CIBOLA SEARCH AND RESCUE GPS TEST

by Chuck Girven

What are your UTM (Universal Transverse Mercator Grid) coordinates? This is a question that is often being asked on Search and Rescue missions. In fact, Search and Rescue Incident Commanders are asking now if teams going into the field have a GPS with them. Last year I purchased a GPS. When I tried to use it on several missions last year, I was very disappointed in it's inability to furnish the UTM coordinates that we needed. After talking with other team members and other SAR teams, I discovered that this was not an uncommon occurrence in typical search and rescue terrain. GPSs need to be able to view the sky. On some of our missions, this is not an easy feat. The rocky canyons and heavy tree coverage we sometimes find ourselves searching in block the GPS's reception. While talking with a fellow team member, we decided to try to determine if there have been improvements in functionality with the new 12 channel units recently released. We gathered information from magazines, books, brochures, web sites, talking with other SAR teams, GPS manufacturers, and universities. We then came up with a list of features we felt were needed specifically for search and rescue, and additional options that would be nice to have.

Search and Rescue teams need some special features on our GPSs. They need to be rugged, waterproof, have a good backlight, be easy to use and all controls and screens must be easy to access. They need to have waypoint storage, battery level indicators, UTM-LAT/LONG conversion, external antenna capability, and to be able to download information into a laptop computer. This last option was with an eye towards the future.

SAR Support and Incident commanders have commented that in the future we might be downloading our search coordinates from a laptop computer, and upon completion of our search, the actual route we traveled. This would be extremely helpful in planning where the next teams would be deployed. These were just a few of the things we researched and considered before we conducted our test. The test included newly released units along with units our team members already had. The models tested were: Garmin 38, 40, 45, 12XL; Eagle Explorer; Magellan 2000; and the Trimble Scout. The Garmin 12XL, Magellan 2000, and the Eagle Explorer were chosen for our test over the other models these companies produce after discussing our needs with each company's representatives and considering their recommendations. Because of cost considerations, other Trimble units were not considered.

Operating a GPS is just like acquiring any other new skill. You need to practice with it to become horizon-aware and make sure you hold the unit so that it's antenna is facing up and not being blocked by obstructions. With this in mind, the people who would be testing the new units were given them in advance with instructions to become comfortable with the controls.

I'm not going to go over all the different features that the various units have. Instead, I will include the web addresses of the various companies and phone numbers in the resource section of this report. All the manufacturers were more than willing to furnish information and brochures when asked.

We met at the Upper Juan Tabo parking lot (La Luz trailhead) on March 29, 1997. For each waypoint acquisition we recorded the acquisition time, number of satellites acquired, terrain and conditions, UTM coordinates, and altitudes. Also recorded were the testers' likes and dislikes on their GPS's performance. After the test, all the testers were asked to fill out a questionnaire on the bottom of their performance forms. The following charts and graphs explain the results. The following comments were taken from these discussions and reports.

The Trimble Scout received top scores in ease of use. With the controls easy to use even with gloves on. Several remarks were made about the size of the Scout and comparing it to the "Star Trek" tricorder. Unfortunately, the price tag is the biggest complaint about the Scout. At $600 to $1000, it is probably more than the average SAR person can afford.

The Magellan 2000 had trouble acquiring in the heavy tree cover, until moving out from under them. The altitude readings differed dramatically from all the other units as can be seen in the graphs. Even with it's 12 channel capability the most satellites it ever acquired were 10. The controls and screens were easy to use. Battery replacement was a little difficult, you had to depress two buttons at the same time and remove the bottom cap.

The Garmin 38 is a basic unit which had some of the longest acquisition times. It could not acquire at all in heavy tree coverage and rocky terrain. Controls were placed so that they could be operated with one hand and the screens provided the information needed on one screen. This model does relatively well in open areas as shown on the graphs.

The Garmin 40 is basically like the 38, but it has waypoint alarms. Control placement is the same as the 38 along with the screen layout and programming. This unit did have several acquisition times over a minute but it did acquire at every stop. The owner is still very happy with it's performance.

