

# Blasting Applications for GPS<sup>1</sup>

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**Abstract.** The location of blasts and nearby structures must be clearly documented for regulatory purposes, post-blast assessment and liability protection. Establishing the spatial relationships between the blast, blasting seismograph and nearby structures allows the blaster to correctly interpret vibration data, evaluate the performance of the blast, and establish compliance with the rules. If structure locations are digitally mapped during the preblast surveys or at another time, the blaster can determine distances for blast design purposes in the field on a daily basis. Furthermore maps detailing the locations of explosives magazines to meet Bureau of Alcohol, Tobacco, Firearms and Explosives requirements may be developed. Today's technology allows the blaster to easily determine and document all these locations with a Global Positioning System (GPS). Wide Area Augmentation System (WAAS) enabled unit, accurate to within 10 feet, provide a satisfactory level of accuracy for determining locations. This coupled with the ease of use and relatively low cost makes them highly suitable for blasting applications.

Additional Key Words: blasting, GPS, seismographs

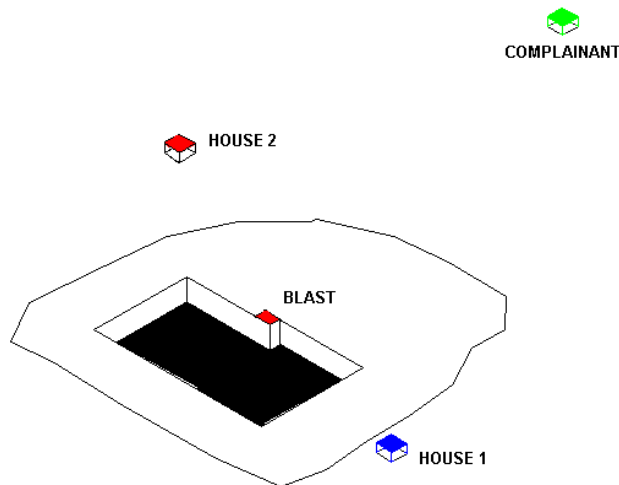
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## **Introduction**

Blasting is a critical part of surface mining. To access coal reserves, the rocks overlying the coal are broken with explosives. Without blasting, a vital part of the nation's energy reserve would be inaccessible. The rock can be broken in place (conventional blasting) or broken and partially displaced into an adjacent pit (cast blasting). In any blast, the majority of energy is spent breaking rock. The balance of energy emanates from the site into the environment as either seismic or airblast energy. As the energy arrives at nearby structures, the buildings will vibrate. If the vibration levels are significant the building may be damaged. The amount of energy received is limited with regulations to prevent damage

Establishing the spatial relationships of blasts relative to nearby structures is important because vibrations do not travel uniformly outward in all directions. The pit location and other surface features can affect vibration levels and character. Figure 1 shows such an example. While House 1 is 450 feet away from the blast, House 2 at 550 feet is likely to get higher ground vibrations because of the continuous propagation pathway between source and receiver. However House 1 will probably receive higher airblast since the highwall face is in that direction.



**Figure 1. Spatial relationships in blasting.**

On a day-to-day basis, blasting at surface coal mines requires constant checking and verification of distances to nearby residential structures for blast design, compliance, and liability protection purposes. Historically, topographic maps, transit surveys and aerial photographs have been used to determine distances. While the fixed points were known, i.e. houses, roads, churches community buildings, pipelines, towers etc., daily documentation of the blast locations on these maps were estimated. Often this resulted in significant distance errors, especially when line of sight was not possible. Furthermore, when more than one structure was nearby, exact verification of the nearest one was not easy.

A Geographic Positioning System (GPS) can easily document these features. The optimum time to gather the information is during preblast surveys. At this time, specific ownership information (e.g. name and address) can be compiled that is not readily available on the topographic or aerial maps. When made available on a GPS unit in the field on a daily basis, blasters will have a significant tool at their disposal for designing blasts and showing compliance with the rules.

