the encoder created RF interference that could not be filtered adequately. The remaining TinyTrakII kits were returned and TigerTrak TM-1 units were purchased. This greatly affected the budget, but this was partially mitigated by the distributor of the TigerTrak, CJ Products, giving us a discount. This also affected our form factor, but this does not seem to be problematic. The image at right shows the TigerTrak board on top and the assembled TinyTrakII board on the bottom.



The TigerTrak TM-1 also required some modification at the factory as well as the inclusion of a diode in the GPS cable to work with the Garmin eTrex GPS. Data suggests that the voltage output on the data line of the eTrex can be below RS-232 and even TTL levels. We assembled the cables with the diode and there hasn't been any difficulty with the eTrex.

We are currently working on packaging for the entire system. Since we are using existing GPS and radio hardware, each with their own packaging, it is not possible to make small packages. We have found that the entire set-up will fit in a standard-sized radio chest harness, and that is what is being used for our testing. The complete assembly of GPS, radio, and encoder is shown at right.



If this package is to shrink significantly the GPS must be of the OEM board type that can be included in the encoder case. One team member is pursuing this with a possible vendor that has the appropriate hardware. There are issues with common packaging, however. First, it does not allow the use of existing team equipment. Second, the package must be able to see the sky, unless there are external antennas, for the GPS to work. Finally, this arrangement would require additional expertise by interested rescue teams for assembly, unless a commercial vendor could be found to produce such a product. Even so, a small, integrated package is desirable.

Each component is powered independently. Currently the encoders are powered by a separate 9 volt battery which should last for approximately 20 hours. The encoder can provide power to other devices, so it is possible to power the GPS and encoder from the same supply, but there are no form factor advantages in doing so. Also, depending upon the model, a GPS may have different power requirements. For instance, the Garmin 12 shown in the image above can run on no more than 8 V, where the eTrex's that we are using for our test can be powered from 12 V. For our test the 9 V batteries were cable-tied to the encoder enclosure.

The base station was assembled with a Kantronics KPC3+ TNC, an existing team radio, and a J-pole antenna.

HARDWARE VENDORS

Computer and power cables were purchased from a number of sources such as Radio Shack and our local electronics stores. A few vendors of the specialized equipment are listed in the table below.

Item	Vendor
TigerTrak TM-1 Encoder	Tigertronics (www.tigertronics.com)
Garmin Data Cables	Purple Open Project (www.pfranc.com)
Yaesu 4 conductor plugs	BuxCommCo (www.packetradio.com)

Item	Vendor
J-pole antennas	JamesPole Antennas (www.jamespole.com)
Kantronics KPC3+	Ham Radio Outlet (www.hamradio.com)

Software

At the outset we knew that the software would be the toughest part of the project. Current APRS software has provision for street-level maps. Also, most commercial vehicle locator services use street-level maps, so that is where the market is. SAR work requires topographic maps, and support for topo maps is lagging in APRS software.

MapTech, a popular topographic mapping package was contacted to see if they had an API available or were interested in developing APRS support. They have an extensive set of tools for topo maps that would make an APRS feature set a perfect fit. They said that they were thinking of adding APRS features, but did not have a time-table. MapTech would own the APRS SAR market if they chose to develop these features. Currently the only APRS package that supports USGS DRG topo maps is Xastir. Xastir is an X Window program that requires a Unix-like operating system such as Linux. One of our team members is using Xastir, but we have not used it in the field yet.

Two software authors (WinAPRS and PocketAPRS) have expressed an interest in adding topo support. WinAPRS already has some rudimentary topo support, and we have sent a set of desired topo maps to these authors for their inclusion into their respective products. WinAPRS is a Windows APRS program and PocketAPRS is a similar product that runs on the popular Palm OS.

COORDINATE SYSTEMS AND DATUMS

The biggest issue with the software is the fact that all APRS maps use the WGS84 map datum and the USGS topographic maps use the NAD27 datum. In addition, the position reports from the APRS information are in degree minute second (NMEA standard), where SAR teams generally prefer UTM (unless one is dealing with air resources). We have requested from the various authors to provide a table with datum and coordinate system transformations. In this manner, position reports can be transferred more readily to the master search area map. In our first field test we could see the relative location of each team, and their absolute location with respect to roads as we only had street-level computer maps. To display on a topographic map we took the position data from the APRS plots and entered them into the National Geographic topo map product that has the ability to work within different map datums and coordinate systems. The software authors are much more receptive to providing topo map support than they are with coordinate transformations.

SOFTWARE VENDORS

The following are vendors of APRS software and related mapping software.

Item	Vendor
WinAPRS	aprs.rutgers.edu
Xastir	www.xastir.org
APRSPoint	www.aprspoint.com
PocketAPRS	www.pocket.aprs.com
MapTech	www.maptech.com

Field Test

Our first field test allowed us to deploy our six tracking packages (radio, encoder, and GPS) with teams that were pursuing an overdue hiker. This training activity took place in the mountains near Big Bear Lake, CA in hilly terrain and covering an area of approximately 6 km^2. Each tracker was packaged in a radio chest harness and issued to teams with minimal instruction. Each team was told to periodically check the radio and GPS to make sure the displays were reporting that they still had power. All of the buttons were disabled on the encoders, the radios were locked, and the encoders were set to report at two-minute intervals.