Garmin's 45 model also acquired at every stop, but it had several times it was one minute or more to do it. The controls were placed on the bottom of this GPS, making it hard to operate one handed. This unit comes with a flip up antenna that can be removed for use in a vehicle. This feature was viewed with some doubt whether it could stand up to heavy use and not get snagged on something and break off.

One of Garmin's newest releases is the 12 channel 12XL. It has the user friendly controls of the 38 and 40 models. In the field test, it's longest acquisition time was 37 seconds and several times it was the fastest unit to acquire position. The performance under the trees ranked right up there with the Trimble. One nice feature with this GPS is the quick reference card that comes with it and the carrying case, an option that the Trimble and Garmin 38 and 40 share.

The Eagle Explorer was bulkier than all the other models except the Trimble. Where the Trimble was compared to a tricorder, the Explorer was a "STAR TREK" phaser. It had the most complaints of all the units tested. The controls were located on the bottom, making it hard to operate one handed. It was necessary to page through several screens to get the desired readings. It was also not possible to display altitude and position on the same screen at the same time. Waypoints were marked with anchors or fish probably coming from the Lowrance shared technology from their marine applications. Battery replacement was another large complaint. It is necessary to turn the unit over and depress two small tabs at the same time. Several testers had trouble getting it open on the first try. It would be a lot harder in cold conditions with stiff fingers. Batteries seemed to have a life of their own. We would no sooner get one side in and start on the other and they'd jump back out. In the dark this would be really frustrating! The separate removable back panel also caused some concern about possible loss in the dark. A nice feature the Explorer offered was replacing the four AA batteries with a single rechargeable Duracell battery and a ten year lithium backup battery. The instruction book was difficult to understand compared to the Garmin and Magellan models.

In conclusion, the various GPS models performed pretty much the same in the open area. Unfortunately this is not where most of our searches take place. A GPS is only as good as it's operator and it will not replace the need to know how to read a topo map and compass. With the combination of three it should give you a good reliable source of information to answer the question, “What are your UTM coordinates?”

Resources:

Garmin	1-800-800-1020	http://www.garmin.com
Magellan	1-909-394-7062	http://www.magellangps.com
Eagle	1-918-437-6881 Ext. 8691	http://www.eaglegps.com

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John Florio at Holman’s, 6201 Jefferson St., NE, Albuquerque, NM 87109, for their assistance.

Conclusions: (supplied by Mike Dugger)

While the results for the field test are further discussed below, from a cost and performance standpoint, the new 12 channel Garmin 12XL seems to far outperform its competition. It consistently gave the faster acquisition times, and demonstrated ease of field use. The choice of display screens (and the type of information displayed) also seemed most useful for our search and rescue activities. While the display features of other units (notably the Eagle) might be useful in other situations, for field use in this trial, the unit proved difficult to use.

Field test data for all units is attached as Appendix 1. For a direct comparison of the performance of the units, bargraphs are attached for acquisition time, positon error, altitude error, cumulative acquisition time, and cumulative position error in Figs. 1-5, respectively. For determination of average acquisition time, the acquistion times of all of the units that were able to acquie position were averaged. For position and altitude error, the acquired positions and altitude readings of each unit were averaged. A total of ten waypoints were used for the test. Results that are not shown for a particular unit in the figures indicate that the unit was either unable to acquire satellites for a position fix, or it was not possible to identify which position fix (for a particular unit) was associated with the waypoint of interest. For results that are missing in the figures, Appendix 1 can be referenced to see which of the two cases is responsible for the missing data. The later situation mentioned above was the result of several of the teams acquiring additional waypoints. Since there is always a small amount of position error, and position fixes were frequently obtained during the test, it was in several instances difficult to determine which position was associated with which waypoint. However, as may be seen from the figures, there are only one or two instances in which this was a problem.