Blasting applications will benefit from three primary features of GPS:

1. Waypoints to document structure locations
2. Tracks or lines to outline the perimeter of the blast and
3. Distance measurement feature

Lastly, with the passage of the Homeland Security Act, the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) is requiring schematics of explosive magazines and adjacent structures for inspection and emergency response. GPS data can be used to provide this documentation on either topographic maps or aerial photographs.

**GPS options**

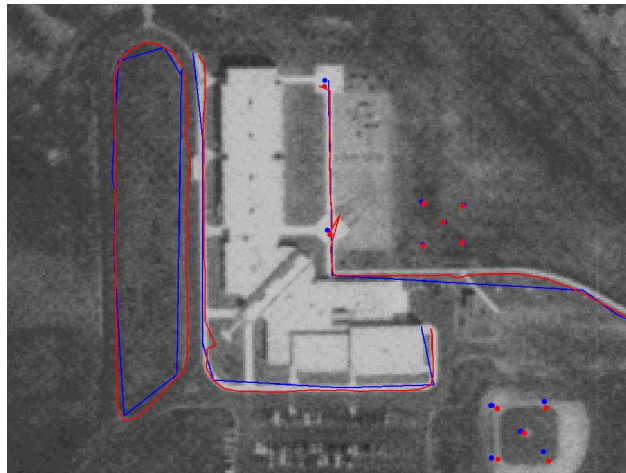
GPS units currently available to the public range from moderately to very accurate and from cheap to expensive. Figure 2 shows a brief comparison of available hand-held GPS units. Survey grade units are not addressed because they are not as portable, are cost prohibitive and require more time and training for use.

For blasting applications, the mid-range units provide an acceptable level of accuracy and are in the “affordability” range of most blasters in the field. Mid range units are defined as Wide Area Augmentation System (WAAS) units with at least 24 MB of RAM and capable of interfacing with a computer. Fortunately, in most blasting applications, a clear view of the sky is common place and satellite signals, including WAAS satellites, are easily acquired.



**Figure 2. Comparison of GPS units.**

Mid-range units produce comparable levels of accuracy to the more expensive high end units. Figure 3 compares the results of a highend Trimble GeoExplorer non-WAAS GPS (red points/lines) with a Garmin WAAS enabled GPS (blue points/lines). The baseball diamond gives a sense of scale. Any two waypoints are generally less than 10 feet apart. Tracks have the same relative accuracy when the points coincide. However care must be taken when obtaining waypoint and tracks to maintain an acceptable level of satellite reception for the desired accuracy.



**Figure 3. Garmin etrex vs Trimble GeoExplorer.**

In blasting applications, distance measurement to two significant digits is adequate for blast design and regulatory compliance. That is when a blast is 1000 feet distant, a measurement to the nearest 100 feet is adequate and when under 1000 feet, an accuracy of 10 feet is necessary. Furthermore all measured distances for blasting are horizontal distances without concern for elevation changes. Thus the midrange GPS provides satisfactory accuracy. Note that the mid-range GPS units are not acceptable for construction blasts within 100 feet of structures. Generally in these applications, distances are easily measured because structure proximity and blast locations can be referenced to existing survey markers.

The midrange GPS units also have sufficient memory for the necessary number of waypoints and tracks for common blasting applications. Data may be downloaded or uploaded. When coupled with the available software, simple schematics can be developed to show the spatial relationships.

