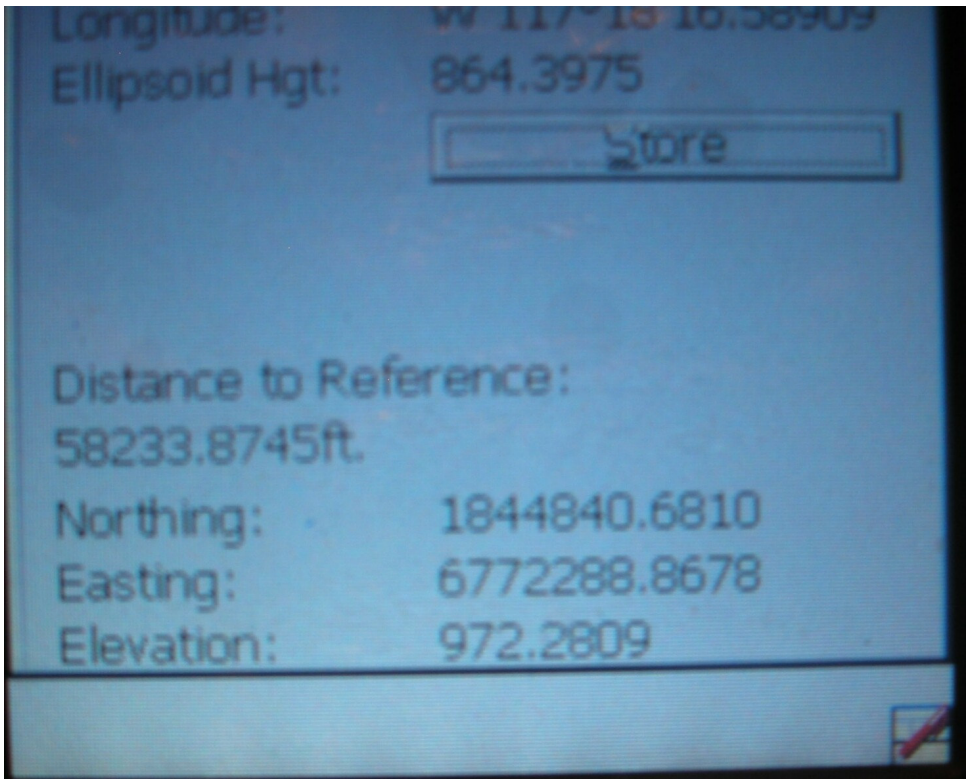
ProMark3 - Internet RTK with base & rover

The Concept

The ProMark3 RTK system can be configured with the base broadcasting RTK corrections to the Internet and the rover receiving RTK corrections from the Internet through a cell phone used as a modem.

Advantages of this method include extended range of RTK operation for areas where radios have limited range but cell phone access to the Internet works well. It takes advantage of the Magellan BLADE technology offered by the ProMark3 base / rover combination. It provides a way to determine accurate local base station coordinates at extended range to set a point for a ProMark3 base station that broadcasts corrections through a radio data link.

The following photo of a ProMark3 RTK rover eleven miles from the base illustrates this imaginative method of doing ProMark3 RTK work.



Comprehending the Techno-babble

People who know about Internet RTK use terms that are as baffling as the words typically used by surveying and mapping professionals in their daily work. Some definitions may aid understanding.

IP - Internet Protocol - in conversations about Internet RTK this is often associated with the IP address of the computer that is broadcasting the RTK corrections. The IP address of a computer can be found by using a web browser to connect it to the web site at

http://www.ipaddressworld.com/ or http://www.ipchicken.com/

Port Forwarding - a method of instructing the router where to send the request for data. Port forwarding opens a pipe. The ProMark3 rover will be configured to come looking through that pipe to find the base station data. The procedure for setting up the port forwarding is specific to different brands of routers and will not be detailed in this paper. Find more help with this task on the web page at

http://portforward.com/help/portforwarding.htm

TCP/IP - Transmission Control Protocol / Internet Protocol - Defines the way to translate and transmit data through the Internet. Knowing how it works is not essential to this task. The term is used frequently when Internet RTK is described or used. Learn more at

http://en.wikipedia.org/wiki/Internet_protocol_suite

Direct IP - A way to acquire base station RTK corrections at the rover through the Internet by direct connection to the IP address of the computer that sends the corrections. One or more ProMark3 rovers will connect directly to the computer that is connected to the ProMark3 base.