Acquisition Time:
Results for acquisition times for all GPS units are shown in Fig. 1. Several of the units generally gave acquisitions times faster than the average. These were: the Eagle Explorer, the Garmin 12XL, and the Trimble Scout. However, at two of the waypoints, tthe Explorer gave acquistion times much slower than the average. One of the surprising results was the relatively long acquisition times (under easy acquisition conditions) of the Garming 38 and 45 (see results for parking lot, where there was no overhead cover). For a low cost unit, the Magellan 2000, in general, performed well with regard to acquisition time. However, the Garmin 12XL (a twelve channel, simultaneous tracking reciever) was the GPS unit to consistently demonstrate rapid acquisition under all field conditions tested. These included some fairly narrow canyons with overhead (moderate) tree cover.

Position Accuracy:
Despite rather fast acquisitions, Magellan had some apparent position accuracy problems. For example, the position error in the parking lot is is particularly surprising. Also, with this reading included in the determination of position, the error of the other units may appear artificially high. Under most acquisition conditions, most units gave an apparent position error of less than 0.1 km. One final interesting result was that when a waypoint was acquired with the units facing a rock face (as might be the situation for a very narrow canyon), there was an apparent bimodal distribution in determined position, which generated an average position with a large standard deviation. (See Appendix 1). Therefore while all of the units show a large error (0.4 - 0.7 km), some of the uints may actually have given a fairly accurate reading of position. In general, under “normal” acquisition conditions, the position error differences were generally within selective availability specifications (100 m).

Altitude Accuracy:
Of the measured performance data, altitude error seemed to be the most inconsistent. Only in the easiest acquisition conditions (parking lot) did the units seem to have little difference in altitude reading. In general, all units had similar performance at the same waypoints. It as also interesting to note that for some of the units, the measured altitude would change with time after turning the unit on for acquisition. This data is of little merit, since altitude corrections can be input to improve subsequent accuracy, and I doubt this was done.

Graph Notes: (supplied by Mike Dugger)

The figure of merit used for acquisition time is simply the difference between an individual unit's performance and the average acquisition time for that waypoint.

The figure of merit for position was computed as follows.

◊ First, the "average" position for a given waypoint was computed by separately averaging the UTM North and East coordinates for all units.

◊ Since the waypoint positions are not absolutely known, this was thought to be the best estimate of "true" position.

◊ The position error is the magnitude of the difference in an individual unit's reported position from the average position.

◊ This magnitude was calculated as SQRT((ind.north-average.north)^2+ind.east-average.east)^2 ala the Pythagorean theorem, or basic statistics if you prefer.

◊ The altitude error is simply the absolute value of the difference between an individual unit's reading and the average altitude.