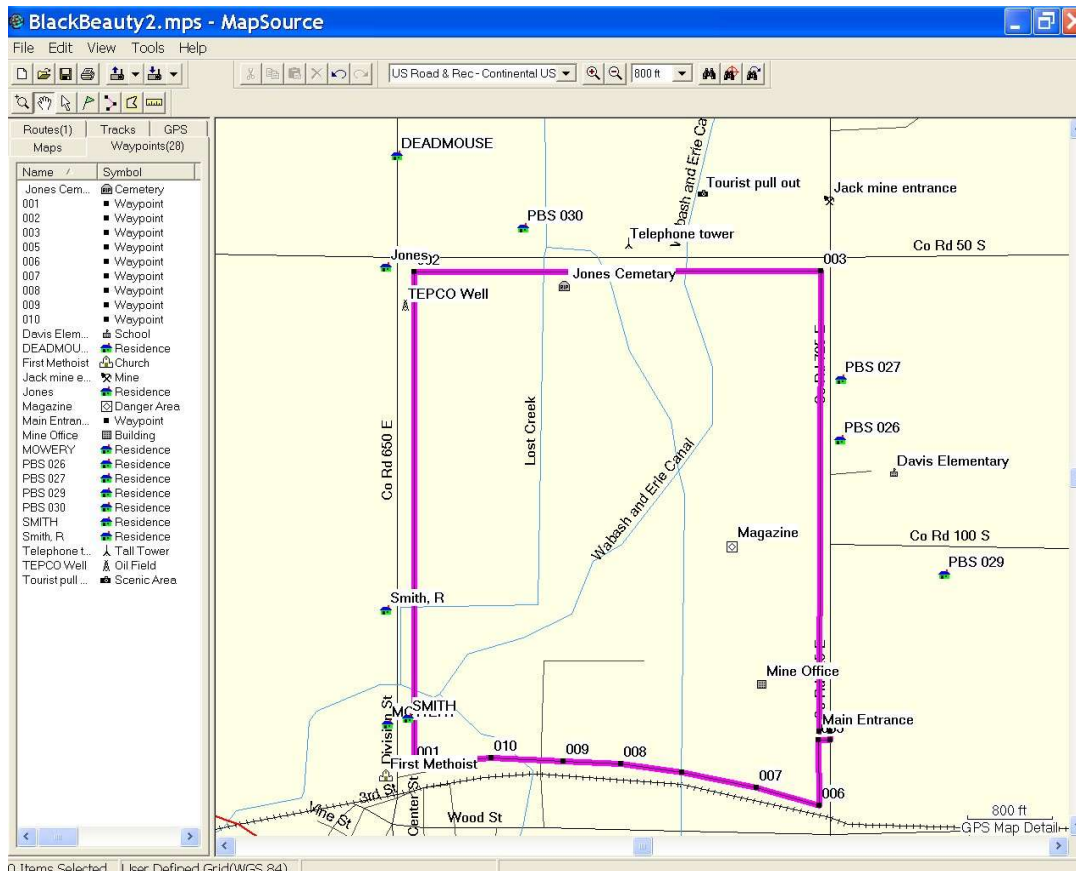
### **Pre-Blast Survey Locations**

Preblast surveys are required for all blasts within ½-mile of the permit boundary. The survey documents the existing condition of the man-made structure and should contain a unique identifier for structure. GPS provides a simple means of mapping structure locations and clearly identifying the owner or resident in a single digital file. If mapping is not preferred, structure coordinates can be written on the face of the preblast survey for identification.

Man-made structures that may be located include:

- Residences
- Office buildings
- Cemeteries
- Oil wells
- Out buildings
- Churches
- Pipelines
- Towers

Most GPS units have waypoint symbols for these and allow the user to affix a name to the waypoint as shown in Figure 4. Data acquired and stored in the GPS unit can be downloaded into Garmin MapSource for editing and illustration. In addition to the preblast survey structures, some points may be needed for general information or reference, such as the permit boundary, office location, and access points.



**Figure 4. Mine permit boundary and nearby features.**

When blasting is to begin, the blaster can upload all the nearby structures into the GPS unit for field reference. Most units will have a “find nearest waypoint” feature to query for distances from the day’s blast to the nearest structure.

