By Shawn Billings, LS

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ProMark3 RTK from Magellan Professional

The ProMark3 RTK is Magellan's latest precision, entry-level system, offering real-time kinematic power in a system that is substantially less expensive than dual-frequency RTK packages.

The ProMark3 is a rugged Windows CE device (**Fig. 1**). Other than the operating system itself (CE.Net v4.2), most of the Windows applications have been stripped away (there is no mobile Word, Excel, Outlook, etc.), and it is a closed platform so no third-party programs can be added. Manual data entry is performed by using either an on-screen pop-up keypad or the 19-button/four position rocker keypad. The keypad is arranged in the increasingly common cell phone layout, which for many of today's Gen Xers and Yers makes typing on a cell phone almost as fast as on a Qwerty keyboard. The option of keyboard input or on-screen keyboard input allows for a practical button size on this compact unit.

The unit is powered by a removable, proprietary, lithium ion 3.7v battery with a 3900 mAh capacity that is accessed at the back of the unit by turning two screws with a coin. The battery is recharged either in the unit or in an optional charger. Magellan offers a two-bay external charger. Charging the batteries via the receiver was fine except for one serious inconvenience–there is no indication that the unit is actually being charged unless the unit is turned on during charging, in which case the LED display indicates the status of the charge. The batteries are spec'd to operate in RTK mode for about six hours. From my testing, this seemed to be a fair assessment and perhaps even slightly conservative.

Figure 1

Users can store files on the 128 Mb of flash memory onboard or on an SD card with a capacity of up to 1 gigabyte.

A series of fourteen brass contacts located above the battery compartment allow an I/O module to be attached. The I/O module is a hollow plastic box with a charging jack, a host USB port, a client USB port, and a serial port, for upload/download to a PC. The ProMark3 is also Bluetooth-enabled for wireless connectivity. The contacts at the rear of the unit are also used for attaching the RTK radio in the field. At the center of the contacts is a

Figure 2

small threaded hole for receiving a retention screw with a knurled head located in the radio cable connector (**Fig. 2**). The screw and hole are fairly small and don't inspire much confidence with respect to longevity, yet there was never an issue with the connection while I was reviewing the system. The radio cable allows for input and output communications between the receiver and the radio and also serves to power the radio.

Radio Communications

The radio is powered by the ProMark3 battery, and I was impressed by the low power draw the radio imposed on the receiver. Battery life was affected by the radio but not drastically. Keeping each set-up limited to one battery for the controller, receiver and radio makes it easier to keep up with batteries at the end of the day when it's time to recharge, but also places more strain on battery life. Carrying spare batteries would probably be a good idea for heavy field use.

The license-free radios for North America operate at 900 MHz and run at 500 mW (**Fig. 3**). As such, range is a concern using the Magellan radios. The area in which I performed range tests was crossed by ravines and rolling terrain, populated by dense, juvenile pine trees, brick houses and an overpass embankment. The maximum distance I was able to receive stable radio corrections in this environment was about 3,000 feet. Walking through a neighborhood with three or four houses along the line of sight between base and rover, three or four hundred feet of pine trees and the overpass embankment, I was limited to about 2,000 feet.

This limitation can be overcome in one of several ways. An optional Pacific Crest UHF radio kit is available that is cabled similarly to the Magellan radio with an added external adapter for powering the base radio. The rover radio is powered internally. The UHF radios significantly improve range according to trusted sources. Furthermore, the ProMark3 RTK supports NTRIP and Direct IP via a Bluetooth-enabled cell phone and can work in Network RTK environments including VRS, FKP and MAC. I was unable to test either of these options, but they should offer a great deal of flexibility for many users. One final technique that may be used to offset the limited range of the Magellan radios is to set the receivers (base and rover) to log raw data files. Should you get beyond radio range and need to collect a few points, you don't have to stop working, just stop-and-go. This will enable you to quickly pick up those points beyond radio range (for post-processing) and then move back into radio range and continue working in real-time.

