



Z-Max™

Operation and Applications Manual

Z-Max Surveying System

Operation and Applications Manual



Z-Max Surveying System

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Printed in the United States of America.

Part Number: 630880-01, Revision A

May 2003

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ACRONYMS USED IN THIS MANUAL

BIN	Binary (file)
CHN	Channel Number
CPD	Carrier Phase Differential
DGPS	Differential GPS
DOY	Day of Year
FAST	Field Application Survey Technology
PC	Personal Computer (IBM compatible)
GNSS	Global Navigation Satellite System
GSM	Global System for Mobile Communication
LNA	Low-Noise Amplifier
PIN	Personal Identification Number
PWR	Power
RTK	Real-time Kinematic
SD	Secure Digital (memory card)
SIM	Subscriber Identification Module
USB	Universal Serial Bus
UTC	Coordinated Universal Time

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SECTION 1

Operation and Reference Guide

Introduction

Try to imagine a GPS surveying system that is accurate, reliable and easy to operate. A professional measurement system that integrates mechanical flexibility, state-of-the-art wireless technology and innovative application software. We did, and then we built it! Thales Navigation is proud to introduce the Z-Max Surveying System (Figure 1.1). Because we're surveyors too, we understand how frustrating it is to get out to a job site only to find that a failed, missing, or incorrect part of the system causes downtime. We designed a system which reduces the number and complexity of components required for GPS surveying. We improved the performance in critical areas such as RTK, weight and power consumption. We added software functionality and workflow efficiencies drawn from years of surveying experience. The result is the Z-Max Surveying System. The Z-Max system is designed to meet the needs and requirements of land surveyors involved in demanding applications including: topography, construction, mining and oil exploration. The Z-Max system is perfect for any surveying application that requires both high precision and high productivity.



Figure 1.1 Z-Max Surveying System

The Z-Max Surveying System is based on a modular mechanical design. Each module is designed to attach easily, quickly, and securely. In some configurations, the Z-Max system is completely cableless. Where cables are required, they are designed to be durable and easy to use. Survey setup is easy, and you only have to use the modules that you need. Modules are interchangeable, so different systems can be put together using the same core parts. Want to do a static survey? Attach the GPS Antenna Module and the Power Module to the GPS Receiver Module and you're ready to thread the unit on to a tripod. Want to perform an RTK survey? Connect the Communication Module and you are ready for that too. The Z-Max system can be tripod mounted for base station setups or static surveys, and either backpack mounted or pole mounted for rover system RTK surveys. With its lightweight, durable, magnesium housing the rover system is light enough to be carried around all day. Battery issues won't slow you down either. The Z-Max Power Module containing Lithium Ion battery cells can power the receiver for over 13 hours. The Z-Max also includes the latest in wireless technology to eliminate cables when transferring data between devices. You can communicate with the receiver wirelessly with a small handheld data collector and you can even wirelessly download data to the PC!

The Z-Max System includes the following major components :

- **Z-Max GPS Module:** the GPS Receiver Module that contains the GPS receiver, the removable SD memory card, front panel display, external serial ports, USB port and the power port.
- **Max-Trac GPS Antenna Module:** the module that contains the GPS antenna hardware that supplies GPS signal to the Z-Max.
- **Communication Module:** the module that contains data links that enable real-time GPS surveying. If the system is not intended for real-time surveying, an empty Communication Module (V-Module) will be required to seal the Z-Max against moisture.
- **Vortex UHF Antenna Module:** the module that contains the antenna for UHF radios. If the system is not intended for real-time surveying, an empty UHF antenna module will be used to complete the 2-meter range pole.
- **Power Module:** contains the lithium ion batteries to power the Z-Max.
- **Handheld Computer/Field Application Software:** the Z-Max system offers you a choice of portable data collectors and graphical field software to control the receiver during GPS surveys.

Additional algorithmic enhancements inside the Z-Max significantly increase the availability of precision RTK solutions at long ranges and in harsh environments. The Z-Max algorithms automatically analyze operational conditions and optimize internal parameters to best meet the challenges of real-world environments.

Functional Description

The receiver is activated when the Power button is pushed. Provided that a power source is connected, the unit will perform a self-test and then initialize its tracking channels and begin searching for all satellites (SVs) within the field of view of the GPS antenna. The receiver can track up to 12 satellites at the same time. The number of available satellites varies based on the geographic location and the time of day. In an open environment, the receiver will typically track 5-10 satellites simultaneously. As the receiver acquires (locks onto) each SV, it obtains the time information, collects the ephemeris data for that SV, and collects almanac data for all SVs in the constellation. The Z-Max will begin recording satellites automatically as soon as 3 satellites are tracked and will be computing a position when 4 satellites are tracked.

Each SV broadcasts information about its own position every 30 seconds (ephemeris) and information about the position of every satellite in orbit every 15 minutes (almanac). The unit automatically records this information in its memory. The unit has an L1/L2-band RF port and 3 external input/output ports that include RS-232, RS-422 and USB protocol. The receiver also contains an internal Bluetooth wireless module for wireless communication between the receiver and peripheral devices. The receiver contains an internal serial interface for interfacing with the Communication Module.

Receiver Memory

The receiver records data internally using an SD Memory Card. The SD (Secure Digital) Memory Card is a highly-sophisticated memory device about the size of a postage stamp. SD Memory Cards are non-volatile, solid-state devices so they do not require power to retain the stored data and have no moving parts to skip or break down. Weighing less than 2 grams, they offer a powerful combination of small size, high storage capacity, and fast data transfer.

The duration of data recording on the SD card depends upon the storage capacity of the card, the recording interval, the data recording mode, and the number of satellites being tracked. A receiver with a 64 MB SD card recording data at 20 second intervals with an average of 8 satellites tracked could log about 28 days worth of continuous data. Standard Z-Max SD memory cards have a capacity of 64Mb. For intensive data storage requirements, higher capacities are available.

Technical Specifications

Table 1.1 lists the technical specifications of the Z-Max modules.

Table 1.1 Technical Specifications

Characteristic	Specification
Tracking	12 channels C/A, P-code L1 & P-code L2 (Z-Tracking)
Power input	10-28 VDC
Regulatory compliance	FCC and CE Mark class B, R&TTE
Interfaces Z-Max GPS Receiver Module	<ul style="list-style-type: none">• Eight-character alphanumeric LED Display• Up/down control keys• 1 power ON/OFF button• 4 tri-color LEDs• 3 External data ports<ul style="list-style-type: none">- 1 RS-232 serial- 1 RS-232/422 port- 1 USB port• 1 internal Bluetooth port• 1 external power input port• 1 GPS Antenna Module connector• Event marker and 1PPS via serial port connector

Table 1.1 Technical Specifications (continued)

Characteristic	Specification
Communication Module	Choice of: <ul style="list-style-type: none"> • Thales Navigation U-Link Radio • Pacific Crest PDL Radio • GSM modem/antenna • Thales Navigation U-Link Radio & GSM modem/antenna • Pacific Crest PDL Radio & GSM modem/antenna (all options have plug-in internal connectors for power and serial connection to GPS Receiver Module)
Vortex UHF Antenna Module	<ul style="list-style-type: none"> • Antenna for Thales U-Link Radio or PDL Radio
Power Module	<ul style="list-style-type: none"> • Lithium Ion 'smart' battery module • Max-Run = 13+ hours of operation • Max-Lite = 6+ hours of operation

Receiver Options

Receiver firmware options enable different functionality within the receiver. The option must be enabled for that feature to be available. For example, the RTCM Base option must be enabled to set up the receiver as an RTCM differential base station. Table 1.2 provides a complete list of the firmware options.

Table 1.2 Receiver Firmware Options

Option Letter	Description
B	RTCM Base
U	RTCM Rover
E	Event Marker
M	GSM Modem
F	Fast Data Output
T	Point Positioning
3	Observables
J	RTK Rover
K	RTK Base
I	Instant RTK
G	Long Range RTK
H	Synchronized 5 Hz RTK

There are two ways to determine what options have been enabled; using the front panel display or a serial port command. To use the front panel display, go to the OPTIONS function in the SYSINFO menu. The firmware option characters will be displayed in the order presented in Table 1.2. If the character is displayed, then that option is enabled. If the option is disabled, then a dash will occupy the space where that character would be. (See the Front Panel User Interface section of Chapter 4 - **Operation** for more information about accessing the front panel display.)

Enabled options can also be verified by issuing the \$PASHQ,RID serial port command. The response message to the \$PASHQ,RID command is a string that will look similar to the following:

```
$PASHR,RID,ZA,30,ZM30,BUEMFT3JKIGH0A01*cc
```

To see which options are enabled, look at the string "BUE-MFT3JKIGH" in the response message. Each option is represented by a character displayed in the order presented in Table 1.2. The description of all options available is as follows:

OPTION B - RTCM Base

When this option is enabled, the receiver can be set as an RTCM base station capable of outputting real-time RTCM differential corrections. The output will be in RTCM-104, version 2.3 format. Message types available are types 1, 2, 3, 6, 9 and 16. If the K option (RTK Base) is enabled, RTCM message types 18/19 and 20/21 are also available.

OPTION U - RTCM Rover

When this option is enabled, the receiver can be set as an RTCM rover station capable of receiving real-time RTCM differential corrections. The receiver will decode the RTCM-104, version 2.3 format message types 1, 2, 3, 6, 9 and 16. If the J option (RTK Rover) is enabled, RTCM message types 18/19 and 20/21 can also be decoded.

OPTION E - Event Marker

The E option enables the storage of event time created from a trigger signal. The receiver measures and records event times with high accuracy (down to one microsecond). The receiver stores an event time at the rising edge of the trigger signal (or the falling edge on command) and the time is recorded in the receiver's SD card and/or output through the NMEA-format TTT message.

OPTION M - GSM Modem

The GSM Modem option allows you to set the GSM modem's data link parameters, dial, and display transmit/receive status of the GSM communication link.

OPTION F - Fast Data Output

When this option is enabled, the receiver can be set to output NMEA messages and raw data from the serial port at rates up to 10 Hz (0.1 second intervals). Without this option, frequencies up to 5 Hz (0.2 second intervals) are available.

OPTION T - Point Positioning

When this option is enabled, the receiver can be put into point positioning mode using the \$PASHS,PPO command. Point positioning mode improves the accuracy of an autonomous position of a static point.

OPTION 3 - Observables

This option determines the number of data observables available (Table 1.3).

Table 1.3. Option 3 Observables

Option	Code Phase	Carrier Phase
None	C/A on L1, P-Code on L1/L2	None
1	C/A on L1, P-Code on L1/L2	None
2	C/A on L1, P-Code on L1/L2	L1 only
3	C/A on L1, P-Code on L1/L2	L1/L2

OPTION J - RTK Rover

When this option is enabled, the receiver can be set as an RTK (CPD) rover station capable of receiving carrier phase data transmitted by the Base receiver and used to compute real-time centimeter-level RTK positions. This option requires that the Observables option be set to 3. For RTCM message types 18/19 and 20/21, the RTCM Rover option [U] is also required.

OPTION K - RTK Base

When this option is enabled, the receiver can be set as an RTK base station capable of outputting carrier phase data used by the Rover receiver to compute real-time centimeter-level RTK positions. The output will be in proprietary DBEN or RTCM-104, version 2.3 format. This option requires that the Observables option be set to 3. To transmit RTCM 18/19 or 20/21 the B option is also required.

OPTION I - Instant-RTK

The I option is an extension of the J option. When this option and the J option are enabled, the receiver can use the mode Instant RTK which uses a new data processing strategy for integer ambiguity initialization. The initialization time using Instant RTK typically requires only a single epoch of data to compute a position if there are 6 or more satellites available with reasonably open sky, low multipath, and the baseline length is less than 10 km.

OPTION G - Long Range RTK

The G option is also an extension of the J option. When the G and the J options are enabled, the rover receiver uses the Long Range RTK algorithms incorporating a new data processing strategy for integer ambiguity initialization over long baselines. Using Long Range RTK the rover can typically fix integer ambiguities over baselines up to 50 kilometers in length, when 6 or more satellites are available with reasonably open sky and low multipath.

OPTION H - 5 Hz Synchronized RTK

The H option enables the receiver to output synchronized or matched time-tagged RTK positions at rate of up to 5 Hz (5 positions per second). 5 Hz Synchronized RTK allows the user to attain the better accuracy of matched time-tagged RTK with nearly the same productivity of Fast CPD. This feature is not available when using RTCM format data.

Equipment Description

The modular approach of the Z-Max Receiver system has been designed to simplify survey configuration, use, and setup. It is important to become familiar with each of the modules and its function and capabilities. All of the modules that comprise the Z-Max Surveying System are listed in Chapter 1. In this chapter, we introduce and provide a functional overview for each module.

In Chapter 3 - *Getting Started*, we will present a more detailed initiation and put these components together to create a working system.

GPS Receiver Module

The Z-Max GPS Receiver Module is the main receiver module (Figure 2.1). The GPS Receiver Module contains the GPS receiver, the memory card, front panel display, external serial ports, USB port, and power port. The GPS Receiver Module also contains the internal Bluetooth module that allows the receiver to wirelessly communicate with external devices. Virtually all the modules will attach in some way to the GPS Receiver Module.



Figure 2.1 GPS Receiver Module

Front Panel

The Z-Max GPS Receiver Module front panel, Figure 2.2, allows you to power on/off the receiver, monitor basic receiver functions, control many receiver parameters, configure surveying parameters and collect survey data.



Figure 2.2 Z-Max Front Panel

At the top of the front panel are the four tri-colored status LEDs. The LEDs from left to right are the RTK SOLUTION, COMMUNICATION, Data Log, and the Satellite/Power. Directly below the LEDs is the front panel display. Below the display are the four control keys that are used to navigate through the display menu tree. The 2 yellow keys are the UP arrow and DOWN arrow control keys. The round green key below the yellow keys is the ENTER control key, and the square red key is the CANCEL control key. Below the control keys is another green key, the Power ON/OFF key, which can also be used to reboot and initialize the receiver to factory defaults. Lastly, below the Power key is a small door that contains the SD memory card slot, and the USB port.

The functionality of the keys and the LEDs is described below.

Status LEDs

The Z-Max GPS Receiver Module front panel has four status LEDs located at the top of the front panel (Figure 2.3). The 3-color LEDs allow you to quickly monitor several receiver functions at a glance. From left to right, the four LEDs are RTK SOLUTION, COMMUNICATION, DATA LOG, and SV/Power. Each LED is described below.



Figure 2.3 LED Indicator Lights

RTK SOLUTION LED

The RTK SOLUTION LED is used to show the RTK solution status. This LED is only operational when the receiver is configured as an RTK rover.

During RTK rover operation, if the LED is blinking green then the carrier phase ambiguities have been resolved (or fixed) and the resulting solutions have centimeter-level accuracy. This is more commonly referred to as a "fixed" solution. If the LED is blinking orange, then the ambiguities are not resolved (or floating). This is commonly referred to as a "float" solution. Accuracy of a float solution can range between 10 cm and a few meters depending on the operational scenario. If the LED is blinking red, then the receiver is not computing RTK positions and indicates a problem in the RTK setup or configuration. The LED blinks at the frequency of the solution output.

COMMUNICATION LED

The COMMUNICATION LED indicates when real-time data transmitted from the base receiver has been received by the rover. It covers all data links including the Communication Module data links and external wireless modems. If the light is blinking GREEN, then the real-time data being transmitted by the base station has been received by the rover and is useable. If the light is blinking RED, then the real-time data being received by the rover is detected but not usable for some reason. Regardless of color, the LED will blink at the frequency of data reception. If the LED does not blink at all, no data is being received by the rover.

Data Log LED

The Data Log LED will blink green each time GPS measurement data is recorded to memory. The LED will blink at the frequency of the Recording Interval setting (20 seconds by default). If the SD card fills up and is unable to log any more data to memory, the LED will go to constant red. To free up space on the SD card, see the SESSIONS submenu of the Front Panel User Interface in Chapter 4 on page 66.

Satellite/Power LED

After power up, the Satellite/Power LED will continue to blink red once every 1-2 seconds to indicate that the unit is powered on. Between each red blink, the LED will also blink green once for each satellite that the receiver is tracking.

Front Panel User Interface

Below the LEDs is the Front Panel User Interface (Figure 2.4). The interface is an 8-character, scrolling alphanumeric LED display that allows you to monitor receiver status, set receiver parameters and configure the receiver to perform different types of surveys. You can check for available memory and battery life, save parameters, and configure the data links for RTK surveys. The display also shows warning messages and equipment status messages.



Figure 2.4 Front Panel Display and Control Keys

The functionality of the display is organized in a menu tree. The menu tree is navigated by the 4 control keys located on the front panel below the display: the yellow Up arrow (G) and Down arrow (H) keys, the green Enter key (↵), and the red Cancel (K) key. The control keys allow you to move up and down the menu tree, select parameters, and enter alpha and numeric characters like a keypad. The screen displays up to eight characters at one time. Messages or parameters longer than eight characters are scrolled from right to left. For more information about the display, see the Front Panel User Interface section in Chapter 4 - **Operations** on page 43.

Power ON/OFF Key

Power the Unit 'ON'

Power up the unit by pressing and holding the power key on the front panel for two seconds, and then release the key. During the two-second period that the key is being held, the satellite/power LED will blink red. After these two seconds, the front panel will display the firmware version and then SYSINFO. If the power button is pressed for more than 4 seconds, the unit will initialize (see below).

Once the power key is released, the Satellite/Power LED will begin to blink red every second, indicating that the unit is turned 'ON'.

Turn the Unit 'OFF'

Power down the unit by pressing and holding down the power key for two seconds. The receiver will generate a beep every second, a “shutdown” message will be displayed, and the receiver will then power down.

If the user releases the power key before the complete two seconds has elapsed, the unit will remain powered on and there will be no disruption of receiver functionality during the time that the key was pressed down.

Reset the Unit

A reset of the receiver will initialize the receiver, restoring all receiver parameters to factory defaults, clear all ephemeris and almanac information from the internal memory, and reformat the SD memory card. See Appendix B for a list of the default values for many user parameters.

The unit must be powered OFF to initialize the receiver. First, the unit must be powered off, then press and hold the power key for five seconds. After the five seconds, the phrase "re-init" will be displayed on the front panel display until the initialization process is complete. After the unit completes the re-initialization procedure, the receiver will stay powered on and be in normal operation mode.

If the user releases the power key at any time prior to starting the initialization, the receiver will simply power up normally with no reset.

CAUTION

Turning the unit "OFF" while the receiver is in the reset mode can have adverse effects. If this occurs, repeat the Reset process immediately.

The reset process will reformat the SD card, deleting all information recorded previously on the card. During constant use, reformatting the SD card using the initialization process is recommended every two weeks.

SD Card Slot/USB Port

Below the four control keys is a small door fastened by two thumbscrews. Unscrew the attaching screws and open the door to reveal the SD Card slot and the USB port (Figure 2.5).

The SD card slot holds the SD memory card that serves as the receiver's data storage memory. All data recorded by the GPS receiver is stored on the SD card. The USB port is one of the external ports available for connecting to a computer.

The USB port is a type-B connector. With the USB connection, the Z-Max can establish a bi-directional link to a host computer for transferring data from the SD memory card, or data being streamed in real-time from the Z-Max. Utilizing the USB port requires a USB interface cable. Be aware that it shares the internal connection with the Serial A port located on the rear panel (see below), so the USB port and the Serial A port can not be in use at the same time.

Pinout descriptions of the USB port are provided in Appendix A - **Serial and Port Pinouts**. The SD memory card is described in more detail in the next section.



Figure 2.5 SD Memory Card Slot and USB Port

SD Memory Card

All data recording in the Z-Max is done on an SD (Secure Digital) memory card (Figure 2.6). The SD memory card is a highly-sophisticated memory device about the size of a postage stamp. The SD card slot is located inside the small panel door on the front panel of the receiver (Figure 2.5). The SD card is used to record data and load new receiver firmware. The receiver comes with a 64 MB SD card as standard, but optionally, SD cards with larger capacities are available. Weighing less than two grams, the SD card offers a powerful combination of small size, high storage capacity, and fast data transfer.



Figure 2.6 SD Memory Card

CAUTION

It is important to power off the receiver using the Power key on the Front Panel before removing the SD card.

Rear Panel

The narrow rear panel of the Z-Max GPS Receiver Module, Figure 2.7, contains the serial and external power ports for connection to external equipment.



Figure 2.7 Z-Max Rear Panel

Serial Ports

The serial ports are used for connecting the Z-Max GPS Receiver Module by cable to external equipment including a PC or handheld computers, external radios, timing devices, and event logging devices. These ports can be used to transfer data or NMEA messages to another device, send receiver commands or queries, receive or transmit RTK or code phase corrections. The serial ports include the ports seen on the rear panel, and the USB port located inside the small door on the front panel (described on page 11).

Serial A

Serial A is a full duplex serial port with RS-232 protocol. Pin 1 supplies 12 V output that can be used to power external devices. Pin 7 is a 1PPS output.

NOTE: Internal to the receiver, the USB port and the Serial A port share the same internal port. Therefore, only one of these ports can be in use at the same time. If both Serial A and the USB port are in use at the same time, the USB port will have precedence.