NTRIP - Networked Transport of RTCM via Internet Protocol provides a way to connect multiple base stations to one server using one IP address to access any of the base stations. Seek more information on the web page at

http://igs.bkg.bund.de/

GSM - Global System for Mobile communications. Read more about it on the web page at

http://en.wikipedia.org/wiki/GSM

CDMA - Code Division Multiple Access is an alternative to GSM. Read more about it on the web page at

http://en.wikipedia.org/wiki/CDMA_2000

Bluetooth DUN - Bluetooth Dial-Up Networking - connects the ProMark3 rover to the Internet through a cell phone modem.

http://www.wisegeek.com/what-is-bluetooth-dun.htm

Connecting the ProMark3 RTK base to the Internet

A ProMark3 RTK base station that provides corrections to the Internet requires hardware and software. A NAP100 GPS antenna on the roof provides a clear view of the sky.

Feasibility testing will begin with an approximate base station position just to determine whether this method of RTK work offers any advantage over more generic Internet RTK solutions. At this point the questions outnumber the answers:

Will this work?

Is there an advantage to operating a ProMark3 base station to provide RTK corrections to a ProMark3 rover?

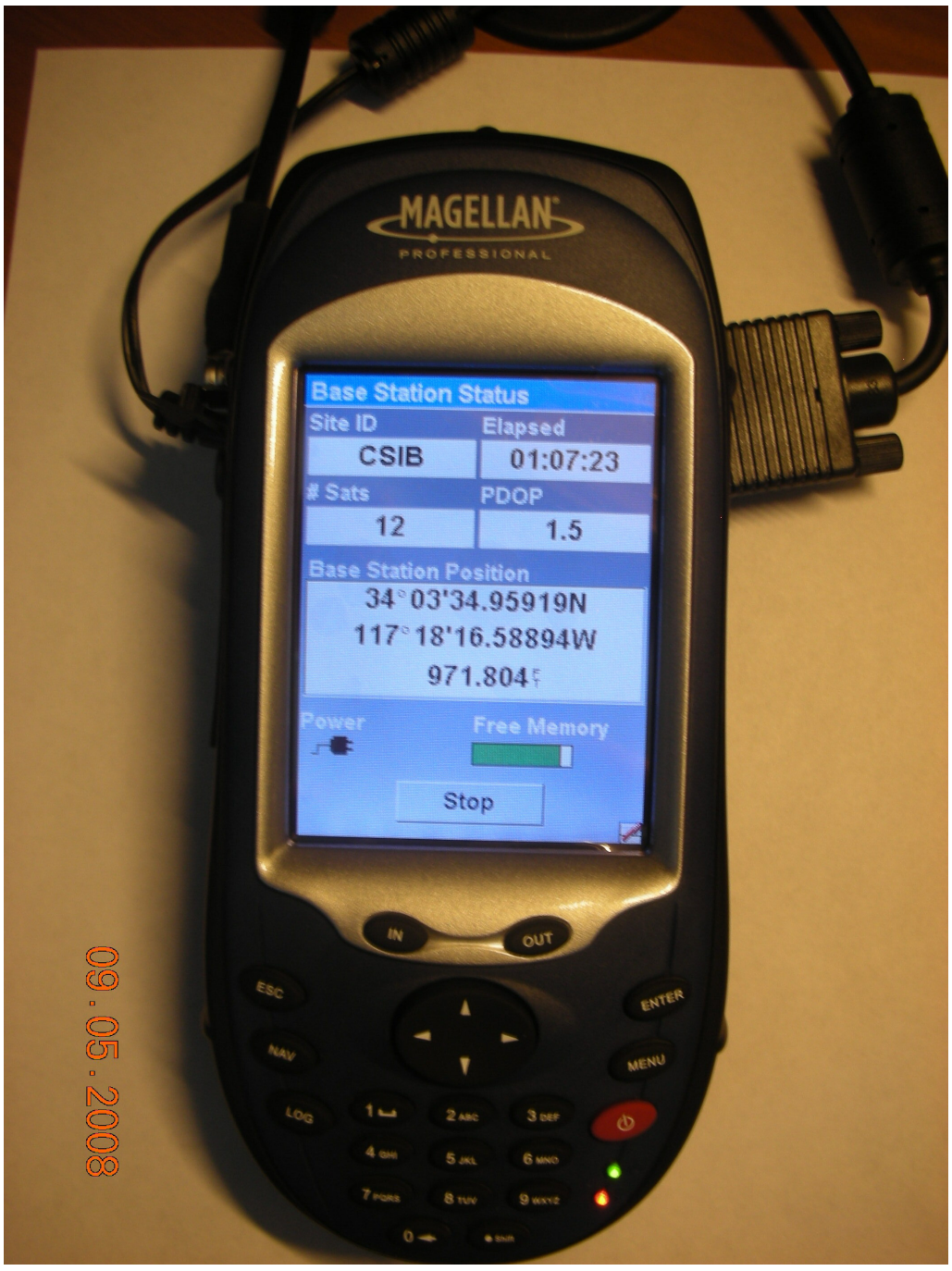
What is the maximum range for a fixed solution?