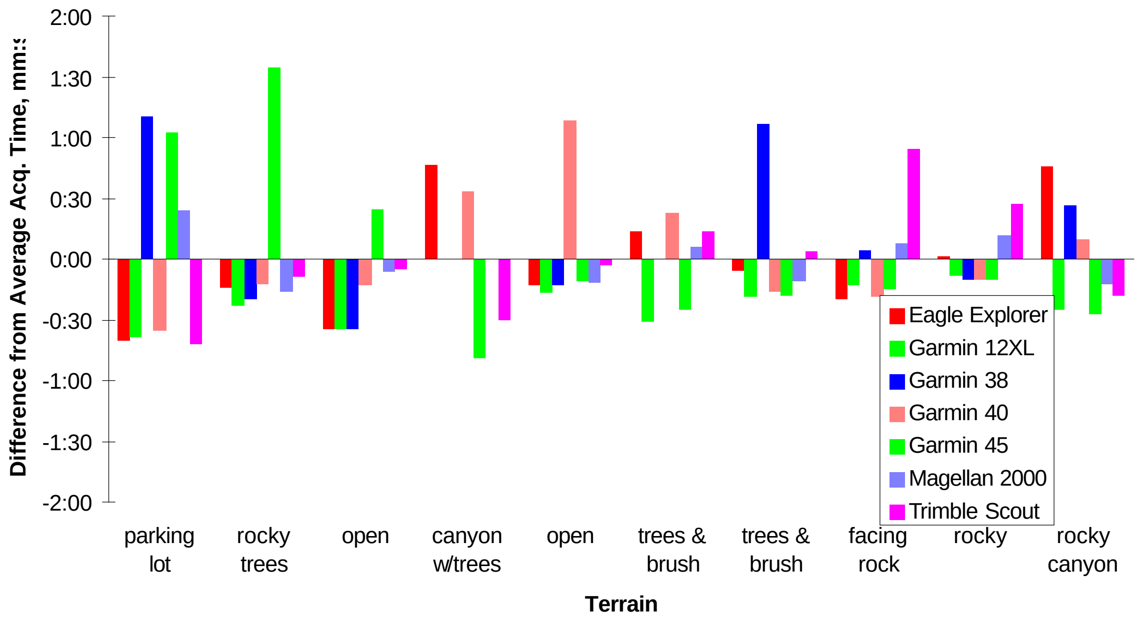

Figure 1. For each waypoint, the difference between a particular unit's acquisition time and the average acquisition time.

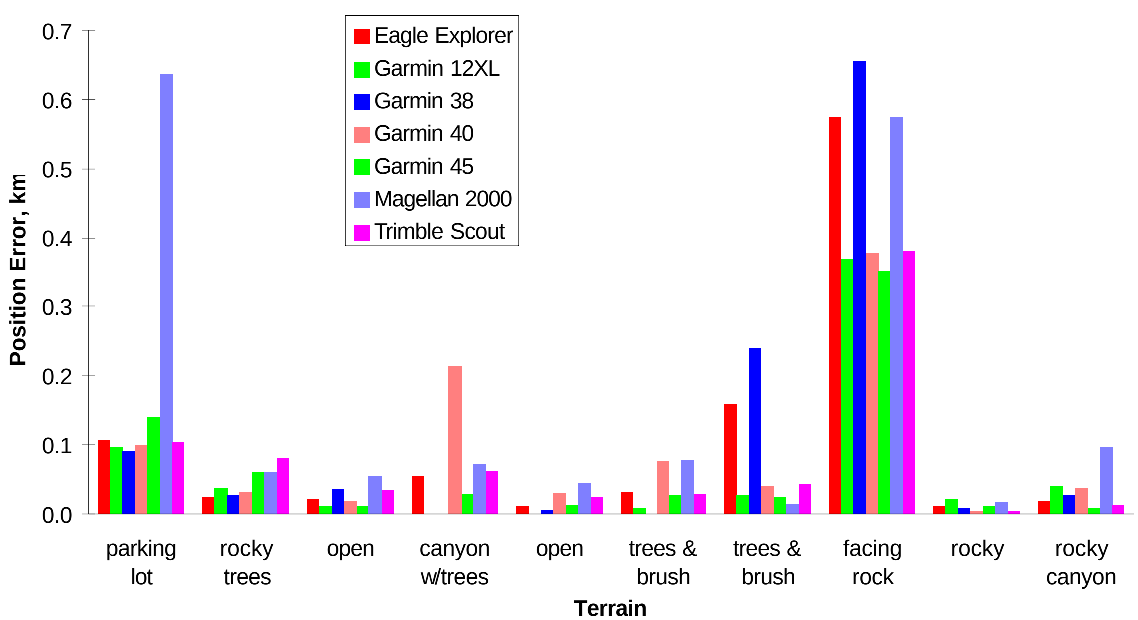

Figure 2. For each waypoint, the magnitude of the difference between a particular unit's measured position and the average position coordinate.