Serial B

Serial B is a full duplex serial port which can be toggled between RS-232 and RS-422 protocols. As an RS-422 port, it interfaces with the Thales U-Link transmitter. The port will automatically convert to an RS-422 port when configuring the Thales U-Link radio transmitter to use port B.

Pin 1 supplies 12 V output that can be used to power external devices. Pin 7 is an event marker input. The pinout descriptions of all ports are defined in Appendix A, ***Serial and Power Port Pinouts***.

Power Port

The Z-Max GPS Receiver Module contains an external power connector that allows you to power the receiver with an external power source such as a battery or an auto lighter. The port is a 3-pin Fischer connector with a voltage input range of 10-28VDC. For pinout definitions, see Appendix A - ***Serial and Power Port Pinouts***.

GPS Antenna Module

The Max-Trac GPS Antenna Module, Figure 2.8, contains the GPS antenna which allows the Z-Max receiver to track signals from the GPS satellites. This geodetic quality antenna will accurately and consistently track satellites above the horizon and provide good multipath rejection for signals reflecting from intermediate surfaces such as the ground.



Figure 2.8 GPS Antenna Module

The GPS Antenna Module is designed to either connect directly to the GPS Receiver Module, or to the top of the UHF Antenna Module if the Z-Max is intended for real-time operation. The GPS Antenna Module connects without cables. The base of the

Antenna Module is circular except for a flattened area. Insert the Antenna Module into the antenna receptacle at the top of either the GPS Receiver Module or the UHF Antenna Module. Make sure the base of the GPS Antenna Module is oriented so that the flattened side of the antenna base is lined up with the flattened area of the receptacle, and the module will easily slide into place. Once in place, twist the threaded collar on the GPS Antenna Module until securely locked in place.

Power Module

The primary power source for the Z-Max is the Power Module (Figure 2.9). Inside the Power Module are rechargeable lithium ion battery cells. The Max-Run Power Module has a capacity of 8.8 amp-hours and should power the Z-Max for over 13 hours in typical user scenarios. The Max-Lite Power Module is a lighter configuration that provides 4.4 amp-hours of power. The Max-Lite Power Module is capable of powering the receiver for over 6 hours in typical user scenarios.

The Power Module also contains a battery charger and other "smart" functionality to provide usage information, monitor the battery while it's recharging, and advise the user about battery maintenance. The Power Module does not require any cables; it simply plugs into the left-hand side of the GPS Receiver Module. To plug in the module, insert the small ledge of the Power Module into the rear of the GPS Receiver Module housing first as shown in Figure 2.10. This will correctly align the module. Using the ledge like a hinge, swing the module closed until the latch on the Power Module clicks into place.



Figure 2.9 Z-Max Power Module

To help you keep track of battery life, the Power Module has a pushbutton and LED indicators to provide a quick indication of the percentage of battery time remaining. Each of the four lights represents about 25% of battery life. Four green lights indicate the battery is fully charged (100%). One red light indicates that there is less than 25%

of battery life left. The LEDs only provide a rough indication of battery life to the nearest 25%. Also, because the pushbutton is on the side of the Power Module that connects to the GPS Receiver Module, the pushbutton can only be used to check battery life with the Power Module removed from the receiver. For a more precise report of the amount of battery time remaining or to check battery life with the Power Module attached, see the BAT function in the SYSINFO menu of the Front Panel User Interface (page 50).



Figure 2.10 Connecting the Power Module to the GPS Receiver Module

If you require additional or backup battery power, an external power source can be used. An external DC power source connects to the Z-Max external power port via a dedicated power cable. Voltage must be between 10-28 VDC. The external power source can be connected at any time without concern for damage to the Power Module. When both the Power Module and an external power source are connected, the Z-Max will use power from the external source first. When the unit transitions from an external source to an internal source, or from an internal source to an external source, there is no interruption to any data recording or receiver functionality.

Charging

The Power Module contains rechargeable lithium-ion battery cells and 'smart' charging circuitry. Recharging the Power Module is done using the AC/DC power supply included with the System. This power supply can be used to provide power to the Z-Max through an external connector. The charger is designed to work with a 110-240 VAC power source and delivers 12 VDC of input voltage with at least 4A current capability to the Power Module. Figure 2.11 shows the Power Module and the

charger. The Power Module's lithium-ion batteries do not have a memory effect, meaning that they can be recharged without being fully discharged with no effect on the battery capacity. In other words, recharge the Power Module whenever it's convenient. To extend the life span of the batteries in the Power Module, it is best not to always fully discharge them. To keep your Power Module ready for field use, we recommend that you keep it connected to the charger when not in use.



Figure 2.11 Power Module and Battery Charger

The charging of the Power Module from a fully discharged state takes about five hours. To charge, remove the Power Module from the GPS Receiver Module and plug the charger into the connector on the module. Plug the charger into a 100-240 VAC power source. The status lights on the charger indicate the following:

- Yellow - Standby
- Red - Charging
- Green - Charged
- Blinking Red - Error

Conditioning

The battery circuitry in the Power Module stores and communicates charge capacity and charge level information. The accuracy of the charge level indicator will degrade over time. When this happens, the battery information obtained from the front panel display or the Power Module button will no longer be accurate. To restore the accuracy of the charge level, the Power Module must be calibrated or conditioned.

While the Power Module is initially conditioned at the factory, conditioning should be done periodically to calibrate the Power Module and restore the charge level accuracy. We recommend that the Power Module be calibrated every 20 charge

cycles, or about once a month, whichever comes first. The Power Module should also be conditioned after prolonged periods when the battery has been stored while not connected to the charger.

Conditioning is a three-step process. The first step charges the battery to capacity, the second step discharges the battery at a constant rate. The third step again charges the battery to capacity. There are two methods for conditioning the Power Module. The first method relies completely on the charger to do the calibration. The second method uses both the receiver and the charger.

To condition the Power Module with the charger:

1. Remove the Power Module from the GPS Receiver Module.
2. Plug the charger into an electrical socket.
3. Push the Power Module pushbutton that controls the Power Module LEDs
4. While continuing to push the button, plug the charger into the Power Module. This combination of pushing the button and plugging in the charger will initiate the conditioning sequence.

The entire conditioning process (all three steps) will take up to 18 hours for the Max-Run Power Module and up to 12 hours for the Max-Lite Power Module. While calibration is in progress, the status lights on the charger will indicate the following:

- Yellow - Calibrate mode is in progress
- Off - Calibration completed

The duration of the conditioning process can be shortened by using a combination of the receiver and the charger to perform the calibration process.

To condition the Power Module with the receiver and the charger:

1. Use the charger to fully charge the Power Module.
2. Attach the fully-charged Power Module to the receiver, and use the receiver normally until the Power Module is completely discharged and the receiver shuts itself off.
3. Use the charger to fully recharge the Power Module.

There are two important things to remember using this method. First, do not recharge the battery until it has fully discharged. Secondly, you do not have to run the battery down all in one day. You may use the receiver for several hours, turn it off, and resume the next day. But do not let it sit idle for several days or the conditioning sequence will reset. The key is consistent and steady discharge over a short period of time (1-3 days). This method requires a little more attention, but allows you to use the receiver as you are simultaneously conditioning it.

Disposition

If the Power Module fails to hold an adequate charge, either due to damage or because it has outlived its useful life, the Power Module can be returned to Thales Navigation for refurbishing. Refer to the hardware limited warranty information for specifics regarding warranty repairs. If for any reason you are unable to return the module, the cells in the module may be recycled, or the modules may be discarded. Spent lithium batteries are not considered hazardous waste because they are neither toxic nor reactive.

Communication Module

The Communication Module, Figure 2.12, contains the data link(s) for transmitting or receiving data during DGPS and RTK applications. The Communication Module can include one or a combination of the following options:

- Thales U-Link radio receiver
- Pacific Crest PDL radio receiver
- Cellular Modem



Figure 2.12 Communication Module

Depending upon the option you have selected, the Communication Module may have both a UHF radio and a cellular modem, a UHF radio by itself, or a cellular modem by itself. The module does not require any cables; simply plug it into the left-hand side of the GPS Receiver Module. To plug in the module, insert the small ledge of the

Communication Module into the rear of the GPS Receiver Module housing first as shown in Figure 2.13. This will correctly align the module. Using the ledge like a hinge, swing the module closed until the latch on the Communication Module clicks into place.

UHF Communication Modules

The Communication Module may contain various types of UHF radio receivers. The antenna for the radios is the UHF Antenna Module which is described in the next section. Certain radio settings are configurable such as channel and data transfer rate (or link rate). Configuring the radios is most commonly accomplished using field application software running on the handheld computer. Communication Modules can also be configured using the front panel display of the Z-Max. Instructions for configuring Communications modules using field application software can be found in the software user manuals. Instructions for configuring Communications modules using the front panel display can be found in the *Front Panel User Interface* discussion on page 43.

Thales Navigation U-Link

The only configurable parameters of the Thales Navigation U-Link radio are the channel frequency and the baud rate. The data transfer speed (or link speed) is fixed at 4800 bps.

Pacific Crest PDL

Configurable parameters of the PDL radio include the link speed, sensitivity and the channel frequency index. For more information about advanced configuration of Pacific Crest radios, please refer to the PDL user manuals.

The UHF radios in the Communication Module are receivers and do not transmit. They are only used with the rover receiver. To transmit data while operating a real-time system, the base Z-Max requires an external radio.

Cellular Communication Modules

The Z-Max uses cellular phone technology to transmit and receive data. Unlike the UHF radios that require an external radio transmitter at the base station, the cellular modem in the Communication Module will work as both the transmitter and the receiver. Operating cellular devices requires you to set up cellular service with a service provider. The service provider will vary by region and will supply the phone number and other account information for the service.

GSM Communication Module

A Communication Module that contains a GSM modem operates similarly to a GSM phone. The GSM service includes certain security features which prevent unauthorized use. GSM service typically includes a SIM card and the use of a PIN number. The GSM Communications Module supports the use of a SIM card and the Z-Max supports the use of a PIN number. The GSM Communication Module has 2 additional hardware features: a built-in GSM antenna, and a slot to hold the SIM card (Figure 2.14). The SIM card comes from your GSM service provider and must be installed for the GSM modem to operate. To install the SIM card, slide it into the slot provided and close the door.



Figure 2.13 Connecting Communication Module to GPS Receiver Module



Figure 2.14 GSM Antenna and SIM Card Slot

UHF Antenna Module

The Vortex UHF Antenna Module (Figure 2.15) is the UHF antenna for all UHF Communication Modules. The UHF Antenna Module is connected between the GPS

Antenna Module and the GPS Receiver Module and routes the radio signal to the radio inside the Communication Module.



Figure 2.15 Vortex UHF Antenna Module

The UHF Antenna Module connects without cables. The base of the Antenna Module is circular except for a flattened area. Insert the Antenna Module into the antenna receptacle at the top of the GPS Receiver Module. Make sure the base of the Antenna Module is oriented so that the flattened side of the Antenna Module base is lined up with the flattened area of the receptacle, and the module will easily slide into place. Once in place, twist the threaded collar on the UHF Antenna Module until it's securely locked in place. Once the UHF Antenna Module is connected to the GPS Receiver Module, the GPS Antenna Module attaches to the top of the UHF Antenna Module.

Handheld Computer/Field Application Software

The handheld computer and the field application software are used to interface with and control the GPS receivers in the field. The field application software and field computer are primarily used with the rover receiver during kinematic, RTK and code-phase differential surveys. Most users will use a handheld computer and graphical application software to execute intensive real-time operations such as real-time navigation (stake-out). The standard handheld computer supplied with the Z-Max system is designed to operate with Bluetooth short range wireless technology, so no cable is required between the handheld computer and the receiver. The operator can either communicate with the receiver from up to 10 meters away without cables, or may choose to use a cable.

FAST Terminal

The standard handheld computer used by the Z-Max Survey system is the FAST Terminal (Figure 2.16).



Figure 2.16 FAST Portable Data Terminal

The FAST Terminal features wireless communication via a Bluetooth enabled Compact Flash card, a 320x240 touch-screen display, and an RS-232 port located at the top of the unit. In addition, the unit comes with 64 MB RAM and 32 MB ROM. With an Intel[®] processor and the Microsoft[®] Pocket PC operating system, the FAST Terminal delivers high performance, low power consumption, and fast throughput.

Running on the handheld is the field application software, Fast Survey™. Fast Survey has been designed by Thales Navigation specifically for use with the Z-Max Surveying System and emphasizes ease of use and flexibility.

For more information on using the FAST Terminal and the Fast Survey software for GPS surveying, refer to the Fast Survey user's manual.

Getting Started

Getting the Z-Max Surveying System up and running is a straightforward procedure that involves simply connecting the modules required for your particular type of survey, turning the receiver on, and quickly checking the receiver status to ensure that the receiver is tracking satellites and recording data.

This chapter will guide you through this process in a step by step procedure that starts with opening the case and ends with checking some of the basic functionality to help you become more comfortable with the receiver. This chapter will also provide a short tutorial on using the front panel display. Prior to working with this chapter, it is strongly recommended that you review Chapter 2 - **Equipment Description** to get an overview of the different modules and their functionality. At the very least, you should be able to identify each module and its purpose, be able to identify the power button and know how it works, identify the front panel display control buttons, and be aware of the functionality of the LEDs.

The purpose of this chapter is to help you become comfortable with the different modules that comprise the Z-Max System and how to operate them. Therefore, this chapter will focus on the basic system setup and will not cover surveying applications. Once you are familiar with basic system operation you can find more information about static and kinematic surveys in the "**System Guide for Post-Process Surveying**" section of this manual and more information regarding RTK setup in the "**System Guide for RTK Surveying**" section of this manual.

Follow these steps to setup your Z-Max Surveying System to tracking satellites and recording GPS measurements:

Step 1: Charge up the Power Module

The Power Module contains battery cells that are used to provide power to the receiver. Although the Power Module may be partly charged when you receive it, it should be fully charged prior to use. To charge the Power Module, connect the module to the charger as shown in Figure 3.1 and charge for a

minimum of five hours or preferably overnight (even if the charger indicates the battery is 'full').

As described in Chapter 2, the Power Module is a 'smart' battery that reports the current level of charge and other operational information. To calibrate the reporting capability so that it provides an accurate reading of battery level, the Power Module must be periodically conditioned. The Power Module is conditioned at the factory so it is not necessary to perform any initial conditioning. Conditioning should be performed once a month or after the battery has been stored for long periods of time without being connected to the charger. Verify that the battery is fully charged by pressing the button on the back side of the Power Module. The four LEDs should light up green.



Figure 3.1. Charging the Power Module

Step 2: Attach the Power Module to the GPS Receiver Module

As you are facing the front panel of the GPS Receiver Module, the Power Module attaches to the right-hand side. Attaching the Power Module does not require any cables. To attach the module, insert the small ledge of the Power Module into the rear of the housing first as shown in Figure 3.2. This will correctly align the module. Using the ledge like a hinge, swing the module

closed until the latch on the Power Module clicks into place. Make sure the module is well seated and the latch on the edge of the module clicks shut.



Figure 3.2 Connecting Power Module to GPS Receiver Module

Step 3: Attach the Communication Module to the GPS Receiver Module

Depending upon the options that you purchased, the Communication Module either contains data links or is an empty V- Module. While operating the Z-Max in a basic configuration does not require the Communication Module, the module is needed to maintain a weather-tight seal of the Z-Max GPS Module.

As you are facing the front panel of the GPS Receiver Module, the Communication Module attaches to the left-hand side. Attaching the Communication Module does not require any cables. To attach the module, insert the small ledge of the Communication Module into the rear of the GPS Receiver Module housing first as shown in Figure 3.3. This will correctly align the module. Using the ledge like a hinge, swing the module closed until the latch on the Communication Module clicks into place. Make sure the module is well seated and the latch on the edge of the module clicks shut.



Figure 3.3 Connecting Communication Module to GPS Receiver Module

Step 4: Attach the GPS Antenna Module to the GPS Receiver Module

In order for the GPS Receiver Module to track GPS satellites, the GPS Antenna Module must be connected, and the antenna must have a relatively unobstructed view of the sky.

The GPS Antenna Module is designed to either connect directly to the GPS Receiver Module, or to the top of the UHF Antenna Module. In order to verify that the Z-Max tracks satellites and records data we will connect the GPS Antenna Module directly to the GPS Receiver Module. Attaching the GPS Antenna Module to the UHF Antenna Module is covered on page [181](#) in the System Guide for RTK Surveying section of this manual.

The GPS Antenna Module connects to the GPS Receiver Module without cables. The base of the Antenna Module is circular except for a flattened area. The top of the GPS Receiver Module is keyed so there is only one way it can be inserted. Make sure the base of the Antenna Module is oriented so that the flattened area is lined up with the flattened area of the receptacle. Once aligned, insert the Antenna Module into the antenna receptacle. The module should push easily into place. Once in place, twist the threaded collar on the Antenna Module until the antenna is securely locked in place. (Figure 3.4).



Figure 3.4 Connecting GPS Antenna Module to GPS Receiver Module

Step 5: Insert the SD Memory Card

All data recording in the receiver is done on a removable SD Memory Card that is installed in the GPS Receiver Module. The SD Memory Card slot is located inside the small compartment found on the front panel. To access the card slot, unscrew the two thumbscrews that secure the door, and open the door.

To ensure that you are comfortable with both installing and removing the SD Memory Card, perform both procedures.

Installation

To install the SD Memory Card into the slot, orient it so that the card label is facing to the right as shown in Figure 3.5. Gently push the card into the slot until you feel a soft 'click'. The click indicates that the card is properly seated. A correctly inserted SD Memory Card should not move once you have removed your hand from the card.



Figure 3.5 SD Memory Card Installation

Removal

To remove the SD Memory Card from the card slot, gently push the card until you feel a soft 'click', then release the card. The SD Memory Card should pop out of the slot enough that it can be easily removed. Do not force or tug on the card. If the card does not come out easily, repeat the procedure.

Step 6: Turn the System ON

Once the various modules are connected, the system is ready to be powered on. Power on the system by pressing the Power button on the receiver front panel for 2 seconds then release the Power button.

During the 2-second period, the LEDs will be solid (not blinking) green. Once the Power button is released, the SV/Power LED should begin to blink red once per second to indicate that the receiver is powered up.

CAUTION

It is important to power off the receiver using the Power key on the Front Panel before removing the SD card.

Step 7: Initialize the Receiver

It is a good practice to initialize the receiver prior to operating it for the first time. A receiver initialization (also called a memory reset) will clear the internal memory, reset the user settings to their default values, clear ephemeris and almanac information in memory, and reformat the SD card. A receiver can be initialized from either the front panel LED display or the Power button.

Receiver initialization using the Front Panel User Interface:

When using the front panel to initialize the receiver, parameters will be reset to default values, ephemeris and almanac information will be cleared, but the SD card will not be reformatted.

1. Press the UP arrow button (G) until the submenu SETTINGS is seen on the display.
2. Press the Enter button (←) to enter the SETTINGS submenu.
3. Press the UP arrow button (G) until the function MEMORY RESET is seen on the display.
4. Press the Enter button (←) to initiate a Memory Reset (initialization). The query "Reset memory?" will be displayed on the screen. Press the ENTER button again to confirm or CANCEL to cancel.

Receiver initialization using the Power button:

When initializing the receiver using the power button, parameters will be reset to default values, ephemeris and almanac information will be cleared, and the SD card will be reformatted.

1. With the receiver powered OFF, press the Power button for at least 5 seconds.
2. The display will show "re-init", indicating the receiver is in the initialization process.
3. The initialization process will take several minutes depending on the size of the SD card. The front panel will continue to display re-init until the process is complete. When complete, the receiver will be powered on and in the normal state with the front panel displaying "SYSINFO" and the SD card is ready to use.

After a complete reset, the receiver does not have current information about where it is or where the GPS satellites are. If the GPS antenna has a reasonably good view to the sky, within a few minutes, the receiver should begin to track satellites and the SV/Power LED should blink green one or more times between each red blink. It will blink green once for each satellite that is being tracked.

Within 15 minutes of tracking a satellite, the receiver will acquire satellite almanac data that provides the location of all the GPS satellites in the sky. After almanac data is stored, acquisition of satellites and data recording should begin within 10-20 seconds of a power cycle.

Step 8: Monitor System Operations

With the receiver powered up and operational, several receiver functions can be quickly checked to get status information and ensure that everything is working. Some of these functions are checked via the LEDs and some are checked using the front panel display. While Chapter 4 provides much more in-depth information regarding the front panel display and the menu tree, these quick step-by-step procedures will supply a quick tutorial to the Front Panel User Interface.

Power/Satellite Status

To verify that the power is on and all available satellites are being tracked:

1. Check the SV/Power LED.
2. It should blink RED once per second to indicate that power is on, and blink GREEN several times between each RED blink. It will blink once for each satellite that is being tracked. With the knowledge of how many satellites are visible, verify that all available satellites are being tracked. The number

of satellites visible can be determined with the Mission Planning module of the GNSS Studio software.