What is the maximum range for a float or DGPS solution?

What coordinates should be used for the base?

How “accurate” is it?

A ProMark3 with cables connected is set to broadcast RTK corrections using the Surveying program.

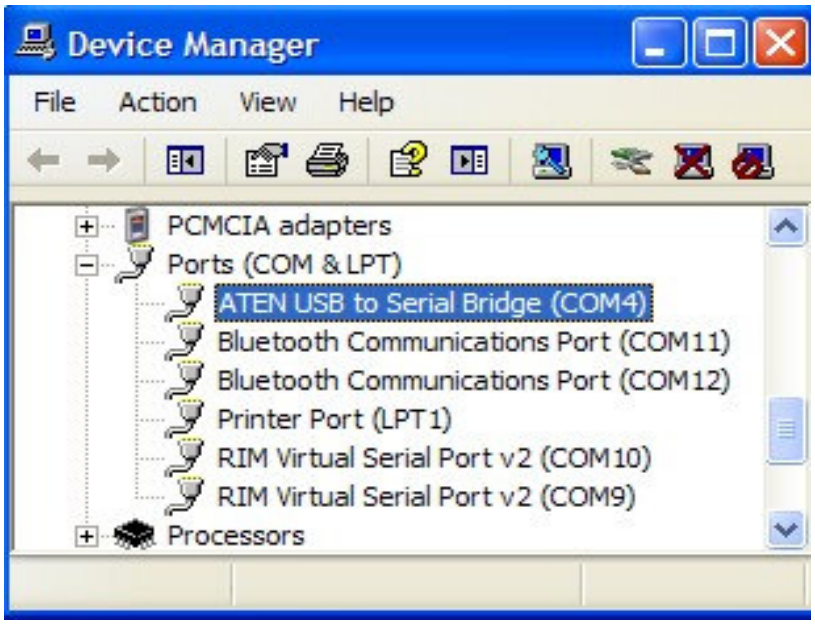


Base station setup using the Surveying program is described in the ProMark3 manual. Get additional help from the application note named Achieving Reliable Results_PM3. The ProMark3 manuals and a variety of other valuable resources are available from the ftp server at ftp://ftp.magellangps.com

Connect the null modem serial cable directly to the nine pin port on a computer that has a serial port. http://en.wikipedia.org/wiki/Null_modem Because the computer used in this example does not have serial port a USB-to-Serial adapter connects the USB port on the computer to a null modem serial cable connected to the I/O module on the ProMark3.

