GPS Software for GIS and Surveying

GPS units continue to drop in price and size, new software features give users more power, and Pocket PC's take the show on the road.

by Kyle Bohnenstiehl

Introduction

The Global Positioning System (GPS) has become an essential tool for GIS database developers and users over the last 10 years. GPS hardware is portable, relatively easy to use, and can locate features to within several millimeters using sophisticated software, to about 1m using resource grade differential correction software/hardware or to within 10 meters autonomously using hand held units. GPS software falls into two main categories: survey grade software for network (least squares) adjustment of GPS points, and GIS mapping software that produces GIS ready files containing features, attributes and differentially corrected position information. A third software category runs on Pocket PC platforms with low-cost handheld or PCMCIA GPS instruments.

For an overview of GPS and an introduction to the myriad of hardware solutions out on the market, see GISVision Magazine October 2000.

A new component has been added to the GPS constellation recently and is worth looking at: the Wide Area Augmentation Service (WAAS) managed by Ratheon Inc. Trimble Navigation has also produced a WAAS PDF brochure. This is a satellite broadcast signal that increases GPS accuracy to about 5-7m, is free, and works with most GPS units manufactured after January 2001. It was developed by the FAA to increase aircraft navigation accuracy but works poorly in forest canopy and obstructed areas.

OEM GPS Hardware and Software

A GPS instrument is a rather unsophisticated piece of hardware by itself. Several manufacturers make and sell OEM GPS chips/pucks/mouselike devices with interface cables that are capable of taking input from a GPS antenna and returning a NMEA ASCII string of Latitude/Longitude/HAE (in WGS84) and the precise UTC time. Cell and satellite phones with GPS chips use this information to return the location of the phone to central call centers to route calls more efficiently, dispatch emergency services, or deny service to/from unlicensed countries. These single frequency (L1/CA code) OEM GPS chips cost upwards of $20 and even the more sophisticated dual frequency (L1/L2) chips are relatively inexpensive. GPS manufacturers add value to their products by designing sophisticated GPS receiver interfaces, antennae systems, and PC software to process raw GPS data into GIS data and surveyed points. Recently, GPS Compact Flash cards with integrated antennas and power supplies have become available.

Very Accurate Systems

Survey grade instruments are defined as GPS units that collect data using both L1 and L2 carrier phase data with a sophisticated antennae mounted on a tripod or other fixed mount for static observations. These units can also go mobile and collect L1/L2 data on the fly using kinematic observations. Generally, GIS data capture is cumbersome with survey type systems and attributing is difficult. Real Time Kinematic (RTK) systems do allow users to collect point, line and polygon GIS data to a high degree of accuracy (+/- 2cm XYZ potentially) and some companies have good data logger interfaces to allow attribution of features. It is possible to link RTK systems to other dataloggers like Trimble's

ASPEN software on a pen based notebook PC. However, the ability to collect GIS features using RTK GPS technology is still limited.

Survey grade systems rely on very sophisticated software programs to process data to centimeter level accuracy. GPS data from several known points is processed with simultaneously with GPS data from at least one unknown point. The GPS data files must overlap in time and hopefully use the same constellation of satellites. A vector is calculated (delta X, delta Y, delta Z) from each point in the network to every other point in the network. These baselines are then put into a network adjustment package to create a best fit solution. The resulting coordinates of the previously unknown points will have a set of statistics associated with them that is an excellent indicator of the absolute accuracy of the position.