The command post used an HT for the receive radio and an external half-wave antenna on a ten foot mast. The computers were provided by teammates participating, and we used APRSPoint (www.aprspoint.com) for our tracking software.

Our team vehicle was employed as a portable digipeater using the existing VHF radio in the truck. If coverage became poor this vehicle was to drive about to provide coverage. Digipeating is unlike using a typical voice repeater. Its use is completely transparent to the end-user. The only thing the teams in the field had to do was periodically check to make sure everything was powered-on and to find the lost person. All of our operations took place on the national amateur APRS frequency of 144.390 MHz. By using the national standard frequency we have access to a host of existing infrastructure that can often be of great help to getting a report back to the command post.

With a few exceptions lasting approximately 10 minutes, we maintained position lock on all teams throughout the exercise. The roving digipeater was necessary as the search teams were deployed in canyons and other RF “dark” locations. In fact our position data was often more reliable than voice communications. Since this is all new, and our display map was not a topo map, the search managers did not make use of the technology early in the search. As the day progressed, and the location of teams became much less certain, the search managers began to lean heavily upon the APRS data. At one point three teams were waiting at a road junction for further instructions. One team “caught sign” and began tracking. Right away the command post noticed that one of the teams was leaving the meeting point and radioed to the departing team asking why they were leaving. The funny part is that just prior to the command post call, another one of the teams at the location suggested to the departing team that they should call the command post to tell them they had resumed tracking. In another instance the APRS position data showed that three teams, who were out of sight and earshot of each other, were actually following each other in a line and tracking each other. The command post was able to see this and tell them to fan out so that they covered the area adequately.

We also deployed two personally-owned tracking devices; one in a transport vehicle, and another in the digipeater. Since these placements were ad-hoc, their stations were compromised by poor antennas. If a low-power radio (5 watts) is to be used in a vehicle, it is important to have an external antenna. This limited the ability of these stations to report their location regularly. One station also used a radio that transmitted no more than approximately 1 watt, which was not adequate outside of direct view of the command post or digipeater.

One feature of APRS software is the ability to leave a track of a station's travel. This is very beneficial in a search scenario, but for a variety of reasons we did not lay track on each station. At one point this would have been very helpful in that the command post was trying to ascertain if a particular team went north or south of a certain hill. If we had been plotting a track then we could have answered this question quickly without tying up any radio networks.

Overall the test was a rousing success. The system worked better than we had expected for the first time. No user errors occurred in the field since there was nothing for the operators to do, and the system provided useful information to the search managers. There was much interest generated with many asking where they could purchase such a system. Below is a summary of our test findings.

- The radio chest harnesses worked well for a tracker package. They provide a good view of the sky for the GPS and the radio is held in the correct orientation.
- A roving digipeater is crucial to success in hilly terrain. A minimum of one, but two or more would be required for difficult terrain. Digipeaters do not have to be run by the technically savvy.
- Topographic APRS maps are a must as well as the ability to display positions in UTM format.
- This tracking system can work effectively in real-world SAR environments.

Our next field test is next month in the desert over a larger area. We are hoping to deploy two digipeaters, and study the optimum routing of packets.

Budget

Most of the money is already spent. There is enough left to purchase software licenses. Our license purchases are pending the decision of which software package to license. The fact that we budgeted for the TinyTrakII's, but had to purchase the TigerTrak TM-1's reduced our ability to investigate enclosures for the device. This became much less of a requirement as the TigerTrak comes with its own enclosure. Also, it was determined that packaging the radio, GPS, and encoder, each with its own enclosure, would only add weight and bulk to the system. We are still pursuing enclosures, however. Also, the inclusion of the digipeater (a second KPC3+ TNC) was not in the original budget. This was purchased by a team member from his personal funds for our use during testing. Therefore, we would like to purchase two additional KPC3+ TNC's dedicated to this project's use. We are pursuing additional funding for this, and Kantronics, the manufacturer of the KPC3+, has offered a $20 discount ($149.00) for our current project.

We were able to receive discounts on the TigerTrak encoders, data cables, and base station antenna which helped off-set the increases over the TinyTrakII's. The San Bernardino County Sheriff's Cave Rescue Team purchased two radios and a GPS so that we could field 6 tracking stations. The original budget did not contain enough for "Connectors and misc. cable"; this has turned out to be the second largest budget item. Below is a summary of our expenditures as well as the budget from the original proposal.

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Budget in Original Proposal

Qty	Item Description	Cost	Extension
6	TinyTrakII position encoder & enclosure	$50.00	$300.00
4	PC Data cable for Garmin eTrex	$35.00	$140.00
4	PC Data/Power cables for Garmin eTrex	$50.00	$200.00
1	TNC for command post	$200.00	$200.00
1	Antenna and mast for command post decoding station	$150.00	$150.00
	Connectors and misc. cable	$80.00	$80.00
1	Map Software	$210.00	$210.00
		Total	$1280.00

Current Budget

Encoders & Enclosures	$510.14
Data/Power Cables	$126.02
TNC for Command Post	$183.16
Antenna & Mast	$75.49
Connectors and Misc. Cable	$269.84
Map Software	$-
Total Granted	$1,280.00
Total Spent	$1,164.66
Remaining	$115.34