Z-Xtreme™ GPS Receiver

SYSTEM GUIDE FOR RTK SURVEYING

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Introduction to Real-Time Kinematic (RTK) Surveying

In the early days of surveying with GPS, data collection time on a point was measured in hours, few was the appropriate adjective to describe the number of points established in a day, and completion of a large project could take weeks. The results of a days work was not known until days later when the data was finally processed at the main office. The equipment required to perform this seemingly magical task filled the back of a Chevy Blazer and came at a price tag of approximately $150,000 each. And, by the way, two sets of equipment were needed.

Imagine the scepticism if a user of that system were told that some day, data collection times would be measured in seconds, hundreds would describe the number of points established in a day, and large projects could be completed in hours. Results would be known immediately, in real time. The equipment required to perform this truly magical task would be carried by one person all day, and the price of the entire system would be under $40,000 (including both sets of equipment).

What you've just read is the difference between GPS surveying in the early 1980s and GPS surveying today. Early GPS surveying was static in nature. A user sat on a point for an extended period of time, 1-3 hours or more. If time permitted, this user would move to another point after collection was completed. Data was then sent off to the main office for post-processing. Only after the data was processed were the results of the survey obtained. Since then, GPS surveying has become more dynamic in nature. Equipment has become small enough to be portable. With the incorporation of a radio link between sets of GPS equipment, data can be processed in real-time, as it is being collected. New techniques in data processing has resulted in the ability to establish precise positions in seconds. These advances allow for a user to move around a project site, quickly establishing the position of objects of interest and seeing immediately the fruits of his/her labor. This is RTK Surveying.

The Global Positioning System (GPS)

Let's take a quick look at what makes this all possible, the Global Positioning System (GPS). GPS consists of three primary components: satellites, ground-based control and monitoring stations, and receivers.

The control and monitoring stations' main purpose is to monitor and maintain the satellites. As a user, these stations are invisible to you. You need know nothing else about them except that they exist to ensure the satellites are functioning properly.

Satellites make up the second primary component of GPS. A full constellation is defined as 24 satellites, although at the time of this writing 27 are currently operational. Each satellite is positioned approximately 20,000 km above the earth's surface and has an orbital period of slightly less than 12 hours. On board each satellite, among other things, is a radio transceiver. The transceiver receives information and instructions from the control station and transmits information about its identity, location, time, etc. Each satellite is capable of transmissions on two separate frequencies, L1 at 1575.42 MHz and L2 at 1227.60 MHz. Unlike control and monitoring stations, you are required to have knowledge regarding the location, geometry, and number of satellites available during data collection periods. These important factors will dictate the reliability and accuracy of a GPS survey.

GPS receivers function exactly as the name implies, they receive and store transmissions from the GPS satellites. This is their primary function, and for some receivers, this is their only function. In addition to reception and storage of satellite transmissions, some receivers perform additional functions such as compute and display receiver position in various datums and grid systems, output raw data and computed position through serial ports, display satellite availability information, etc. The more sophisticated receivers are capable of receiving raw data from a second GPS receiver collecting data simultaneously, and combining this data with its own to compute a very accurate position of its location in real-time. This is how an RTK receiver functions.

Real-Time Kinematic (RTK) Surveying

RTK mode of GPS surveying requires the use of at least two GPS receiver systems functioning simultaneously, as shown in Figure 1.1. In fact, this is true for any mode of GPS use where better than 100 meters of positional accuracy is required. In a two-receiver GPS RTK system, one receiver subsystem is designated as the base, and the other is designated the rover. The base receiver system is usually located on a known position, i.e. known latitude, longitude, height or easting, northing, height. Once operational, the base system collects raw data from all available satellites. This raw data is packaged and sent out the serial port to an awaiting radio transmitter. The transmitter broadcasts the packaged raw data to anyone who wants to listen. This is the basic function of a base receiver in an RTK system.

Figure 1.1 RTK Setup for GPS Surveying

The RTK rover is the business end of the system. The rover system is man-portable, usually situated in a backpack. You interface with the system through a handheld computer/data collector. Once operational, the radio portion of the rover system receives the transmissions from the base system containing the base GPS receiver raw data. The radio passes the received base raw data to the rover receiver via the serial port. Simultaneously, the rover GPS receiver collects its own raw data at its current position. The raw data from the base GPS receiver and the raw data from the rover GPS receiver are processed by the rover receiver and the centimeter-level vector (horizontal angle, vertical angle, and distance) between the base and rover receivers is computed. Finally, the rover receiver computes the rover position using the known base position and the computed vector. This is the basic function of the rover receiver in an RTK system.

With the base and rover functioning as described above, a user carrying the rover system can move about a project site and position features of interest quickly and accurately. Positions are computed immediately, giving the user confidence that all is functioning properly. And since the base system does not discriminate to whom it transmits its raw data, there is no limit to the number of rover systems that can operate off of one base station.

Applications

The two primary survey tasks for which RTK systems are used are **feature location** and **feature stakeout**.

Using GPS RTK for feature location was briefly discussed above. With the base and rover systems operational, a user, carrying the rover system, moves around the project area positioning features of interest. Features of any type can be positioned, centerline of a road, perimeter of a pond, light poles, corners of buildings, etc. Features can include existing boundary monuments or new monuments needing to be positioned for the first time. This capability makes GPS RTK a great tool for mapping applications, such as topographic and planimetric surveys, and as-built surveys. RTK systems are also very efficient for mapping stockpiles and gravel pits for volume computations.

Feature stakeout is a task that can only be accomplished with GPS operating in RTK mode. Stakeout of a feature involves stakeout of a point or series of points that define the location of the feature. Given the coordinates of a point, you must be able to find the exact location on the ground that corresponds to those coordinates. Conventionally, this is done by the total station operator directing the rod person to the correct location through observing the rod person's current location and directing the amount of movement to the correct location. With RTK, the rover operator can determine his/her current location by observing the handheld computer screen. The coordinates of the point of interest are also known by the handheld computer. With the RTK system knowing its current location and the location of the point to be staked, the system can direct the user to the correct location. This capability makes RTK a very effective stakeout tool. Any object can be staked out with GPS RTK including roads, pipelines, DTM's, grids, etc.

In most cases, an RTK system will be vastly more productive in these types of surveys than a conventional total station with the added benefit that an RTK system can be operated by only one person.

Limitations

GPS RTK does have limitations that affect its ability to perform some of the survey tasks discussed above. Being aware of these limitations will ensure successful results from your RTK surveys.

The main limitation is not limited to RTK but is a limitation of the GPS system in general. As discussed earlier, GPS depends on reception of radio signals transmitted by satellites approximately 20,000 km from earth. Being of relatively high frequency and low power, these signals are not very effective at penetrating through objects that may obstruct the line of sight between the satellites and the GPS receiver. Virtually any object that lies in the path between the GPS receiver and the satellites will be detrimental to the operation of the system. Some objects, such as buildings, will completely block out the satellites signals. Therefore, GPS can not be used indoors. For the same reason, GPS cannot be used in tunnels or under water. Other objects will partially obstruct or reflect/refract the signal, such as trees. Reception of GPS signals is very difficult in a heavily forested area. In some cases, enough signal can be observed to compute a rough position. But in virtually every case, the signal is not clean enough to produce centimeter-level positions. Therefore, RTK is not effective in the forest.

This is not to say that GPS RTK can only be used in areas with wide-open view of the sky. RTK can be use effectively and accurately in partially obstructed areas. The trick is to be able to observe, at any given time, enough satellites to accurately and reliably compute a position. At any given time and location, 7-10 GPS satellites may be visible and available for use in RTK surveying. The RTK system does not require this many satellites to function. Accurate and reliable positions can be determined with 5 satellites properly distributed throughout the sky. Therefore, an obstructed location can be surveyed if at least 5 satellites can be observed. This makes RTK use possible along a tree line or against the face of a building but only if that location leaves enough of the sky open to allow the system to observe at least 5 satellites.

Ashtech ZX SuperStation

The Ashtech solution for RTK surveying is the ZX SuperStation. The ZX SuperStation includes all required components to perform post-processed and real-time GPS surveys. The ZX SuperStation is powered by the Ashtech Z-Xtreme dual-frequency GPS receiver. Being a dual-frequency receiver (utilizes satellite signals on both L1 and L2 frequencies), the Z-Xtreme makes your GPS system versatile. When performing post-processed surveys such as control establishment and densification, the Z-Xtreme will allow for long separation between base and rover receivers while maintaining the highest level of accuracy. For RTK surveys, system initialization times are short and the solution reliable, resulting in high productivity.

2

System Components

An RTK system is made up of a number of components that, at first glance, may seem a bit overwhelming. On the contrary, setup of an RTK system is not a complicated task. The trick is understanding the purpose of each component in the system and how they relate to each other. With this understanding, connecting the hardware components and using the software components becomes logical and straightforward.

Hardware

An RTK system includes a number of hardware components, each with a specific function. The ZX SuperStation offers options for many of the components, each with specific advantages. Choosing the right component will depend on the requirements and environment in which the system is to be used. In this section, each of the major components of the ZX SuperStation is presented. If options exist for a specific component, each option is discussed.

GPS Receiver

The GPS receiver, Figure 2.1, processes and stores the satellite signals. An RTK system requires at least two GPS receivers, a base and a rover.

Figure 2.1 Ashtech Z-Xtreme GPS Receiver

The ZX SuperStation is built around the Z-Xtreme dual-frequency GPS receiver. The Z-Xtreme supports an integral battery, removable PC card memory, and optional internal radio. It is capable of functioning as the base or rover in RTK and post-processed surveys. The integrated display and control panel supports the ability to perform some survey tasks without a handheld computer. Environmentally, the receiver meets MIL-STD-810E specifications for wind-driven rain and dust.

In order for the GPS receiver to receive satellite signals, it must utilize an antenna. The GPS receiver antenna is the actual collection point of the satellite signals. It is also the point for which the position of the rover system is computed. Therefore, to determine the location of a feature, the GPS receiver antenna must be placed over this feature. The horizontal position of the feature is determined by the location of the center of the antenna. The vertical position of the feature is determined by the location of the center of the antenna minus the known height of the antenna above the feature. Each GPS receiver in the system has one GPS receiver antenna. The ZX SuperStation offers a choice between two different GPS receiver antennae for the base system: the Geodetic IV antenna and the Choke Ring antenna. Obstruction conditions at the base position will dictate which antenna is appropriate.

Geodetic IV Antenna

The Geodetic IV antenna, Figure 2.2, is the standard antenna used by the base and rover RTK systems. It is small, lightweight, and meets the needs of most users. This is the only antenna available for use with the rover system. The other antenna option is too large and heavy for practical use on the rover.

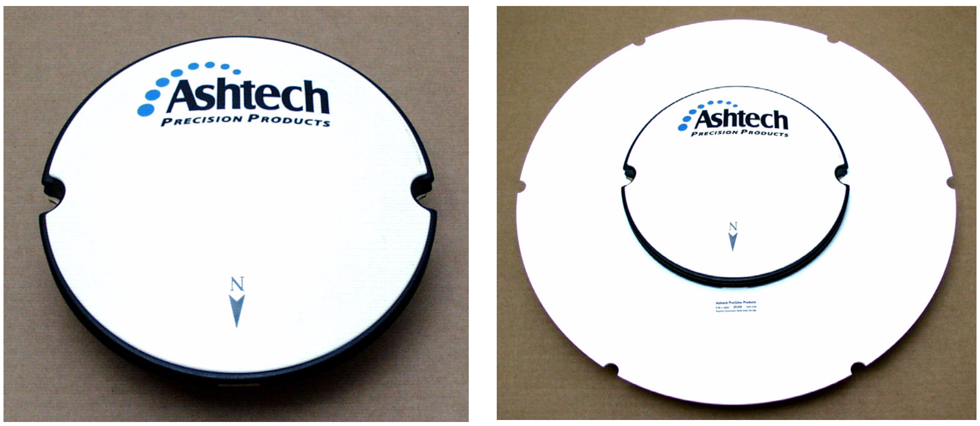

Figure 2.2 Geodetic IV GPS Antenna - without and with Groundplane

The Geodetic IV antenna is available with an optional groundplane attachment, which is effective in reducing noise created by satellite signals reflecting off nearby obstructions. The technical name for this noise is multipath. The groundplane attachment reduces the effects of multipath on the data collected. In order to be effective at reducing the effects of multipath, the groundplane attachment significantly increases the size and weight of the antenna. For this reason, the groundplane attachment is only recommended for use at the base station. If the base system is to be located in an area where obstructions, such as metal buildings, may cause multipath, the groundplane attachment is a good option.

Choke Ring Antenna

The choke ring antenna, Figure 2.3, is the ultimate antenna for multipath rejection. If the base system is to be located in a harsh multipath environment, the choke ring antenna is advisable. An example of a harsh multipath environment would be the top of a building which houses large metal compressors and air conditioning units. These structures will reflect satellite signals which the antenna may pick up. The choke ring antenna is designed to function in the most demanding multipath environments.