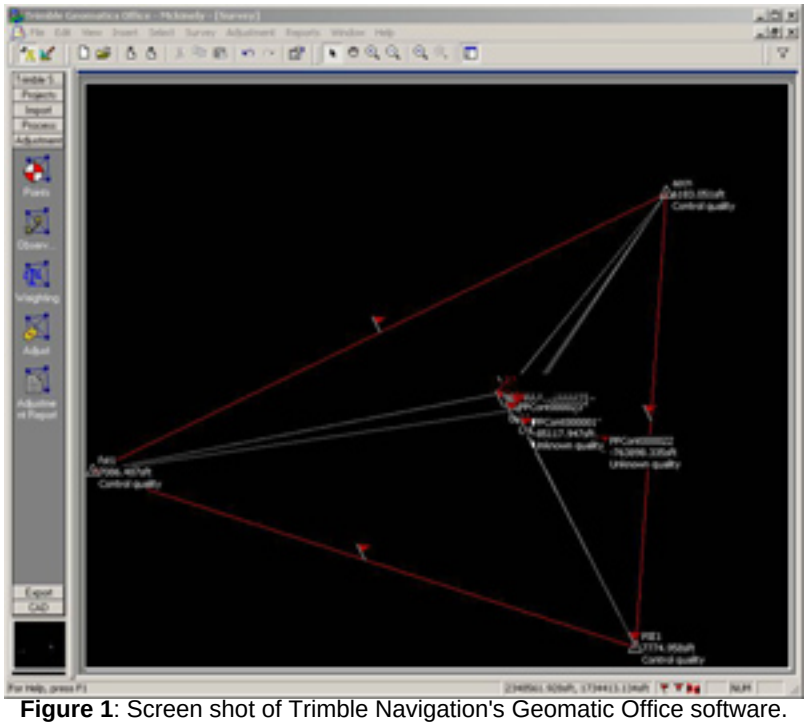

Figure 1: Screen shot of Trimble Navigation's Geomatic Office software.

Good Enough for GIS?

So-called resource grade systems are GPS receivers (and software) that allow users to collect GIS data with GPS at an accuracy of 0.50m (differentially corrected) and to about 10m (autonomous). Detailed data dictionaries are a part of the data logger software and the post processing software allows for editing of topology and attributes and the display of background GIS data and imagery. This type of GPS system has to have a datalogger front end for GIS data collection. The TSC1 from Trimble Navigation, a variety of products from Corvallis Microtechnology, and the Leica GS50 do this with a ruggedized solution . All of these products have both a field software (firmware) and an office software module for differential correction and GIS data export.

Trimble Navigation has developed a very mature product called PathFinder Office which allows for sophisticated differential processing and GIS feature manipulation. Sub-meter accuracy can be obtained with phase processing and the program can even automatically batch process your data and create the proper GIS output file. The software will go to the internet to find suitable base station data and request the proper times and dates. The best feature of this class of software is the ability to create detailed data dictionaries for GIS features. Overall, this type of software and hardware solution is still the best system for most GIS users given the flexibility and control it affords. A series of screenshot images offer some

insight into the sophistication of the software.

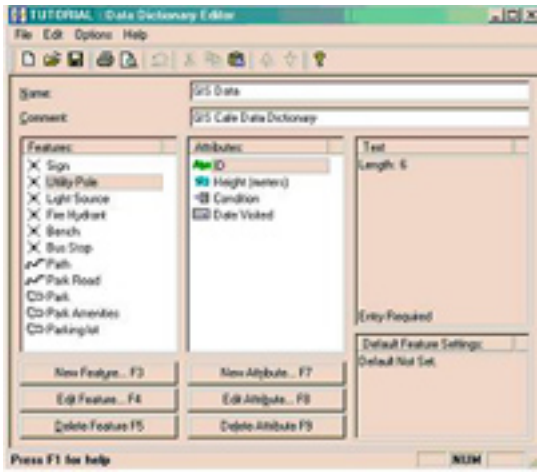

Figure 2: The data dictionary editor allows for the creation of GIS point, line and polygon features with many attribute types and is fully customizable.

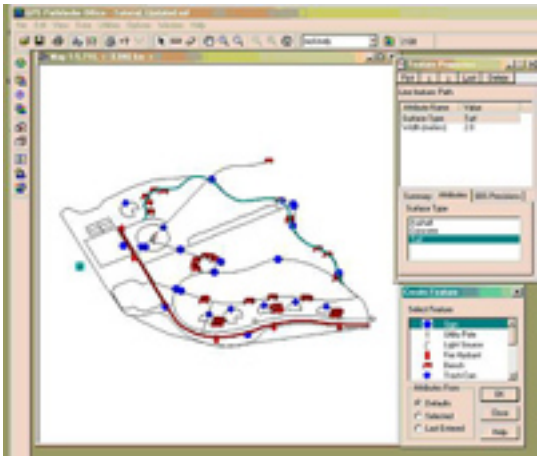

Figure 3: Maps showing the different features collected with the GPS can be generated.