Data Recording

To verify that data is being recorded to the SD Memory Card:

1. Check the Data Log LED.
2. Within 5 minutes of the completion of an initialization, the Data Log LED should blink green once every 20 seconds, indicating that data is being recorded to the SD Memory Card at the default rate of once every 20 seconds. If the Data Log LED is not blinking or is solid red check the memory status menu.

Memory/Battery Status

To check for remaining memory and battery time available:

1. If the front panel display is in sleep mode (nothing is displayed) press any of the display control buttons.
2. If SYSINFO is not displayed, press the up arrow button (C) until the submenu SYSINFO is visible on the Display.
3. Press the Enter button (↵) to enter the SYSINFO submenu.
4. Press the up arrow button (G) to scroll through the options until the function MEM: **% is seen on the Display. The MEM function displays the memory left on the SD Memory Card as a percent of the total memory.
5. Press the up arrow button (G) until the function BAT: **min is seen on the Display. The BAT function displays the amount of battery time left in minutes.
6. Press the Cancel button (K) to return to the top level of the menu tree.

NOTE: After the receiver is powered on, the battery information is analyzed for 60 seconds before it is reported to the front panel display. During this initialization period the time remaining will report 0 minutes.

If the SV/Power LED or the Data Log LED does not behave as expected, check the following:

- If the SV/Power LED is not blinking at all, verify that Power Module is charged and is securely connected to the GPS Receiver Module.
- If the SV/Power LED is blinking red every 1-2 seconds but not blinking green even after several minutes, verify that the GPS Antenna Module is securely connected, and that the antenna has a clear view to the sky.
- If the Data Log LED is not blinking green every 20 seconds, verify that the SD Memory Card is correctly installed, and is not full.
- Check the front panel display for any warning messages. Warning messages are described in [Table 4.6](#) on page [88](#).

Receiver Position

To check that the receiver is computing a position:

1. If the front panel LED display is in sleep mode (nothing is displayed) press any of the display control buttons.
2. Press the up arrow button (G) until the submenu SURVEY:STATIC is visible on the Display.
3. Press the Enter button (↵) to enter the SURVEY:STATIC submenu.
4. Press the up arrow button (G) until the submenu STATUS is seen on the Display.
5. Press the Enter button (↵) to enter the STATUS submenu.
6. Press the up arrow button (G) until the following scrolls across the screen:
LAT:N/S ** ** *.*** LON: E/W *** ** *.***** ALT: **.*** .**
7. This position is the current computed position of the Z-Max in degrees/minutes/seconds of latitude and longitude, and the height above the ellipsoid in meters. Verify that this position is close to your current position.
8. Press the Cancel button (K) twice to return to the top level of the menu tree.

Step 9: Setting and Saving Receiver Parameters (optional)

The receiver has a number of user parameters that can be changed. Many of these parameters are available via the Front Panel User Interface, while others are only available via the serial port. User parameters affect data recording, position computation, file management, and receiver configuration,

along with many others. A list of the most common parameters may be seen in Appendix B.

Ordinarily, receiver parameters that have been changed will return to their default status after a power cycle. However, the front panel display has a function that allows you to save changed receiver settings so that they will remain at their new values even after a power cycle. Perform the following steps to save receiver settings:

1. If the front panel LED display is in sleep mode (nothing is displayed) press any of the display control buttons.
2. From the main menu press the up arrow button (G) until the submenu SETTINGS is visible on the Display.
3. Press the Enter button (↵) to enter the SETTINGS submenu.
4. Press the up arrow button (G) to scroll until the function SAVE is seen on the Display.
5. Press the Enter button (↵) to initiate parameter saving. The message "Save settings?" will be displayed.
6. Press the Enter button (↵) to confirm the action.
7. Press the Cancel button (K) to return to the top level of the menu tree.

The user-changed parameters are now stored to memory and will not be lost after a power cycle.

There are 3 ways to restore the parameters back to default values via the front panel:

- Perform a parameter reset from the front panel display. The SETTINGS submenu has an option called RESET TO FACTORY DEFAULTS. This will reset all changed user parameters to default values.
- Perform a receiver initialization via the front panel display as described in **Step7 - Initialize the Receiver** (page 37). (Note that this will also clear almanac and ephemeris information from memory and reformat the SD card).

Perform the following steps to reset parameters from the front panel:

1. If the display is in sleep mode (nothing is displayed) press any of the buttons.
2. From the main menu press the up arrow button (G) until the submenu SETTINGS is visible on the Display.
3. Press the Enter button (↵) to enter the SETTINGS submenu.
4. Press the up arrow button (G) until the function RESET TO FACTORY DEFAULTS is seen on the Display.
5. Press the Enter button (↵) to initiate a parameter reset. The message "Reset to factory defaults?" will be displayed.
6. Press the Enter button (↵) to confirm the action. Parameters are now reset to their default values.
7. Press the Cancel button (K) to return to the top level of the menu tree.

Congratulations! The Z-Max Surveying System should be tracking satellites and recording satellite measurements into its internal SD card. It may not seem like much, but tracking a signal no stronger than small light bulbs from 20,000 km in space and calculating your position on the face of the Earth is impressive. Tracking satellites and recording measurements is the first step in the process of learning about GPS and the first step in learning how the Z-Max system can be used to dramatically improve the efficiency and profitability of surveying work.

Operation

This chapter provides a more detailed description of how to operate the front panel user interface, graphically displays the front panel menus and submenus, and defines each parameter available via the front panel. This chapter also provides information on common receiver operations such as data recording, downloading the data, and the front panel warning messages.

Front Panel User Interface

General

The Front Panel User Interface allows you to monitor and control many receiver parameters and functions. The display is an 8-character scrolling alphanumeric LED screen and control keys that allow you set receiver parameters, configure the receiver to perform different types of surveys and to monitor system status during operation. The front panel user interface is also used to show equipment status messages and warnings that are automatically generated by the Z-Max.

All functions in the Front Panel User Interface are organized in a menu tree (Figure 4.2 on page 48). The menus are displayed in the Front Panel User Interface and controlled by the 4 control keys (Figure 4.1). The functions in the menu tree are covered in great detail in the Menus section, page 47. Note that although the Z-Max is powered on, the display may not be active. If no keys are pressed for more than 20 seconds, the front panel user interface will shut down to save power. Press any control key to restore the display to its original state before it shut down.

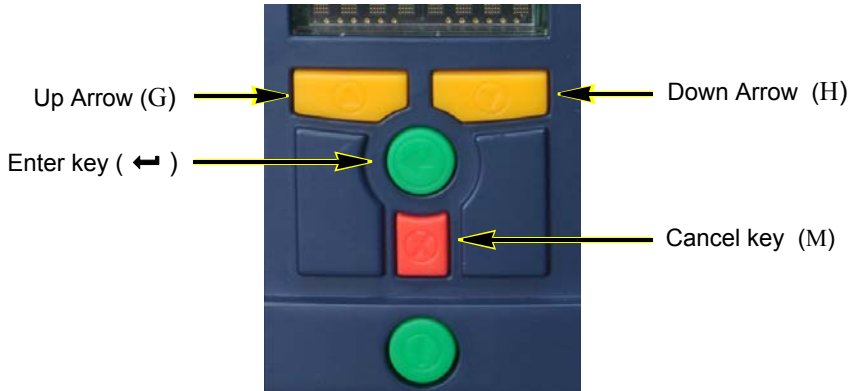


Figure 4.1 Control Keys

When GPS measurements are being collected or when surveys are being performed, data is automatically stored in the Z-Max memory. Therefore, there are no additional steps required to save information collected during a survey. Operational parameters control how the Z-Max operates and collects data. Operational parameters, including recording interval and antenna height, entered or modified by the user with the Front Panel User Interface will not automatically be saved to memory after a power cycle unless they are explicitly saved. The operational parameters of the Z-Max are saved as a group in one step. Go to the SETTINGS submenu and select the SAVE option to save operational parameters to memory. If the operational parameters of the Z-Max are not explicitly saved, the unit will revert to factory defaults or the last saved parameter set after a power cycle.

By default, the receiver will emit a beep every time a control key is pressed. To disable this beep, go to the SETTINGS menu, and scroll to the BEEP submenu, and select OFF. Be aware that the beep is used as an audible alert for many types of messages and warnings. Disabling the BEEP will disable the audible warnings as well.

Control Keys

The Front Panel User Interface is accessed using the 4 control keys located on the front panel of the Z-Max GPS Receiver Module: the G (up arrow), the H (down arrow), **↵** (enter), and M (cancel). The UP and DOWN arrow key are yellow, the ENTER key is green, and the CANCEL key is red. The control keys provide access to all the functionality of the display including moving within the menu tree, selecting available parameters, and entering letters or numbers like a keypad. The keys will work differently depending upon whether the screen is in Display mode or Edit mode. In **Display** mode, the screen does not contain any parameters that are changeable. The UP/DOWN keys are used to scroll forwards and backward within a submenu level. The ENTER/CANCEL keys are used to move to a lower level submenu or up to a higher level. In **Edit** mode, the keys are used either to scroll through and select from a parameter list, or as a keypad to enter letters or numbers into a parameter field that requires either alpha or numeric input.

For example, the LED screen is initially at the top level of the menu tree (see Figure 4.2) and is in display mode. Pressing the G (up arrow) key will scroll through the submenus SYSINFO, SURVEY:mode, SURVCONF, SESSION, SETTINGS, and COM OPTN. Pressing the H (down arrow) key will scroll through the same submenus, but backwards. If you stop when the display reads "SETTINGS", you are now at the entry point for the SETTINGS submenu. Press the **↵** (ENTER) key, and you move down one level into the SETTINGS submenu. Pressing the G(up arrow) key will scroll through the available functions in the SETTINGS submenus: MEMORY RESET, RESET TO FACTORY DEFAULTS, etc. Holding the UP or DOWN arrow keys for 3 seconds will initiate fast scrolling. Use fast scrolling when you have a large list of items to scroll through. To perform a function in the SETTINGS submenu, press the **↵** (ENTER) key. To return to the top level, press the K (CANCEL) key.

The control keys functions in Display mode are described in Table 4.1. The control key functions in Edit mode are described in Table 4.2.

Table 4.1. Display Mode Control Buttons

Button	Operation
G (UP arrow)	Scrolling menu (at same level): forward
H (DOWN arrow)	Scrolling menu (at same level): backward
↵ (ENTER)	Select and move down to next level
K (CANCEL)	Return to upper level

Table 4.2 Edit Mode Control Buttons

Button	Operation
G (UP arrow)	Keypad: scroll forward through characters Parameter list: scroll forward
H (DOWN arrow)	Keypad: scroll backward through characters Parameter list: scroll backward
G (UP arrow) H (DOWN arrow) Hold for 3 seconds	Fast scrolling forward (G) or backward (H)
← (ENTER)	Keypad: accept character and move to next space Parameter list: select parameter
K (CANCEL)	Keypad: delete last edited character, stay in Edit mode Parameter list: move from Edit mode to Display mode without selecting the parameter

Using the Control Keys to Enter Alphanumeric Data

When the Front Panel User Interface is in Edit mode for a parameter that requires a word, letter, or number to be entered, the control keys are used to select and enter alphanumeric characters. When you select (by pressing the ENTER key) a parameter that requires character entry, the front panel user interface will automatically go into Edit mode, and the control keys will now control which number or character can be entered.

When the Front Panel User Interface is in Edit mode, the cursor starts at the first character position and blinks to indicate that this character is active. Use the UP/DOWN keys to scroll through the available characters. (Use the fast scrolling to move quickly through a long character list.) When the desired character appears, press the ENTER key to select it. The cursor will shift to the next character position and will again blink to indicate that this character is now active. Continue entering characters in this way until the field is complete. If you press the ENTER key when the cursor is on the last character, the Display will accept the changes, leave Edit mode and display the new parameter value of the parameter.

If the character has been entered incorrectly, press the CANCEL key and the cursor will backspace one character. If you backspace when the cursor is at the first character, the Display will cancel any changes to the field, leave Edit mode, and will display the original value of the parameter.

Menus

All of the functionality of the Front Panel User Interface is organized into a multiple-level menu tree. The menu tree is used to access all the available functionality. Use the control keys described above to move around inside the menu tree and to set and enter parameters.

Main Menu

Figure 4.2 depicts the main menu tree for the Front Panel User Interface. When the Z-Max is first powered up, the front panel user interface is at the top level of the menu tree. From the top level, the six main submenus are accessible: SYSINFO, SURVEY:mode, SURVCONF, SESSIONS, SETTINGS and COM OPTN. Table 4.3 describes the six main submenus of the main menu tree. Scroll to one of the six main submenus by using the UP or DOWN control key. Move down into one of the submenus by pressing the ENTER key. Once into a submenu, you have access either to the functions available at that level, or to additional submenus.

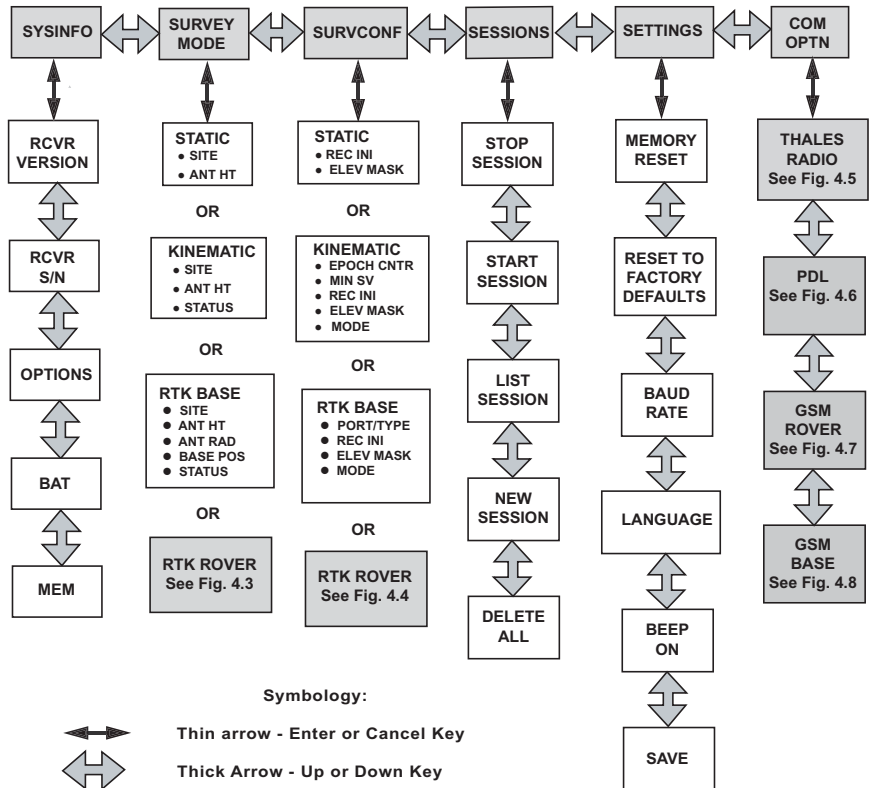


Figure 4.2 Front Panel User Interface Main Menu Tree

Table 4.3. Main Menu Submenus

Submenu Name	Category	Description	Page
SYSINFO	System Information	Basic information about the receiver and battery/memory status	50
SURVEY: <i>mode</i>	Survey parameters and status	Site parameter settings and survey status information for static, kinematic, RTK base and rover survey modes.	51
SURVCONF	Survey Configuration	Select survey type and set general parameters for static, kinematic, RTK base and rover survey modes.	60
SESSIONS	Session and file management	Start/stop the current session, start a new session, output a session list, and delete all sessions in memory.	66
SETTINGS	Receiver Control settings	General receiver parameter settings.	67
COM OPTN	Communication Options	Configure the Communications Module or external communications device.	68

In the following sections, each of the six main submenus will be explained in detail, with each available function, option and parameter defined and described. Some of the submenus have submenus of their own. The submenus for RTK ROVER and all of the COM OPTN submenus require separate submenu trees. These submenu trees are shown in Figures 4.3 - 4.8.

NOTE: The units of measure are always in meters.

System Information (SYSINFO)

The SYSINFO menu displays basic receiver information such as serial number, options and version and receiver power and memory status. To enter SYSINFO from the top level, use the UP/DOWN keys until 'SYSINFO' is displayed and press ENTER. Use the UP/DOWN keys to display the following parameters.

- **Receiver Software Version Number (VER: ****)**
Version of the firmware installed within the receiver.
- **Receiver Serial Number (S/N: *****)**
Serial number of the receiver.
- **Firmware Options. (Options: *****)**
A string that denotes the options enabled in the receiver. See the *Receiver Options* section in Chapter 1 for an explanation of the option codes.
- **Power Status (BAT:** min)**
Indicates the amount of power left in the Power Module. This value is expressed in minutes of remaining time left based upon the current rate of power consumption. If the Power Module is not connected, it will show 0 minutes. Power status does not apply to the external battery.
- **Memory Status (MEM: *** %)**
Displays the percentage of memory left on the SD memory card. Occasionally after a power cycle, the receiver file system will slow mount. This process takes several minutes and the field MEM will display xx%.

NOTE: The firmware version number, the receiver serial number and the firmware options are needed when contacting Technical Support.

Survey Parameters and Status (Survey:mode)

The SURVEY: *mode* menu is used to set site-specific survey parameters, execute surveys and view survey status parameters.

This menu tree is mode-dependent, meaning that the parameters displayed in this submenu are dependent on the type or mode of survey selected in the Survey Configuration (SURVCONF) screen. The default survey mode is STATIC. If a different survey mode is desired, enter the SURVCONF menu to select the desired survey mode and enter the initial parameters for that mode before returning to this menu and setting parameters. There are 4 possible modes:

- **Static (default)**
- **Kinematic**
- **RTK Base**
- **RTK Rover**

To enter this menu from the top level of the menu tree, use the UP/DOWN keys until 'SURVEY: mode' is displayed, then press the ENTER key. The parameters displayed and available will depend upon which survey mode has been set in the SURVCONF menu. Use the UP/DOWN keys to scroll through the following parameters.

SURVEY: STATIC

The parameters displayed in SURVEY: STATIC are the following:

- **Site ID (SITE: ****)**
Displays and sets the 4-character Site ID. To change the Site ID, press the ENTER key and use the control keys to enter the desired site name.
- **Antenna Height (ANT HT: **.**** m)**
Displays and sets the height of the antenna above the survey mark. To change the antenna height, press the ENTER key and use the control keys to enter the height. Valid range is from 0.00 - 64.0000 meters.
- **Vector Length (DESIRED VECTOR LENGTH: *** km)**
Not implemented in this release.
- **Survey Status (STATUS)**
This is the entry point to the submenu that displays the static survey status parameters. To enter this submenu, press the ENTER key and the following parameters are accessible:

▶ **Current Position**

(LAT: N/S ** ** *.**** LON:E/W *** ** *.**** ALT: ****.* m)

This field displays the computed latitude and longitude in degrees, minutes, and seconds, and the computed height above the ellipsoid in meters. The displayed position is either an autonomous or code-phase differential position.

▶ **PDOP (PDOP: **.*)**

Displays the PDOP value for the current satellite constellation.

▶ **Number of Satellites Used (#USED: **)**

Displays the number of satellites used in the position computation. If the elevation mask is the same as the position elevation mask, then this is also the number of satellites being recorded on the data card.

▶ **Time (CNT/GPS/UTC: **.**.**)**

This screen displays the current time and will show one of three types of time. CNT is the time since power up and is displayed until the receiver first locks onto a satellite. GPS is GPS time and is displayed between locking onto a satellite and until receiving UTC time corrections. UTC is UTC time.

SURVEY: KINEMATIC

The parameters displayed in SURVEY: KINEMATIC are the following:

- **Site ID (SITE: ****)**

Displays and sets the 4-character Site ID. To change the Site ID, press the ENTER key and use the control keys to enter the desired site name.

- **Antenna Height (ANT HT: **.**** m)**

Displays and sets the height of the antenna above the survey mark. To change the antenna height, press the ENTER key and use the control keys to enter the height. Valid range is from 0.00 - 64.0000 meters.

- **Survey Status (Status)**

This is the entry point to the submenu that displays the kinematic survey status parameters. To enter this submenu, press the ENTER key and the following parameters are accessible:

► **Current Position**

(LAT: N/S ** ** *.**** LON:E/W *** ** *.**** ALT: ****.*** m)

This field displays the computed latitude and longitude in degrees, minutes, and seconds, and the computed height above the ellipsoid in meters.

► **PDOP (PDOP: **.*)**

Displays the PDOP value for the current satellite constellation.

► **Number of Satellites Used (#USED: **)**

Displays the number of satellites used in the position computation. If the elevation mask is the same as the position elevation mask, then this is also the number of satellites being recorded on the data card.

► **Time (CNT/GPS/UTC: **.**.**)**

This screen displays the current time and will show one of three types of time. CNT is the time since power up and is displayed until the receiver first locks onto a satellite. GPS is GPS time and is displayed between locking onto a satellite and until receiving UTC time corrections. UTC is UTC time.

SURVEY: RTK BASE

The parameters displayed in SURVEY: RTK BASE are the following:

- **Site ID (SITE: ****)**

Displays and sets the 4-character Site ID. To change the Site ID, press the ENTER key and use the control keys to enter the desired site name.