The radio cable and separate GPS antenna cable are spliced together with a spiraled plastic sheathing that runs from the unit to the antenna (**Fig. 4**). The whole set-up isn't very pretty, and bor-

SINGLE-FREQUENCY PAST AND MAGELLAN PRESENT

Historically, RTK systems built on single frequency platforms have not fared well, mostly due to the long initialization and re-initialization times required. First, it isn't really fair, or even technically correct, to consider the ProMark3 RTK a single frequency GPS system in the classical sense of the term. Looking into the Magellan ancestry, we find the 1996 vintage Ashtech GG-24 receiver. The GG-24 was a single frequency receiver that also tracked Russian GLONASS signals to improve initialization speeds over single-frequency receivers at a lower cost than dual-frequency receivers. When the GLONASS satellite constellation began to falter in the late 90s, the GG-24 slipped from cutting edge to technological antiquity. But, the concept of single-frequency, dual constellation GNSS positioning was revived after the global proliferation of Satellite Based Augmentation Systems (SBAS). SBAS is a combined system of continuously operating ground stations networked to a main processing center that then sends information to geostationary satellites. In return, the satellites send that data back to the user segment on Earth, all for the purpose of improving accuracy and reliability of GPS over coverage areas, particularly for the aviation industry. Interestingly, these SBAS satellite signals are very much like GPS satellite signals (without those pesky differences between GPS and GLONASS such as signal structure, timing and reference frames). Magellan's Blade technology makes use of these SBAS signals very much like the GG-24 did with GLONASS, technically making the ProMark3 a dual constellation system. The ProMark3 does *not* use the ionospheric corrections of the SBAS when working in RTK mode, which means that even users outside of the coverage areas of WAAS, EGNOS and MSAS (South America, Africa, Australia, *et al*) can make use of these satellites. The SBAS satellites are only used as observable satellites, like GPS, but with the added benefit of being geostationary, making them easier for the real-time processor to incorporate.

Figure 4

Figure 3

ders on unsightly, particularly considering the bulky bracket used to mount the radio to the pole. But it is utilitarian, and other than the lack of aesthetic appeal, I didn't notice the cabling or radio bracket when working. Setting up the base and rover on two meter poles was accomplished in short order. From the time I set the bags on the ground to the time I was ready to log points with a fixed solution took only 15 minutes.

The system was delivered for review in three nylon carry bags (**Fig. 5**). Two bags contained the receivers, antennae and receiver/pole brackets, and the other contained the base and rover radios. The cables and radio antennae seemed cramped in the bag, and could possibly be damaged over time (say, kinked cables or a broken antenna). Also, the radio assembly does not disassemble. The bracket and cabling appear to be permanently affixed. If I were to own this system, I would make it a point to find a more suitable way to carry the radios.

Software

The system optionally includes Magellan's FAST Survey, a data collection software developed by Carlson Software. I found the software to be very capable, in spite of driving an entry-level system. With options for total station data collection available, you can even disconnect from the GPS antenna and RTK radio and connect to a total station either by Bluetooth or by serial connection using the I/O module (not really recommended because of its lightweight construction). Even without the total station option enabled, total station data can still be manually entered into the unit.

The mapping features included in FAST are impressive. It's like having CAD right in the field with you. You have the ability to import and export .dxf files so that data collection can be performed right on top of linework, the addition of a nifty array of common CAD routines–such as drawing 2D and 3D polylines, circles, offsets (2D and 3D), layer control, area (including sliding side and hinge method, predetermined areas)–as well as tools to perform field-to-finish, and even triangulation and contouring.