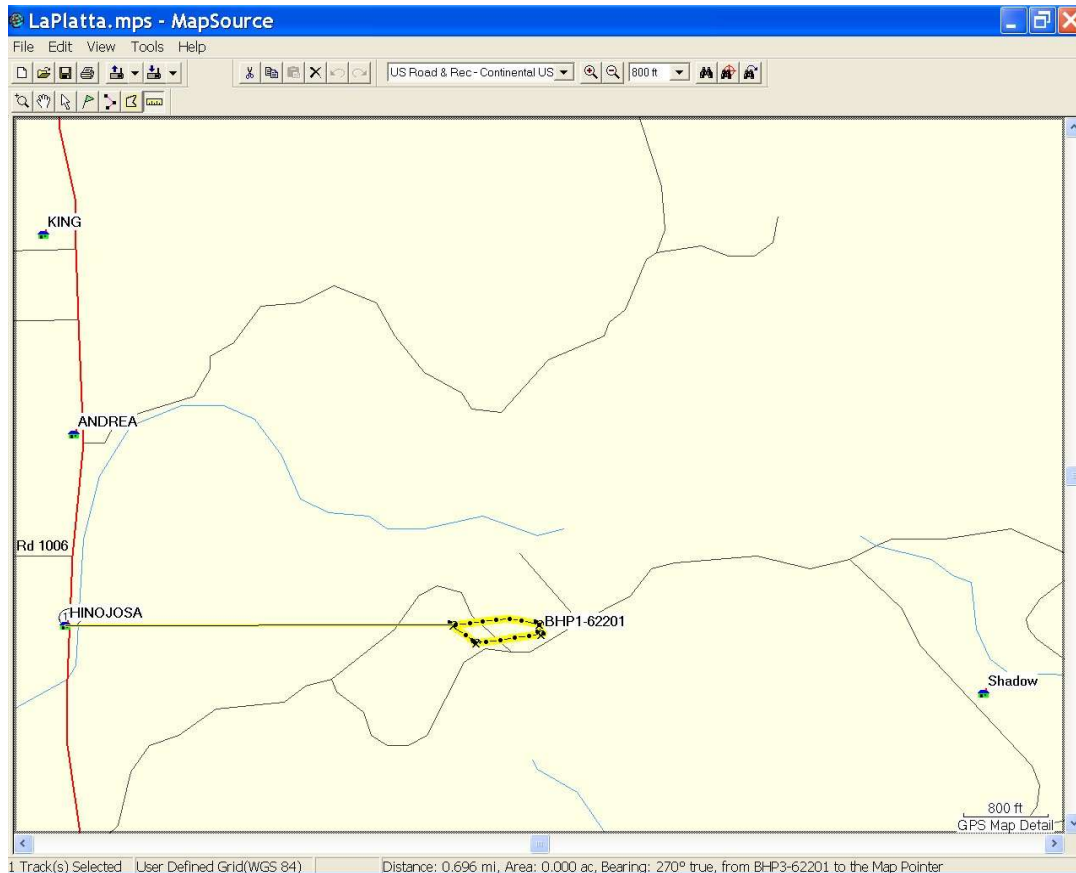
## **Blast Locations**

Blast locations are important because they:

- Are required by Federal and state regulations,
- Establish distances to protected structures and
- Establish spatial relationships.