- **Antenna Height (ANT HT: **.**** m)**

Displays and sets the height of the antenna above the survey mark. To change the antenna height, press the ENTER key and use the control keys to enter the height. Valid range is from 0.00 - 64.0000 meters.

- **Antenna Radius (ANT RAD: *.**** m)**

Displays and sets the radius of the antenna. To change this parameter, press the ENTER key and use the control keys to enter the radius . Valid range is from 0.00 - 9.9999 meters.

- **Entered Base Station Position (BASE POS)**

Entry point to the submenu that allows you to enter the known accurate base station position. To enter this submenu, press the ENTER key. The following fields are now accessible:

- ▶ **Latitude (LAT: N/S dd mm.mmmmmm)**
To enter the base station latitude, press ENTER and use the control keys to enter the latitude in degrees and decimal minutes.
- ▶ **Longitude (LON:E/W ddd mm mmmmmm)**
To enter the base station longitude, press ENTER and use the control keys to enter the latitude in degrees and decimal minutes.
- ▶ **Ellipsoidal Height (ALT: *****.** m)**
To enter the base station height, press ENTER and use the control keys to enter the ellipsoidal height in meters.
- ▶ **Set to current position. (HERE)**
HERE will set the base station position to the current computed position. To set this position, press ENTER. The query "Set Current Position to Base?" appears. Press ENTER to confirm or CANCEL to cancel.
- **Survey Status. (STATUS)**
This is the entry point to the submenu that displays the status parameters current position, PDOP, number of satellites, and time. To enter this submenu, press the ENTER key and the following parameters are accessible:
 - ▶ **Current Position**
(LAT: N/S ** ** **.***** LON:E/W *** ** **.***** ALT: *****.** m)

This field displays the computed latitude and longitude in degrees, minutes, and seconds, and the computed ellipsoidal height meters. The displayed position is either an autonomous or code phase differential position.
 - ▶ **PDOP (PDOP: **.*)**
Displays the PDOP value for the current satellite constellation.
 - ▶ **Number of Satellites Used (#USED: **)**
Displays the number of satellites used in the position computation. If the elevation mask is the same as the position elevation mask, then this is also the number of satellites being recorded on the data card.
 - ▶ **Time (CNT/GPS/UTC: **.**.**)**
Displays the current time and will show one of three types of time. CNT is the time since power up and is displayed until the receiver first locks onto a satellite. GPS is GPS time and is displayed between locking onto a satellite and until receiving UTC time corrections. UTC is UTC time.

SURVEY: RTK ROVER

The menu tree for the RTK rover is shown in Figure 4.3.

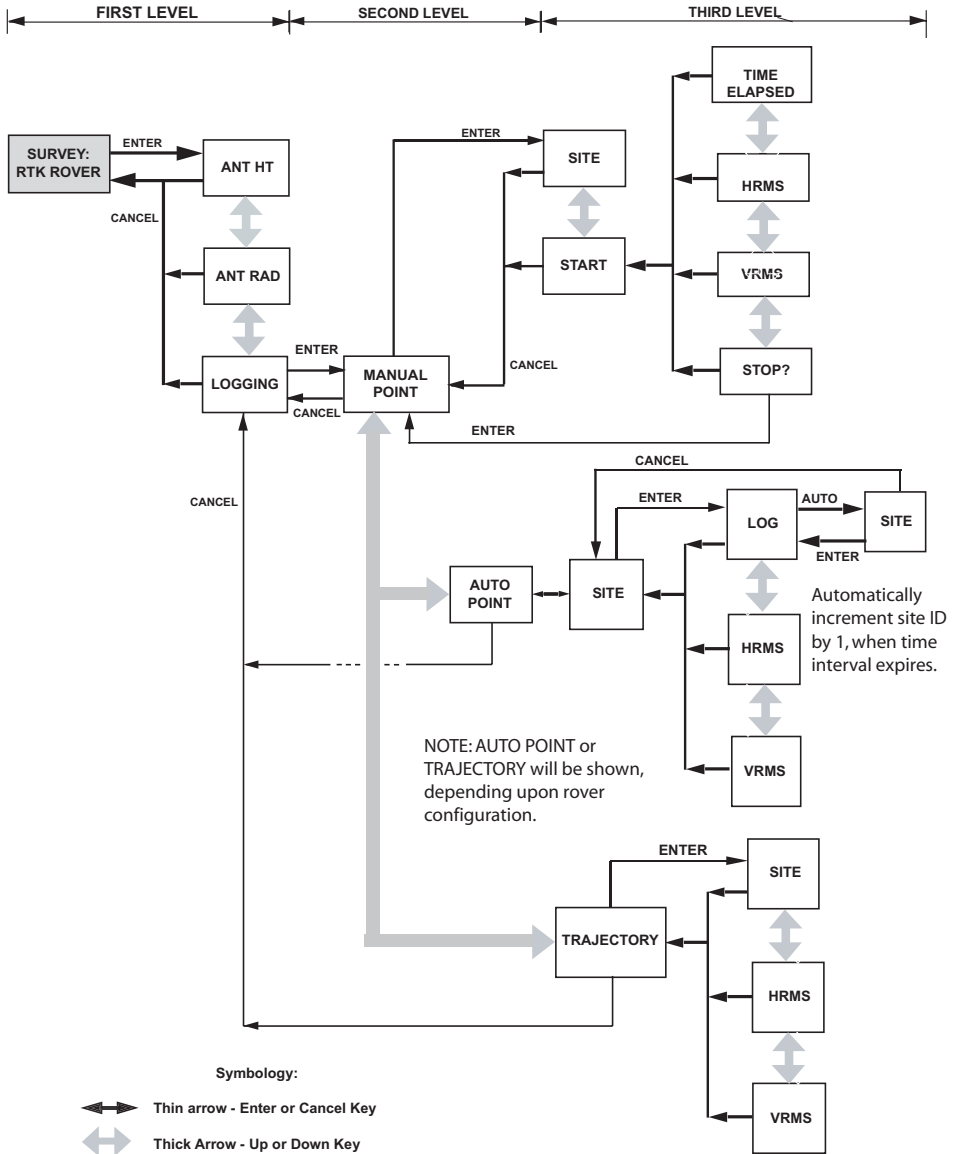


Figure 4.3 Survey: RTK Rover Menu

There are many parameters used to configure the RTK Rover. To improve useability, the RTK Rover menu tree has been broken up into three levels. **Level 1** sets the antenna parameters, **level 2** selects between manual or auto/trajectory data logging, and **level 3** accesses the parameters particular to the selection made in level 2. Some of the parameters in **level 3** are mode-dependent, meaning that the parameters displayed will depend upon the parameters that were selected in the Survey Configuration (SURVCONF) menu.

Each level will be described separately.

1st Level

The top level parameters displayed are the following:

- **Antenna Height (ANT HT: **.**** m)**
Displays and sets the height of the antenna above the survey mark in meters. Valid range is from 0.00-64.0000 meters. To change this parameter, press the ENTER key. The default is 0.0 meters.
- **Antenna Radius (ANT RAD: *.**** m)**
Displays and sets the radius of the antenna in meters. Valid range is from 0.00-9.9999 meters. To change this parameter, press the ENTER key.
- **Entry to Logging submenu (LOGGING)**
Entry point to the second level of submenus. Press the ENTER key to reach the 2nd level submenu.

2nd Level

The 2nd level submenu allows you to select between MANUAL and AUTO POINT if the Auto Point option was selected as the LOG TYPE in the SURVCONF menu, or between MANUAL and TRAJECTORY if the Trajectory option was selected as the LOG TYPE in the SURVCONF menu. Selecting one of these options in the 2nd level will take you automatically to the 3rd level. To enter the third level, use the UP/DOWN control keys to select the desired RTK logging type and press ENTER. This selection will take you to the 3rd level.

- **Manual Logging (MANUAL POINT)**
Entry point to the submenus to set manual logging parameters and to execute a Manual Point RTK survey. In a Manual Point survey, the user sets the site name and monitors the elapsed time to determine when to end the site occupation. To enter this level, press the ENTER key.
- **Automatic Logging (AUTO POINT)**
Entry point to the submenus to set automatic logging parameters and to execute an AUTO POINT RTK survey. In an AUTO POINT survey, the user

sets an initial site name and a 'time to stay;' parameter in the Survey Configuration menu (SURVCONF). The receiver will collect data on each point based on the 'time to stay' parameter and automatically increments the Site ID by 1 at the end of the occupation. To enter this level, press the ENTER key.

NOTE: The Site ID will automatically increment only if the last character is numeric.

- **Trajectory Logging (TRAJECTORY)**

Entry point to the submenus to set trajectory logging parameters and to execute a TRAJECTORY RTK survey. In Trajectory logging, the receiver will compute RTK positions each time an interval of a certain distance has been traversed. The Site ID will automatically increment each time RTK data is logged to the receiver. The Distance Interval parameter is set in the Survey Configuration menu (SURVCONF).

NOTE: The Site ID will automatically increment only if the last character is numeric.

3rd Level

The third level parameters allow you to set survey parameters, execute the survey, and monitor accuracy for the type of data logging selected in level 2. Only the parameters applicable to that logging type will be displayed. The possible data logging modes are: AUTO POINT, MANUAL POINT, and TRAJECTORY.

MANUAL POINT

- **Site ID (SITE: ****)**

Displays and sets the 4-character Site ID. To change the Site ID, press the ENTER key and use the control keys to enter the desired site name.

- **Start Logging (START)**

Initiates data logging at the site entered in the above Site ID field. Also, the entry point to monitor accuracy parameters and to stop data logging. Press the ENTER key to start data logging. The following parameters will be available by using the UP/DOWN keys:

- ▶ **Time Elapsed (TE: ***s)**

Displays the amount of time in seconds elapsed since data logging began. The field will display up to 9999 seconds of data logging. This field will not increment if no SD card is inserted.

- ▶ **HRMS (HRMS: *.***m)**
Displays the horizontal RMS value (in meters) computed during data logging. RMS is an estimate of the 1-sigma position accuracy. This field will display up to 99.999 meters.
- ▶ **VRMS (VRMS: *.***m)**
Displays the vertical RMS value (in meters) computed during data logging. RMS is an estimate of the 1-sigma position accuracy. This field will display up to 99.999 meters.
- ▶ **Stop Data Logging (STOP?)**
Press the ENTER key to stop manual data logging. The query "Stop data logging?" will appear. Press ENTER to confirm or CANCEL to cancel. If data logging is stopped, the display will jump back to level 2.

AUTO POINT

- **Site ID (SITE: ****)**

Displays the current setting of the 4-character Site ID. To change the Site ID and begin data logging, press the ENTER key and use the control keys to enter the Site ID.

Once the Site ID is entered, data will automatically log for the duration of the Time To Stay field set in the SURVCONF menu. Data will only be logged if the receiver is computing "fixed" RTK positions (the RTK SOL LED is blinking green). While logging is in progress, data can be monitored with the LOG, HRMS, and VRMS parameters described below.

When logging at this site is complete, the Site ID field will automatically increment by 1 (if the last character is numeric) and display the new Site ID. Data logging resumes when the ENTER key is pressed.

- ▶ **Data Logged (LOG: ***s)**
Displays the amount of data logged in seconds. When this value reaches the 'Time To Stay' value set in the SURVCONF submenu, the incremented Site ID will be displayed. This field will not increment if no SD card is inserted.
- ▶ **HRMS (HRMS: *.***m)**
Displays the horizontal RMS value (in meters) computed during data logging. RMS is an estimate of the 1-sigma position accuracy. This field will display up to 99.999 meters.

► **VRMS (VRMS: *.***m)**

Displays the vertical RMS value (in meters) computed during data logging. RMS is an estimate of the 1-sigma position accuracy. This field will display up to 99.999 meters.

TRAJECTORY

● **Site ID (SITE: ****)**

Displays and sets the 4-character Site ID. To log data, press ENTER and input a Site ID. Data will be collected at every interval equal to the Distance Interval parameter set in the Survey Configuration (SURVCONF) submenu. If the last character of the Site ID is numeric, the Site ID will increment each time data is logged to the receiver.

● **HRMS (HRMS: *.*** m)**

Displays the horizontal RMS in meters during data logging. RMS is an estimate of the 1-sigma position accuracy.

● **VRMS (VRMS: *.*** m)**

Displays the vertical RMS in meters during data logging. RMS is an estimate of the 1-sigma position accuracy.

Survey Configuration (SURVCONF)

In the SURVCONF menu, you select the desired survey mode and set initial survey parameters. There are four possible survey modes:

- **Static**
- **Kinematic**
- **RTK Base**
- **RTK Rover**

To select a survey mode from the top level, press the ENTER key to enter the SURVCONF menu and use the UP or DOWN control keys until MODE is displayed on the screen. Press ENTER again and use the UP or DOWN control keys until the desired mode is displayed. Press ENTER to select that mode.

Once the desired survey mode is selected, only the parameters relevant to that choice will be available. Access these parameters by using the UP/DOWN control keys. Complete the survey set up procedure by going to the SURVEY: *mode* menu. Note that certain choices made in the SURVCONF screen will affect what parameters and options are available in the SURVEY: *mode* menus.

SURVCONF:STATIC

- **Recording Interval (REC INI: *.*s)**
Displays and sets the data recording interval. To change this parameter press the ENTER key and use the control keys to enter the desired value in seconds. The default is 20 seconds. The valid range is 0.2 - 999 seconds.
- **Elevation Mask (ELEV MASK: **)**
Displays and sets the data collection elevation mask. To change this parameter press the ENTER key and use the control keys to enter the desired value in degrees. The default is 10 degrees.
- **Mode (MODE: STATIC)**
Displays and sets the selected survey mode. Change the survey type by pressing the ENTER key and use the UP/DOWN control keys to choose the desired survey mode. Press ENTER to select it. The mode selected will determine the parameters displayed.

SURVCONF: KINEMATIC

- **Epoch Counter (EPOCH COUNTER: ***)**

Displays and sets the value of the epoch counter. The epoch counter is the number of epochs that will be recorded at each point every recording interval. When the epoch counter counts down to 0, the Site ID (SITE) is automatically reset to question marks ("????"). Reset the epoch counter by entering a new Site ID. To change this parameter, press the ENTER key, use the control keys to enter a value and press ENTER to select it.

- **Minimum Number of Satellites (MIN SV: *)**

Displays and sets the minimum number of satellites required to perform a kinematic survey. If the number of locked satellites falls below this number, the receiver will issue a warning message and an alarm (beep) indicating that you must return to the last known point. To change this parameter, press the ENTER key, use the control keys to enter a value, and press ENTER to select it. The default is 0 (alarm disabled).

- **Recording Interval (REC INI: *.*s)**

Displays and sets the data recording interval. To change this parameter press the ENTER key and use the control keys to enter the desired value in seconds. The default is 20 seconds. The valid range is 0.2 - 999 seconds.

- **Elevation Mask (ELEV MASK: **)**

Displays and sets the data collection elevation mask. To change this parameter press the ENTER key and use the control keys to enter the desired value in degrees. The default is 10 degrees.

- **Mode (MODE: KINEMATIC)**

Displays and sets the selected survey mode. Change the survey type by pressing the ENTER key and use the UP/DOWN control keys to choose the desired survey mode. Press ENTER to select it. The mode selected will determine the parameters displayed.

SURVCONF:RTK BASE

- **Port and Type (PORT/TYPE)**

Displays and sets the RTK data link port and data type. The receiver will transmit the selected data type via the selected port. The data link (radio or GSM) must be connected to this port.

To set the port and data type, press ENTER. The cursor will blink on the port field, indicating that this field is active. Use the UP/DOWN control keys to scroll to the desired port. Press ENTER, and the cursor shifts to the data type field. Use the UP/DOWN control keys to scroll to the desired data type, and press ENTER to select it. Possible data types are:

DBEN: Proprietary compact binary format

RTCM: RTCM type 18/19 and 3/22 are enabled

CMR: Compact Measurement Record (CMR) format

OFF: No RTK base station data is output.

- **Recording Interval (REC INI: *.*s)**

Displays and sets the data recording interval. To change this parameter press the ENTER key and use the control keys to enter the desired value in seconds. The default is 20 seconds. The valid range is 0.2 - 999 seconds.

- **Elevation Mask (ELEV MASK: **)**

Displays and sets the RTK data elevation mask. To change this parameter press the ENTER key and use the control keys to enter the desired value in degrees. The default is 10 degrees.

- **Mode (MODE: RTK BASE)**

Displays and sets the selected survey mode. Change the survey type by pressing the ENTER key and use the UP/DOWN control keys to choose the desired survey mode. Press ENTER to select it. The mode selected will determine the parameters displayed.

SURVCONF:RTK ROVER

The Survey Configuration menu tree for the RTK rover is shown in Figure 4.4.

The Survey Configuration RTK Rover submenu provides access to the more general RTK parameters such as data port, data type and the RTK positioning algorithm. Parameters selected in this menu will affect what parameters are available in the SURVEY: RTK Rover menu.

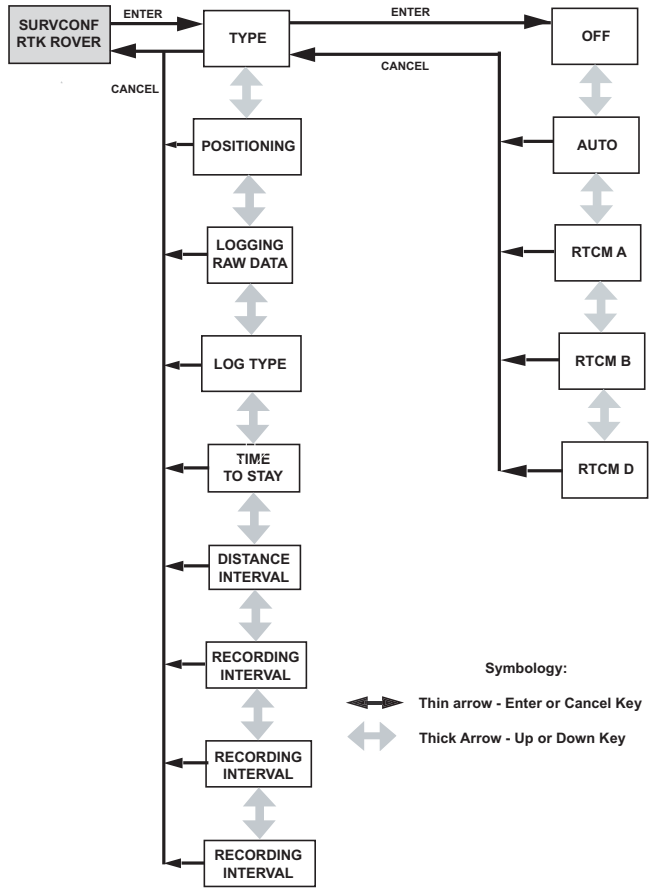


Figure 4.4 SURVCONF: RTK Rover Menu

The parameters available in this submenu are the following:

- **Data Type and Port (TYPE: ****)**

This parameter displays and sets the RTK data type and port. To change this parameter, press the ENTER key and use the UP/DOWN control keys to choose the desired port and type. Press ENTER to select it. The possible settings are:

OFF: RTK rover mode is off.

AUTO: Will automatically detect CMR, CMR+, DBEN, or DSNP format on any port.

RTCM A - RTCM D: RTCM format on port A, B, or D.

- **RTK Positioning Algorithm (POSITIONING:)**

Displays and sets the RTK positioning algorithm. COARSE outputs Fast RTK positions. FINE outputs time-tagged RTK positions. The default is COARSE. To change the setting, press the ENTER key and use the control keys to select the desired algorithm.

- **Log Raw Data (LOGGING RAW DATA:)**

Display and sets raw data collection status. ON will log raw data (B, E, and S files) along with the epoch solution file (CBEN data) and the vector solution file (OBEN file). OFF will log the CBEN and the OBEN files only. The default is ON. To change this setting, press the ENTER key and use the control keys to select ON or OFF and press ENTER.

- **RTK Logging Method (LOG TYPE:)**

Displays and sets the method of RTK logging. The options are Auto Point (AUTO PT) and Trajectory (TRAJECT). Select AUTO PT if you wish to occupy points for a set period of time. Select TRAJECT if you are collecting data at set distance intervals. The default is AUTO PT. To change the setting, press the ENTER key.

- **Time on point (TIME TO STAY: *** s)**

Visible only if LOG TYPE is set to AUTO PT. This parameter defines how long each point will be occupied in seconds. Valid interval is 0 - 999 seconds. The default is 10 seconds. To change this parameter, press the ENTER key.

- **Distance interval (DISTANCE INTERVAL: *.* m)**

Visible only if LOG TYPE is set to TRAJECT. This parameter sets the distance interval between point computation during a trajectory survey. Valid

range is 0.0 - 999.9 meters. The default is 0.0 meters. To change this parameter, press the ENTER key.

- **Recording Interval (REC INI: *.*s)**

Displays and sets the data recording interval. To change this parameter press the ENTER key and use the control keys to enter the desired value in seconds. The default is 20 seconds.