The USB to Serial adapter used is like the one on the web page at
http://www.iogear.com/product/GUC232A/

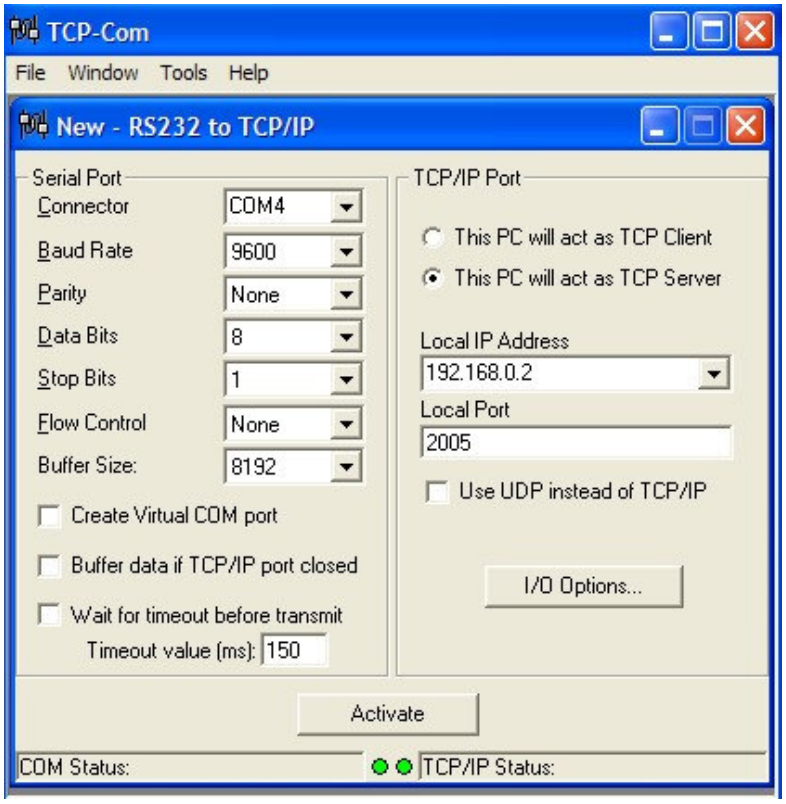
Part of the challenge is to figure out what COM port on the computer is assigned to the USB to serial adapter.



If a router is used to connect the PC to the internet port forwarding is required. Configure port forwarding using the instructions that come with the router. That will not be described in detail here because it varies from router to router. Assign a port number that will be used by TCP-Com.

TCP-Com was selected as the software interface between the ProMark3 serial data and the Internet.

http://www.taltech.com/products/tcpcom.html



Note the difference between the Local IP Address and the IP address that will be used to connect the rover to the PC. The Local IP address represents the PC connected to the ProMark3 base station. The IP address that will be needed by the rover is found with a connection to IPChicken. The port number 2005 was assigned when port forwarding was configured on the router.

Field Work

Once the base station is activated it is time to set up the ProMark3 RTK rover and make some measurements. The ProMark3 RTK Reference Manual is essential. The cell phone connection is explained in chapter 11. Follow that with the instructions for the Direct IP connection in chapter 12. Will this require a trip back to the office to get the IP address and port number from the notes?

Tip: Set up the rover and test the connection to the base before burning gasoline.

Initial performance testing offered some surprises. Fixed solutions at short ranges came as quickly as fixed solutions using the radios. The ProMark3 RTK base station provided faster fixed solutions than more generic Internet RTK data providers because it included the BLADE technology.