FAST also includes a capable COGO suite: intersections, point projection (which also performs inverse to line and inverse to arc), inversing from point to point (by point number), area calculation, point entry by station and offset, a fully-featured rotate, translate and scale routine, a virtual RPN calculator that also performs curve and triangle calculations, and conversion utility for latitude and longitude and grid coordinates; metric, US Survey Feet and International Feet; slope distances, zenith angles and horizontal distances and vertical distances; and for azimuth to bearing. FAST also features a raw data editor and processor with adjustments. There is also a routine for point in direction allowing users to enter points manually by a variety of methods. Local projections can be accommodated as well as a seemingly endless list of predefined grid systems found around the globe (closer to home, State Plane, NAD83 and 27, and UTM are predefined).

Collection is performed in a variety of ways. FAST generates an .rw5 (raw data) file and a .crd (coordinate) file. I may be one of five people in the world who even care, but I was a little disappointed to find that there was no way to store RTK vectors. Collection can be configured to store only fixed observations as well as limiting the maximum allowable RMS values. This makes data collection a little easier by not allowing the user to accidentally store shots that are obviously unreliable. The user should still keep in mind what kinds of conditions affect accurate GPS positioning such as tree canopy, high voltage power lines, nearby buildings, etc.

Collection methods include: *Store*, for general collection, *Offset*, which offers several handy methods for getting to points that just can't be set up on directly, and the *Average* method which offers some additional statistics to the raw data file over the *Store* method for priority points. Auto by Interval either takes a shot whenever the receiver travels beyond a user-specified horizontal or vertical distance, or when a user-specified time interval has elapsed. I found the Auto by Interval to be very useful, accom-

modating the rapid mapping of edge of pavement lines and other similar features.

Staking

Staking points and lines is easy to do. The one-hertz position update requires a little patience when staking out. The user must wait for the position to refresh after the pole is plumbed, and likely wait for several more seconds to ensure the displayed coordinates are stable. Other than the slow initial position update, the stakeout worked perfectly and I quickly recovered some buried points at our testing range by following the displayed azimuth, distance and cut/fill values. The software even enables the user to stake selected polylines from the map.

For working with orthometric heights, a geoid file can be loaded and/or a localization can be performed. Small areas of the geoid must be selected, converted and exported using GNSS Solutions. Conservatively selecting the size of your geoid model will certainly help reduce the time required to load the file once in the field. For the two-degree square grid I used from Geoid '03, the ProMark3 took about two minutes to load the geoid when the job was opened.

Initialization can be done in one of four ways: On-the-Fly (OTF) initialization for situations when the user may be walking from one point to the next while attempting to have the software determine a fixed solution; Static OTF, for occasions the user may set the unit up on at a random location (since the rover is not in motion, fixed status can be determined more easily than OTF); Initialization Bar method, which by all appearances, seems like a holdover from days gone by; and Known Point initialization for occasions when the user may occupy a point with known coordinates in the same coordinate system as the base station coordinates. If radio contact is lost, the receiver automatically goes from fixed or float to the next best available solution. If DGPS is available, the receiver will begin to display DGPS positions.

Figure 6

Accuracy

I was impressed to find that in my testing over a 6+ hour session, recording an epoch every 60 seconds, only 5.5 percent of the observations strayed more than 0.033' (one centimeter) from the overall horizontal average, with the worst outlier being only 0.045' from the average 2D coordinates of all points. Vertically, none of the observations exceeded 0.067' (two centimeters), with the worst outlier being 0.055' from the average elevation of all points. (Baseline distance was 20 centimeters, as the antennas were mounted on the initialization bar.) (**Fig. 6**) Locating points along our own testing range at distances of 50-600 feet reflected the same high accuracy.

The system functions very well. With its relatively fast initialization and reinitialization times and full featured data collection, it compares rather well to the more expensive RTK systems on the market. Magellan has developed a simplistic, entry-level product at an entry-level price, that surprisingly does not scrimp on features or flexibility. For work areas that are mostly not suited for RTK or in which RTK may only be used on occasion, the price tag (under $12,000) may make the return of investment come much faster. Being able to perform surveying and GIS data collection using post processed static, stop-and-go, kinematic or submeter positioning as well as real-time submeter and real-time centimeter level positioning all from one device gives the surveyor a powerful arsenal.

Figure 5