- **Elevation Mask (ELEV MASK: **)**

Displays and sets the RTK data elevation mask. To change this parameter press the ENTER key and use the control keys to enter the desired value in degrees. The default is 10 degrees.

- **Mode (MODE: RTK ROVER)**

Displays and sets the selected survey mode. Change the survey type by pressing the ENTER key and use the UP/DOWN control keys to choose the desired survey mode. Press ENTER to select it. The mode selected will determine the parameters displayed.

Session Control (SESSIONS)

The SESSIONS menu allows you to perform various actions related to file management including stop/start a session, list sessions in memory, create a new session, and delete one or more session files in memory. To get into SESSIONS from the top level, use the UP/DOWN keys until 'SESSIONS' is displayed, then press the ENTER key. Use the UP/DOWN keys to display the following functions and initiate an action by pressing the ENTER key.

- **Stop a session. (STOP SESSION)**

Stops the data recording during the current session. Should be done prior to removing the SD memory card. To stop a session, press the ENTER key. The query "Stop Session?" will appear on the display. Press ENTER to confirm or CANCEL to cancel.
- **Restart a session. (START SESSION)**

Restarts data collection during the current session. Must be done to continue data collection if a STOP SESSION has been performed. To restart a session, press the ENTER key. The query "Start Session?" will appear on the display. Press ENTER to confirm or CANCEL to cancel.
- **List/delete sessions in memory. (LIST SESSIONS)**

Lists all of the session files on the memory card in the order that they were recorded. Individual session files can be deleted by using the UP/DOWN control keys to select a file, and pressing the ENTER key. The query "Delete file?" appears. Press ENTER to confirm or CANCEL to cancel.
- **Create a new session. (NEW SESSION)**

Closes the current session file and opens a new file. To create a new session, press the ENTER key. The query "Create new session?" will appear on the display. Press ENTER to confirm or CANCEL to cancel.
- **Delete session files from memory (DELETE ALL)**

Deletes all of the session files on the memory card. To delete all data files, press the ENTER key. The query "Delete ALL sessions?" will appear on the display. Press ENTER to confirm or CANCEL to cancel.

Receiver Parameters Settings (SETTINGS)

The SETTINGS menu allows you to configure miscellaneous receiver settings such as baud rate, the beep, and the screen language, and perform receiver operations such as memory reset, restore factory defaults, and save set parameters. To get into SETTINGS from the top level, use the UP/DOWN keys until 'SETTINGS' is displayed, then press the ENTER key. Use the UP/DOWN keys to display the following parameters.

- **Reset memory. (MEMORY RESET)**

Memory reset will clear the internal memory. User settings will revert to their default values and the ephemeris and almanacs will be cleared. Press ENTER to initiate the reset. The query "Reset memory?" will be displayed. Press ENTER to confirm or CANCEL to cancel.

- **Restore defaults. (RESET TO FACTORY DEFAULTS)**

This function restores receiver parameters to their default values. Press ENTER to initiate the reset. The phrase "Reset to factory defaults?" will be displayed on the screen. Press ENTER to confirm, or CANCEL to cancel.

- **Serial port baud rate. (BAUD RATE)**

Displays and sets the baud rate for each port. Valid baud rates are 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200. The default for each port is 9600. To change a baud rate, press ENTER and use the UP/DOWN control keys to scroll through the current baud rate setting for each port. When the port of interest is displayed, press ENTER and use the UP/DOWN control keys to choose the desired baud rate for that port. Press ENTER to select it.

- **Set screen language. (LANGUAGE)**

Displays and sets the display language. This parameter affects the language for all display menus and submenus as well as the front panel warning messages. Five languages are available: English, French, German, Italian, and Spanish. To change the language, press the ENTER key and use the UP/DOWN control keys to select the desired language. Press ENTER to set the new language.

- **Enable/disable Beeper. (BEEP)**

Allows you to turn the receiver beeper on or off. Be aware that this will turn off the display beeper as well as any audible alarms issued during warning messages. To change the setting, press the ENTER key.

- **Save receiver parameters. (SAVE)**

Saves the current user parameter settings to memory. Saved parameters will not be lost when the receiver is powered cycled. To save parameters, press the ENTER key, the query "Save settings?" appears. Press ENTER to confirm or CANCEL to cancel.

Communication Options (COM OPTN)

The Communication Options menu allows you to configure the communications devices. Each communication device supported by Z-Max will have its own specific menu choice. The COM OPTN is used to configure both the radio in the Communication Module as well as an external radio connected to an external serial port. If the data link is not available, then you will not be able to configure it. To get into COM OPTN from the top level, use the UP/DOWN keys until 'COM OPTN' is displayed, then press the ENTER key. Use the UP/DOWN keys to display the four submenus. Enter each submenu by pressing the ENTER key.

COM OPTN: THALES RADIO

The Thales Radio menu is shown in Figure 4.5. To access the Thales radio menu from COM OPTN, use the UP/DOWN control keys until THALES RADIO is displayed, and press the ENTER key.

When the Thales radio submenu is entered, the PORT parameter is the first parameter displayed. From this level, all other Thales Radio parameters can be accessed using the UP control key. To move back to a previous menu item, press the DOWN control key. Pressing the CANCEL key from any of the submenus will exit the Thales radio submenu.

Note: it is recommended that you configure the parameters in the order in which they are displayed. In particular, you must load the radio parameters (LOAD) prior to sending user settings (PROGRAM).

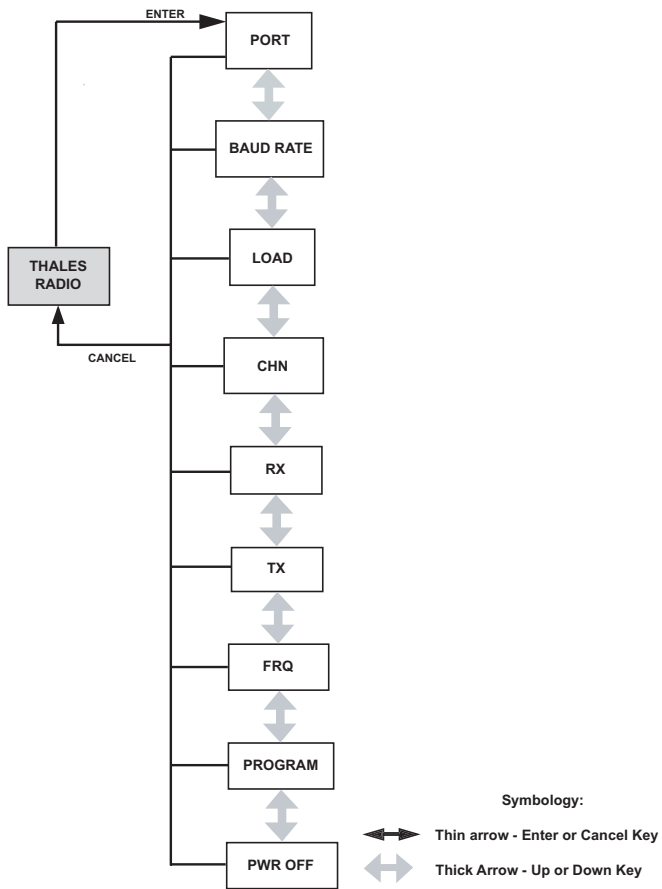


Figure 4.5 Thales Radio Menu

The Thales radio parameters are described in order as follows:

- **Radio serial port setting. (PORT)**

This is the serial port to which the radio is connected. Valid settings are B or D. Port D (default) is the internal port and must be selected if the Communication Module is being used. If an external Thales U-Link radio is used, the radio should be attached to serial port B. When this parameter is set to port B, the port protocol will be switched to RS-422 (required for Thales radios). Any other port selection will change the port B protocol to RS-232. To select a port, press ENTER to access the submenu, scroll to the desired port setting and press ENTER to select it.

- **Radio Baud Rate. (BAUD)**

This submenu sets the baud rate of the radio serial port. Valid baud rates are 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 56800, and 115200. The default is 19200 and should not be changed. To select the baud rate, press ENTER, scroll to the desired baud rate, and press ENTER to select it.

- **Load radio parameters to the receiver. (LOAD)**

Press the ENTER key to load Thales radio parameters to the receiver. This is done to ensure that any other active data links are fully turned off and the receiver is ready to use the Thales radio. Perform a LOAD before attempting to send user parameters (PROGRAM) to the receiver.

- **Channel selection. (CHN: **)**

Displays and sets the radio frequency channel number. Channel numbers range from 00 to 15 and each channel number is linked to a particular radio frequency set at the factory. To set the channel number, press ENTER and use the control keys to pick a channel number and press ENTER to select it.

- **Receive frequency. (RX: ***.****)**

Displays the receive frequency in MHz. This field will display the receive frequency matched to the channel number (CHN) parameter.

- **Transmit frequency. (TX: ***.****)**

Displays the transmitter frequency in MHz. This field will display the transmit frequency matched to the channel number (CHN) parameter.

- **Frequency (FRQ: ***.****)**

Displays the current receive/transmit frequency. This field is useful when the frequency cannot be found in the channel table, since in this case, both RX and TX will show 0. When the current frequency matched the channel table, RX or TX will be equal to FRQ.

- **Send user selected parameters to the receiver. (PROGRAM)**
Press the ENTER key to send your selected radio parameters (frequency, channel) to the receiver. Any errors in sending the parameters will trigger a warning message that will be displayed on the front panel.
- **Power off the radio. (PWR OFF)**
This is **NOT** a power status indication for the radio, but a function to turn off the radio in the Communication Module. It is required that the port needs to be set to D before entering this field. Press the ENTER key to power off the Thales radio.

COM OPTN: PDL RADIO

The PDL Radio menu is shown in Figure 4.6.

To access the PDL radio menu from COM OPTN, press ENTER and use the UP/DOWN keys until PDL is displayed. Press the ENTER key to enter the submenu.

When the PDL radio submenu is entered, the PORT parameter is the first parameter displayed. From this level, all other PDL radio parameters can be accessed by using the UP key. To move back to a previous menu item, press the DOWN key. Press CANCEL from any of the submenus to leave the PDL submenu.

When the PDL radio is in the Communication Module, the PORT and BAUD RATE settings should be left at the default settings of Port D and 19200 baud.

NOTE: It is recommended that you configure the parameters in the order in which they are displayed. In particular, you must load the radio parameters (LOAD) prior to sending user settings (PROGRAM).

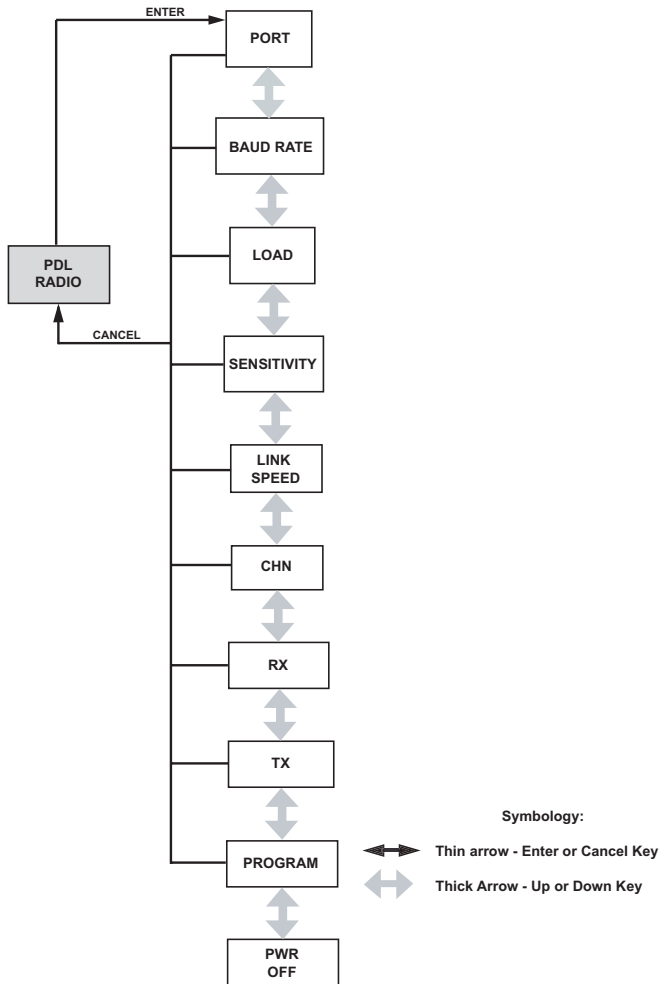


Figure 4.6 PDL Radio Menu

The PDL radio parameters are described in order as follows:

- **Radio serial port setting. (PORT)**

The PORT submenu sets the serial port to which the radio is connected. Port options are A, B, or D. The default is port D (the internal radio port) and should not be changed if using the Communication Module. To select a port, press ENTER to access the submenu, scroll to the desired port setting and press ENTER to select it.
- **Radio baud rate. (BAUD RATE)**

This submenu sets the baud rate of the radio serial port. Valid baud rates are 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200. The default is 19200 and should not be changed if using the Communication Module. To select the baud rate, press ENTER, scroll to the desired baud rate, and press ENTER to select it.
- **Load radio parameters to the receiver. (LOAD)**

Press the ENTER key to load PDL radio parameters to the receiver. This is done to ensure that any other active data links are fully turned off and the receiver is ready to use the PDL radio. Perform a LOAD before attempting to send user parameters (PROGRAM) to the receiver.
- **Radio sensitivity. (SENSITIVITY)**

This submenu sets the radio sensitivity. Options are LOW, MEDIUM, HIGH and OFF. Normal settings are LOW for the external transmitter and HIGH for the radio receiver. It is recommended that this parameter is never set to OFF. To select the sensitivity, press ENTER, scroll to the desired value and press ENTER to select it.
- **Link speed. (LINK SPEED)**

This submenu sets the radio link speed. Options are 4800, 9600, and 19200. The default is 9600. To select the link speed, press ENTER, scroll to the desired value and press ENTER to select it.
- **Channel selection. (CHN: **)**

Displays and sets the radio frequency channel number. Channel numbers range from 00 to 15 and each channel number is linked to a particular radio frequency set at the factory. To set the channel number, press ENTER, scroll to the desired channel number, and press ENTER to select it.
- **Receiver frequency. (RX: *.**)**

Displays the receiver frequency in MHz. This field will display the frequency matched to the channel number (CHN) parameter.

- **Transmit frequency. (TX: *.**)**
Displays the transmit frequency in MHz. This field will display the transmit frequency matched to the channel number (CHN) parameter.
- **Send user selected radio parameters to the receiver. (PROGRAM)**
Press the ENTER key to load your selected radio parameters (channel, sensitivity, link speed) to the receiver. Any errors in sending the parameters will trigger a message that will be displayed on the front panel.
- **Power off the radio. (PWR OFF)**
This is **NOT** a power status indication for the radio, but a function to turn off the radio Communication Module. The Port must be set to D before entering this field. Press the ENTER key to power off the PDL radio.

COM OPTN: GSM ROVER

The GSM Rover menu is shown in Figure 4.7.

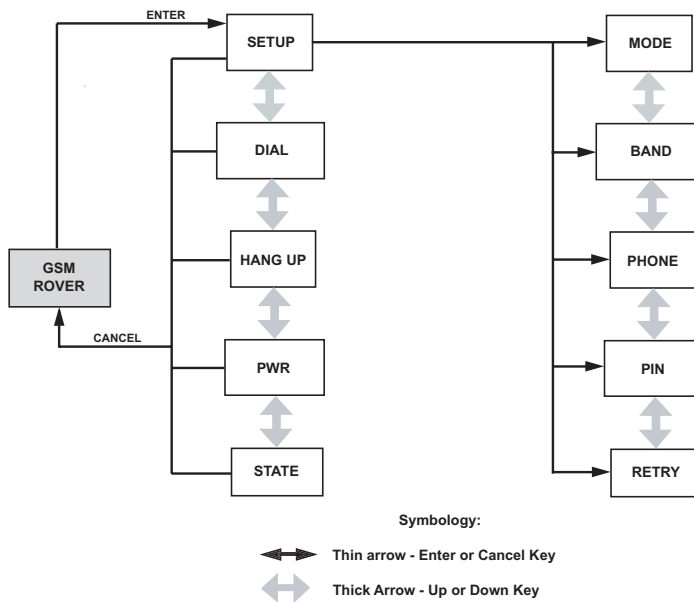


Figure 4.7 GSM Rover Menu

To access the GSM ROVER menu from COM OPTN, press ENTER and use the UP/ DOWN keys until GSM ROVER is displayed. Press the ENTER key to enter the submenu.

When the GSM Rover menu is entered, the SETUP submenu is the first submenu displayed. The SETUP submenu contains configuration parameters for the modem. To save these parameters to memory, perform a SAVE from the SETTINGS menu. From this SETUP submenu, all other GSM Rover functions can be accessed by using the UP key. To move back to a previous menu item, press the DOWN control key. To exit the GSM ROVER menu, press the CANCEL key from any of the submenus. The GSM ROVER parameters are described in order as follows:

- **Configure the GSM. (SETUP)**

This submenu is the entry point for the initial setup of the GSM modem. Press the ENTER key to access the following parameters:

- ▶ **Set MODE. (MODE:)**

Select either AUTO mode for the rover to call the base automatically, or MANUAL to manually dial the base receiver. To select the mode, press ENTER, scroll to the desired value and press ENTER to select it. The default is AUTO.

For the receiver to dial the base automatically, the modem must be turned on using the PWR parameter (see below) and CPD or RTCM rover mode must be enabled and set to the correct port.

- ▶ **Band setting. (BAND: ****)**

The band parameter sets the operable frequency band. In general, set this parameter to 1900 in North America or 900/1800 elsewhere, but verify this with your GSM service provider. To select the band, press ENTER to access the submenu, scroll to the desired value and press ENTER to select it.

- ▶ **Phone number. (PHONE: *****)**

This parameter sets the phone number of the base station GSM modem. The field will allow from 7-11 digits. To set the phone number, press ENTER and use the control keys to enter the number.

NOTE: Be sure to enter the phone number of the GSM modem you want to call (the base receiver modem), and not the number of the modem you are currently configuring.

- ▶ **PIN number. (PIN: ****)**

Sets the Personal Identification Number required to access the GSM modem SIM card. This number is provided by your service provider, and ranges from 4-8 digits. To set the PIN, press ENTER and use the

UP/DOWN control keys to enter the PIN number. If no PIN number is set in the SIM card then nothing is entered in this field.

- **Number of retries. (RETRY: **)**

This parameter sets the number of times the rover modem will attempt to redial the base modem before giving up. Valid values are from 0 to 15. To set the number of retries, press the ENTER key and use the control keys to enter a value. The default number of retries is 2.

- **Dial the base GSM modem. (DIAL)**

This parameter dials the base modem. To dial the base modem, press ENTER. A confirmation message "Dial base?" will appear. Press ENTER to confirm or CANCEL to cancel. The modem will dial the number entered in the SETUP submenu. While dialing, the STATE submenu (see below) will display "DIALING". When the connection has been established, the STATE submenu will display "ONLINE".

- **Disconnect the call. (HANG UP)**

Press ENTER to terminate the current connection to the base modem. The confirmation message "Disconnect call?" will appear. Press ENTER to confirm or CANCEL to cancel.

- **Power on/off the modem. (PWR: **)**

The PWR submenu is **NOT** a power status indicator for the GSM modem, but a submenu that allows you to power the modem on or off. The power must be turned on for the GSM modem to be used; AUTO mode will not automatically turn on the modem. Once the power is turned on the modem will automatically initialize to the carrier. To change the power status, press ENTER and scroll to either OFF or ON. Press ENTER to select it. The modem status can be monitored in the STATE submenu (see below).

- **GSM modem operational status. (STATE: **)**

Displays the current state of the GSM modem. Status values are:

GSM ON = power on

GSM OFF = powered off

GSM INITIALIZED = modem has been initialized

DIALING = dialing the base modem

ONLINE = powered on and connected to the base modem.

COM OPTN: GSM BASE

The GSM Base menu is shown in Figure 4.8.

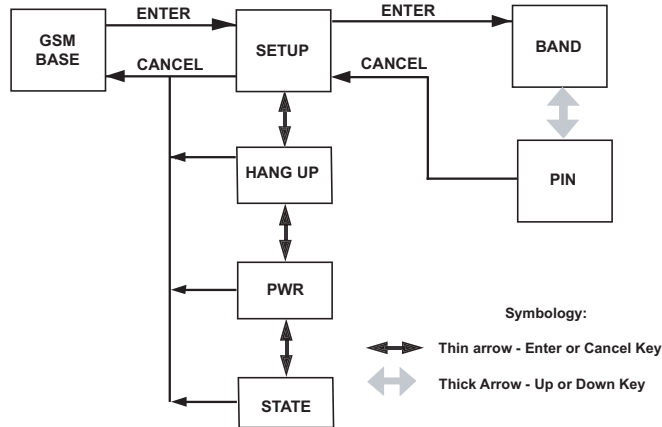


Figure 4.8 GSM Base Menu

To access the GSM BASE menu from COM OPTN, press ENTER and use the UP/DOWN control keys until GSM BASE is displayed. Press the ENTER key to enter the menu.