Figure 2.3 Choke Ring Antenna for Severe Multipath Environment

Radio

The radio is the mechanism through which the base and rover GPS receivers communicate in the RTK system. Therefore, a radio is a component of both the base and rover systems. As explained earlier, the base GPS receiver must transmit its raw data to the rover GPS receiver in order for the rover GPS receiver to compute the vector between the base and rover systems. The base system transmits the data and the rover system receives the data using radios. The base radio is usually the larger of the two since it must have transmit capabilities. It also consumes much more power. The rover receiver needs only to receive the transmission. This requires much less capability and power consumption. In some RTK systems, the rover radio is so small that it is embedded inside the rover GPS receiver. Two distinctly different radio types are available with the ZX SuperStation, one working in the UHF/VHF frequency range, and another in the spread-spectrum frequency range. Distance requirements between the base and rover systems will primary dictate which radio system to choose.

UHF/VHF

If the intent is to perform RTK surveys with distances between the base and rover in excess of 2 km, then a radio functioning in the UHF or VHF frequency range is recommended, for example the Pacific Crest PDL model shown in Figure 2.4.

Figure 2.4 Pacific Crest UHF/VHF Base Radio

The advantage of a UHF or VHF radio is that radios operating in these ranges can legally transmit data using high powered transmitters. Though UHF and VHF radios are affected by line-of-sight obstructions between the base and rover systems, the increased transmission power of these radios allow for transmissions to push through more obstructions than other radios functioning at higher frequencies, i.e. spread-spectrum. Because of the power levels at which these radios function and the frequency they utilize, a license must be obtained from FCC to operate them.

The radio in the rover system is available as a stand-alone component or embedded in the Z-Xtreme receiver. The advantage of the embedded option is the simplicity of not having another component with attendant cabling. This option is only available at the rover. Since the base system must transmit data, the radio at the base is combined with a 35-watt power amplifier. This requires that the radio be external to the receiver. Figure 2.5 shows a typical rover receiver.

Figure 2.5 Pacific Crest UHF/VHF Rover Receiver

The UHF and VHF radios offered in the ZX SuperStation are manufactured by Pacific Crest Corporation.

Spread Spectrum

RTK surveys conducted on small project sites not exceeding 2 km between base and rover systems can utilize spread-spectrum radios. An advantage of spread-spectrum radios is the license-free operation. No FCC license is required to operate them since spread-spectrum radios are limited in power output to only 1 watt. In addition, areas with a great deal of radio traffic in the UHF or VHF frequencies can make it difficult to perform RTK surveys if the radios being used are close to the same frequency. Since spread-spectrum radios function at a much higher frequency and utilize a frequency hopping scheme, they are not affected by the traffic. Figure 2.6 shows a spread-spectrum radio manufactured by Ashtech.

Figure 2.6 Ashtech Spread-Spectrum Radio

Spread-spectrum radios have been known to function at ranges much greater than 2 km, but to do so requires clear line-of-sight between the base and rover systems. Any obstructions will greatly reduce the range.

The spread-spectrum radio used at the base system and the rover system are identical and interchangeable. The spread-spectrum solution for the ZX SuperStation is manufactured by Ashtech and called the SSRadio. The rover SSRadio has the option of being embedded into the rover receiver. The base SSRadio must be external to the base receiver.

Radio Antenna

The base and rover radios cannot function without antennas. The transmission and reception point of the radio signal is the antenna. The base radio antenna is usually larger than the rover antenna radio since its task is to transmit the signal. Figure 2.7

shows two antennas - spread spectrum and UHF.

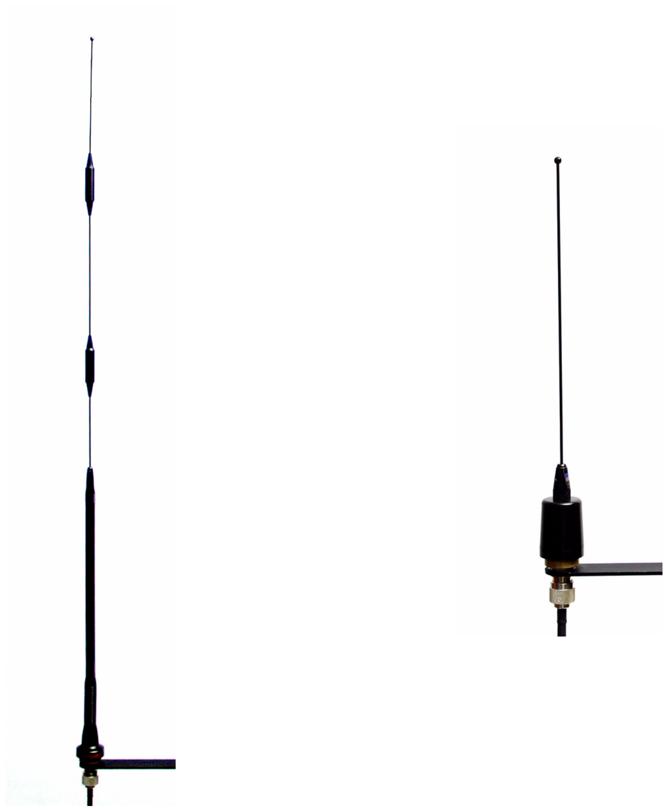

Figure 2.7 Spread Spectrum and UHF Radio Antennas

The ZX SuperStation offers no choice in radio antennae for either the base or rover systems. Only the choice in radio type will affect which antennas are included in the system.

There are no options in radio antennas for the UHF/VHF radio. There is only one set of UHF/VHF antennae available. The UHF/VHF radio antenna for the base and rover systems are identical and interchangeable.

Handheld Computer

A handheld computer, Figure 2.8, serves as the user-interface to the rover system.

Figure 2.8 Handheld Computers: TDS (left), Husky MP2500 (right)

Many users will recognize this component as a data collector commonly used with conventional total stations. In fact, the handheld computer used with an RTK system is very similar in function to those used with total stations. In many cases, the same data collector software (i.e. TDS) is used to interface to an RTK system and a total station. Only one handheld computer is required in an RTK system.

The ZX SuperStation offers a choice of two handheld computers. The choice of field application software will dictate the choice in handheld computers, since one computer is DOS based and the other is Windows CE based.

A ZX SuperStation includes one handheld computer.

TDS Ranger

The TDS Ranger is a rugged handheld computer developed especially for surveying applications. It is designed to withstand harsh environments encountered during normal field use. The TDS Ranger operates under the Windows CE operating system. It's manufactured by At Work Computers, a subsidiary of Tripod Data Systems.

Husky MP2500

The Husky MP2500 is a rugged, field-worthy computer housed in impact-resistant plastic. It's designed to withstand harsh environments encountered during normal field use. The MP2500 operates under the DOS operating system. It's manufactured by WPI Husky Computers.

Power System

Both the base and rover systems need a source of power to operate. At the rover, the GPS receiver and radio utilize the same power source. For the base system, the base GPS receiver and radio may utilize the same power source or separate sources. In any case, the power requirements at the base system may be much higher than the rover system depending on the radio being used. If a base radio transmission must reach a rover system that is more than 5 km away, the transmission power of the base radio must be high, consuming a great deal more power. Figure 2.9 shows an internal battery power source and the same battery configured as an external power source.

Figure 2.9 Power Sources: Internal (left) and External (right)

A number of options are available for powering the ZX SuperStation. Each is described below:

Internal Power

Each Z-Xtreme receiver in the ZX SuperStation includes one internal battery for power. Each battery will operate the receiver for approximately 11 hours.

External Power

For extended periods of operation, an external power source can be connected to the Z-Xtreme receiver via a power connector on the back of the receiver. The battery used for external power is identical to the internal battery. To use it as an external battery, the internal battery is placed in a special pouch. The pouch includes a cable to connect the battery to the receiver. With both the internal and external batteries installed, the receiver can be expected to operate for approximately 22 hours.

The radio at the rover system is powered by the GPS receiver through the communication cable connecting the two components. Therefore, there is no separate power system requirement for the radio at the rover system.

The radio at the base system is powered by either the GPS receiver or by an external power source, depending on the radio type used. The spread-spectrum radio is powered by the GPS receiver through the communication cable connecting the two components. The UHF/VHF radio cannot be powered this way due to the amount of power required to support this radio. Therefore, it requires an external power source. Since the 35 watt UHF/VHF radio draws so much power, it is recommended that a vehicle battery be used as a power source. The ZX SuperStation does not include such a battery in its standard configuration; one is available as an option.

Software

As with hardware, an RTK system includes a number of software components used both in the office and in the field. The ZX SuperStation offers options for some of the software components. Each component is discussed below.

Field Application Software

The field application software resides in the handheld computer/data collector used with the rover system. As with a conventional total station, this software is the user's interface to the base and rover systems, facilitating survey preparation and execution. This software may be specifically designed to work only with the RTK system, or may be usable with both GPS and conventional surveying equipment.

The ZX SuperStation provides two options for field application software: **FieldMate** and **Survey Pro**.

GPS FieldMate (Mine Surveyor II/Seismark II)

FieldMate was designed by Ashtech specifically for use with Ashtech RTK systems. FieldMate offers all basic requirements for performing RTK surveys. The software guides you through all steps required in feature location and feature stakeout tasks. Its interface is straightforward and easy to master. If GPS FieldMate is the choice for field application software, the choice in handheld computer is limited to the Husky MP2500, since FieldMate is a DOS-based program.

Survey Pro with GPS

Survey Pro with GPS offers advanced functionality not found in FieldMate, most prominent of which is the ability to use the same field application software with the RTK system and with conventional surveying total stations. If the ability to standardize on one data collector system for both your satellite surveying and conventional surveying needs is a desirable feature, then Survey Pro with GPS is the right choice. If Survey Pro with GPS is the choice for field application software, the choice in handheld computer is limited to the TDS Ranger since Survey Pro with GPS is a Windows CE-based program. Survey Pro with GPS was developed by Tripod Data Systems (TDS).

Office Support Software

Office support software forms the link between the field and the office. This software facilities the ability to move survey data collected in the field into the office computers. Also, it facilitates the ability to move design (stakeout) information from the office into the field. These are the primary tasks of the office support software. In addition, this software may perform other tasks such as storing survey results in different formats for use in other software, transforming results into other datums or grid systems, and supporting the ability to check the data.

The choice of field application software will dictate which office support software will be included in the ZX SuperStation system.

Handheld Transfer/Mconvert

Handheld Transfer and Mconvert are two office computer utilities that accompany the FieldMate field application software. Handheld Transfer connects the office PC to the handheld computer allowing the transfer of data between the two. Mconvert converts collected field data, stored in binary, into ASCII files for use in other software packages. Mconvert also converts ASCII files containing stakeout information into the file format used by FieldMate.

Survey Link

Survey Link is the office computer utility that accompanies the Survey Pro with GPS field application software. Its basic task is the same as Handheld Transfer and Mconvert, with the added ability to store field data in a number of ASCII file formats used by many civil engineering and surveying design softwares.

Post-Processing Software

For certain types of surveys, GPS in post-processed mode is more suitable than RTK. For this reason, and since GPS receivers designed for RTK use can also be used in post-processed mode, post-processing software is included with the RTK system. When using GPS in post-processed mode, data is first collected in the field and then post-processed in the office to compute positions of occupied points. The post-processing software performs this task. In addition, the post-processing software includes tools to examine satellite availability at any given time, to download data from the GPS receivers, and to create export formats and reports of survey results.

The ZX SuperStation offers a choice between two post-processing software packages: Ashtech Solutions and Ashtech Office Suite.

Ashtech Solutions

Ashtech Solutions includes all functionality required to support post-processing of data collected using receivers in the ZX SuperStation. Using Solutions, the user can examine satellite availability prior to field operations (Mission Planning utility), transfer data between the GPS receivers and office computer, process raw data to produce vectors between surveyed sights, adjust vectors to produce accurate and reliable positions, export, and create reports of survey results. This is all accomplished through a very user-friendly software environment.

Ashtech Office Suite

Ashtech Office Suite includes the Ashtech Solutions features and some added features. Ashtech Office Suite offers the ability to download and process data collected from other manufacturers of GPS receivers. It also supports the ability to process data using precise orbits. If either of these two capabilities is required, Ashtech Office Suite is the proper choice in post-processing software.

This concludes the presentation of hardware and software components which make up the ZX SuperStation system. Next, we will examine the relationship between the hardware components.

3

Hardware Connectivity

After reading the previous section, you should have an understanding of the function of each hardware component of an RTK system and how they relate to each other. In order for the different components to function as a system, they must communicate. This requires that the components be connected for both communication and power. Here we will examine the connectivity of the RTK system hardware components. Since the base system and the rover system have different connectivity requirements, they will be presented separately. In addition, the rover system is available in two configurations, backpack configuration and an optional pole-mounted configuration. Each of these configurations will be presented separately below.

Base System

Below is presented a list of all connections required to make the base RTK system function.