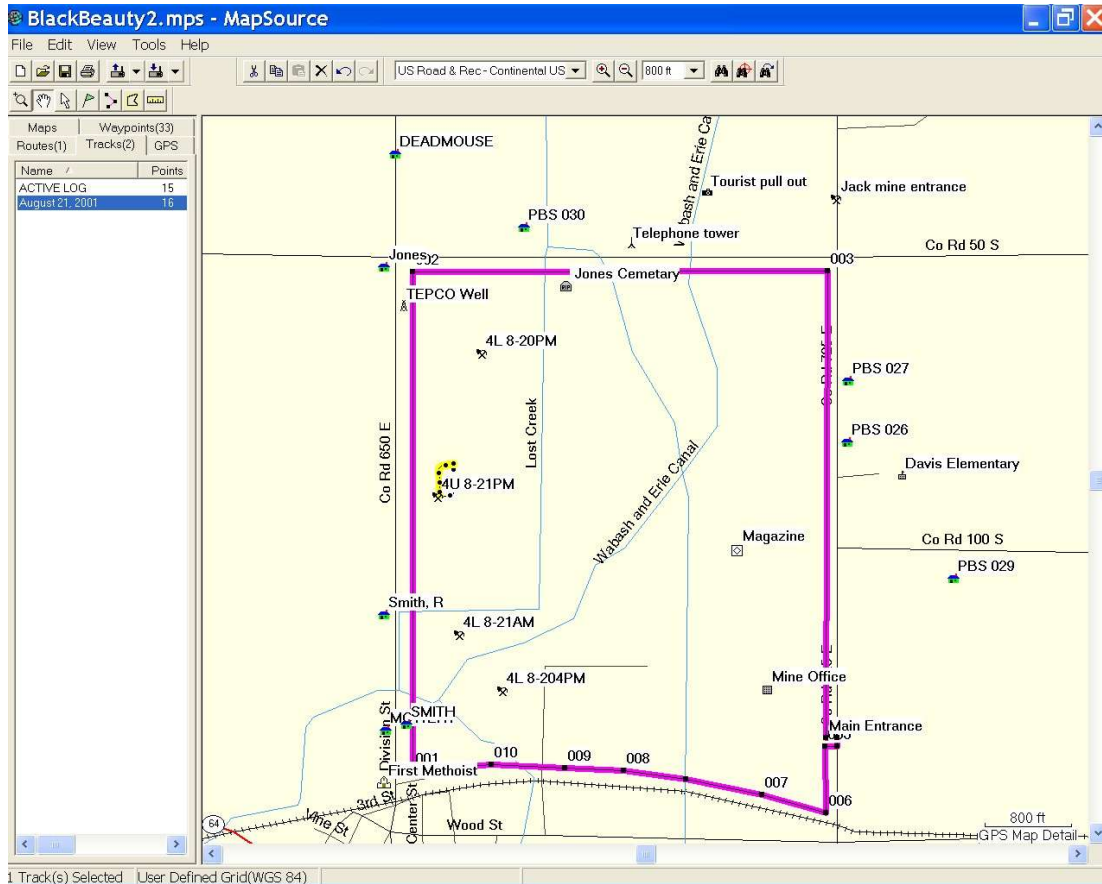
Each blast location can be stored as a waypoint with the coordinates recorded on the blast log. Another option is to enable the track feature and walk the perimeter of the blast to get the aerial extent of the blast pattern. Tracks are useful to orient the blast and document unusual configurations.

Figure 5 shows a non-rectangular blast with dimensions of about 810 by 270 feet in New Mexico as obtained with the track feature. The four nearby residential structures were obtained as waypoints. Distances can be obtained in either the software or GPS unit. The Hinojosa house is 0.696 miles (3680 feet) west of the blast and the Shadow house is 0.803 miles (4240 feet) east of the blast. Without the actual blast perimeter, the closest structure is not obvious or may be errantly determined. With this information the blaster can now determine the maximum amount of explosives to use. In this example all three of the residences to the west had blasting seismographs in the front yards.



**Figure 5. Blast location and distance measurements.**

While Figure 5 illustrates only one blast, a series of tracks or waypoints can be used to document daily, weekly or monthly blasting. Figure 6 shows all adjacent structures and recent blasts. Blasts are located as both waypoints and tracks. The waypoint names indicate the coal overburden being blasted, the data and time of day (4L 8-20 PM : Lower number 4 seam, August 20, 2001 in the afternoon). Nomenclature can be established based on individual needs. The relative size of the track and waypoints illustrate that the option used is a function of blast size and proximity to structures. Small blasts with distant structures can be located with waypoints. Otherwise tracks are preferred.