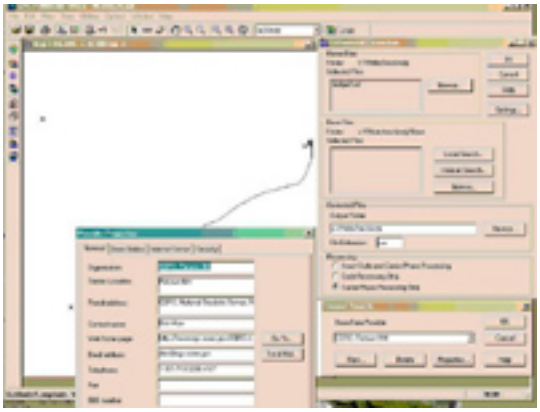

Figure 4: Pfinder Office will go out to the Internet and download GPS base station data from the closest GPS base station, in this case Pie Town, NM CORS station.

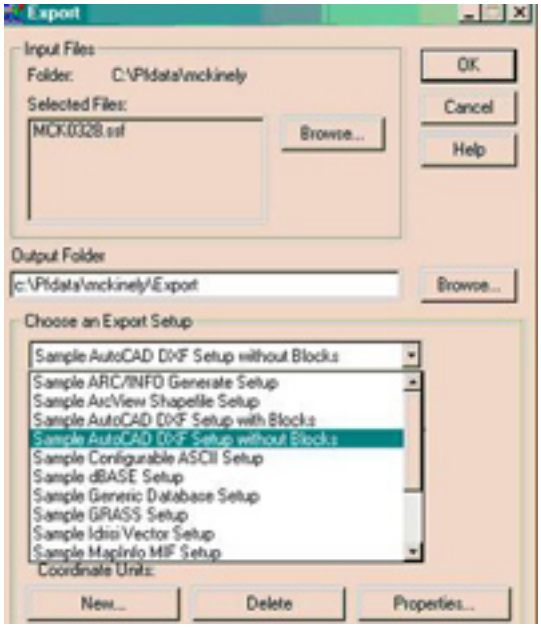

Figure 5: After differential processing and filtering, editing of attributes and topology, you can export the GPS data out in many different GIS and CAD formats.

Another interesting data collection system is the Red Hen Media Mapper which integrates a GPS position, a digital picture or video clip, and the Red Hen software to create "multimedia GIS files". The software will export MapInfo or ArcView files that have features with hotlinks to the digital image files.

Low Cost, High Stress GPS for GIS

The least expensive GPS hardware is the recreational GPS receiver. These units are small and very portable but can only collect point feature data easily. Attribution is limited to one or two fields (name and type of landmark for example) and the elevation may or may not be recorded, depending on the model. There is a wide variety of free and low cost software packages on the market, although very few can generate GIS compatible files directly (in the DXF format with one or two attribute tags, usually no elevation information). A comprehensive set of software links is provided here (scroll down the page to 3rd Party Software) and a good set of ArcView tools can be had from the Minnesota DNR. If you want to create a DXF file from Garmin data try this program. ESRI has posted a user submitted ArcView script to do some Garmin translations. Another good free package is available from TopoGrafix.

Differential corrections with recreational grade GPS are not a routine procedure, but it can be done, resulting in static point accuracy of about 0.50m. If you have a Garmin instrument, you can log the phase data to a laptop in the field by executing a series of commands via a DOS program available here or here. Note that you cannot move the GPS during the data logging which means you will only be able to map points in this manner. Once you have logged sufficient GPS data, you will need to convert it to RINEX (receiver independent exchange) format using a conversion program available from the same two websites. Now you can process the data in any differential corrections software that accepts RINEX files. This would be an excellent example of how one could utilize the CORS NGS GPS base station data. If you are looking for a good differential processing program for a low cost (there are not too many out there) then try this link. This may all seem rather cumbersome but differential corrections with a low cost GPS is a tremendous capability at a cost of around $600 for a GPS unit and the licensed versions of the software.