When the GSM BASE menu is entered, the SETUP submenu is the first submenu displayed. The GSM setup should be done first. Setup parameters can be saved to memory by performing a SAVE from the SETTINGS submenu.

From the SETUP submenu, all other GSM Base parameters can be accessed by using the UP control key. To move back to a previous menu item, press the DOWN control key. To exit the GSM Base setup menu, press the CANCEL key from any of the submenus. The parameters are described in order as follows:

- **Configure the GSM. (SETUP)**

This submenu is the entry point for the initial setup of the GSM modem. Press the ENTER key to access the following parameters:

- ▶ **Band setting. (BAND: ****)**

The band parameter sets the operable frequency band. In general, set this parameter to 1900 in North America or 900/1800 elsewhere, but verify this with your GSM service provider. To select the band, press ENTER, scroll to the desired value and press ENTER to select it.

► **PIN number. (PIN: ****)**

Sets the Personal Identification Number required for the GSM modem SIM card. This number is provided by your GSM service provider, and ranges from 4-8 digits. To set the PIN, press the ENTER key, use the control keys to enter the number, and press ENTER again to select it.

● **Disconnect the call. (HANG UP)**

Press ENTER to terminate the current connection to the remote modem. The confirmation message "Disconnect call?" will appear. Press ENTER to confirm or CANCEL to cancel.

● **Power on/off the modem. (PWR: **)**

The PWR submenu is **NOT** a power status indicator for the GSM modem, but a submenu that allows you to power the modem on or off. The power must be turned on for the modem to be used. Once the power is turned on the modem will automatically initialize to the carrier. To change the power status, press ENTER to access the submenu, scroll to either OFF or ON and press ENTER to select it. The modem status can be monitored in the STATE submenu (see below).

● **GSM modem operational status. (STATE: **)**

Displays the current state of the GSM modem. Status values are:

GSM ON = power on

GSM OFF = powered off

GSM INITIALIZED = modem has been initialized

ONLINE = powered on and connected to the remote modem.

Data Recording

All data recording in the receiver is done on a removable SD memory card that is installed in the receiver. The amount of data that can be stored depends upon the size of the card. The Z-Max standard memory card size is 64 Mb. Larger cards are optional.

Data recording to the SD memory card is automatic if the card is correctly inserted in the SD card slot, correctly formatted, and the receiver is tracking satellites. Optionally, the user can change a variety of data collection parameters including the recording interval, the data-recording mode, the site name, the elevation mask, and the minimum number of satellites tracked before recording data. While data is recording on the SD memory card, the Data Log LED will flash green for each epoch recorded, indicating that the SD memory card is actively in use. If the receiver memory fills up and is not able to log any more data to the SD memory card, the LED will go to constant red. If the SD memory card is full, you can either delete old files from the card using the SESSIONS menu of the front panel user interface, or else put in a new card.

CAUTION

It is important to power off the receiver using the Power key on the Front Panel before removing the SD card. Also, reformatting the SD card every two weeks during constant use is recommended. See “Reset the Unit” on page 14 for procedures.

Setting the Data Recording Interval

The default recording interval is 20.0 seconds. The data recording interval can be changed from the front panel LED display (in the SURVCONF submenu) to any value between 0.1 and 999 seconds. Recording interval can also be controlled by entering text based commands through the serial port of the Z-Max. Refer to **Appendix B** for the formats of many common serial commands.

Data Modes

The Z-Max receiver can record data in 5 different modes, called Data Recording Modes. The modes available are Data Modes 0, 2, 4, 5, and 6. The Z-Max automatically sets the receiver to record data in the data mode which best fits the type of surveying being done. The Z-Max can be explicitly set to record in any data mode by entering text commands through the serial port (see **Appendix B**).

Data Mode 0 is the default data recording mode and is the normal recording mode when collecting data during a static or kinematic survey. This mode records raw data records, ephemeris records, site information, an almanac file, and if desired, an event file. Recording data continuously at 1-second intervals on a 64 MB SD memory card, Data Mode 0 can store approximately 2 days worth of data, assuming an average of 8 satellites tracked. Data mode 2 records only position records, a site information file, and an almanac file. Data mode 2 is not used as a default setting for any surveying mode.

Data mode 4 is data mode 0 combined with data mode 2. This mode will record raw data records, ephemeris records, position records, site information, and an almanac file. Data mode 4 is not used as a default setting for any surveying mode.

Data modes 5 and 6 are only applicable with RTK. Data mode 5 will store ONLY the epoch solution record (CBEN data) and the vector solution file (OBEN file). Data mode 6 combines data mode 0 and data mode 5. Data mode 5 is the best mode to use when recording trajectory RTK data. Trajectory RTK data is the primary method for mapping lines or paths the user has traveled. Data mode 6 is the default data recording mode for surveying individual RTK points.

Figure 4.4 provides a summary of the Data Recording Modes.

Table 4.4. Data Recording Modes

Data Recording Mode	Data Types Stored	File Type After Conversion
0	Raw data Ephemeris data Site data Event marker data Almanac data	B-file E-file S-file M-file ALMyy.ddd
2	Position Site data Almanac file	C-file S-file ALMyy.ddd
4	Raw data Ephemeris data Position data Site data Event marker data Almanac data	B-file E-file C-file S-file M-file ALMyy.ddd
5	RTK epoch solution records Vector solution	T file O file

Table 4.4. Data Recording Modes (continued)

Data Recording Mode	Data Types Stored	File Type After Conversion
6	RTK epoch solution records Vector solution Raw data Ephemeris data Site data Event marker data Almanac data	T file O file B-file E-file S-file M-file ALMyy.ddd

Downloading the Data

During survey operations data is stored in either the SD memory card in the Z-Max or in the memory of the handheld computer. Downloading data involves the transfer of this data to the PC for subsequent processing. During the downloading process, the session files are decoded and converted into the individual data files (B-file, E-files, etc) and stored onto the desired directory of the PC. One set of data files is created per session. The files are named using the file naming convention described below.

Downloading the SD Memory Card Data

There are several ways to download data from the SD card to the PC for processing. The most convenient methods are to download data directly from the SD card or download data via the USB port. Both processes will use the Download utility of the GNSS Studio software download files.

Downloading Directly from the SD Memory Card

Downloading directly from the SD memory card is the fastest way to download data, since the data does not need to be transferred from the receiver to the PC. To use this method, an SD card reader must be connected to the PC.

To download data directly from the SD card:

1. Power off the receiver using the Power key on the Front Panel.
2. Manually move the SD card from the SD card slot in the receiver to the SD card reader in the PC.
3. From the PC, run GNSS Studio software.
4. If a project has not already been created, create a project. This project should be open.
5. From the **Project** menu, select '**Download Data from External Device**'.

6. Select '**Raw Data**' from the list on the left. This will open the Download utility and the Download main window appears. The left pane is the source directory (currently blank) and the right pane is the currently selected destination directory.
7. From the **File** menu , select '**Connect**' - '**Receiver**' - '**PC Drive**'
8. From the left pane of the Download main window, select the drive letter of the connected SD card reader port.
9. Download will read the contents of the SD card (this may take 1-2 minutes) and then will display the list of session files on the SD card.
10. In the right pane of the Download main window, change the destination directory to either the project directory or the directory where you want the data files to be stored.
11. Select the desired session data file(s) from the SD card pane that you want to download and drag them to the PC pane. This will start the downloading.
12. The selected files will be downloaded and converted into individual data files and placed in the selected destination directory. A progress dialog box indicates the status of the download. Note that the files on the SD card will not be erased after download is complete.

If you need instructions on how to remove the SD card from the receiver, refer to Chapter 3 - **Getting Started, Step 4**.

Downloading Using a USB cable

When using the USB port to download data, the USB interface cable is attached from the receiver USB port to the PC USB port.

To download data from the SD card via the USB cable:

1. Verify the receiver is turned on.
2. From the PC, run GNSS Studio software.
3. If a project has not already been created, create a project. This project should be open.
4. From the **Project** menu, select '**Download Data from External Device**'.
5. Select '**Raw Data**' from the list on the left. This will open the Download utility and the Download main window appears. The left pane is the source directory (currently blank) and the right pane is the currently selected destination directory.
6. From the **File** menu , select '**Connect**' - '**Receiver**' - '**Connect via USB**'
7. A list of any available USB devices is displayed in the drop-down list. Select the correct port/device and press OK. Download will display the session files on the SD card in the left pane.

8. In the right pane of the Download main window, change the destination directory to either the project directory or the directory where you want the data files to be stored.
9. Select the desired session data file(s) from the SD card pane that you want to download and drag them to the PC pane. This starts the download.
10. The selected files will be downloaded and converted into individual data files and placed in the selected destination directory. A progress dialog box indicates the status of the download. Note that the files on the SD card will not be erased after download is complete.

Downloading the Handheld Computer Data

There are two ways to download data from the handheld data collector to the PC. You can either wirelessly download data using the Bluetooth module, or download data with a serial cable. Both of these processes will use the SurvCom utility of the GNSS Studio software download files.

Downloading FAST Survey Data Using Serial Cable

To download data from the handheld data collector to the PC using a cable, connect the data collector cable from the handheld computer to the PC serial port and perform the following steps:

1. If Active Sync (on PC) is in use, turn it off (disabled).
2. Verify the data collector is turned on.
3. On data collector, go to File/Data Transfer function and choose SurvCADD/Carlson Survey Transfer button.
4. From the PC, run GNSS Studio software.
5. If a GNSS Studio project has not already been created, create a project. This project should be open.
6. From the **Project** menu, select '**Download Data from External Device**'.
7. Select '**Real-time results**' from the list on the left. This will open the CE Download utility and the CE Download main window appears. The right pane of the main window is the source directory from the data collector (currently blank) and the left pane is the currently selected PC destination directory.
8. From the **File** menu, select '**Connect**'-'**Data Collector**'-'**Connect via Serial**'
9. If the communication parameters are set correctly, CE Download will display the data files on the data collector in the right pane.
10. In the left (destination) pane of the CE Download main window, use the **Set Path** button to change the destination directory to either the project directory or the directory where you want the data files to be stored.
11. To select data collector files to download, highlight the desired data files. Click the **Transfer** button to start data downloading.
12. The selected files will be downloaded into the selected destination directory. A progress dialog box indicates the status of the download. Note that the files on the data collector will not be erased after download is complete.

Data Files

During a data recording session, all the data for that session is stored on the SD memory card as a U-file. The U-file is a compressed file that contains the data that is converted to individual files during the download process. These files include: the raw data files (B-files) that store all carrier and code phase data, ephemeris files (E-files) that store satellite position and timing information, and a site information files (S-files) that store site occupation information. The B-, E-, S- and ALM files are standard files that are recorded during virtually every session. If the receiver is an RTK rover, the receiver creates and stores the CBEN file containing RTK solution records and the OBEN solution vector files. An event file (D-file) is created if the receiver is collecting attribute or event driven data. Lastly, the receiver creates and stores an almanac file (ALM file) that stores satellite almanac data used by the Mission Planning program. Table 4.5 provides a summary of the file types, including file names, a description of the information contained in the files, and the file format.

Table 4.5. File Types

File Type	Description	Format
B-file	Raw code and carrier phase data, range data, clock data	Binary
E-file	Satellite ephemeris and timing data	Binary
S-file	Site information data	ASCII
ALM file	Satellite almanac data	Binary
D-file	Event time tags and data	ASCII
CBEN	RTK epoch solution records	ASCII
OBEN	RTK vector solution file	Binary

SD Memory Card File Structure and File Naming Convention

While the receiver is recording data, data files are collected as part of a session. A session may be 30 seconds long or 24 hours, but all the data collected during that session are stored as a single session file in the root directory of the SD memory card. New sessions are created by:

- cycling the receiver power
- initiating a 'NEW SESSION' in the SESSIONS submenu of the front panel LED display
- issuing the \$PASHS,FIL,C command using text messages sent through a serial port
- running Session Programming

As previously discussed, all the data created during a single session are stored on the SD memory card as a U-file. The U-file (session file) is a compressed file containing all the data records recorded during the session. During the downloading process, the U-files are decoded into the individual file types onto the PC for storage and processing.

Both the session file and the created individual files follow a naming convention that includes the file type, the site name, a session identifier, year, and the day of the year (DOY). Figure 4.9 outlines the file naming convention. The single exception to this convention is the almanac files. The almanac files are named ALMyy.ddd where yy is the last two digits of the year and ddd is the day of the year.

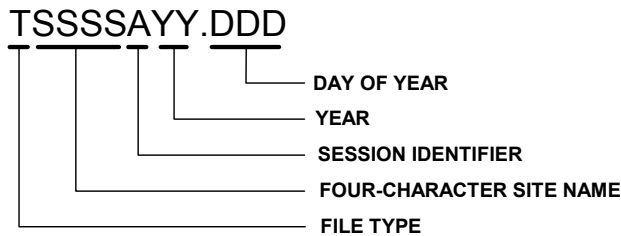


Figure 4.9 File Naming Convention

- The first letter is the file type ('U' for U-files, 'B' for B-files, etc)
- The next 4 characters indicate the station location or site name. If the user has not entered a site name, then these 4 characters are underscores ("____") unless a previous location name is still in memory. If the site name

has been changed during the course of the session, then the last entered site name is used.

- The next character is the session identifier. This field automatically increments from A-Z with each new session on a given day.
- The next two characters indicate the last two digits of the year when the session was terminated (e.g. 03 for year 2003).
- The 3-digit file extension is the day of the year when the session was terminated (e.g. January 1 is day 001; December 31 is day 365)

Warning Messages

The receiver monitors a number of conditions that are of interest to the user. Whenever a problem is detected in one of these conditions, the LED display is interrupted to show a warning message stating the problem. The warning message scrolls across the display to distinguish it from a regular menu parameter, and a beep will sound every 10 seconds (unless the beep has been disabled by the user). Press any key to acknowledge the message, which removes the warning text from the display and stops the beep. If the receiver is experiencing more than one problem at the same time, the receiver will generate a separate warning for each problem. In this case, the receiver will display the highest priority warning first. When this warning is acknowledged, it will display the next highest priority warning. This process will continue until all warnings have been acknowledged. Table 4.6 describes the possible warnings the receiver may issue.

Table 4.6. Warning Messages

Warning	Definition	Action
THALES RADIO WARNINGS		
Wrong setting	A conflict in one of the parameters is preventing radio programming.	Check and reset radio parameters.
Communication Error	A timeout or checksum error has occurred during setup or user is trying to power off an external device by front panel menu.	Recheck the port and baud rate parameters.
Not Loaded Yet	The LOAD function was not performed prior to programming user parameters.	Load radio parameters (LOAD) submenu and then resend the user parameters (PROGRAM) submenu.
PDL RADIO WARNINGS		
Channel Not Programmed	The frequency channel selected is not programmed in the channel table.	Reload (LOAD) radio parameters.
Wrong setting	A conflict in one of the parameters is preventing radio programming.	Check and reset radio parameters.
Communication Error	A timeout or checksum error has occurred during setup, or the external radio has been powered off.	Recheck the port and baud rate parameters .If using an external radio, verify it is powered up.
Not Loaded Yet	The LOAD function was not performed prior to programming user parameters.	Load radio parameters (LOAD) submenu and then resend the user parameters (PROGRAM) submenu.

Table 4.6. Warning Messages (continued)

Warning	Definition	Action
GSM WARNINGS		
MODEM Not Detected	GSM modem not detected	Verify a GSM modem is in the Radio .Module, and verify that the module is securely connected.
MODEM Not Responding	Can not communicate with GSM modem	Verify a GSM modem is in the Radio .Module, and verify that the module is securely connected.
Enter Phone Number	Need to enter Base receiver phone number	Enter the correct base station GSM modem phone number.
MODEM No Carrier	Attempt to call Base receiver unsuccessful	Verify that the GSM base is up and operational.
MODEM Line Busy	Base receiver gives busy signal when called	Re-try later.
MODEM Invalid PIN	PIN is required and the one provided by user is incorrect and does not work.	Verify PIN number.
MODEM SIM Card Locked	Wrong PIN has been entered, causing the SIM card to lock up.	Contact your GSM service provider.
MODEM Insert SIM Card	There is no SIM card in the Communication Module.	Insert valid SIM card.
MODEM Initialization Error	Cannot initialize modem	1. Verify the BAND is correct. 2. The GSM network may be temporarily down. Wait 20-30 minutes and try again. 3. Contact your service provider.
MODEM SIM Card Failure	SIM card failed.	Contact your GSM service provider.
RTK/RTCM WARNINGS		
Solution Is Float	The CPD solution is a float not a fixed solution.	n/a
Invalid Site ID	One or more characters entered in the Site ID field are invalid	Re-enter valid Site ID
Distance Interval is 0 Meter	For a trajectory survey, the distance interval must be > 0 meters.	Enter a value > 0 in the Distance Interval field of the SURVCONF submenu.
Time To Stay Is 0 Second	For an Auto Point survey, the Time to Stay must be > 0 seconds.	Enter a value > 0 in the Time To Stay field of the SURVCONF submenu.
Not Receiving Base Data	Not receiving RTK carrier phase data from the base receiver.	Check serial/data link with the base. Ensure base is computing a position. Ensure a valid position was entered into the base receiver.

Table 4.6. Warning Messages (continued)

Warning	Definition	Action
Not Receiving RTCM Base Data	Not receiving RTCM code phase corrections from the base receiver.	Check serial/data link with the base. Ensure base is computing a position. Ensure a valid position was entered into the base receiver.
Bad Base Coordinates	The position entered in the base receiver for CPD operation is not correct (too far from the computed position).	Enter the correct base position.
Bad RTCM Base Position	The position entered in the base receiver for RTCM code operation is not correct (too far from the computed position).	Enter the correct base position.
BATTERY WARNINGS		
Int. Battery Error: SMBus	The SMBus control for the internal battery communication is not working.	Remove Power Module and reinsert it.
Int. Battery Error: Access	Can't access the internal battery.	Remove Power Module and reinsert it.
Low Int. Battery: < 10 min	Remaining life of internal battery is < 10 minutes.	Change Power Module, or attach external battery.
Low Int. Battery: < 30 min	Remaining life of internal battery is < 30 minutes.	Change Power Module, or attach external battery.
Low Backup Battery	The internal battery that powers the non-volatile memory and the real-time clock is low and needs to be changed.	Contact Customer Support. Backup battery must be replaced.
MEMORY WARNINGS		
† Memory Test Error: RAM	Error with RAM	Perform a receiver initialization.
† Memory Test Error: BBRAM	Error with battery backed up memory.	Perform a receiver initialization.
† Memory Test Error: ROM	Error in the ROM (flash).	Perform a receiver initialization.
† Memory Test Error: BOOT	Error with boot section of flash	Perform a receiver initialization.
SD MEMORY CARD WARNINGS		
No Data Card Detected	The SD memory card is either missing or not properly inserted and has not been detected; no data recording will be done.	Insert or re-insert SD memory card.

Table 4.6. Warning Messages (continued)

Warning	Definition	Action
Data Card Full	There is no space left on the SD memory card.	Delete data from the current card or replace current SD memory card with another SD memory card with available memory.
† Data Card Full < 5 min	There is less than 5 minutes of data recording left on the current SD memory card.	Delete data from the current card or replace current SD memory card with another SD memory card with available memory.
Data Card Error: Access	Cannot read or write to SD memory card.	Power cycle receiver. If problem persists, re-initialize the receiver using the power key (download data first). If problem persists, replace the SD memory card.
Data Card Error: Update	Cannot update the FAT (file allocation table) of the SD memory card.	Power cycle receiver. If problem persists, re-initialize the receiver using the power key (download data first). If problem persists, replace the SD memory card.
Data Card Error: Create	Cannot create the files for a new session: cannot record data.	Power cycle receiver. If problem persists, re-initialize the receiver using the power key (download data first). If problem persists, replace the SD memory card.
Data Card Error: Rename	Cannot rename the files of the session.	Power cycle receiver. If problem persists, re-initialize the receiver using the power key (download data first). If problem persists, replace the SD memory card.
Data Card Error: Corrupted FAT	File Allocation Table on the SD memory card has been corrupted.	Power cycle receiver. If problem persists, re-initialize the receiver using the power key (download data first). If problem persists, replace the SD memory card.
MISCELLANEOUS WARNINGS		
Not Enough Satellites	Tracking fewer than the minimum number of satellites required for kinematic survey.	The kinematic survey must be reinitialized on the last point.
Antenna Overload	Antenna installation problems. The setup is drawing more than 150 mA (there is a short on the antenna cable or the LNA is drawing too much current).	Check that the antenna connection is secure. If using optional cables, check for loose or incorrect connection or damaged cable.

Table 4.6. Warning Messages (continued)

Warning	Definition	Action
No Antenna Detected	No GPS antenna has been detected by the receiver.	Verify antenna connection is secure. If a DC block is being used as part of a multiple antenna setup, check that at least 1 receiver is not DC blocked.
High Receiver Temperature	Internal receiver temperature is > 80 degrees Celsius. The receiver will automatically turn off at 82 degrees.	Shield receiver from the sun or increase air flow around the receiver.
Download in Progress	Receiver is currently downloading data from the SD memory card to a PC. No session management operations can be conducted at this time.	Wait for download to complete operation before performing the command. If Download is not running, run Download again to perform proper shutdown routine.
† - Indicates warning is permanent. The warning will NOT go away if the condition disappears, but only if it is acknowledged.		