GPS Receiver - GPS Antenna

The GPS receiver requires an antenna in order to observe the data being transmitted by the satellites. Therefore, the GPS antenna must be connected to the GPS receiver. This connection is made through a coaxial cable ranging in length from 3 to 30 meters (Figure 3.1).

Figure 3.1 GPS Antenna Cable with TNC Connectors

This cable serves two purposes: it supplies power to the GPS antenna from the receiver, and it sends the satellite signals observed by the antenna to the receiver.

The GPS antenna cable connects to the Z-Xtreme via a TNC type connector found on the back panel of the receiver, as shown in Figure 3.2. The proper connector is labeled **GPS**.

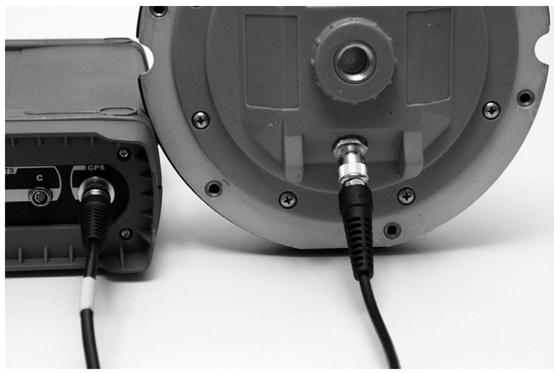

Figure 3.2 Cable Connected to Z-Xtreme Receiver and Geodetic IV Antenna

The other end of the cable connects to the GPS antenna via either a TNC type or N type connector depending on which antenna used. A TNC connector is found on the Geodetic IV antenna. An N type connector is found on the Choke Ring.

The GPS antenna can be connected to the receiver at any time before or after the receiver is powered on. Make sure the connection at both the receiver and antenna is tight and not cross-threaded.

Radio - Radio Antenna

The base radio requires the use of an antenna to transmit GPS receiver raw data. Therefore, the radio antenna must be connected to the radio. This connection is also accomplished with a coaxial cable although a different type than the GPS antenna cable. The connectors on the two cables are different, allowing easy differentiation between the two.

The radio antenna cable connects to the radio via either a TNC or BNC type connector depending on which type of radio used. If the base radio is a Pacific Crest UHF/

VHF radio, the connector is BNC as shown in Figure 3.3.

Figure 3.3 Pacific Crest Base Radio Antenna Cable

If the base is utilizing an Ashtech SSRadio, the connector is a TNC with reverse polarity. With a standard polarity TNC connector, the pin within the connector is found on the cable. With a reverse polarity TNC connector, the pin is in the receptacle on the radio. This difference ensures that the radio antenna cable is not used for the GPS antenna and visa-versa.

The antenna connector for the Pacific Crest radio is on the back panel, labeled **ANTENNA**. The Ashtech SSRadio has its antenna connector located on the front panel, labeled **ANT**.

The other end of the cable connects to a connector embedded into a bracket designed to facilitate the mounting of the base antenna onto the tripod holding the GPS antenna. The radio antenna itself mounts on the same bracket forming the connection to the radio, as shown in Figure 3.4.

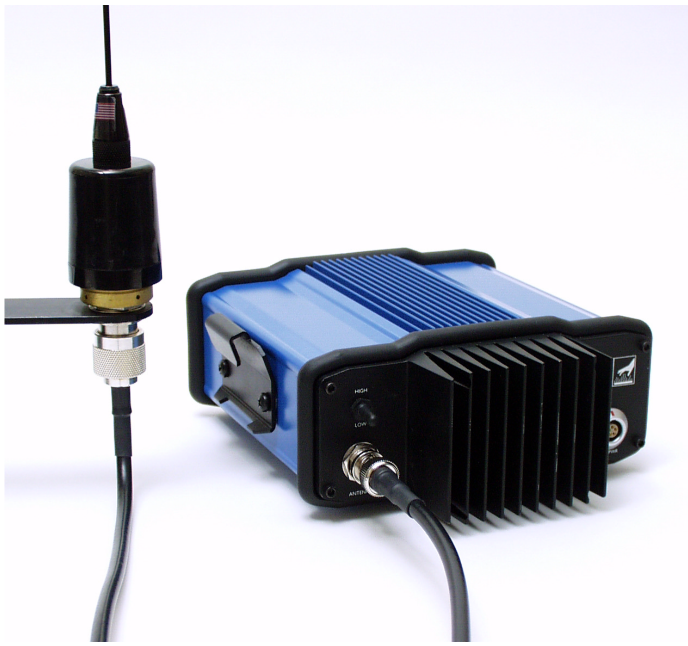

Figure 3.4 Cable Connected to Pacific Crest Radio and Base Radio Antenna

CAUTION
It is important that the radio antenna be connected to the radio prior to applying power to the radio. Failing to due so may result in damage to the radio.

GPS Receiver - Radio

Raw data collected by the GPS receiver must be transmitted by the radio to any rover systems that wish to listen. To accomplish this, the GPS receiver must supply the radio with the raw data. This requires that the GPS receiver and the radio be connected. This connection is made through an RS232 cable, Figure 3.5.

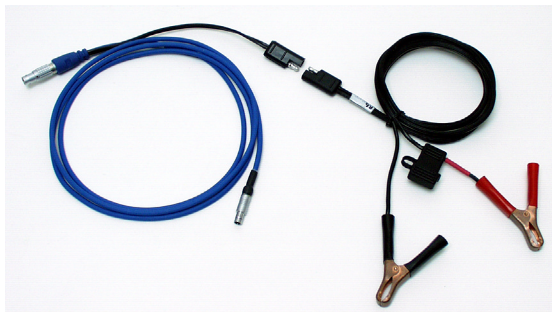

Figure 3.5 Pacific Crest Base Radio Power/Communication Cable

On the back panel of the Z-Xtreme are three serial ports into which the radio cable can be connected. These 3 ports are grouped together and labeled 'SERIAL PORTS'. Although any one of the 3 ports will accept the connection to the radio, it is recommended that the radio be connected to the port labeled 'B'.

The radio communication/power cable connection to the radio will be via either a 7-pin Fischer connector, or a 5-pin Lemo connector, depending on which radio is being used. The Pacific Crest UHF/VHF uses a Lemo connector with the connection being made on the rear panel of the radio. This serves as a power connector and an RS232 connector. The cable is Y-shaped allowing connection between the radio↔receiver and the radio↔power source. The Ashtech SSRadio uses a 7-pin Fischer connector on the front panel of the radio and labeled SERIAL PORTS as shown in Figure 3.6.

Figure 3.6 Communication Cable Connecting Z-Xtreme Receiver and Pacific Crest Radio

It is recommended that the radio be connected to the receiver prior to powering up the receiver. This will ensure a clean power-up of the radio since, with spread-spectrum radios, the receiver supplies power to the radio through this connection.

Handheld Computer - GPS Receiver

Although the base system does not have a dedicated handheld computer, the rover system handheld computer may need to be connected to the base to configure the base GPS receiver. This is done by connecting the handheld computer to the GPS receiver using an RS232 cable (Figure 3.7).

Figure 3.7 Computer Communication Cable

The cable supplied with each Z-Xtreme receiver for downloading of data to a PC is also used for communication between the Z-Xtreme and the handheld computer. Since you will receive two of these cables with your system (one with each receiver) it is recommended that you keep one of them with your base receiver for field use and the other with your PC in the office for data download.

The computer communication cable connects to the Z-Xtreme via one of the three serial ports on the back panel of the receiver. These three ports are grouped together and labeled 'SERIAL PORTS'. Although any one of the three ports will accept the connection to the handheld, it is recommended that the handheld be connected to the port labeled 'A' (Figure 3.8).

Figure 3.8 Communication Cable Connecting Z-Xtreme and Ranger Handheld

Connection of the computer communication cable to the handheld is made via a standard 9-pin serial connector.

The handheld can be connected to the receiver at any time during the equipment setup and data collection process.

GPS Receiver - Receiver Power System

Power can be supplied to the base GPS receiver in two ways.

The Z-Xtreme receiver has a battery integrated into the receiver for power. This connection does not require a cable. The battery is simply inserted into the receiver. If a base station is to function unattended and for a period of time not supported by the internal battery, an external battery can be used. The external power source connects to the Z-Xtreme via a dedicated power cable, Figure 3.9.

Figure 3.9 Z-Xtreme Power Cable and Pouch for External Power

The receiver power cable connects to the receiver via a 3-pin Fischer type connector located on the back panel of the receiver. The correct connector is labeled ‘Power’. The other end of the external power cable connects to the pouch holding the battery (Figure 3.10).

Figure 3.10 Power Cable Connecting Z-Xtreme and External Battery

Obviously connection of the battery to the receiver is required prior to powering up the receiver. The external power source can be connected at any time without concern of the internal battery.

Radio - Radio Power System

The UHF/VHF radio is the only type of radio that requires an external power source. Power is supplied to the radio via a 5-pin Lemo connector that serves as both the power and RS232 port. This connector is found on the rear panel of the radio. The cable supplying power to the radio also serves as the RS232 cable which connects to the GPS receiver. Therefore, the cable is shaped like a Y, with the base of the Y connecting to the radio and the two remaining ends connecting to the power source and the receiver.

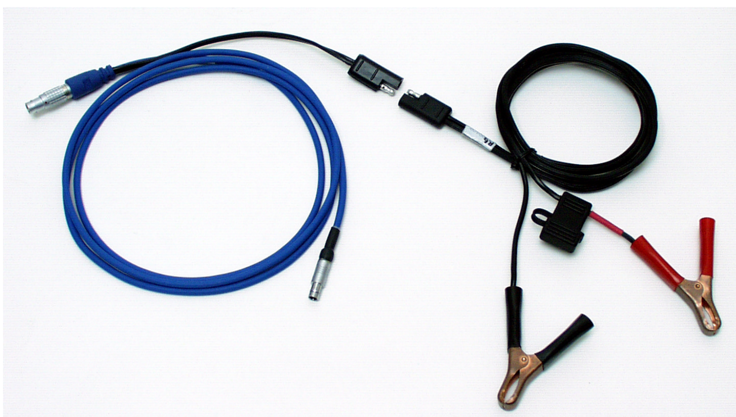

Figure 3.11 Pacific Crest Radio Power/Communication Cable

The battery end of the cable is fitted with alligator clips, allowing the flexibility to connect to any type of power source.

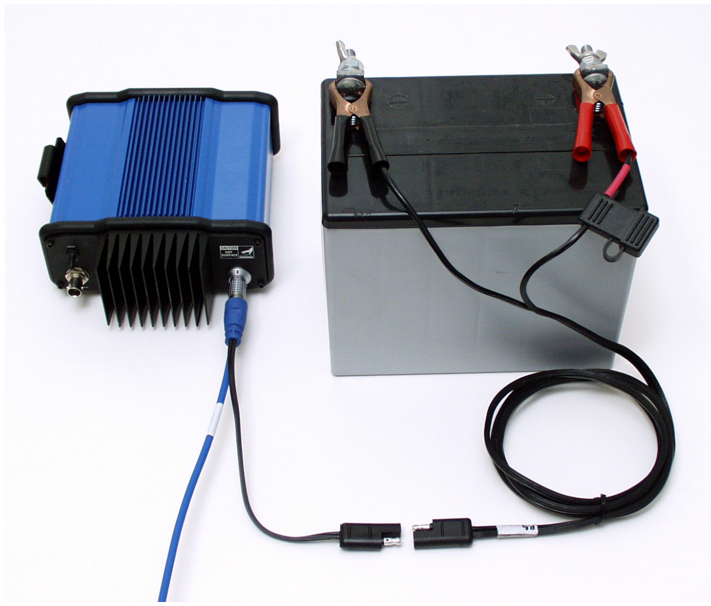

Figure 3.12 Radio Communication/Power Cable Connecting Pacific Crest to External Battery

Connect the external power source to the radio prior to turning on any components of the system.

Now that we have reviewed the connectivity of each Base System component individually, let's examine each primary component fully connected, beginning with the Z-Xtreme receiver.

Fully Connected Z-Xtreme Receiver

A fully connected Z-Xtreme Base receiver will have up to four cable connections, as shown in Figure 3.13.