Topographic Map Viewing Software

On the PC software side of recreational GPS, is a full suite of topographic map viewing software packages. Topographic maps and some proprietary vector file formats can be loaded into the recreational GPS units for display and navigation but no editing is possible. Essentially, for GIS mapping, this capability is not very useful due to the proprietary nature of the files and the limited screen size and resolution. A complete list with software reviews is at the Joe Mehaffey GPS site. These are not GIS programs by any means, but do allow for some good cartography and easy transfer of waypoint, route and track data to and from the GPS. A very recent release on the market is MapTech Terrain Navigator 2001. It performs 2-D and 3-D viewing of topographic maps (see Figure 6) and runs on a laptop or desktop PC and can accept GPS input for real-time tracking (see Figure 7). There is quite a bit of capability in this software, like 3-D anaglyph viewing of topographic maps, powerful route and waypoint editing tools, and a large library of CD map libraries for sale, and good cartographic tools. They also make a product for boat navigation called Digital Chart Kit 2001. This provides some excellent tools for navigators and can even plot bathymetry in 3-D (see Figure 8) and show the boats real-time position. Overall, the MapTech products install and perform flawlessly and are a good value for users needing to plot real-time positions.

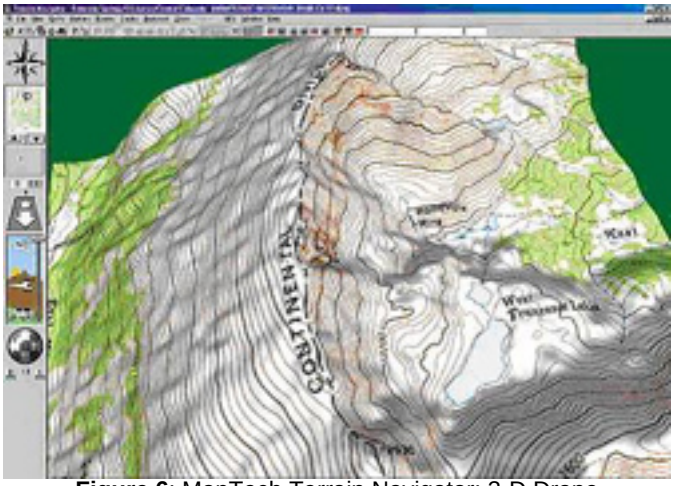

Figure 6: MapTech Terrain Navigator: 3-D Drape

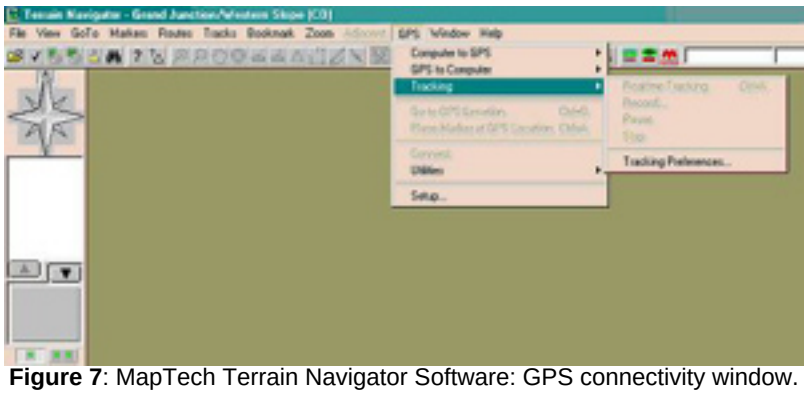

Figure 7: MapTech Terrain Navigator Software: GPS connectivity window.