It was important to understand the potential for both fixed solution performance and accuracy. Geodetic survey control monuments established by the National Geodetic Survey would be used to evaluate the accuracy at various ranges. NGS control points were selected because they represent a national standard.

Among the first lessons learned: This was working very well in the field. Better base station coordinates were needed. The base station needs NAD83(CORS96) latitude, longitude, and ***ellipsoid*** height. The rover needs a good Geoid03 model file (gsf). Excitement builds as performance discoveries are made.

The decision was made to process a long static session recorded by the ProMark3 base station against two NGS CORS. Even this requires climbing outside the box a little to process such long vectors. Repeatability and redundancy builds confidence. Requirements include understanding of the NGS data sheets, coordinate sheets, and log files to ensure that CORS coordinates, antenna types, and antenna heights are properly applied. It is easy to get in a hurry and get this wrong through dependency on automated answers. The prudent professional studies what is available to gain understanding and double checks everything.

The National Geodetic Survey offers information as well as help to understand the information.

http://www.ngs.noaa.gov/cgi-bin/datasheet.prl

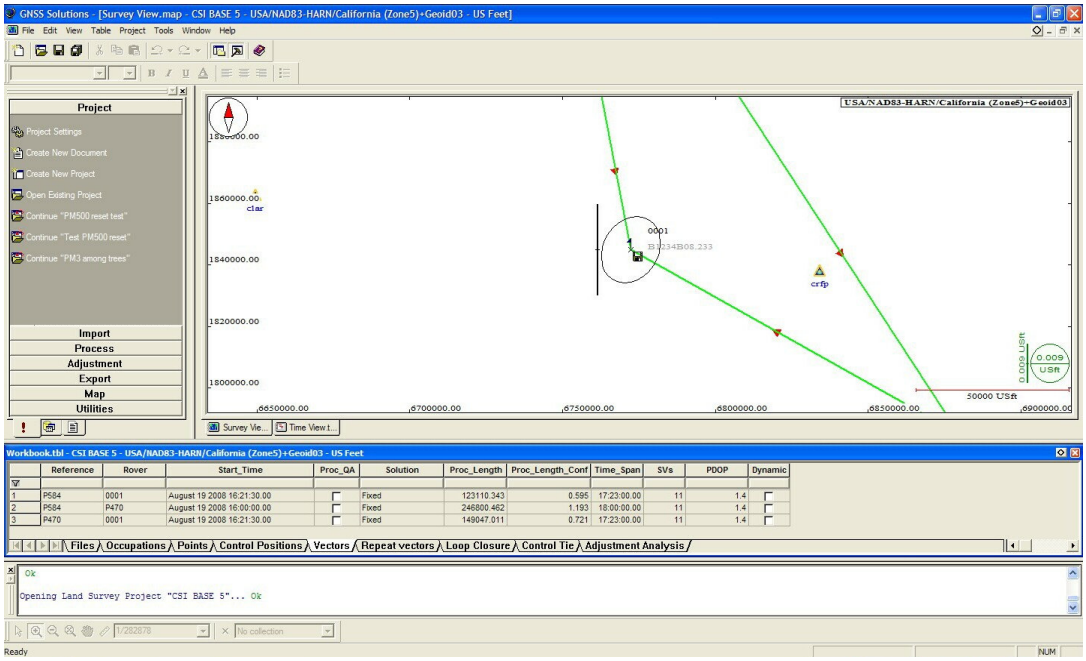
http://www.ngs.noaa.gov/CORS/

http://www.ngs.noaa.gov/GEOID/

http://www.ngs.noaa.gov/NationalReadjustment/

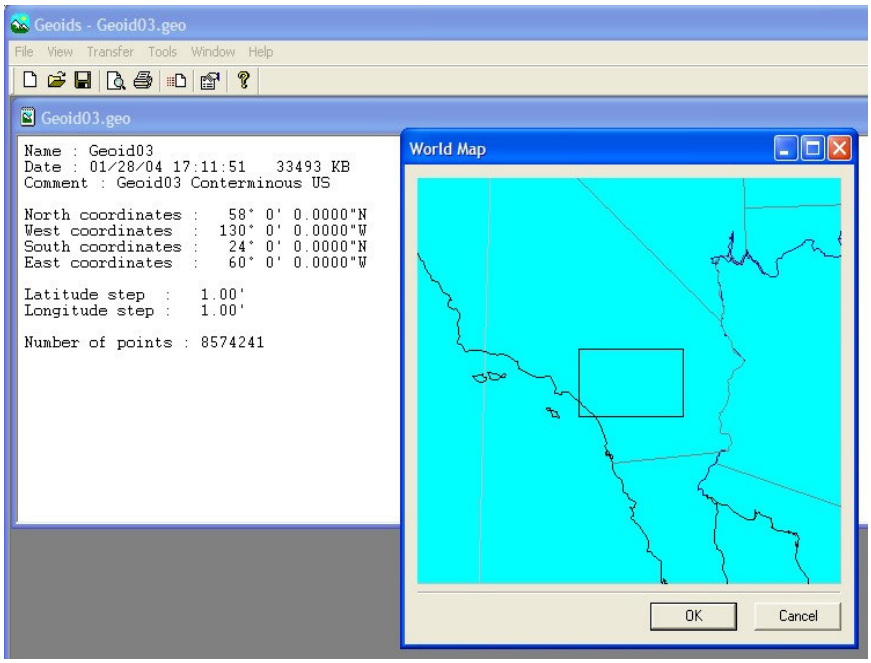
http://www.ngs.noaa.gov/PC_PROD/WorkShops/

Data processing of the base station static session was done with GNSS Solutions. Project settings and numbers from the data sheet are used to ensure the ProMark3 base station coordinates will be accurate NAD83(CORS96) latitude, longitude, and ellipsoid height. This is essential because the base station will be using the basic Surveying program with RTK. The Surveying program does not use a geiod model. The ellipsoid height is required.