SECTION 2
System Guide
to
Post-process Surveying

Introduction

Although difficult to believe, it has been over 20 years since precise positioning using the Global Positioning System (GPS) was first demonstrated. In a relatively short time, this capability was put to commercial use with the introduction of the Macrometer V-1000 GPS receiver. Although the Macrometer was unwieldy, temperamental, and very expensive (\$150,000 each), its ability to geodetically position points at an accuracy of 1-2 parts-per-million of point separation (1mm per 1 kilometer), without the benefit of line-of-sight between the points, was a tremendous asset. This was the birth of surveying with GPS.

From its beginning in the early 1980s to the mid 1990s, GPS surveying went through a tremendous evolution as equipment became much more affordable, reliable, and manageable in size and weight. But through this entire period, two important characteristics remained the same; accuracy and the surveying method used to achieve this accuracy. The method was post-process GPS surveying.

With post-process GPS surveying, data is collected in the field and later downloaded and processed on a computer to produce the final results, i.e. positions of all points surveyed. This method can be equated to using a conventional theodolite and an EDM to collect a sequence of angles and distances between points, later computing the coordinates of the surveyed points.

Until the mid-1990s, post-processing was the only method available to determine survey-grade positions using GPS. A new method was then introduced called Real-Time Kinematic (RTK). With the RTK method, point positions are determined immediately during data collection. This method can be equated to using a total station to collect a sequence of angles and distances between points, with the total station computing the coordinates of these points as the data is collected.

RTK GPS surveying has a number of advantages. The results of your survey are known immediately. Also, with the ability to determine your position in real-time comes the ability to stakeout. But balancing the RTK advantages are some significant disadvantages. RTK-enabled GPS systems are more expensive, in some cases considerably so. RTK systems are somewhat more complex, requiring management

of a robust communication link between GPS receivers. Finally, RTK GPS surveying is slightly less accurate than post-processed GPS surveying.

Even with the introduction of RTK GPS surveying in the mid 1990s, post-processed GPS surveying has continued to be the most popular method of surveying with GPS. It remains the most accurate and reliable method to survey with GPS.

The Global Positioning System (GPS)

The system that makes all this possible is the Global Positioning System or 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, 28 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, it is important to have knowledge regarding the location, geometry, and number of satellites available during data collection periods. Since the satellites are not geosynchronous, the number of satellites that are available and the satellite geometry (PDOP) at any given time will vary significantly. It is important that you are aware of the favorable times of the day and choose the times when the most satellites and the lowest PDOP are available to perform your surveys. 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 positions in various datums and grid systems, output raw data and computed position through serial ports, and display satellite availability information.

Surveying with GPS

A GPS surveying system consists of at least two GPS receivers. The receivers collect data simultaneously to determine the location of one receiver relative to the other(s). The positional relationship between the receivers is presented in the form of a vector, i.e. (ΔX , ΔY , ΔZ) or (ΔN , ΔE , ΔH) between the receivers. This is a 3-dimensional relationship. It is analogous to a conventional observation of horizontal angle, vertical angle and slope distance. Vectors are produced between all combinations of GPS receivers used during the survey.

It's important to remember that GPS observations result in vectors defining the relationship between the points observed. In other words, it is the vector between the points that is the result of a GPS observation, not the coordinates of the surveyed points themselves. To determine coordinates of surveyed points, a set of control coordinates must first be supplied for one of the points. Based on this set of coordinates and the GPS vectors observed for all other points, coordinates for the other points can be computed. In this manner, coordinates for the newly surveyed points are determined. Similar to a conventional traverse, your initial set of coordinates can originate from a known control point incorporated into your survey. Alternatively, assumed coordinates can be used.

Post-process GPS Surveying

Post-process GPS surveying can be broken down into two primary tasks, data collection and data processing. Let's examine each task in detail.

Post-process Data Collection

Data collection can be performed using two different methods; static and kinematic. The following is a description of each method.

Static Data Collection

As the name implies, static data collection is stationary in nature. The GPS systems simultaneously collect raw data from all available satellites while remaining stationary on their respective points. Data collection continues at these locations for an amount of time dependent upon several factors including the distance between the receivers, the satellite geometry, and obstruction conditions at the data collection locations (for example, trees or building blocking some of the sky). When data collection is complete at these points, the GPS systems may move to a new set of points to begin another static data collection session. In most cases, one GPS system will remain on its current point in order to link the previous set of points to the new set of points. After data collection is complete,

data is downloaded to a computer for post-processing. Post-processing the data will compute vectors to determine the position of all points observed.

Static data collection produces the most accurate and reliable results due to the amount of data collected during each observation. The disadvantage is in productivity. Long observations at each point reduce the number of points that can be collected in a day.

Kinematic Data Collection

With kinematic data collection, one of the GPS receivers in the system is designated as the base and remains stationary throughout the survey. All surveyed points are determined relative to the base. Once operational, the base system simply collects and stores raw data from all the available satellites.

The other GPS receiver(s) is designated as the rover. The operator of the rover system moves around the project site collecting data on points or items of interest. While moving around the project site, the operator will stop for a short period of time to position a specific item, such as a manhole. Occupation time of the point can range from 6 seconds to 60 seconds. Once finished, the operator moves on the next point. Also, the operator can position linear features, such as the centerline of a road, by simply walking along the centerline and instructing the rover system to store a position every five seconds, for example. The result is a trail of points defining the centerline.

To facilitate the mobility required to utilize the kinematic method of data collection, the rover system is designed to be man-portable, usually carried either in a backpack or on a survey pole. The user interfaces with the rover system through a handheld computer/data collector, and the antenna is mounted on a portable survey pole.

While it is obvious that kinematic data collection has the advantage of high productivity, there are disadvantages. Accuracies are not as good as with static data collection. In addition, the rover system must maintain lock on GPS satellites as it moves around the project area. Loss of lock requires the user to re-initialize the receiver.

Post-processing GPS Data

Post-process GPS surveying requires that the collected GPS data be processed after the data is collected to obtain results. Processing is accomplished by the GNSS Studio software included with the system. Processing normally occurs on a PC back at the office, but can also be performed on a laptop in the field.

To accomplish the post-processing, data is downloaded from each GPS receiver into the computer. The processing software utilizes this data to calculate vectors between all GPS receivers operating simultaneously. The vectors define the 3-dimensional relationship between the GPS receivers. From these vectors, coordinates are determined for all points in the project, based on the coordinates of one or more known points. If the survey included any redundant observations (closed loops, repeat observations), then a least-squares adjustment can be performed to help identify any blunders in the data and improve on the final point positions. The capability to perform a least-squares adjustment is included with the GNSS Studio post-processing software package.

Applications

Post-process GPS is well suited for most surveying tasks. Systems are being used today for control establishment, boundary surveys, and mapping applications such as topographic, planimetric, and as-built surveys. Post-process GPS is also very efficient for volumetric measurements such as stockpiles and gravel pits.

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

Limitations

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

The main limitation is not confined to post-process GPS 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 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, can completely block the satellite signals. Therefore, GPS can not be used indoors. For the same reason, GPS cannot be used in tunnels or under water. Other objects such as trees can partially obstruct or reflect/refract the signal, so that 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, GPS is not effective in a dense forest.

This is not to say that GPS surveying systems can only be used in areas with wide-open view of the sky. GPS can be used 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 above the horizon and available for use, although the GPS system does not require this many satellites to function. Accurate and reliable positions can be determined with five satellites properly distributed throughout the sky. Therefore, an obstructed location can be surveyed if at least five satellites can be observed. This makes GPS 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 five satellites.

Thales Navigation Z-Max System

The Z-Max System is Thales Navigation's most advanced post-process survey system. This modular system includes all the required components to perform post-process GPS surveys. The Z-Max System is built around the Thales Z-Max dual-frequency GPS receiver. Being a dual-frequency receiver (utilizes satellite signals on both L1 and L2 frequencies), the Z-Max makes your GPS system more versatile and productive compared to a post-process GPS system based on a single-frequency GPS receiver. A dual-frequency system requires shorter observation times on point for static surveys, requires less time to initialize, less effort to remain initialized during kinematic surveys, and will maintain the highest level of accuracy even when surveying points are separated by 50 kilometers or more. There is no more advanced post-process survey system than one based on the Z-Max dual-frequency GPS receiver.

System Components

The Z-Max GPS surveying system is made up of a number of modules. If setup is taken step by step, the process of assembling a system for collecting GPS data is simple. The trick is understanding the purpose of each module in the system and how they connect to each other. With the understanding of how to assemble the hardware and when to use the Z-Max software applications, collecting GPS data for post-processing becomes logical and straight-forward.

Compared to most GPS Surveying systems, the Z-Max System is unique in two important ways. First, most of the components of the Z-Max Surveying System are modular; they attach directly to the GPS Receiver Module without the need for cables. This greatly simplifies the configuration process. Secondly, in most of the configurations, the GPS Receiver Module attaches directly to the tripod (in the case of static surveys) or to the survey pole (in the case of stop-and-go kinematic surveys). Keep these concepts in mind as we explain each of the components.

Hardware

The Z-Max system includes a number of hardware components, (or modules) each with a specific function. Choosing the right combination of modules will depend on the user's needs and the environment in which the system is to be used. In this section, each of the major components of the Z-Max system is presented.

Z-Max GPS Receiver Module

The GPS receiver is the component of the system that processes and stores the satellite signals. A GPS surveying system typically requires at least two GPS receivers. In the Z-Max Surveying System, the GPS receiver electronics are contained in the Z-Max GPS Receiver Module (Figure 2.1). As previously mentioned, the Z-Max System is a modular system. The GPS Receiver Module is the core module. All other modules will attach to the GPS Receiver Module.



Figure 2.1 Z-Max GPS Receiver Module

The GPS Receiver Module contains the GPS receiver itself, the SD memory card, Front Panel User Interface, external serial port, USB port and power port. Most of the functionality of the GPS Receiver Module is located on the front and the rear panel.

The GPS Receiver Module is capable of functioning in a number of different ways including; static data recorder, kinematic data recorder, RTK base or RTK rover. The Front Panel User Interface provides an easy way to control receiver functions and also supports the ability to perform most post-process survey tasks without a handheld computer.

GPS Antenna Module

In order for the GPS Receiver Module to receive satellite signals, it must utilize an antenna. The GPS antenna is the actual collection point of the satellite signals. It is also the point from which the position of the system is computed. To determine the precise location of a point on the ground, the GPS receiver antenna must be precisely centered over the point. The height of the GPS antenna above the point must also be measured. The vertical position of the point is determined by subtracting the

measured height of the antenna above the point. When the antenna is perfectly centered over the point and the height of the antenna is measured, the three dimensional position of the ground point can be computed. Each GPS receiver in the system will have one GPS receiver antenna.

The GPS antenna for the Z-Max system is the GPS Antenna Module, Figure 2.2. The GPS Antenna Module contains highly sensitive antenna electronics housed in a durable, waterproof housing. The Z-Max Antenna Module employs a unique design that allows the signal path to enter directly at the top of the receiver or to pass through other modules without the need of any cables.



Figure 2.2 Z-Max Antenna Module

Z-Max Power System

All electronic devices require power to operate and the Z-Max is no different. A number of options are available for powering the Z-Max system. Each is described below:

Power Module

The internal power source for the Z-Max is the Power Module (Figure 2.3). Inside the Power Module are rechargeable lithium ion battery cells. There are two options for the Power Module, either the Max-Lite or the Max-Run Power Module. The Max-Run Power Module is capable of running the receiver for 13 hours or more at room temperature. The Max-Lite Power Module is capable of running the receiver for 6 hours or more at room temperature. The Power Module does not

require cables; it simply plugs into the right-hand side of the GPS Receiver Module.



Figure 2.3 Z-Max Power Module

To help you keep track of battery life, the Power Module has a push button and 4 LED indicators to provide a quick indication of the percentage of battery time remaining. Each light represents about 25% of battery life. Four green lights indicate the battery is fully charged (100%). One red light indicates that there is less than 25% of battery life left. To maintain the accuracy of the battery indicator the Power Module must be calibrated periodically. To calibrate the Power Module, see the Operation and Reference section, Chapter 2 - ***Equipment Description***, page 19.

External Power

For extended operation, an external power source is available as an option with the Z-Max. The Z-Max GPS Receiver Module contains an external power connector that allows you to power the receiver externally via an AC to DC transformer or an additional battery. Optional cables are available to allow the use of other DC power sources (10-28VDC) such as a vehicle battery or an auto cigarette lighter port to power the receiver for extended periods.

Communication Module

Depending upon the options that you purchased, the Communication Module either contains data links used in real-time survey applications or is an empty V-Module, Figure 2.4. Operating the Z-Max during a post-process survey does not require data links. The empty V-Module is needed to maintain a weather-tight seal of the Z-Max

GPS Module. The V-Module should be connected to the GPS Receiver Module whenever the receiver might be exposed to dust or moisture.



Figure 2.4 Z-Max V-Module

Mounting Accessories

When using the Z-Max System to perform post-process surveys, various accessories are required to mount the receiver to the tripod, the rover survey post or the backpack. Each of these accessories and their purpose are described in this section. How they fit into the equipment set up will be covered in Chapter 3 - **Connecting System Hardware** and Chapter 4 - **Survey Preparation and Execution**.

HI Measurement Plate

An accurate measurement of the height of the antenna above the survey mark is very important. However, when the Z-Max System is attached to a tripod there is not enough clearance to measure the antenna height from the survey mark to the GPS antenna. The HI Measurement Plate (Figure 2.5) is used to provide a convenient location on the Z-Max System where the slant height of the antenna above the mark can be consistently and accurately measured. It attaches to the Z-Max System between the bottom of the GPS Receiver Module and the tribrach. The HI Measurement Plate is only used when the Z-Max System is either a static receiver or a kinematic base station.



Figure 2.5 HI Measurement Plate

Range Pole RF Adapter

When the Z-Max System is operating as a backpack-mounted kinematic rover, a cable is required to connect the GPS Receiver Module in the backpack to the GPS Antenna Module on the survey pole. The Range Pole RF Adapter is the module where the cable physically connects to the survey pole and the GPS Antenna Module. The Range Pole RF Adapter connects between the survey pole and the GPS Antenna Module (Figure 2.6).



Figure 2.6 Range Pole RF Adapter

Max-RF Adapter

When the Z-Max System is operating as a backpack-mounted kinematic rover, a cable is required to connect the GPS Receiver Module in the backpack to the GPS Antenna Module on the survey pole. The Max-RF Adapter is the module where the cable physically connects to the GPS Receiver Module. The Max-RF

Adapter connects to the top of the GPS Receiver Module in the same receptacle where the GPS Antenna Module connects during a static survey (Figure 2.7).



Figure 2.7 Max-RF Adapter

Pole Adapter

The Pole Adapter is used when the Z-Max System is functioning as a kinematic post-processed rover. The Pole Adapter is used to raise the GPS Antenna Module high enough on the survey pole so that the antenna's view to the satellites is not blocked by the user. The Pole Adapter connects between the GPS Antenna Module and the GPS Receiver Module when using a pole-mounted system, or between the GPS Antenna Module and the Range Pole RF Adapter (see below) when using a backpack-mounted system (Figure 2.8). The pole adapter is the same size and shape as the UHF antenna.



Figure 2.8 Pole Adapter

Handheld Computer

A handheld computer is an optional component of the Z-Max System. It serves as a graphical interface to the Z-Max GPS receiver. The Z-Max GPS Receiver Module has a Front Panel User Interface for configuring parameters and controlling surveys. For some types of post-processed surveys, a handheld computer with a graphical user interface is desirable. The use of handheld computing devices with specialized application software can greatly enhance the utility of the system.

FAST Terminal

The standard handheld computer supplied with the Z-Max System is the FAST Terminal, Figure 2.9. The FAST Terminal is a light-weight, rugged handheld computer running Microsoft Pocket PC operating system. The FAST Terminal is a robust field computer with a full keyboard and an easy to read touch-screen. In addition, FAST Terminal is designed to operate with Bluetooth short range wireless technology, so no cable is required between the handheld computer and the receiver. The operator can

wirelessly communicate with the receiver from up to 10 meters away. The FAST Terminal runs the FAST Survey Field Application software discussed below.



Figure 2.9 FAST Terminal

Z-Max Application Software

The Z-Max System includes both field application software and office software. Each component is discussed below.

Field Application Software

The field application software resides in the handheld computer/data collector. As with the handheld computer, this is an optional component to the Z-Max System for post-processing. The field application software offers an enhanced interface to the Z-Max receiver, supporting additional status information and operational capabilities not available through the Front Panel User Interface of the receiver.

FAST Survey

FAST stands for Field Application Software Technology. FAST Survey was designed specifically for land surveying with the Z-Max system. The software guides you through the steps required to perform surveys using both post-processed and real-time data collection methods. FAST Survey is a graphical Microsoft Windows software based on the Microsoft Pocket PC operating system. FAST Survey can be used for a full range of land surveying operations including, topography and construction. FAST software can control the Z-Max GPS receiver and conventional instruments with the same intuitive user interface. For more detailed information on use of FAST Survey software refer to the FAST Survey user manual.

Office Software

GPS surveying requires a certain level of preparation and also post-analysis after data is collected. With post-processed GPS surveying, data is first collected in the field and then must be processed in the office to generate results. With real-time GPS surveying, office software is useful for preparing stakeout files and then for QA analysis of the collected data. Office software is a critical part of the system whether the system is for post-processing or real-time GPS surveying. Office software enables planning, execution, analysis and reporting in a variety of GPS survey scenarios. Office software enables other valuable functionality including; transfer of data to and from devices, conversion of data formats, creation of maps and sending text-based (advanced) commands to the Z-Max.

Thales Navigation GNSS Studio

The office software for the Z-Max System is Thales Navigation's GNSS Studio. GNSS Studio includes all functionality required to support processing, manipulation and

output of data collected using the Z-Max surveying system. Using GNSS Studio, you can plan field operations, prepare feature codes or stakeout files prior to the field work, transfer data between the office computer and field devices, process collected data, and create your choice of detail rich maps and reports. This is all accomplished through a user interface which is a rare mix of simplicity and power.

This concludes the Z-Max System for post-processed GPS surveys. Next, we will examine how the individual Z-Max hardware and software modules are to build a powerful system for data collection.

Connecting System Hardware

If you have been reading this document sequentially, you should now have a basic understanding of the modules included with a Z-Max System for post-processing. Important information from Chapter 2 includes; the name of each module, what it looks like and its basic function. In Chapter 3, information will be provided about how the modules fit together and how they relate to each other. In order for the different components to function as a system, they must communicate and they must be powered. This requires that the modules be connected correctly. In the following sections, we will examine the connectivity of the Z-Max modules. Below is a list of module connections for a Z-Max post-processed survey system.

GPS Receiver - GPS Antenna Module

The GPS Receiver Module requires that a GPS Antenna Module be connected in order to measure and record the data being transmitted by the satellites. The GPS Antenna Module connects directly to the GPS Receiver Module and does not require any cables.

At the top of the GPS Receiver Module is an antenna receptacle. The base of the GPS Antenna Module is circular except for a flattened area. To connect the GPS Antenna Module, just insert the antenna base into the receptacle at the top of the GPS Receiver Module (Figure 3.1). Make sure the base of the antenna module is oriented so that the flattened area is lined up with the flattened area of the receptacle, and the module will push easily into place. Once in place, twist the threaded collar on the Antenna module until the assembly is securely locked in place.

The GPS antenna can be connected to the receiver at any time before or after the receiver is powered on. Make sure the threaded collar turns easily when tightened and is not cross-threaded.



Figure 3.1 Connecting GPS Antenna Module to GPS Receiver Module

GPS Receiver - Receiver Power System

Supplying power to the Z-Max System can be accomplished by using the Power Module or by connecting a DC power source (10-28V) to the external power port.

The Z-Max Power Module is a self contained power source designed to be conveniently attached to the side of the GPS Receiver Module. The Max-Run Power Module can power the receiver for over 13 hours, so only one Power Module is needed for a full day of data collection.

The Power Module does not require any cables. It simply connects to the right-hand side of the Receiver GPS Receiver Module. To connect the Power Module to the GPS Receiver Module, insert the small ledge of the Power Module into the rear of the GPS Receiver Module housing first as shown in Figure 3.2. This will correctly align the

module. Using the ledge like a hinge, swing the module closed until the latch on the Power Module clicks into place.



Figure 3.2 Connecting Power Module to GPS Receiver Module

If the Z-Max System is to collect data unattended for a period of time exceeding the capability of the Power Module, an external power source can be used. External DC sources can be plugged in using a cable and the external power port. The external power cables come in different types for each type of power source used. External power is applied to the Z-Max GPS Receiver Module by connecting the power source with a cable (Figure 3.3) to the external power port located on the rear panel of the GPS Receiver Module. The power port is a sealed 3-pin connector marked 'Power'.