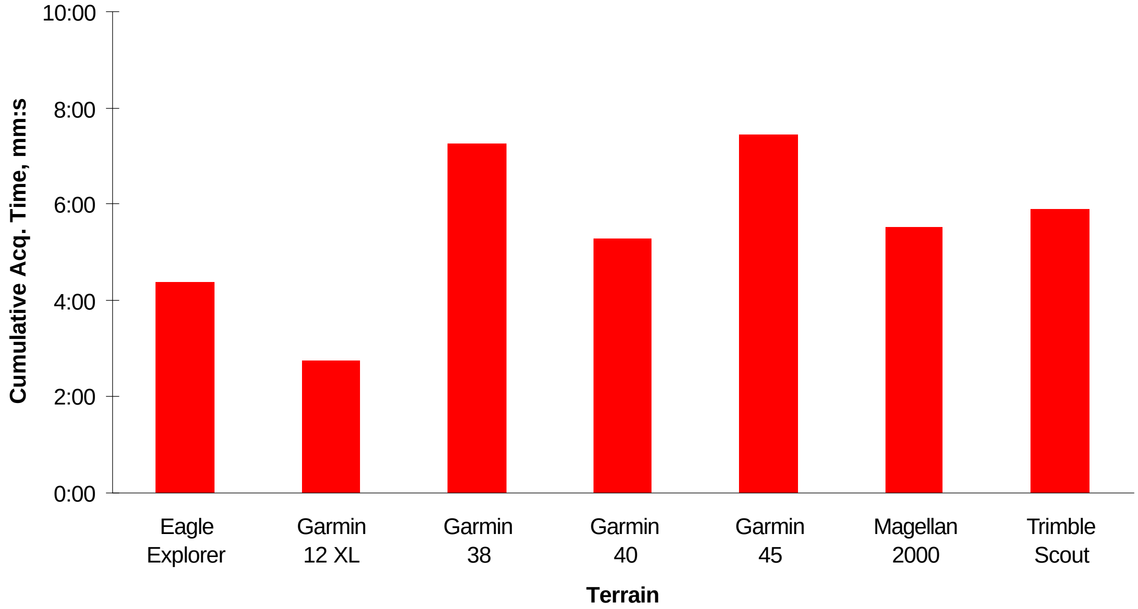

Figure 3. Comparison of the total cumulative acquisition time for all waypoints for each unit evaluated. Waypoints where any unit did not acquire were deleted from the total time calculation for all units.

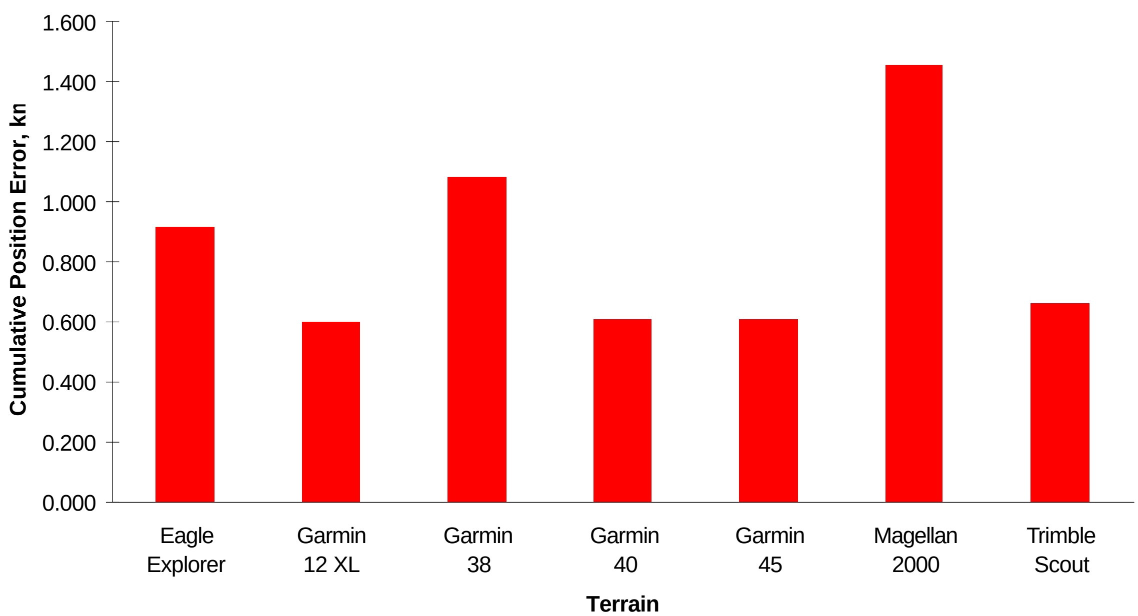

Figure 4. Comparison of the total cumulative position error for all waypoints for each unit evaluated. Waypoints where any unit did not acquire were deleted from the total position error calculation for all units.