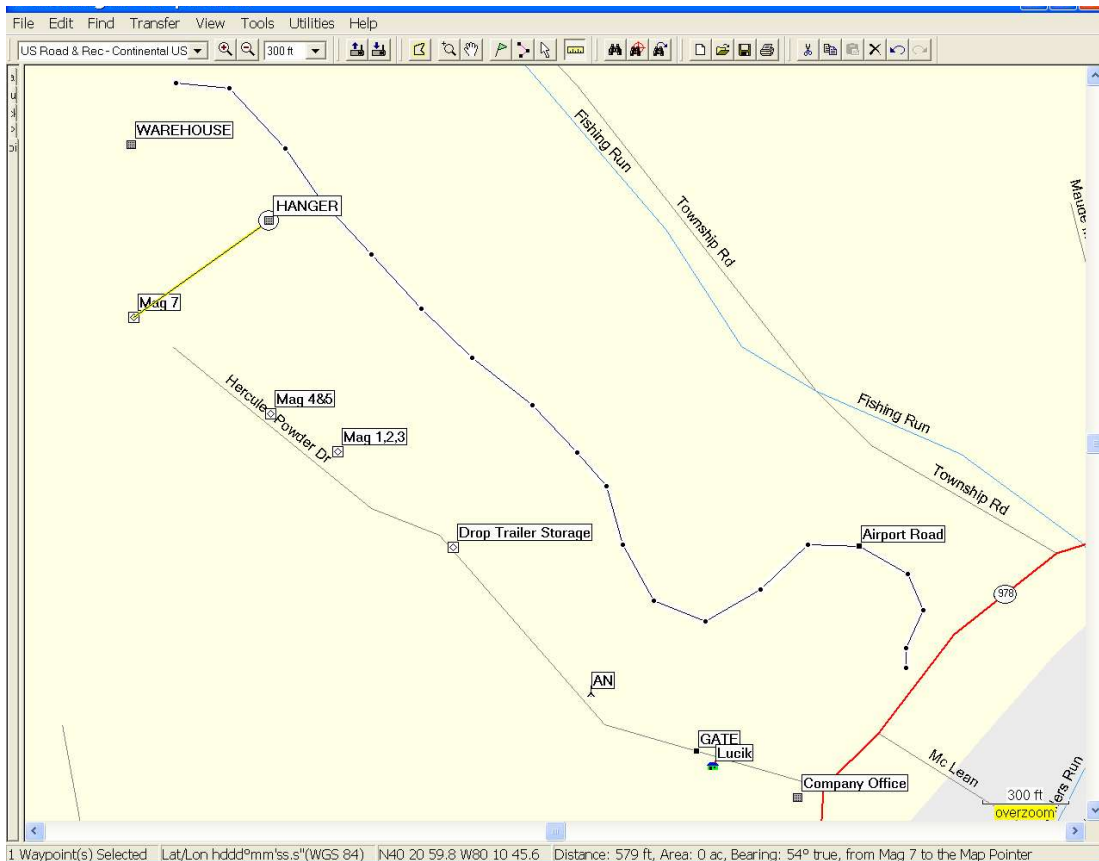
**Figure 6. Blast locations and nearby features.**

### **Explosive Magazine Schematics**

The increased level of security as a result of the Homeland Security Act, requires more detailed documentation of magazine facilities and their locations for the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF). Again both waypoint and tracking features and 3<sup>rd</sup> party computer software such as MapSource and/or TopFusion can be used to document a site.

As shown in Figure 7 waypoints are used to locate the individual magazines with their contents and entry points to the facility. Waypoints are also used to locate nearby structures for compliance with the American Table of Distances. Tracks may also be

used to document fences and access roads to the site for emergency response. In this example, the terrain steepness prevented acquisition of a WAAS satellite and was turned off. However the resultant accuracy was still +/- 20 feet.



**Figure 7. MapSource schematic of explosive magazines and nearby features.**

At this site, the magazines, trailer storage area, ammonium nitrate (AN) prill tower, front gate, company office, nearest residence and office buildings were located as waypoints. The Airport Road to the warehouse and hanger was not available within Mapsource and was located using the track feature.