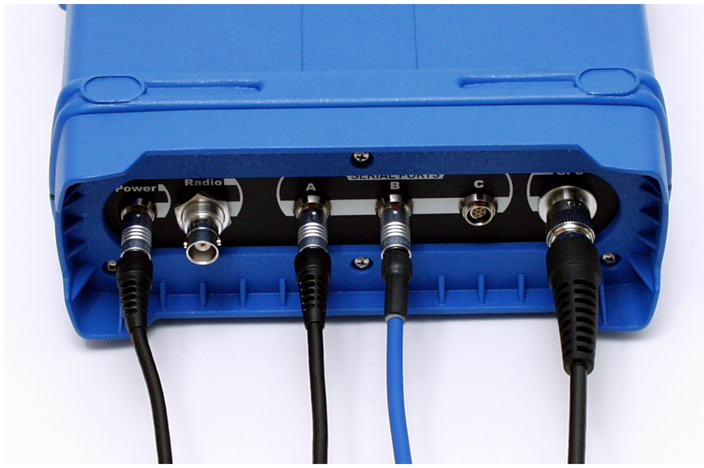

Figure 3.13 Z-Xtreme Base Receiver with all Cable Connections

These connections are:

1. Receiver power cable plugged into the port labeled “POWER”. This cable connects an external power source to the Z-Xtreme receiver. This is an optional connection not required for operation if the Z-Xtreme is fitted with an internal battery.
2. Computer communication cable plugged into the port labeled “SERIAL PORTS – A”. This cable connects the handheld computer to the Z-Xtreme receiver. In most cases, the handheld will need to be connected to the base receiver for configuration. Once configured, the handheld computer connection can be removed during operation.
3. Radio communication / power cable plugged into the port labeled “SERIAL PORTS – B”. This cable connects the Z-Xtreme receiver to the radio. This is a mandatory connection that will remain thoughout operation.
4. GPS antenna cable plugged into the port labeled “GPS”. This cable connects the Z-Xtreme receiver to the GPS antenna. This is a mandatory connection that will remain thoughout operation.

Fully Connected Base Radio

A fully connected radio will have two cable connections, regardless of which type of radio is used. In all cases, both connections are mandatory, as shown in Figure 3.14.

Figure 3.14 Pacific Crest Radio with all Cable Connections

1. Radio communication / power cable plugged into the RS232 / power port.

This port is labeled **DATA/PWR** on the Pacific Crest radio and **SERIAL** on the SSRadio. This cable connects the radio to the Z-Xtreme receiver, and in the case of the Pacific Crest, also connects the radio to an external power source.

2. Radio antenna cable plugged into the antenna port.

On the Pacific Crest radio, this port is labeled **ANTENNA** and on the SSRadio, this port is labeled **ANT**. This cable connects the radio to the radio antenna.

Fully Connected Handheld Computer

A fully connected handheld computer will have only one cable connection, no matter which model of handheld computer is selected, as shown in Figure 3.15.

Figure 3.15 Handheld Computer with all Cables Connected

The computer communication cable is plugged into the serial port. On the TDS Ranger, the RS232 port is on the left when viewed as shown in Figure 3.15. On the Husky, the port is on the right when viewed as shown in Figure 3.15. This cable connects the Z-Xtreme receiver to the handheld computer. Only when the handheld computer is being used to configure the receiver does this connection have to be made.

Backpack Rover System

The backpack rover system places the GPS receiver, radio, and optional external power supply in a backpack. GPS antenna and handheld computer are mounted on a pole. Below is presented a list of all connections required to make the backpack rover RTK system function.

GPS Receiver - GPS Antenna

As with the base system, the rover GPS receiver requires an antenna to receive satellite signals. The same type of cable is used as in the base system. In some cases, the cables will differ only in length. This makes the cables interchangeable if necessary.

The GPS receiver – GPS antenna connection particulars are identical for the base and rover systems. Please refer to the discussion on GPS receiver – GPS antenna connection under the Base System above for more details.

Radio - Radio Antenna

The rover radio requires an antenna to receive transmissions from the base radio. This is accomplished by connecting the radio antenna to the radio through a coaxial cable (Figure 3.16). The radio antenna cable for the rover is specially designed to function at the rover therefore it is not interchangeable with the base radio antenna cable.

Figure 3.16 Pacific Crest Rover Radio Antenna Cable

The radio antenna cable connects to the radio via either a TNC or BNC, type connector depending on which type of radio used. If the remote radio is a Pacific Crest UHF/VHF radio, internal or external to the rover GPS receiver, the connector will be BNC. If the remote is utilizing an Ashtech SSRadio, internal or external to the rover GPS receiver, the connector will be a TNC with reverse polarity.

Figure 3.17 Rover Antenna Connected to Internal Radio

The antenna cable connects to the antenna via an adaptor specifically designed for use on the rover backpack. This adaptor serves as both a connector to the antenna and a mount for the antenna onto the backpack frame.

Note: If the rover radio being used is a Pacific Crest PDL, no radio to radio antenna cable is required. Rather, the radio antenna connects directly to the radio as seen in

Figure 3.18.

Figure 3.18 Pacific Crest PDL Rover Radio with Antenna

It is recommended that the radio antenna be connected to the radio prior to applying power to the radio, although failing to do so will not cause any harm to the equipment.

GPS Receiver - Radio

The rover GPS receiver must be connected to the rover radio in order to get the raw data from the base system. Figure 3.19 shows the cable used for this purpose. Depending on the radio type used, this cable may be identical to the cable used to connect the base GPS receiver to the base radio. In addition to supplying received raw data from the base to the rover receiver, this cable also supplies power to the rover radio from the receiver.

Figure 3.19 Pacific Crest Rover Radio Power/Communication Cable

If the remote receiver is equipped with an internal radio, no connection is required by the user.

On the back panel of the Z-Xtreme receiver are three serial ports into which the radio cable can be connected. These ports are grouped together and labeled **SERIAL PORTS**. Although any one of the 3 ports will accept the connection to the radio, it is recommended that the radio be connected to port **B**.

The radio communication/power cable connection to the radio is made via either a 7-pin Fischer connector or a 5-pin Lemo connector, depending on which radio is being used. The Pacific Crest UHF/VHF uses a Lemo connector with the connection being made on the front panel of the radio, as shown in Figure 3.20. This is the only connector on the front panel of the radio and serves as a power connector and an RS232 connector. The Ashtech SSRadio uses a 7-pin Fischer connector found on the front panel of the radio and labeled **SERIAL**.

Figure 3.20 Communication Cable Connecting Z-Xtreme and PDL Rover Radio

It is recommended that the radio be connected to the receiver prior to powering up the receiver. This will ensure a clean power up of the radio since, with the spread-spectrum radios, the receiver supplies power to the radio through this connection.

Handheld Computer - GPS Receiver

The handheld computer must communicate with the rover GPS receiver in order for the computer to control certain operations in the receiver and for the receiver to send computed positions to the computer. This is accomplished using an RS232 computer communication cable, as shown in Figure 3.21. The rover computer communication cable is coiled for convenience in rover operation. The cable functions the same as the computer communication cable at the base system so they can be interchanged if needed.

Figure 3.21 Computer Communication Cable

The handheld computer – GPS receiver connection particulars are identical for the base and rover systems. Please refer to the discussion on handheld computer – GPS receiver connection under the Base System above for more details.

GPS Receiver - Receiver Power System

Under most operational conditions, the rover system will be powered by the internal battery to the Z-Xtreme receiver. An optional external power source is available for use on the rover system if extended operation is required without interruption. The external power source is connected to the GPS receiver via a dedicated external power cable.

The external power source and cable is identical for the base and rover system. For details on the connection, please refer to the GPS Receiver – Receiver Power System section under Base System above.

Now that we have reviewed the connectivity of each backpack rover system component individually, let's examine each primary component fully connected, beginning with the Z-Xtreme receiver.

Fully Connected Z-Xtreme Rover

A fully connected Z-Xtreme Rover receiver with external radio may have up to four cable connections, as shown in Figure 3.22.

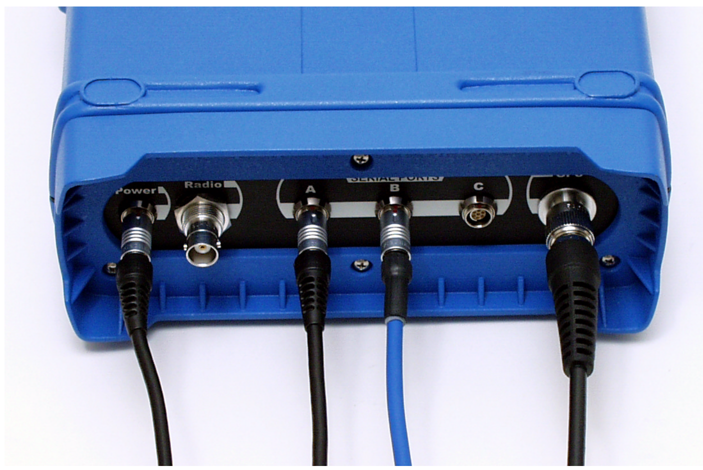

Figure 3.22 Cable Connections for Z-Xtreme Rover with External Radio

These connections are:

1. Receiver power cable plugged into the port labeled "POWER". This cable connects an external power source to the Z-Xtreme receiver. This is an optional connection not required for operation if the Z-Xtreme is fitted with an internal battery.
2. Computer communication cable plugged into the port labeled "Serial Ports – A". This cable connects the handheld computer to the Z-Xtreme receiver. This is a mandatory connection that will remain throughout operation.
3. Radio communication / power cable plugged into the port labeled "Serial Ports – B". This cable connects the Z-Xtreme receiver to the radio. If using an external radio, this is a mandatory connection that will remain thoughout operation. If using a radio internal to the GPS receiver, this connection is not required.
4. GPS antenna cable plugged into the port labeled "GPS". This cable connects the Z-Xtreme receiver to the GPS antenna. This is a mandatory connection that will remain thoughout operation.

If the rover system includes a radio internal to the GPS receiver, the connections to the receiver will be slightly different, as seen in Figure 3.23.

Figure 3.23 Cable Connections for Z-Xtreme Rover with Internal Radio

With the internal radio, the Radio Communication/Power cable is no longer present. In its place, a radio antenna cable is added connecting to the port labeled “RADIO”.

Fully Connected Rover Radio

A fully connected radio, Figure 3.24, will have two cable connections, regardless of which type of radio used. In all cases, both connections are mandatory.

Figure 3.24 Pacific Crest Rover Radio with all Cable Connections

1. Radio communication/power cable plugged into the RS232 / power port. This port is not labeled on the Pacific Crest PDL radio and labeled “Serial” on the SSRadio. This cable connects the radio to the Z-Xtreme receiver, and in the case of the Pacific Crest, also connects the radio to an external power source.
2. Radio antenna cable plugged into the antenna port. On the SSRadio, this port is labeled **ANT**. This cable connects the radio to the radio antenna. On the Pacific Crest PDL radio, the antenna is mounted directly on the radio.

Fully Connected Handheld Computer

A fully connected handheld computer will have only one cable connection, no matter which model of handheld computer is selected, as shown in Figure 3.25.

Figure 3.25 Handheld Computer with all Cables Connected

The computer communication cable is plugged into the serial port. On the TDS Ranger, the RS232 port is on the left when viewed as shown in Figure 3.25. On the Husky, the port is on the right when viewed as shown in Figure 3.25. This cable connects the Z-Xtreme receiver to the handheld computer.

Pole-Mounted Rover System

The pole-mounted system places the GPS receiver on the rover pole along with the other components. All components are pole-mounted, eliminating the need for a backpack. Below is presented a list of all connections required to make the pole-mounted rover RTK system function.

GPS Receiver - GPS Antenna

As with the base system and backpack rover system, the pole-mounted rover GPS receiver requires an antenna to receive satellite signals. The same type of cable is used as in the base system. The only difference will be in the length of the cable. This makes the cables interchangeable if necessary.

The GPS receiver – GPS antenna connection particulars are identical for the base and rover systems. Please refer to the discussion on GPS receiver – GPS antenna connection under the Base System above for more details.

Internal Radio - Radio Antenna

The rover radio requires an antenna to receive transmissions from the base radio. For the pole-mounted configuration, the radio must be internal to the GPS receiver. You have the option of connecting the radio antenna directly to the radio antenna port on the back of the GPS receiver (requiring no cable), or mounting the radio antenna on the pole and connecting it to the radio antenna port on the GPS receiver via a coaxial cable (Figure 3.26). The radio antenna cable for the base and rover are not interchangeable.

Figure 3.26 Pacific Crest Rover Radio Antenna Cable

The radio antenna cable connects to the internal radio via either a TNC or BNC type connector depending on which type of radio used. If the remote radio is a Pacific Crest UHF/VHF radio, the connector will be BNC. If the remote is utilizing an Ashtech SSRadio, the connector will be a TNC with reverse polarity.

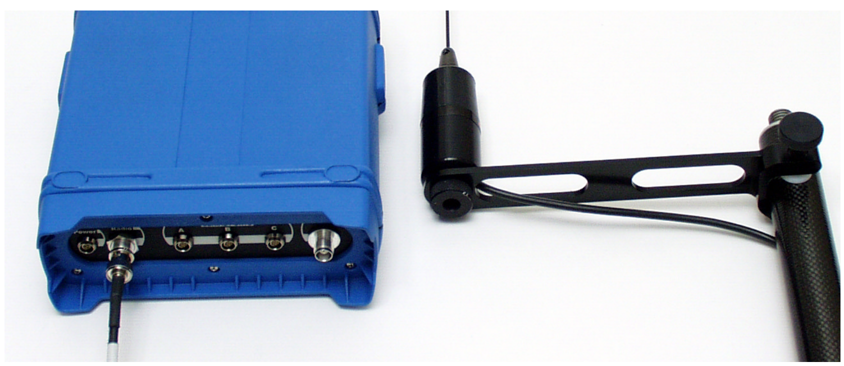

Figure 3.27 Rover Radio Antenna Cable Connected to Internal Radio and Radio Antenna

The antenna cable connects to the antenna via an adaptor specifically designed for use on the rover system. This adaptor serves as both a connector to the antenna and a mount for the antenna onto the pole.