The ellipsoid height used at the base station will need to become NAVD88 orthometric heights at the rover. FAST Survey used in the ProMark3 rover makes this a simple task through application of a Geoid Separation File (gsf) extracted from the large Geoid03 model. Boundaries of the area to be included in the extracted model are rough latitude and longitude positions scaled from a map or mapping software. The Geoids program that comes with GNSS Solutions is used to load the Geoid03 model and extract a gsf that can be easily managed by the ProMark3.

In this screen shot the box is drawn. The gsf is ready to be extracted and uploaded to FAST Survey in the ProMark3 RTK rover. The extracted model is large enough to cover the work area but small enough to load quickly in FAST Survey. After it is loaded to the SD card in the ProMark3 it can be copied back to the PC. The gsf can be used many times on projects inside the boundaries of this box.



Did all this effort pay off? Did it ever!

Tip: As the job file is copied from ProMark3 to ProMark3 be sure to direct FAST Survey where to find the geoid model file. Do not assume that the geoid model file will be used just because it shows up in the job settings.

The performance and accuracy of the ProMark3 RTK rover is equal to the radio data link at distances under 6 miles. This worked as well as expected.

Tip: Make sure the ProMark3 is tracking and using SBAS before making measurements. Two miles from the base, with low PDOP, and a good SBAS position a fixed solution takes 30 seconds. Only fifty feet from the base with high PDOP and the fixed solution takes ten minutes. ProMark3 RTK performs best with a clear view of the sky.

What can we do with the ProMark3 rover at extended range? One of the purposes of this project is to determine how well it might work at distances beyond what it was designed to do.

The ProMark3 helps find the survey monument with confidence.

It helps check the distance to the reference monuments.

It reveals how deep to dig to find a bench mark.