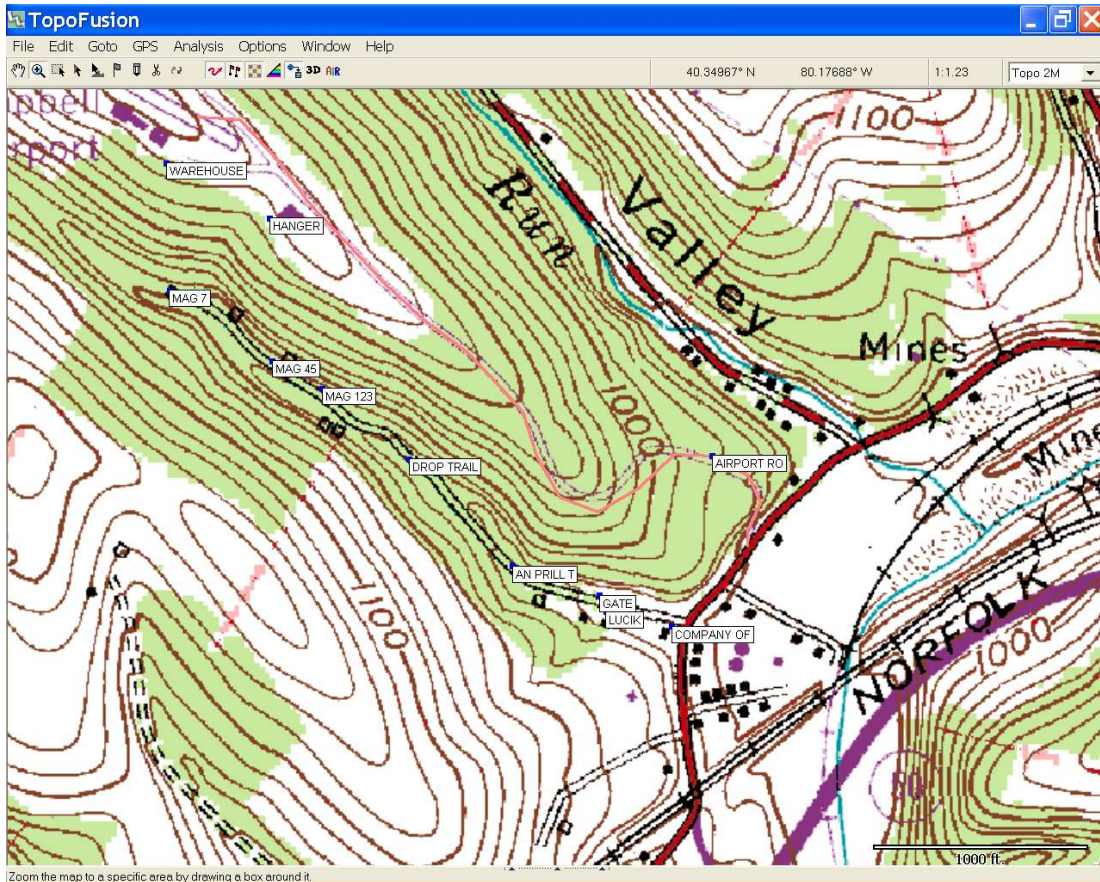
Distances measured within Mapsource are then used to determine the maximum allowable weight of explosive to be stored in each magazine. The distance between Mag 7 and the Hanger is 579 feet as shown at the bottom of the screen. The other distances could be measured as well. Unfortunately as a stand alone program, Mapsource does not provide additional base topographical/spatial features as a “reality check” for close-in applications.

TopoFusion is a third party program that interfaces the GPS data with both USGS topographic maps and aerial photographs from MicroSoft TerraServer, Figures 8 and 9, respectively. This is an inexpensive alternative to other GIS applications such as ArcView and AutoCadd when distance measurements to the nearest 10 feet are



acceptable. Furthermore, waypoint and track plots, can serve as “reality checks” on the data obtained with the GPS.

In Figure 8, the Airport Road track closely matched the topographic feature, up to the old airport runway (at the end of the track). The building waypoints also match the topographic map. The topographic maps will help identify any nearby missed structures or features.