It is recommended that the radio antenna be connected to the radio prior to applying power to the radio, although failing to do so will not cause any harm to the equipment.

Handheld Computer - GPS Receiver

The handheld computer must communicate with the rover GPS receiver in order for the computer to control certain operations in the receiver and for the receiver to send computed positions to the computer. This is accomplished using an RS232 computer communication cable (Figure 3.28). The rover computer communication cable is coiled for convenience in rover operation. The cable functions the same as the computer communication cable at the base system so they can be interchanged if needed.

Figure 3.28 Computer Communication Cable

The handheld computer – GPS receiver connection particulars are identical for the base and rover systems. Please refer to the discussion on handheld computer – GPS receiver connection under the Base System above for more details.

Now that we have reviewed the connectivity of each pole-mounted rover system component individually, let’s examine each primary component fully connected, beginning with the Z-Xtreme receiver.

Fully Connected Pole-Mounted Rover GPS Receiver

A fully connected pole-mounted rover will have only three cable connections as shown in Figure 3.29.

Figure 3.29 Fully Connected Pole-mounted Rover GPS Receiver

1. Computer communication cable plugged into the port labeled “Serial Ports – A”. This cable connects the handheld computer to the Z-Xtreme receiver. This is a mandatory connection that will remain throughout operation.
2. Radio antenna cable plugged into the port labeled “Radio”. This cable connects the radio internal to the Z-Xtreme receiver to the radio antenna. This is a mandatory connection that will remain throughout operation.
3. GPS antenna cable plugged into the port labeled “GPS”. This cable connects the Z-Xtreme receiver to the GPS antenna. This is a mandatory connection that will remain thoughout operation.

Fully Connected Handheld Computer

A fully connected handheld computer will have only one cable connection, no matter which model of handheld computer is selected (Figure 3.30).

Figure 3.30 Fully Connected Handheld Computer

The computer communication cable is plugged into the serial port. On the TDS Ranger, the RS232 port is on the left when viewed as shown in Figure 3.30. On the Husky, the port is on the right when viewed as shown in Figure 3.30. This cable connects the Z-Xtreme receiver to the handheld computer.

This concludes our review of the hardware component connectivity for the ZX Super-Station. We are now ready to examine the setup procedures for performing an RTK survey.

4

RTK Survey Preparation

The previous two chapters laid the ground work for understanding the purpose of each component of the ZX SuperStation system and the relationship between components. This understanding of the functionality and connectivity of the RTK system components will prove invaluable during RTK survey preparation and execution. Let's put this new found knowledge to good use.

In this chapter, we will go through the steps required to set up the base and rover systems to perform an RTK survey.

Base System Setup

Prior to your discussion on setup of the base system, let's examine how the base system is packaged.

All components of the Z-Xtreme RTK base system reside in a transport case, Figure 4.1, with the exception of two items. These items are the tripod and base radio power source (if using a 35-watt UHF/VHF radio). Upon opening the base transport case, you will find two bags housing the components, as shown in Figure 4.1.

Figure 4.1 Base Transport Case

The larger of the two bags is referred to as the Kit bag. It contains the Z-Xtreme receiver, GPS antenna, external power supply, and some cables, as shown in Figure 4.2. There is additional room in the Kit bag for miscellaneous items such as a tribrach and tribrach adaptor. The second smaller bag is referred to as the Accessories bag. It will contain the base radio, radio antenna, radio specific cables, and possibly the HI measurement device (this could be located in either bag). The Kit bag includes shoulder straps in order to use it as a backpack. This is useful in the situation where a short hike is required to access the base station site.

Figure 4.2 Base Transport Case, Kit Opened

Prior to departing for field work, it is recommended that the base system is examined to ensure that all required components are indeed in the transport case.

Now that we have confirmed that all required base system components are accounted for, let's take the system out into the field. Below are the steps required to successfully set up your RTK base system:

Select Appropriate Base System Site

Selection of a proper site to place the base system is crucial to a successful RTK survey. There are two main considerations when selecting a site:

1. The site should be clear of any line-of-sight obstructions between the base system GPS antenna and the satellites. This implies there be no obstructions above 15° from the horizon. Although some obstruction can be tolerated at

the base site, it is best to have a clear location to give the RTK system the most satellites possible to work with.

2. The site should be on a high point in relation to surrounding terrain. This is to facility the greatest range possible for the base radio transmissions. Line-of-sight obstructions between the base and rover systems will reduce the workable distance between the two systems.

If a desired existing control monument does not meet the two considerations above, it is best to either select a different control point or transfer the position of this point to a more suitable site by conventional means or through the use of post-processed static mode of satellite surveying (assuming the site is not too heavily obstructed).

Position GPS Antenna Over Base Point

In most cases, the base receiver antenna will be positioned over a point with known coordinates. In some cases, the coordinates of the base GPS antenna will be assumed (computed by the base receiver to an accuracy of approximately 20 meters). In either case, a physical monument will exist over which the GPS antenna must be accurately positioned. The two most common mounts for the receiver antenna are a conventional tripod and a fixed-height GPS tripod (Figure 4.3). Either is sufficient for the task but the fixed-height tripod is recommended since it eliminates the possibility of incorrectly determining the instrument height of the antenna.

Figure 4.3. Base Antennae Mounted on Conventional (left) and GPS Tripods (right)

Mount the Base Radio Antenna

The radio antenna can be mounted in any location on the base site. The only consideration is cable length. Remember that the radio antenna must be connected to the radio which is connected to the GPS receiver. The GPS antenna must also be connected to the GPS receiver. The length of the cables will dictate the possible locations of the radio antenna. A bracket is supplied to allow the mounting of the radio antenna on the GPS antenna tripod, as shown in Figure 4.4. Alternatively, the radio antenna can be mounted on its own. Some users will mount the radio antenna on a tall pole to give more range between the base and rover systems.

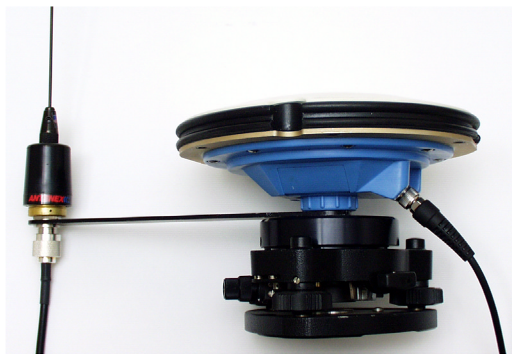

Figure 4.4 Mounted Base Radio Antenna

Measure and Record Instrument Height (HI) of GPS Antenna

Remember that measurements of satellite data are made at the center (horizontally and vertically) of the GPS antenna. Yet the location of the base point monument is not at the center of the antenna but below it on the ground. The HI allows the computed position of the antenna center to be transferred to the ground point. It is critical that the HI of the antenna above the monument is measured accurately. A tool to measure the HI is included in the base system (Figure 4.5).

Figure 4.5 Measuring HI (Height of Instrument) of Base GPS Antenna

Different GPS antennae will have different HI measurement points. For the Geodetic IV, the HI measurement point is the top of the ground plane.

Connect System Components

With the remaining base system components residing in the base field case, connect all components as listed below. Some of these connections will already be made. Check these connections to ensure the connectors are seated properly. Refer to the previous chapter on how to establish these connections.

- GPS antenna ↔ GPS receiver
- Radio antenna ↔ Radio
- Radio ↔ GPS receiver
- Radio power ↔ Radio
- GPS receiver power ↔ GPS receiver
- Handheld computer ↔ GPS receiver

Power Up Base System

Power up the system by pressing the POWER button on the GPS receiver. Turn on the handheld computer using the power button on the keyboard. Check that all components are powered up. The GPS receiver and the radio have a LED to indicate that power has been applied and the component is on.

Configure Base GPS Receiver to Function as an RTK Base

This task is usually accomplished using the handheld computer running the field application software. The Z-Xtreme can be configured through an integrated display and control panel. Configure the base receiver to function as an RTK base by performing the following steps:

1. Set the receiver to RTK Base mode
2. Inform the receiver which port the radio is connected to. This is the port out of which the base receiver will send the raw data to the radio. If you followed the connection procedures above, the radio will be connected to serial port B of the receiver.
3. Set the frequency on which the base radio will transmit data. In most cases, this will not change but it is recommended that the current frequency is checked. This is accomplished using the handheld computer. If using the spread-spectrum radio, you are not required to select a frequency.
4. Inform the receiver if you want to collect raw data for post-processing.

In most cases, these are the only parameters that will need to be set. There are other more advanced parameters that can be changed, but normally the default values for these parameters are sufficient. Following is a list of some of these more advanced parameters:

- Frequency of raw data transmissions - Sets how frequently raw data is transmitted by the base radio. Default is 1 second.
- Raw data format - Sets the format in which raw data is being transmitted by the base. Options are RTCM and PBEN (Ashtech proprietary). Default is PBEN.

If using the field application software to configure the base system, refer to the documentation on the application software being used for specific steps. If using the front panel of the Z-Xtreme, refer to the receiver manual for details.

Enter Base Point ID, Coordinates, and HI Into Base Receiver

Remember that the computation of the rover position is relative to the base position. Since the rover receiver performs the position calculation, it must know the coordinates of the base point. Both horizontal and vertical coordinates are needed. By entering these coordinates into the base receiver, they will be transmitted to the rover along with the base receiver's raw satellite data. The base antenna HI is used to determine the exact location of the base antenna from the base position coordinates. The point ID will help the rover to identify which base receiver it is receiving data from. The HI and point ID are also transmitted to the rover system.

If you plan to set the base system on an unknown point, using the approximate coordinates determined by the base receiver as the base coordinates, there are some disadvantages to this practice that you should be aware of. For every 15 meters of error between the estimated base coordinates and the true WGS84 base coordinates, 1 part-per-million (ppm) of error will be induced into the computed vector between the base and rover system. For example, assume that the coordinates assigned to the base point are 30 meters off the true base position. This 30-meter offset from truth will produce 2 ppm (0.002m per 1 kilometer or 0.010ft per mile) of error in the vector between the base and rover. If the rover is 5 kilometers (3 miles) from the base, this will produce 0.010m (0.030ft) of error in the vector. In most cases, the base receiver will estimate it's position to better than 30 meters (probably closer to 10-20 meters), but an error of 50 meters is possible. If you plan to use an estimated position for the base, keep the vector lengths between the base and rover short and ensure the added error is not significant for the survey you are performing.

Incorrectly entering a known base position will produce the same problem outlined above. It is very important that the base coordinates are checked to ensure they are correct.

Verify Function

Determine if the base system is functioning properly as follows:

- Determine if the base receiver is observing satellites. This can be accomplished by either using the field application software running on the handheld computer, or the display on the receiver.
- Determine if the base radio is transmitting data, as indicated by the transmit LED on the base radio. This LED should flash once very time the base radio transmits a packet of data. The default transmission frequency is 1 second. Therefore, the transmit LED should flash once per second, indicating proper transmission of base raw data.

The base system is now functioning as an RTK base. No further interaction with the base is needed throughout the remainder of the survey. Figure 4.6 shows the base system fully configured and ready to survey.

Figure 4.6 Base System Ready to Survey

Under most operating conditions, the Z-Xtreme receiver and base radio can remain in their respective bags during operation. The lid of the transport case can also be partially closed to ward off rain. Be extremely careful not to pinch the cables coming out of the base. In hot environments, the base radio may need to be operated out of the case. The radio is very resistant to rain, therefore do not worry about leaving it out.

Rover System Setup

As with the base system, the rover system resides in a transport case with the exception of one component, the rover pole. Within the case, you will find the same two bags holding the system components, as shown in Figure 4.7.

Figure 4.7 Rover Transport Case

For the rover system, the Kit bag holds the Z-Xtreme receiver, rover radio (if internal radio is not used), GPS antenna, handheld computer, radio antenna, and some cables. The Accessories bag will hold miscellaneous items such as handheld pole bracket and HI measurement device.

The Kit bag includes shoulder straps to allow it to be used as the rover backpack. If you prefer to have the rover system pole-mounted (all components on the rover pole removing the need for a backpack), an optional kit can be purchased for this purpose.

As with the base system, it is recommended that the rover system be examined prior to leaving for the field to ensure all components are present.

Once in the field, execute the following steps to set up your RTK rover system.