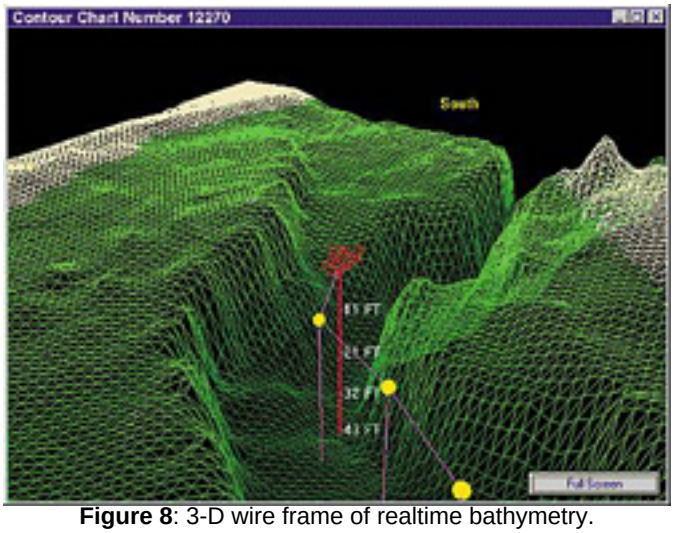

Figure 8: 3-D wire frame of realtime bathymetry.

Palmtop GIS

When the Compaq IPAQ hit the market last year, many people with an interest in mobile mapping took note. This unit and others like it run a Windows CE operating system, can accept a wide variety of expansion and memory cards (including non-differential GPS), and feature dazzling color screens with fast (200+mhz) processors. Sophisticated GIS and CAD software can run on these units and when coupled with a differential GPS through a serial USB connection, a complete mobile mapping solution is at hand. The advantage of a system like this is that a relatively "dumb" and inexpensive GPS unit can be connected to a very sophisticated data logger that can be upgraded and reconfigured with new software as needed. Without a differential GPS connection or GPS post-processing, this system is less useful but certainly has utility for navigation and course plotting.

MapTech has just released its Pocket Navigator software for Windows CE (PocketPC) computers. This software allows you to connect a GPS to a moving map window on the PocketPC and view USGS 7.5', 1:100000, 1:250000 and world maps, NOAA nautical charts, and waypoint and track data. The GPS connects thru a type II PCMCIA slot that that is either built into the PocketPC or is part of a "jacket" that slides onto the back of the PocketPC. Be aware that many of these devices only have one expansion port so additional flash memory and other devices will have to be used one at a time. It is also possible to link bulkier, sometimes less expensive, DGPS enabled recreational or resource grade receivers to the PocketPC via a 9-pin serial to 25-pin serial Pocket PC connector. Essentially, with the MapTech Pocket Navigator, you subset maps from their CD sets, upload them onto your PocketPC, and as you move around outside, a moving map window with a cross hair is displayed. You can add waypoints and routes, and calculate bearings and distances. One drawback to all of the GPS "topographic mapping" software on the market is the impossibility of importing and viewing standard raster and vector GIS data formats. While not the intention of these programs, it would be a nice feature to have.

Full featured GIS/CAD software applications are available for Pocket PCs and when equipped with a GPS, make for very useful tools. Five, well developed products are available and can be recommended. Autodesk makes the On Site software for PocketPCs that allows CAD drawings to be edited and verified in the field. The ArcPad software from ESRI has similar functions and offers most of the vector

functionality of ArcView and good support for compressed imagery. The Fieldworker software by Fieldworker Products has GPS and GIS support and allows for the capture of digital pictures. Trimble Navigation has the TerraSync software for PocketPC, which support vector data collection and editing, raster background images, internet maps and imagery, and most importantly carrier phase high accuracy GPS input (when used with compatible Trimble products). Tripod Data Systems (TDS), a leader in field data collection interfaces, offers the Solo CE GPS-GIS data collector system with many of the same features as the Trimble software. This is not a surprise- Trimble acquired TDS in the fall of 2000.

Conclusions

The rapidly changing state of technology in the GPS hardware and software arena will pose some difficult challenges to GIS users. It will be necessary to thoroughly investigate and demo any system you are considering for purchase to make sure it has the right features for your needs. Fortunately, most companies offer demos or are willing to demonstrate the equipment for you so take advantage of this and the support they offer.

Kyle Bohnenstiehl has been involved in remote sensing, GPS and GIS for over 10 years and is currently a remote sensing scientist with the Department of Interior. His work has taken him throughout the Andes of South America and the desert Southwest where he has worked with tribes, NGO's, government and private sector groups to create innovative solutions using the latest geotechnology. He can be reached at Kyle@nagis.com