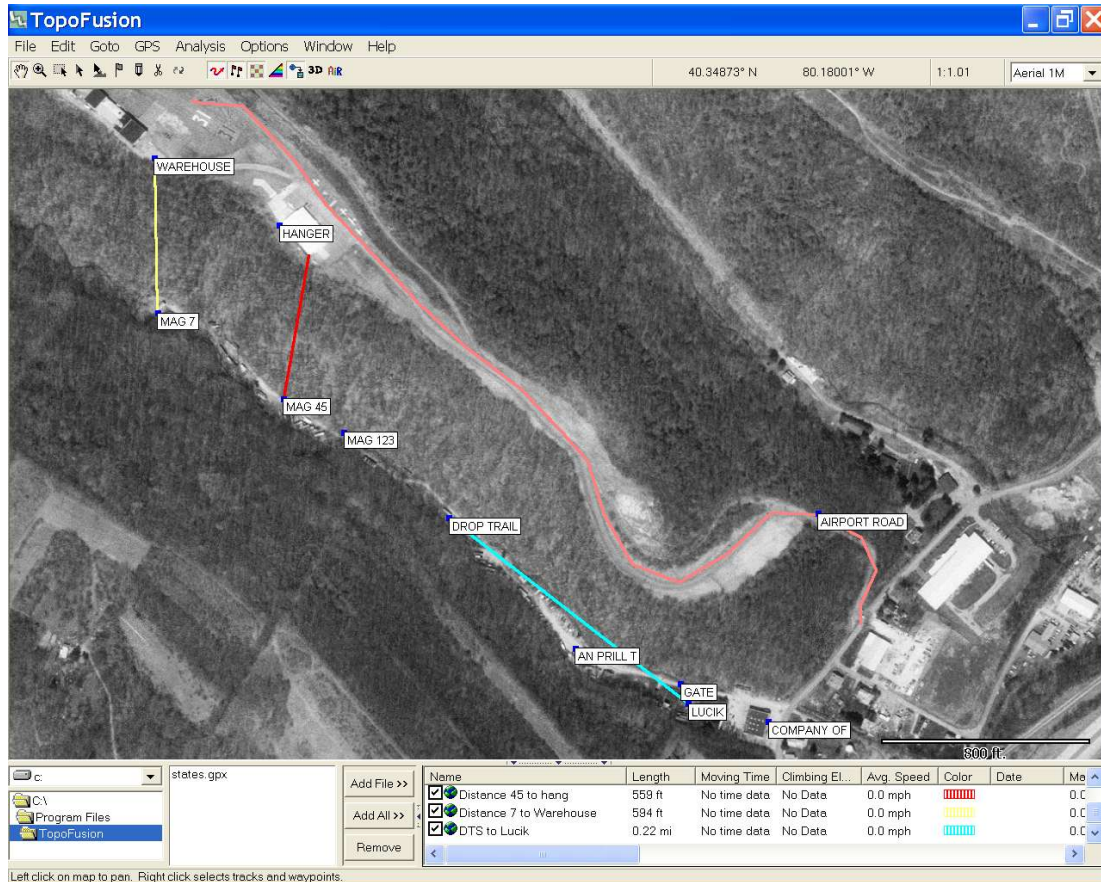


**Figure 8. GPS data overlain on USGS topographic map.**

Figure 9 is the dataset overlain on an aerial photograph. Again all the waypoints matched structure locations well, and represented the points obtained at the various buildings (i.e. same side or corner). The Airport road track matched more closely than the topographic map.

Distances were measured to the closest structure from each magazine. The distances are shown and color coded in the lower right of the figure. One notable observation is the length of the building’s impact on measured distances. For example, the Hanger waypoint was on the north hanger corner and is the closest waypoint to Mag 7 at 570 feet. However based on the hanger size, the south corner is actually closer to Mag 4 and 5 at 559 feet. The aerial photograph allowed measurement to the actual closest corner.

Thus on larger buildings, actual corner measurements are necessary to obtain proper distances. The same would be true with close-in blasting applications of large blast sizes. Always keep the necessary level of accuracy in mind. Some locations will warrant more detailed measurements with other surveying techniques.



**Figure 9. GPS data overlain on aerial photograph and distance measurements.**

## **Conclusion**

Mid range WAAS enabled GPS units with adequate memory and their companion software packages are ideal for blasting applications. The ease of use and affordability make them attractive to the blasters in the field. GPS use in blasting applications is suitable for:

- Establishing preblast survey house locations
- Determining blast locations and distances
- Establishing spatial relationships
- Documenting explosive magazines

Although specific examples were not presented in this paper, this technology can be applied in other blasting related activities such as:

- Documenting seismograph locations for liability protection
- Outlining debris field from flyrock occurrences
- Location blast warning signage and security camera.