Mount Receiver Antenna

The rover GPS antenna is mounted onto a pole that can be accurately leveled over the feature to be positioned (Figure 4.8). The rover system will have a fixed-height pole included for this purpose.

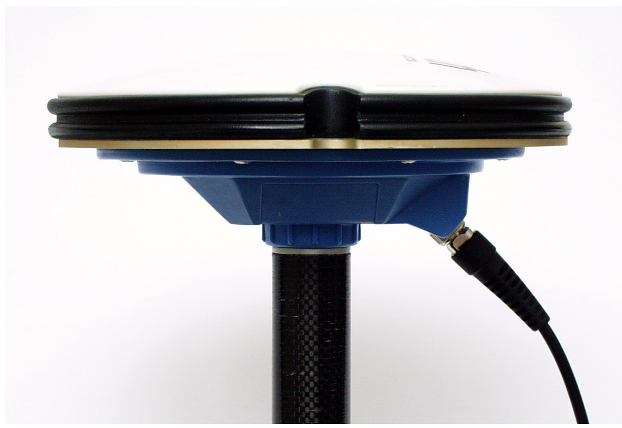

Figure 4.8 Geodetic IV GPS Antenna on Rover Pole

Measure and Record Instrument Height (HI) of GPS Antenna

Remember that measurements of satellite data are made at the center (horizontally and vertically) of the GPS antenna. The HI allows the computed position of the antenna center to be transferred to the ground. It's critical that the HI of the antenna above the ground is measured accurately. It can be physically measured or the HI can be calculated based on the known fixed length of the pole plus the thickness of the antenna from the base to the data measurement point. An HI measurement device is included with the rover system.

Mount Radio Antenna

In the backpack configuration, the radio antenna is mounted on a pole on the outside of the rover backpack. The required accessories to facilitate this mounting are included in the rover system. If the Pacific Crest PDL rover radio is used, the entire radio, along with the antenna, mounts on the backpack pole (Figure 4.9).

Figure 4.9 Rover Radio Antenna and Pacific Crest PDL Radios on Backpack

In the pole-mounted configuration, the radio antenna is mounted on a bracket holding the antenna onto the pole directly below the GPS antenna (Figure 4.10).

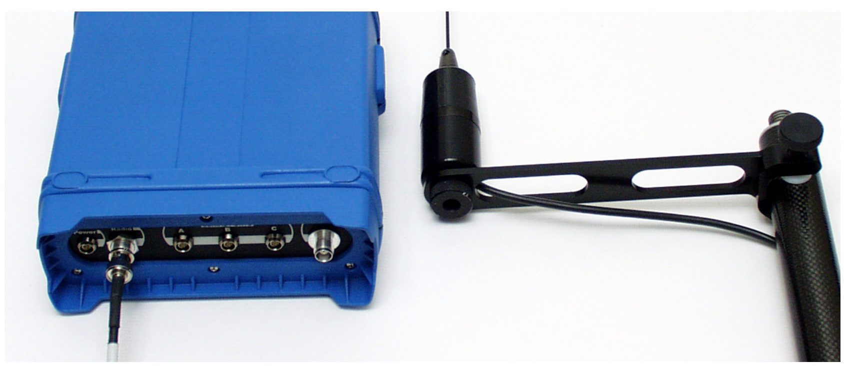

Figure 4.10 Radio Antenna Mounted On Pole and on Back of Receiver

An option for the pole-mount configuration is to use the included rubber duck antenna and connect it directly to the radio antenna connector on the back of the GPS receiver, as shown in Figure 4.11.

Figure 4.11 Rubber Duck Antenna Mounted to Z-Xtreme

The advantage of this configuration is the elimination of the cable and bracket for the radio antenna. The disadvantage is the adverse affect on radio range. This configuration is good for small project sites.

Mount Handheld Computer

The handheld computer is mounted onto the pole along with the GPS antenna. A special mounting bracket for the handheld is included in the rover system, as shown in Figure 4.12.

Figure 4.12 TDS Ranger Handheld Mounted on Rover Pole

Mount GPS Receiver (Pole-mount Only)

For the pole-mounted configuration, the GPS receiver must be mounted onto the pole. A special mounting bracket is supplied for this purpose (Figure 4.13).

Figure 4.13 Receiver Mounted on Pole

Connect System Components

Connect all components as listed below. Some of these connections may already be made, especially if the backpack rover system is being used. Make sure the connectors are seated properly.

- GPS antenna ↔ GPS receiver
- Handheld computer ↔ GPS receiver
- Radio antenna ↔ Radio (radio antenna connector on back of GPS receiver if radio is internal)
- Radio ↔ GPS receiver (not required if radio is internal to GPS receiver)
- GPS receiver power ↔ GPS receiver (optional if internal battery is used for GPS receiver)

Power-up Rover System

Power up by pressing the power button on the GPS receiver. Turn on the handheld computer using the power button on the keyboard. Check that all components are powered up. The GPS receiver and the radio have LED indicators to indicate that power has been applied and the equipment is on.

Configure Rover GPS Receiver to Function as an RTK Rover

This task is accomplished using the handheld computer running the field application software. Configuring the rover receiver to function as an RTK rover as specified in the following steps:

1. Set the receiver to RTK Rover mode
2. Inform the receiver which RS232 port the radio is connected to. This is the port from which the rover receiver expects to see raw data from the base system. If you followed the connection procedures above, the radio will be connected to serial port B of the receiver.
3. Set the frequency on which the rover radio will listen for base transmissions. In most cases, this will not change but it is recommended that the current frequency is checked using the handheld computer. If using the spread-spectrum radio, you are not required to select a frequency.
4. Inform the receiver if you want to collect raw data for post-processing.

In most cases, these are the only parameters that need to be set. There are other more advanced parameters that can be changed, but normally the default values for these parameters are sufficient. Following is a list of some of these more advanced parameters:

- Raw data format - Sets the format in which raw data is being transmitted by the base. Options are RTCM and PBEN (Ashtech proprietary). Default is PBEN.
- Confidence level of RTK initialization - Sets the statistical confidence level for RTK initialization. Options are 99% and 99.9%. Default is 99%.

Refer to the documentation for the field application software being used for specific steps on how to configure the rover system with this software.

Verify Function

Perform the following observations to determine if the rover system is functioning properly:

- Determine if the rover receiver is observing satellites. This can be accomplished by either using the field application software running on the handheld computer or the display on the receiver.
- Determine if the rover radio is receiving data from the base. This can be accomplished by viewing the receive LED on the rover radio, which should flash once every time the rover radio receives a packet of data. The default transmission frequency by the base is 1 second. Therefore, the transmit LED should flash once per second indicating proper reception of

base raw data. If an internal radio is used, the receive LED can be found on the front panel of the Z-Xtreme receiver.

The rover system is now functioning as an RTK rover. The RTK system is ready to perform a survey. Figure 4.14 shows the backpack rover system fully configured and ready to survey.

Figure 4.14 Backpack Rover System Ready to Survey

With the backpack rover configuration, the GPS receiver, rover radio (if internal radio is not used) and optional external power source remain in the backpack. The back-pack is carried on the users back during field operation. Figure 4.15 shows the pole-mounted configuration.

Figure 4.15 Pole-mounted Rover System Ready to Survey

With the pole-mounted configuration, all components of the rover system are mounted on the pole, removing the need for a backpack.

5

Executing an RTK Survey

Your ZX SuperStation is now ready to execute an RTK survey. With the rover system in hand, you can now move about the project site locating features and/or staking out points. The detailed steps for performing these tasks are very dependent on the field application software being used. For this reason, the detailed steps required to perform these survey tasks will not be discussed here. This is best left to the documentation accompanying your field application software. Rather, some basic field procedures will be presented that are universal to RTK surveying.

RTK Rover Initialization

Prior to performing any feature location or stakeout with the rover system, it must first go through an initialization process. This initialization process had been given several different terms: RTK Initialization, Ambiguity Resolution, On-The-Fly (OTF) Initialization, Fixing Integers, etc. All these terms refer to the same process.

Prior to initialization, the rover system is will compute positions at a degraded level of accuracy. The accuracy prior to initialization could be anywhere from 0.15 meters (0.5 ft) to a couple meters. The initialization process is required to fine-tune the rover system. Once initialized, the rover system will function at it's specified level of accuracy until initialization is lost. Your field application software running on the handheld computer will inform you of the current state of initialization and what accuracy level the rover system is currently functioning at.

The initialization process is automatic. No interaction by the user is required to instruct the rover system to initialize. When the rover system detects that it is not initialized, it will automatically execute the initialization process. The time required for the rover system to complete the initialization process is very dependent on the conditions at the survey site during the initialization process. If the survey site is free of obstructions to satellite visibility and the system is observing at least 5 satellites, in most cases initialization will be instantaneous, i.e. less than 5 seconds. The rover receiver must be observing at least 5 satellites in order to initialize. If the survey site is obstructed, causing the rover system to see less than 5 satellites, the system will not initialize. The rover system will need to be moved to a more suitable location for initialization.

Once the rover system is initialized, it will remain initialized as long as the rover receiver remains locked on at least 4 satellites. If, at any time after initialization, the rover receiver does not maintain lock on at least 4 satellites, initialization will be lost. At this time, the rover system will automatically execute the initialization process again.

The only time that the user must worry about initialization is when he/she is ready to store the position of a point of interest or about to stake out a point. The user must ensure that the rover system is initialized at this time. If the rover system is not initialized, accuracy will be poor. Again, the field application software will display information informing the user of the initialization and system accuracy at any given time.

Base–Rover Separation (RTK Range of Operation)

As the rover system moves further away from the base system during an RTK survey, certain aspects of the system are affected. It's important to be aware of the affect on system performance as the separation between the base and rover increases.

Communication

The RTK rover system must remain in constant communication with the base system in order to determine accurate positions. As the rover system approaches the range of the radio system used, communication will begin to get spotty. When the range of the radio system is reached and/or exceeded, the rover system will no longer be able to produce accurate positions since it is not receiving the required data from the base system. The field application software will provide you will information on the status of the communication link. The user is able to monitor this status to keep tabs on the health of the link as the user moves further away from the base.

The allowable separation between the base and rover is very dependent on the radio system used and the conditions at the survey site. Trees, hills, and buildings will shorten the range of the radio system. A UHF/VHF radio system can allow ranges up to 15 km (9 miles) under very good conditions. A spread spectrum radio system is usually limited to a range of no more than 3 km (2 miles) under the best of conditions.

Initialization

The time required for the rover system to perform the initialization process is dependent on the distance from the rover to the base system. The closer the rover system is to the base, the faster the initialization process will be. As the rover moves further away from the base system, initialization times will increase. An initialization time of 2 seconds when the rover is 3 km (2 mile) from the base could become 60 seconds or more when the rover is 10 km (6 miles) from the base.

Accuracy

The accuracy at which the rover system can position is adversely affected as the base-rover separation increases. The accuracy of the rover system degrades at a rate of about 1-2 parts-per-million of base-rover separation. This amounts to about an additional 0.001 m to 0.002 m per kilometer (0.005 ft to 0.010 ft per mile) of positional error. So for a 10 kilometer (6 mile) base-rover separation, the accuracy of the rover system will be 0.01 m to 0.02 m (0.03 ft to 0.06 ft) worse than for a base-rover separation of less than 1 kilometer (0.6 miles).

6

Troubleshooting

So, you followed all the steps to prepare the ZX SuperStation to perform an RTK survey and the system is not working. Why? Well, the problem is usually due to one of two things, either one of the components in the system is malfunctioning, or the system was not set up properly. Improper setup can be caused by a memory lapse on the part of the operator or a system component. Like the operator, some system components must execute a set of steps to properly configure the system. On occasion, the component may get confused and not execute the proper steps. In either case, the problem is normally remedied by either identifying the component of the system causing the problem and re-executing the steps to set up this component, or starting over with the setup process.

In this section, the goal is to provide guidance in determining the cause of a problem with the system. Commonly encountered effects are listed below. Probable causes of the effect are presented along with a remedy. Barring a component failure, the remedies presented in this troubleshooting section should resolve any problems encountered in preparing the ZX SuperStation system to perform a survey.

If the steps outlined in this troubleshooting section fail to get you up and running, there is a good chance that a component in your system has failed. In such an event, contact your local Ashtech dealer or Ashtech customer support for assistance. Explain the steps you have taken to attempt to remedy the problem. They may have more suggestions. If not, they will arrange with you to have the component(s) returned to Ashtech for repair or replacement.

You will be asked throughout the troubleshooting section below to utilize either the front panel display of the GPS receiver or the field application software running on the handheld computer to view status information or set certain parameters. Details on how to use the display or application software to perform these tasks will not be outlined in this section. Refer to the documentation for the receiver or field application software for these details.

Base System Troubleshooting

The base system of the ZX SuperStation has two basic functions, track satellites in order to collect raw satellite data at its position, and transmit this data to any rover system within range of its radio. The inability to perform either one of these functions renders the base system useless. Therefore, the path to troubleshooting the base system should begin with these two items.