U 374 (PID: DX2564) is a NGS first order bench mark with a published elevation of 1979.91 feet. It is located about eleven miles southeast of the ProMark3 base station. There are no published horizontal coordinates to use for a comparison but many people say the elevation is the hard part of GPS accuracy. This project includes several RTK shots on U 374 during the first visit and again on repeat visits on different days.

It was 25 minutes before the ProMark3 showed a fixed solution on the first trip to U 374. This time varied to as little as 10 minutes on different days depending on the PDOP and number of SV's being used. Eleven miles is nearly twice the distance it is supposed to be able to work. The results are good. Eight RTK shots were taken on the bench mark on the first visit. The low was 1979.79 feet. The high was 1979.98 feet. The average was 1979.90 feet. This was repeatable day to day.

FAULT L (PID: DS3746) is a NGS GPS control point with network accuracy estimates computed from what is on the data sheet. The network accuracy is for the ellipsoid height. The NAVD88 elevation was computed from the ellipsoid height and the Geoid height published on the data sheet. FAULT L is 10.6 miles southeast of the base.

Northing: 1,810,218.81 feet +/- 0.09 foot

Easting: 6,816,178.47 feet +/- 0.18 foot

NAVD88 elevation: 2054.42 feet +/- 0.60 foot (ellipsoid height)

Selecting one of the float ProMark3 RTK shots at random provides the following coordinates:

Northing: 1,810,218.64 feet

Easting: 6,816,178.62 feet

NAVD88 elevation: 2054.01 feet

Look at this in very old fashioned terms: The measurement gives a closing error of 0.23 feet at a distance of 55,901.66 feet for an accuracy ratio of 1:243,000. That may have little to do with modern methods of accuracy determination but it is a way that makes sense to a dirt surveyor who is nearly as old as that brass cap. FAULT L was not part of the survey that determined the coordinates for the base station.

What are the range limitations? T 448 RESET (PID: DX2369) is a NGS first order bench mark and GPS control point located 19.1 miles southeast of the base station in a different state plane coordinate zone. To make the grid coordinates fit with other points used in the project the NGS Geodetic Toolkit was used to compute the California Zone 5 state plane coordinates for the point from the coordinates on the data sheet.

Northing: 1,802,895.51 feet Easting: 6,864,236.94 feet NAVD88: 2469.64 feet

The ProMark3 RTK rover was not able to get a fixed solution at this distance but the comparison of several shots showed a consistent float solution. Even more surprising was how well it compared with the coordinates from the NGS. One of the RTK float solutions selected at random from the job file gives the following:

Northing: 1,802,895.18 feet Easting: 6,864,237.16 feet NAVD88: 2470.01 feet

Conclusion

As much fun as it is to explore the potential of the ProMark3 RTK with the Direct IP connection there comes a time when it is time to stop the science project and start the survey. Using a ProMark3 for the base station works better than using a more generic internet base station. Accurate solutions come faster. Even at ranges well beyond those specified the ProMark3 RTK rover could be used effectively to produce coordinates for a base station point. It is a way to bring control to a project to set up base station corrections using a radio data link for a local project. If the objective is precision mapping with the float solutions it seems apparent that sub-foot accuracy requirements provide plenty of room in the error budget for the ProMark3 RTK rover.

Special Thanks

Fred Youna and Colton Surveying Instruments in Colton, California provided the funding and the legs for this project. Email: Fred@Youna.com

Question: Fred, will it work at 100 miles?

Answer: Here is a quick test to answer the 100 mile question. After 40 minutes of floating the ProMark3 RTK rover recorded the following as the position of the CSI Base using Direct IP to EOIC base a distance of 449,576 feet, over 86 miles.

N 1,844,840.72' should be N 1,844,840.68' difference 0.04'
E 6,772,288.86' should be E 6,772,288.87' difference 0.01'
NAVD88 elevation 972.066' should be elevation 972.044 difference 0.02'

Contact Phil Stevenson for the FAST Survey job files recorded during this project.
Email: pstevenson@magellangps.com
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