GPS Receiver Does Not Track Satellites

One function of the display on the front panel of the Z-Xtreme receiver is to inform the user of the number of healthy satellites being tracked and used by the receiver. This information is also available through the field application software running on the hand-held computer. Refer to the receiver or application software for details on how to access this information. Using this feature, you find that the receiver is not tracking satellites. Follow the outline below to determine the cause of this problem.

Step 1. Is the GPS receiver powered up?

To determine if the receiver is powered up, examine the power LED on the front panel of the receiver. If the LED is on (red or green), the receiver is on.

Receiver not powered up

1. Turn on the receiver.

   Press and hold the power switch on the left side of the Z-Xtreme front panel. The button must be held for a few seconds since there is a delay in power on. You will see the power LED turn on and the display will begin to show text.

   Go to step 2 if the receiver does not power up.

2. Check the power source.

   The Z-Xtreme supports both internal and external power sources.

   a. If using internal power, remove the battery and press the power level indicator button. If low, replace battery with a good one and turn on the receiver.

   b. If using external power, check to ensure the power cable is properly connected to both the battery and the receiver.

      (i). If the cable is properly connected, check the power level of the external power source. If low, replace the battery with a good one and turn on the receiver.

      (ii). If external power source is good and the cable is connected to both the receiver and the power source, there may be a problem with the cable. If available, try a different power cable. If the new cable works, the old cable is malfunctioning. Call your local dealer or Ashtech customer support for assistance.

Go to step c if the problem is not yet resolved.

c. You may have a malfunctioning GPS receiver. Call your local dealer or Ashtech customer support for assistance.

Receiver is powered up

Go to Step 2 below.

Step 2. Is the GPS Antenna Connected to the Receiver?

Look on the back panel of the receiver for a cable connecting the receiver to the antenna.

Antenna not connected to receiver

1. Connect the GPS antenna to the receiver.

   On the back panel of the Z-Xtreme, connect the antenna cable to the port labeled 'GPS Antenna'. Ensure the connection is snug and not cross-threaded.

   a. At the antenna, connect the antenna cable to the antenna. Ensure the connection is snug and not cross-threaded.

   b. Once connected, give the GPS receiver a few seconds to lock onto satellites.

Antenna connected to receiver

1. Ensure proper connection.

   The GPS antenna must be connected to the port on the back of the receiver labeled 'GPS Antenna'. Ensure this is the case.

2. Ensure the connection at the receiver and the antenna is tight and not cross-threaded.

   Go to the next step if the problem is not yet resolved.

Step 3. A component may be malfunctioning.

1. You may have a malfunctioning antenna or antenna cable. Follow these steps to help isolate which component is causing the problem.
2. Replace the cable with the one from the rover system. If the receiver locks onto satellites, there is a problem with the base antenna cable. Contact your local dealer or Ashtech customer support for assistance.
3. If the cable swap does not help, replace the antenna with the one from the rover system. If the receiver locks onto satellites, there is a problem with the

base antenna. Contact your local dealer or Ashtech customer support for assistance.

4. You may have a malfunctioning GPS receiver.

   Call your local dealer or Ashtech customer support for assistance.

Base System Does Not Transmit Data

The transmit LED on the front panel of the base radio will blink red each time a packet of data is transmitted. The GPS receiver by default is set to send data to the radio once every second. This data will be transmitted by the radio immediately. Therefore, the transmit LED should blink once every second indicating data transmission. After examining this LED, you find that the base system is not transmitting data. Follow the outline below to troubleshoot this problem.

Step 1. Is the base radio powered up?

To determine if the base radio is on, examine the power LED on the front panel of the radio. If the LED is on (green or red, steady or flashing), the radio is on.

Base radio is not powered up

1. Turn on the radio. The Ashtech SSRadio has a power switch on its front panel. Other radio types automatically turn on once power is applied. Press the radio power switch to turn on the radio.
2. Go to 3) if the problem is not yet resolved.
3. Check the power source.
   a. If using a UHF/VHF radio, power is supplied by an external power source.
   b. Check to ensure that the power cable is connected to both the radio and the power source.
   c. If you find the cable properly connected, check the power level of the power source. If low, charge the battery or replace it with a charged one and connect it to the radio.

      If using a spread-spectrum radio, power is supplied to the radio by the GPS receiver via the RS232 connection.
   d. Check to ensure that the cable connecting the radio to the receiver is connected properly. It is recommended that the radio be connected to the port labeled ‘B’ on the Z-Xtreme.
   e. If the cable is properly connected, check that the receiver is turned on. The receiver must be turned on to supply power to the radio.
   f. If still no power, disconnect the cable at the receiver and connect to another RS232 port. If the radio powers up, there is a problem with the

RS232 port you were previously connected to. Avoid this port until you can arrange to have it fixed.

Go to g) if the problem is not yet resolved.

g. You may have a malfunctioning radio or radio power cable.

   (i). If using Pacific Crest UHF/VHF radios, it is not possible to further isolate the problem. Contact your local dealer or Ashtech customer support for assistance.

   (ii). If using the external Ashtech SSRadio, follow these steps to isolate the problem component:

      Replace the radio cable with the one from the rover system. If the radio powers up, there is a problem with the base radio cable. Contact your local dealer or Ashtech customer support for assistance.

      If the cable swap fails to identify the problem, replace the radio with the one in the rover system. If the radio powers up, there is a problem with the base radio. Call your local dealer or Ashtech customer support for assistance.

Base radio powered up

Go to step 2 below.

Step 2. Is the Base Radio Connected to the GPS Receiver?

In order for the base radio to transmit data, it must receive the data from the base receiver. To determine if the radio is connected to the receiver, look for a cable connecting the two components.

Radio not connected to receiver

1. Connect the base radio to the GPS receiver
2. On the back panel of the Z-Xtreme, connect the radio cable to RS232 port **B**.
3. If using the Pacific Crest UHF/VHF or Ashtech SSRadio, connect the radio cable to the connector labeled DATA/PWR or SERIAL.

Radio connected to receiver

1. Ensure proper connection
2. Ensure that the radio cable is connected to RS232 port B on the back panel of the receiver.
3. Ensure the connection at the receiver and the radio is seated all the way in.

   Go to step 3 if the problem is not yet resolved.

Step 3. Is the Base GPS Receiver Set to Function as RTK Base?

If the base receiver is not set to RTK base mode, it will not send raw data to the RS232 port for transmission by the radio. Use the field application software or front panel of the Z-Xtreme to determine if the receiver is set to RTK base mode.

Receiver not configured as RTK base

1. Set receiver to RTK base mode.
2. Using either the field application software or the front panel of the receiver, set the base receiver to RTK base mode.

Receiver is configured as RTK base

Go to step 4 below.

Step 4. Is Receiver Set to Output RTK Base Data on Port B?

The port set in the GPS receiver for output of RTK base data must be the same port to which the base radio is connected. The base radio should currently be connected to the RS232 port labeled ‘B’ on the back of the Z-Xtreme. Use the field application software or the front panel of the receiver to verify that port B is set as the output port for RTK base data.

Receiver not set

1. Set the receiver to output RTK base data on port B.
2. Using either the field application software or the front panel of the receiver, set the base receiver to output RTK base data on port B.

Receiver set

Go to step 5 below.

Step 5. Base coordinates entered correctly into base receiver?

The base GPS receiver compares the position it computes for it’s location to the position entered by the user as the base position. If the two sets of coordinates differ by more than 500 meters, the base receiver will not output RTK base data. Use the field application software or the front panel of the Z-Xtreme to verify the coordinates entered for the base position.

Coordinates not entered correctly

1. Set the correct base system position. Using either the field application software or the front panel of the receiver, set the base receiver position.

Coordinates entered correctly

Go to step 6 below.

Step 6. Is base receiver tracking satellites?

The base GPS receiver must be tracking satellites in order to collect the data required for the radio to transmit. If the base receiver is not tracking at least 4 healthy satellites, no data will be sent to the radio. Use either the front panel of the receiver or the field application software to determine if the base receiver is tracking satellites.

Receiver not tracking satellites

Refer to ***GPS receiver does not track satellites*** above for steps on how to troubleshoot this problem.

Receiver tracking satellites

Go to step 7 below.

Step 7. You may have a component that is malfunctioning

You may have a malfunctioning radio or radio communication cable.

If using Pacific Crest UHF/VHF radios, it is not possible to further isolate the problem. Contact your local dealer or Ashtech customer support for assistance.

If using the external Ashtech SSRadio, follow these steps to isolate the problem component.

1. Replace the radio cable with the one from the rover system. If the radio begins to transmit data, there is a problem with the base radio cable. Contact your local dealer or Ashtech customer support for assistance.
2. If the cable swap fails to identify the problem, replace the radio with the one found in the rover system. If the radio begins to transmit data, there is a problem with the base radio. Call your local dealer or Ashtech customer support for assistance.
   a. Your base GPS receiver may be malfunctioning. Follow these steps to determine if the base receiver is the problem.
      (i). Replace the base GPS receiver with rover GPS receiver.
      (ii). Follow the steps outlined above to set up the rover receiver as an RTK base.

(iii). If the base radio begins to transmit data, there is a problem with the base GPS receiver. Contact your local dealer or Ashtech customer support for assistance.

Rover System Troubleshooting

The rover system of the ZX SuperStation has three basic functions, track satellites in order to collect raw satellite data at it's position, receive base position satellite data transmitted by the base system radio, and finally, combine the rover satellite data and the base satellite data to compute a precise position of the rover location. The rover system must be able to carry out all three of these primary functions in order for the RTK system to work. Let's examine the recommended steps in troubleshooting a problem in each of these three functions.

GPS Receiver Does Not Track Satellites

Tracking satellites is an important function of both the base and rover systems. The process of troubleshooting this problem on the rover system is identical to that on the base system. Refer to the base system troubleshooting section above for details.

Radio Not Receiving Data Transmitted By Base

The base GPS receiver by default is set to send data to the base radio once every second. The base radio will transmit this data immediately upon receiving it. Therefore, the rover radio should be receiving data from the base once every second. The receive LED on the front panel of the rover radio, or in the case of an internal radio on the front panel of the GPS receiver, will blink red each time a packet of data is received. After examining this LED, you determine that the rover system is not receiving data. Follow the outline below to troubleshoot this problem.

Step 1. Is the rover radio powered up?

When using a radio internal to the GPS receiver, there is no action required to power up the radio other than to power up the GPS receiver. This automatically applies power to the radio. If using an internal radio, go to step 2 below.

To determine if an external rover radio is powered up, check the power LED on the front panel. If the LED is on (green or red, solid or flashing), the radio is on.

Radio not powered up

1. Turn on the radio.

The Ashtech SSRadio has a power switch on its front panel. Other radio types automatically turn on once power is applied.

a. Press the radio power switch to turn on the radio.

   Go to b) if the radio does not turn on.

b. Check the power source.

   Rover radio power is supplied by the GPS receiver via the RS232 connection.

   (i). Check to ensure that the cable connecting the radio to the receiver is connected properly. It is recommended that the radio be connected to port B on the Z-Xtreme.

   (ii). If the cable is properly connected, check that the receiver is turned on. The receiver must be turned on to supply power to the radio.

   (iii). If still no power, disconnect the cable at the receiver and connect to another RS232 port. If the radio powers up, there is a problem with the RS232 port you were previously connected to. Do not use this port until you can have it fixed.

   Go to c) if the problem is not yet resolved.

c. You may have a malfunctioning radio or radio power cable.

   If using Pacific Crest UHF/VHF radios, it is not possible to further isolate the problem. Contact your local dealer or Ashtech customer support.

   If using the external Ashtech SSRadio, follow these steps to isolate the problem component.

   (i). Replace the radio cable with the one from the base system. If the radio powers up, there is a problem with the rover radio cable. Contact your local dealer or Ashtech customer support for assistance.

   (ii). If the cable swap fails to identify the problem, replace the radio with the one found in the base system. If the radio powers up, there is a problem with the rover radio. Call your local dealer or Ashtech customer support for assistance.

Radio is powered up

Go to step 2 below.

Step 2. Is the rover radio antenna connected to the rover radio?

Although it is possible for the rover radio to receive transmissions from the base radio without an antenna, the range will be very limited. The rover radio antenna must be connected to the rover radio for proper operation.

Antenna not connected

Connect the radio antenna to the radio. Ensure that the connection to the radio and the antenna are snug and not cross-threaded.

Antenna is connected

Ensure the connections to the radio and the antenna are snug and not cross-threaded.

Go to step 3 if the problem is not yet resolved.

Step 3. Is the base system transmitting data?

To determine if the base system is transmitting data, observe the transmit LED on the front panel of the radio. The transmit LED will blink red each time a packet of data is transmitted. The GPS receiver by default is set to send data to the radio once every second. The radio will transmit this data immediately after receiving it. Therefore, the transmit LED should blink once every second indicating data transmission.

Base system not transmitting data

See ***Base system does not transmit data*** under ***Base System Troubleshooting*** above to troubleshoot this problem.

Base system is transmitting data

Go to step 4 below

Step 4. Is the base radio antenna connected to the base radio?

The base system will transmit data without a base radio antenna but the range will be severely limited.

Antenna not connected

Connect the radio antenna to the radio. Ensure that the connections to the radio and the antenna are snug and not cross-threaded.

Antenna connected

Ensure that the connections to the radio and the antenna are snug and not cross-threaded.

Go to step 5 if the problem is not yet resolved.

Step 5. Is the rover radio set to the same frequency as the base?

The rover radio must be set to the same frequency as the base radio in order for the rover to receive transmissions from the base. Use the field application software running on the handheld computer to determine on which frequency the base and rover radios are set.

Radio not set to same frequency as base

Use the field application software to set the frequency of the rover radio.

Radio set to same frequency as base

Go to step 6 below.

Step 6. Is line-of-sight between base and rover antennae obstructed?

Obstructions (trees, buildings, hills, etc.) in the line-of-sight between the base and rover radio antennae will reduce the range of the radio system. Spread-spectrum radios cannot withstand a great deal of obstruction. UHF/VHF radios are more resilient to obstructions but an excessive amount can block out the signal.

Line of sight not obstructed

Go to step 7 below.

Line of sight obstructed

1. Move to a less obstructed location. In order to test if the system is functioning properly, move to a location which does not have an obstructed view between the base and rover radio antennae.
2. If this is not possible, move to higher ground or a location where there is less obstruction.
3. If, after moving, the rover radio begins to receive data from the base, then the previous location is too obstructed from the base. You will need to either raise the base radio antenna higher, or move the base to a location with less obstruction between the base and rover radio antennae.

   Go to step 7 below if the problem is not yet resolved.

Step 7. Are you within range specifications of your radio system?

The range within which your radio system will function varies greatly with the conditions under which the system is being used. With clear line-of-sight between the base and rover radio antennae, and no interference on the frequencies you are working on, a spread-spectrum radio can function with miles of separation between the base and rover, and a UHF/VHF system can function with tens of miles of separation. Unfortunately, these are ideal situations seldom found. In most situations, the range of the spread-spectrum radio will be limited to 1-2 miles and the UHF/VHF to under 5 miles.

Not within range specifications

Move within range. Either move closer to the base system, or move the base system closer to you.

Within range specifications

Move closer to base to test system. Since radio range is difficult to predict due the varying effects of local conditions, try moving closer to the base in an attempt to resolve the problem.

If by moving closer you find that the rover radio begins to receive data, the previous location is out-of-range of the radio system. You will need to elevate the base radio antenna or move the base to a location closer to you to solve the problem.

Go to step 8 below if the problem is not yet resolved.

Step 8. Are you being jammed?

When working with UHF/VHF radios, it is possible that the frequency you are using is being shared with other people in your vicinity. Traffic on this frequency can interfere with the rover system's ability to receive data from the base. The effect may be no reception of base data or intermittent reception of data. Both are detrimental to proper operation of the RTK system. Interference is more a problem with UHF/VHF radios than with spread-spectrum radios.

There are two methods to determine if there is traffic on the frequencies you wish to use. The best method is to acquire a handheld scanner and to listen for traffic on the frequency you plan to use. The second method is to observe the receive LED on the base or rover radios. The base and rover radio will receive any traffic on the frequency they are set to causing the receiver LED to flash. This is best done before setting up the base system to transmit data. Any flashing of the receive LED indicates some traffic on your frequency. If the base is transmitting data, the rover receive LED will flash once per second if receiving data from the base. If you observe more random flashing of the receive LED, this is an indication of traffic on the frequency other than the base transmissions.

Not being jammed

Go to step 9 below.

Being jammed

1. Lower sensitivity of rover radio. Some field application software packages let you change the sensitivity of the rover radio. If your software has this capability, lower the sensitivity of the rover to medium or low. If the traffic on your frequency is not strong in power, lowering the sensitivity of the rover

radio may cause the radio to ignore the traffic. This will not help if the traffic is caused by a nearby or very high powered radio. The disadvantage of lowering the sensitivity is a reduction in the range of your radio system. A lower sensitivity at the rover may cause the rover to not hear the base transmissions as the rover moves farther away from the base.

2. Try another frequency. If you are licensed to operate on more than one frequency, move to a different frequency in hopes that the new frequency has less traffic. If you have a license for only one frequency, you may need to find another frequency in your area that is clear of traffic in order for the system to function reliably and acquire a license for this frequency if possible.

Step 9. You may have a malfunctioning component in your system

Your rover radio, radio antenna, or radio antenna cable may be malfunctioning. There is no way to further isolate this problem unless you have spares for these components. Call your local dealer or Ashtech customer support for assistance.

Rover System Is Not Computing A Position

Once the rover GPS receiver is set to function as an RTK rover, it will only compute RTK quality positions. In order to accomplish this, the rover receiver must collect raw satellite data at it's position and also receive base satellite data transmitted by the base system. Without these two components, the rover receiver will not compute a position.

To determine if the rover system is computing a position, you can utilize either the display on the front panel or the field application software running on the handheld computer. Refer to the appropriate documentation to determine how to perform this task. Using either the receiver display or the application software, you have determined that the rover system is not computing a position. Follow the steps outlined below to troubleshoot this problem.

Step 1. Is the radio receiving data transmitted by the base?

To determine if the rover radio is receiving data from the base, examine the receive LED on the radio. It should blink once every time it receives data transmitted by the base. The default frequency of data transmission is once per second.

Not receiving data

See ***Radio is not receiving data transmitted by the base*** under Rover System Troubleshooting above to troubleshoot this problem.

Receiving data

Go to step 2 below.

Step 2. Is the radio connected to the GPS receiver?

The rover radio must send the base satellite data it receives to the rover GPS receiver in order for the rover receiver to compute a position. For an external radio, this requires a cable connection between the radio and receiver. For an internal radio, this connection is made internally to the receiver, therefore no action is required of the user.

Radio not connected

Connect the rover radio to the GPS receiver.

On the back panel of the Z-Xtreme, connect the radio cable to RS232 port B.

If using the Pacific Crest UHF/VHF or Ashtech SSRadio, connect the radio cable to the RS232 connector labeled DATA/PWR or SERIAL.

Radio connected

Ensure proper connection. Ensure that the radio cable is connected to RS232 port B on the back panel of the receiver. Ensure the connections at the receiver and the radio are fully seated.

Go to step 3 if the problem is not yet resolved.

Step 3. Is the radio connected to the correct port?

When setting up the rover GPS receiver, one of the parameters is the port through which the rover receiver should expect data from the radio. If the parameter setting does not match the port to which the radio is connected, the rover receiver will not find the base data. Use the field application software to determine which port has been set in the rover to receive base data. Then look on the back of the GPS receiver to determine if the radio is indeed connected to this port. Its recommended that you select a port to which the radio will always be connected and the port parameter be always set to. Port B is recommended for this purpose.

When using an internal radio, you have no choice of which port to connect the radio. The radio is automatically connected to port D internally to the radio. Therefore, the port for receiving base data should be set to D.

Not connected to correct port

Correct inconsistencies between port setting and radio port connection. You must either connect the radio to the port set in the receiver for receiving raw base data, or change the port setting in the receiver to match the port to which the radio is connected. For an internal radio, the port to receive data must be set to D.

Connected to correct port

Go to step 4 below.

Step 4. Is the GPS receiver tracking satellites?

The rover receiver must track satellites in order to compute it's position. Use either the front panel of the receiver or the field application software running on the handheld computer to determine if the rover receiver is tracking satellites.

Not tracking satellites

See ***GPS receiver does not track satellites*** under ***Base System Troubleshooting*** above to troubleshoot this problem.

Tracking satellites

Go to step 5 below.

Step 5. Are base and rover tracking at least 4 common satellites?

In order for the rover system to compute an RTK position using both the base satellite data and rover satellite data, the base and rover receivers must observe data from at least 4 common healthy satellites simultaneously. Without this common data, the rover cannot compute an RTK position. Your field application software includes the ability to inform you of which satellites are being tracked by the base and which are being tracked by the rover and whether or not these satellites are healthy. Use this feature to determine if the base and rover are indeed tracking at least 4 common healthy satellites.

Not tracking 4 satellites

1. Check satellite availability.
   a. Use the Mission Planning software to check satellite availability for your current location and time.
   b. Look for the number of satellites available higher than 15° above the horizon.
   c. Ensure at least 4 healthy satellites are available.

   d. If not, you will need to perform your survey at another time.
   e. Go to step 6) below if the problem is not yet resolved.
2. Move base or rover if sites have satellite obstructions.
   a. If your base or rover site have any obstructions above 15° to the horizon, the obstructions may be blocking essential satellites. If obstructions exist at the base or rover, more the system to an open area.

Tracking 4 satellites

Go to step 6 below.

Step 6. Your rover receiver may be malfunctioning

Contact your local dealer or Ashtech customer support for assistance.

Rover Computing Position With High Uncertainties

Using the field application software you find that the rover is computing a position but the uncertainties (HRMS, VRMS) assigned to the position are unacceptably high. Follow the steps outlined below to troubleshoot this problem.

Step 1. Is the GPS receiver set to function as an RTK rover?

The rover GPS receiver must be set to function in RTK rover mode in order for it compute accurate RTK positions. If not set in RTK rover mode, the receiver will compute autonomous positions which could contain about 10 meters or more of error. This is probably the problem if HRMS and VRMS values are in the 10s of meters. Use the field application software to determine if the rover GPS receiver is set to RTK rover mode.

Not set to function as RTK rover

Set the rover receiver to RTK rover mode. Use the field application software to set the receiver to RTK rover mode.

Set to function as RTK rover

Go to step 2 below.

Step 2. Are base and rover tracking at least 5 common satellites?

Although the rover receiver is capable of computing a position with only 4 common healthy satellites with the base, the rover will not attempt to fix ambiguities unless 5 common healthy satellites are observed. Fixing ambiguities is a required process for the rover system to compute highly precise RTK positions. Your field application software will inform you if you currently have a fixed ambiguity solution or a float ambiguity solution. Your field application software will also inform you which satellites are being tracked by the base and which are being tracked by the rover and whether or not these satellites are healthy. If you find that your solution will not fix, look to determine if the base and rover are indeed tracking at least 5 common healthy satellites.

Not tracking at least 5 satellites

1. Check satellite availability.
   a. Use the Mission Planning software to check satellite availability for your current location and time.
   b. Look for the number of satellites higher than 15° above the horizon.
   c. Ensure at least 5 healthy satellites are available.
   d. If not, you will need to perform your survey at another time.

   Go to step 3) below if the problem is not yet resolved.
2. Move base or rover if sites have satellite obstructions.
   a. If your base or rover site has any obstructions higher than 15° above the horizon, the obstructions may be blocking essential satellites. If obstructions exist at the base or rover, more the system to an open area.

Tracking at least 5 satellites

Go to step 3 below.

Step 3. HDOP & VDOP Values Too High for Precision Requirements?

Dilution of Precision (DOP) values give a quality indication of the satellite geometry at any given time. Satellite geometry is important to the precision of an RTK solution. In fact, the DOP value is used as a multiplier in the computation of position precision. For example, in the computation of horizontal RMS (HRMS), an estimated precision value is multiplied by the HDOP at that given time to produce HRMS. The larger the HDOP value, the larger the HRMS value. The same relationship holds for VDOP and VRMS. Therefore, poor satellite geometry will result in poor solution precision. The smaller the DOP value, the better the geometry and solution precision. Your field application software supports the ability to view current DOP values. If your precision estimates (HRMS, VRMS) do not meet expected values, use this feature to examine the current DOP values.

DOP values not too high

Go to step 4) below.

DOP values too high

1. Look for a satellite window with more suitable DOP values to perform the survey.

a. Use the Mission Planning software to examine expected DOP values for periods during which you would like to perform your survey.
b. Avoid surveying during periods where DOP values are above 4.
c. For the highest level of accuracy, limit surveying to periods where DOP values are between 1 and 2.
d. Remember that obstructions to line-of-sight between the GPS receiver antenna and the satellites will block out satellite signals. Every time a satellite is lost due to obstructions, DOP values will be adversely affected. An obstructed area may not be suitable to meet your precision needs due to the adverse effect on satellite geometry.

Step 4. Precision requirements too stringent for RTK?

If the RTK system is not delivering the precision requirements you need for your specific task, it is possible that your precision requirements are too stringent for the RTK system. Review your system documentation to determine the precision specifications for the RTK system.

Precision not beyond capability

Go to step 5 below

Precision beyond capability

Your precision requirements are not attainable through RTK surveying. You will need to find some other measurement system to perform your survey.

Step 5. Your rover receiver may be malfunctioning

Contact your local dealer or Ashtech customer support for assistance.

This concludes the troubleshooting section. If the tips given here did not help you to resolve your problem with your ZX SuperStation, please call your local dealer or Ashtech customer support for assistance.

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