Figure 3.3 External Power Port Connection

The Power Module and external power sources can each be used alone or at the same time. As long as one or the other power source is plugged in, the receiver will operate without interruption. When both the Power Module and external power source are used, the Z-Max will draw power from the external source first. If the voltage supplied to the external port is insufficient to power the receiver, the Z-Max will automatically switch over to the Power Module with no interruption in operation.

Handheld Computer - GPS Receiver

Handheld computers (Figure 3.4) may be used to control the Z-Max during surveying operations. The use of a handheld computer with application software can add significant utility to the system. Connection of the handheld computer is accomplished either wirelessly using the Bluetooth protocol module, or with a cable. If the handheld interface with the receiver is wireless, no physical connection is required. The Bluetooth module in the receiver is on anytime the receiver is powered on. Make sure that the Bluetooth module is present in handheld terminal.

If you plan to use the backpack configuration, then we recommend that a cable be used between the handheld and the receiver. If you need to use a cable, the computer communication cable connects to the Z-Max via one of the two serial ports on the back panel of the receiver. These two ports are labeled **SERIAL A** and **SERIAL B**. The handheld can be connected to the receiver at any time during the equipment setup and data collection process.



Figure 3.4 FAST Terminal

FAST Terminal

The FAST Terminal is offered as an option with the Z-Max System for post-processed surveys. It is lightweight, durable and weather resistant for use in outdoor environments. The FAST Terminal allows both wireless and cabled connections with the Z-Max Receiver Module and a PC. When using a cable connection, the FAST Terminal should be connected to serial port A on the GPS Receiver Module (labeled SERIAL A). The FAST Terminal supports use of Bluetooth wireless with a module that is installed in the compact flash receptacle of the device. The compact flash receptacle is located underneath the FAST Terminal battery in a compartment located at the lower back of the device. Please refer to the FAST Terminal user manual for more details.

Z-Max System - Tripod/Survey Pole/Backpack

The Z-Max System for post-processed surveying is modular, virtually removing cables from the configuration. It also has a female threaded receptacle built into the bottom of the receiver to support secure mounting to standard survey mounting devices including; tribrach and range pole. This design greatly simplifies equipment setup for post-processed surveys.

Since the GPS Antenna must be centered and leveled over the survey point to be able to achieve centimeter-level accuracy, it is important to understand how to connect the Z-Max to the survey mounting device. We will review the three basic types of setups and the equipment configuration for each.

Static - The Static setup (Figure 3.5) is used with all receivers in a static survey, and the base receiver in a kinematic survey. In the Static setup, the receiver system (with Antenna and Power Modules attached) is mounted on the tripod that is set up over the point. In order to accurately measure the antenna height, the HI Measurement Plate is also attached between tripod and the receiver system.

The bottom of the Z-Max GPS Receiver Module includes a 5/8" threaded receptacle that fits to a standard tribrach adapter. The HI Measurement plate has a hole in the center of the plate. Insert the adapter into the hole of the Measurement Plate, and screw the adapter/plate combination into the Z-Max

System. The system is then placed in the tribrach mounted on the tripod over the point.



Figure 3.5 Static Setup

Rover - A rover setup is designed to be mobile and carried by a person. The Z-Max rover setup is used for post-processed kinematic data collection. A Z-Max rover may either be range-pole mounted or backpack mounted.

Pole-Mounted: A typical configuration for a pole-mounted rover includes, GPS Receiver Module, Power Module, V-Module and Pole Adapter. In the pole-mounted configuration (Figure 3.6), the entire rover system (with modules attached) is attached to the top of the survey pole. The bottom of the Z-Max GPS Receiver Module has a 5/8" threaded receptacle that fits standard survey poles. The handheld computer, if used, can also be attached

to the survey pole. In this configuration, all of the components are on the survey pole, and the system can be moved easily from point to point.



Figure 3.6 Pole-Mounted Rover Setup

Backpack-Mounted: The Backpack-Mounted configuration for post-processed data collection (Figure 3.7) requires a cable between the pole and the backpack. The GPS Receiver Module, Power Module, and V-Module are attached in a backpack with a cable. A Range Pole RF Adapter and a Pole Adapter attach to the top of the survey pole. The GPS Antenna Module is attached to the top of the survey pole assembly. The GPS signal is passed from the survey pole assembly to the GPS Receiver Module with a cable. The cable is attached to the Range Pole RF Adapter to the Max-RF Adapter on the top of the GPS Receiver Module.

If you are collecting data using a backpack mounted system without a range pole, modify the above hardware connectivity in the following ways:

1. Attach the GPS Antenna Module to the Pole Adapter.
2. Attach the GPS antenna and Pole Adapter assembly to the GPS Receiver Module.

3. Mount the Z-Max assembly in the backpack with the GPS Antenna Module pointing up.
4. Attach the handheld computer (if applicable) to SERIAL A on the GPS Receiver Module using the data collector cable.



Figure 3.7 Z-Max Backpack Connectivity

Before connecting the cables from the backpack to the pole assembly, put on the backpack. The last step is to connect the cable(s) to the connectors on the pole assembly. The completed backpack-mounted system for collecting post-processed data is shown in Figure 3.8. The handheld computer, if used, can be carried or attached to the survey pole.



Figure 3.8 Backpack-Mounted Rover Setup

Congratulations! You have learned about the Z-Max modules, how they work and how they fit together to create a flexible, streamlined system for recording GPS data. In the following chapters you will learn about how to set up the equipment in the field and execute a post-processed GPS survey.

Survey Preparation and Execution

The previous chapters laid the groundwork for understanding the purpose and connectivity of each Z-Max module with respect to the post-processed surveying system. This understanding of the system will prove invaluable during survey preparation and execution. This chapter will step through the process of preparing for and executing a post-processed survey with the Z-Max System.

Previously, we discussed the static and kinematic methods of performing a post-process GPS survey. Since the two methods require different procedures in equipment setup and data collection, each is discussed separately below.

Before proceeding any further, let's review how your Z-Max System is packaged for field work. Your Z-Max surveying system typically consists of at least two Z-Max receiver systems, each of which will include a GPS Receiver Module, GPS Antenna Module, Power Module and V-Module. Each Z-Max system resides in its own padded soft case which has semi-rigid compartments for each module and additional storage for miscellaneous items. The compartments in the soft-case are adjustable to accommodate different collections of modules and peripheral hardware. All components required to perform your post-processed survey can be housed in the soft case with the exception of the tripod and the rover pole. The soft case is designed to fit snugly into a hard shell case that is optional with the system. The hard shell case is recommended for shipping equipment through package delivery companies or checking as baggage on an airline. The hard-shell case can also protect the equipment when the gear is being transported in conditions where rough impacts are common, like the back of a truck.

The soft case (Figure 4.1 and Figure 4.2) not only contains the Z-Max system and all its various modules but has compartments for optional items for post-processing systems such as the handheld computer, cables, the Range Pole RF Adapter, the Pole Extender, and the HI measurement device.



Figure 4.1 Soft Case



Figure 4.2 Inside View of Soft Case

Static Surveys

Prior to leaving the office to perform a GPS survey, check the following items:

- Check through the Z-Max equipment and the modules to ensure all components are present to successfully perform the survey. Going through a written checklist before fieldwork is a good practice.
- Check to ensure that the Power module and any external batteries to be used are charged. Z-Max Power Modules need to be calibrated periodically to ensure precise agreement between the battery capacity indicators and the actual battery capacity.
- Use the Mission Planning module from GNSS Studio software to check the satellite availability for the time period when data are collected. Ensure that the number of satellites, their geometry and the observation time is sufficient to support the desired results.

The number of satellites needed for a given result will vary based on factors such as baseline length and occupation time. Typically for Static surveying, continuous lock must be maintained with 4 or more satellites during 10-60 minute blocks of time. For Kinematic surveying, continuous lock must be maintained with 5 or more satellites during blocks of at least 15 min. The longer the baseline length, the longer occupation time that is required for survey quality results.

Satellite geometry is measured using a calculated value called Dilution of Precision (DOP). A number of different DOP metrics exist, the most useful of which is Position Dilution of Precision (PDOP). The Mission Planning software module will give PDOP values for the time periods in which data is intended to be collected. Avoid collecting data during periods where PDOP values are larger than 4 (the lower the number the better). Refer to the documentation accompanying the GNSS Studio software for more details on PDOP and how to use the Mission Planning software module to determine when data should be and should not be collected.

With the previous checklist completed, field data collection can begin.

When collecting data using the Static method, each Z-Max receiver will follow precisely the same steps in equipment setup and survey execution. These steps are presented below.

1. Determine if point location is suitable for GPS observations

As discussed earlier, obstructions between the GPS antenna and the GPS satellites interfere with data collection. The best results are obtained while observing points that have a clear view to the sky. When obstructions are present, observation times need to increase to obtain the same level of accuracy. With enough obstructions, it becomes impossible to obtain enough quality data to determine an accurate position for the point. If the exact location of the point to be surveyed is flexible, select a location that contains the least amount of obstructions. If the location is not flexible and is obstructed, extend the observation time for the point. With a severely obstructed point, it may be necessary to observe a pair of points offset from the point of interest. The position of the point of interest can later be established through conventional means using the offset points. Determining if a location is suitable for GPS observations is not an exact science but it benefits from care and common sense. Successes and failures will eventually give you a feel for the suitability of a location.

2. Connect system components

Connect the system modules together as listed below. Check these connections to ensure the connectors are seated properly. Refer to the previous chapter on how to establish these connections.

- GPS Antenna Module ↔ GPS Receiver Module
- Power Module ↔ GPS Receiver Module
- V-Module ↔ GPS Receiver Module
- External power source ↔ GPS Receiver Module (if applicable)

Using the handheld computer to configure the receiver for a static survey is optional, as the receiver can easily be configured and monitored using the front panel user interface interface of the GPS Receiver Module. If the handheld device supports Bluetooth it can be used to communicate with the GPS Receiver Module wirelessly. If the handheld computer does not support Bluetooth, then a direct cable connection can be used.

3. Position tripod over point to be surveyed

Accurate positioning and leveling of the tripod are critical to an accurate static survey. The GPS Antenna Module is the data collection point for GPS observations, i.e. the computed position for the point will be the location of the GPS antenna. Therefore, it must be precisely positioned over the point to be surveyed. 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 Conventional and Fixed-Height Tripods

4. Attach HI Measurement Plate and Tribrach Adapter

Insert the brass tribrach adapter through the hole in the HI Measurement Plate and screw the adapter/plate into the 5/8" threaded receptacle in the bottom of the Z-Max GPS Receiver Module.

5. Mount the GPS Receiver Module on the tripod

Once the tripod is accurately centered and leveled over the point, and the tribrach adapter and HI Measurement Plate are attached to the GPS Receiver Module, carefully place the assembly into the tribrach mounted on the tripod over the point).

6. Measure and record instrument height (HI) of GPS antenna

Remember that the measurement of satellite data is made at the center (horizontally and vertically) of the GPS antenna. Yet the location of the point to be surveyed 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 with each GPS receiver (Figure 4.4). Use the tape measure to measure from the center of the point to the measurement point of the Z-Max. The height from the bottom of the GPS Receiver Module to the GPS Antenna Module is printed on the outside of the Receiver Module housing.

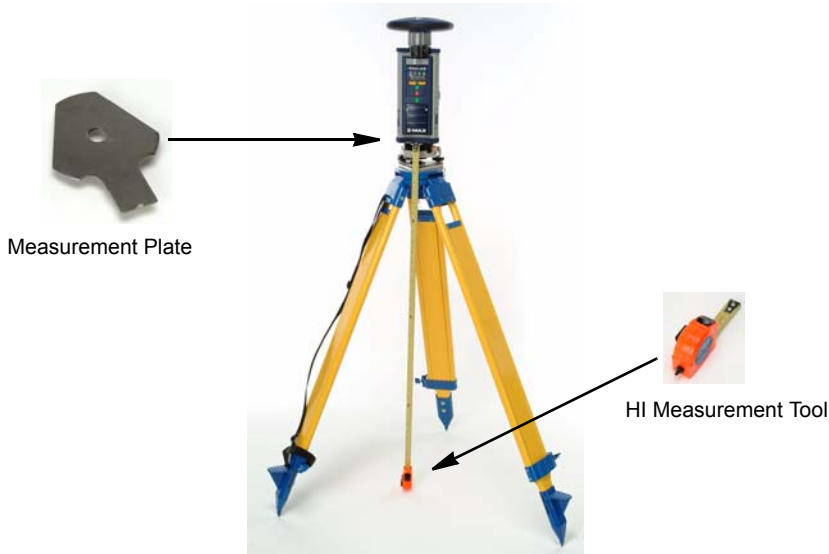


Figure 4.4 Measuring HI (Height of Instrument) of GPS Antenna

7. Power-up system components

Power on the system by pressing the power button on the GPS Receiver Module front panel for 2 seconds. The handheld computer (if used) is turned on using the power button on its keyboard. Check that all components are powered up. The GPS Receiver Module has an LED to indicate that power has been applied and the receiver is on.

8. Configure GPS receiver to perform a Static survey

By default, the Z-Max system is configured to perform a static survey. When turned on, the receiver automatically begins to collect and store data in a new data file with a data recording interval of 20 seconds and an elevation mask of 10 degrees. These are the default settings for these parameters. These settings can be changed either in the SURVCONF menu of the Z-Max front panel user interface or by using the handheld computer running field

application software. The recording interval for static surveys commonly range from 5 to 30 seconds. Normally, it is not necessary to change the elevation mask.

NOTE: If you want to change the recording interval, it is important to set the same recording interval for all receivers used in the survey. GPS surveying depends on simultaneous data being collected by all GPS receivers used. If one receiver is set to a recording interval of 20 seconds and the other is set to 15 seconds, there will only be common data once every 60 seconds.

9. Enter the Site ID and HI

The Site ID and the antenna HI are important attributes of the point being surveyed. Each point in the survey requires a unique point identifier so that /i1 processed vectors and least-squares adjustments can clearly be associated with a specific point. This point identifier is the 4-character Site ID. If a specific point is observed more than once during the project, the same Site ID must be assigned to this point each time. And as previously discussed, the accurate HI is critical for reducing the computed vector to the survey mark. Both the Site ID and HI are required for each observation during data processing. These parameters can be entered either in the SURVEY:Static menu of the Z-Max front panel user interface or by using the handheld computer running field application software. The Site ID and the antenna HI should also be written down on the observation log. It is recommended to have the manually written information as a cross-check.

10. Fill out the observation log (optional).

For each observation, an observation log sheet should be filled out, containing the attribute information of the point being observed along with additional information about the observation. The log sheet accompanies the raw data for use during data post-processing. Critical information includes the full point name and location, the Site ID, antenna HI, and any important additional information about the point.

11. Verify operation

Perform the following visual checks to determine if the GPS system is functioning properly:

- a. Determine if the GPS receiver is tracking satellites by observing the SV/ Power LED on the Front Panel User Interface of the GPS Receiver Module. It should blink green 5 or more times between each red power blink.
- b. Verify that data is being recorded by observing the Data Log LED on the front panel of the receiver GPS Receiver Module. It should blink green once at the frequency of the data recording interval (default is 20 seconds).

The handheld computer and application software may also be used to verify operations. If these operations are successful, your Z-Max system is now collecting GPS measurement data. No further interaction with the system is required for the duration of data collection at this location.

Continue data collection until it is determined that enough data has been collected to precisely position this point. The amount of data required is dependent on a number of factors including:

- the quality of the satellite geometry (PDOP),
- the number of satellites above the elevation mask,
- any obstructions between the satellites and the GPS antenna, and
- the distance (or vector length) between the GPS receivers collecting data simultaneously.

A general guide for good conditions is five or more satellites tracked continuously during the occupation and PDOP less than 4.

For dual-frequency receivers, a reasonable occupation time for the Z-Max system is 10 minutes plus 1 minute for every kilometer of vector length. For example, if three receivers are collecting data simultaneously and the longest vector being observed is approximately five kilometers, the simultaneous observation time would be 15 minutes. Since it takes less time to collect additional data than to return to the site on a different day, some safety factor (20% or more) added to observations is recommended.

Optimistic observation times are generally adequate when vector lengths are less than 30 km (19 miles), there are more than 6 satellites visible, obstructions are minimal, and there is very little multipath (buildings or bodies of water that reflect signals). If any of these factors is present, observation times should be increased. Experience will give you the ability to take all factors into account and determine an appropriate observation time for any given situation.

Vectors longer than 30km (19 miles) may require occupations longer than 60 minutes. When surveying baselines in excess of 50km (31 miles), precise ephemerides should be used. Refer to the user manuals for the GPS processing software for further details about optimum parameters and procedures.

Also be aware that ionospheric activity can negatively impact GPS measurement quality similar to the way rising heat from a hot road can negatively affect a long laser distance measurement. Increasing occupation times can almost always compensate for ionospheric activity the way a larger prism array can enable a longer laser distance measurement on a hot day.

Once data collection is completed at a given location, the Z-Max receiver system can be moved to the next location for another data collection session. Remember that only common data between receivers is used. When the receiver is powered down the active measurement file is automatically closed, and when the receiver is powered back up a new measurement file is automatically created. At the end of the day the receivers are returned to the office where the data are downloaded to the PC for post-processing.

Figure 4.5 shows what a typical Z-Max system for static data collection should look like.



Figure 4.5 Z-Max Survey System Performing a Static Survey

Kinematic Surveys

When using the kinematic method of GPS data collection, one of the GPS receiver systems is designated as the base. This system remains stationary throughout the survey while another GPS receiver system (rover), moves about the project area collecting GPS data at points of interest. If more than two GPS receivers are being used in the survey, you have two options on how to utilize the additional receivers. Additional receivers can be configured as rovers, resulting in added productivity during kinematic data collection. An additional receiver system can also be configured as a second base station and positioned on a point at the opposite end of the project. A second base system adds redundancy to each point established with the rover which can be used during the least squares adjustment.

Kinematic Survey Setup

Base Receiver Setup

The base system for a kinematic survey is set up in precisely the same manner as a system set up for a static survey, with one possible exception. During kinematic data collection, it is recommended that a more frequent recording interval be utilized. Common recording intervals for kinematic data collection are 1-5 seconds. Be sure that the recording interval for all receivers is set to the same value. Keep in mind that unless a new recording interval setting has been explicitly saved using the Front Panel User Interface, it will revert back to the default (or last saved) value after a power cycle. When a handheld data collector and field application software is used, all new settings are typically saved automatically.

Rover Receiver Setup

The rover system for a kinematic data collection is set up in a different manner due to the fact that kinematic data collection is mobile, i.e. the operator must be able to easily move around the project site with the rover system in order to position objects of interest. This requires that the rover system be set up in a portable configuration; either on a survey pole, or as part of a backpack. These two configurations are described below.

1. Connect system components

Connect all the modules in the system as listed below. The pole-mounted configuration will have different connections than the backpack mounted configuration. Refer to the previous chapter on how to establish these connections. Check these connections to ensure the modules are secure and seated properly.

Pole-Mounted:

- Power Module ↔ GPS Receiver Module
- Communication Module ↔ GPS Receiver Module
- GPS Receiver Module ↔ Range Pole
- Pole Adapter ↔ GPS Receiver Module
- GPS Antenna Module ↔ Pole Adapter

Backpack-Mounted:

- Power Module ↔ GPS Receiver Module
- Communication Module ↔ GPS Receiver Module
- Range Pole RF Adapter ↔ Survey Pole
- Pole Adapter ↔ Range Pole RF Adapter
- GPS Antenna Module ↔ Pole Adapter
- Max-RF Adapter ↔ GPS Receiver Module
- GPS Receiver Module ↔ Backpack
- Max-RF Adapter ↔ Max RF Cable ↔ Pole Adapter
- Handheld Computer ↔ Handheld Computer Cable ↔ GPS Receiver Module (optional)

2. Mount the Rover system on a survey pole or on a backpack

For kinematic data collection, the rover system is either mounted on a survey pole carried by the operator (Figure 4.6) or on a backpack with the range pole assembly connected to a backpack with a cable (Figure 4.7). Both configurations uses a forward reading level vial to assist the operator in leveling the pole and antenna over the features to be surveyed.

3. 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 is critical that the HI of the antenna above the ground is measured accurately. It can be physically measured, or the HI can be calculated using predefined vertical values for the equipment.

On a pole-mounted system, the HI is based on the known fixed length of the survey pole plus the height of Z-Max assembly. On a backpack mounted system, the HI is the known fixed length of the survey pole plus the height of the Range Pole RF Adapter, the Pole Extension and the GPS Antenna Module. The vertical height of typical Z-Max configurations are printed on the front of the receiver.



Figure 4.6 Pole-Mounted Rover System



Figure 4.7 Backpack-mounted Rover System with Survey Pole

4. Mount handheld computer

For kinematic method of data collection, an optional handheld computer and application software add utility to the system. The handheld computer is mounted onto the survey pole, as shown in Figure 4.8. A special mounting bracket for the handheld is typically required when a handheld computer is used. When mounting the mobile system in a backpack, the handheld computer must still be secured to the range pole with a bracket but it will also require a cable to connect the handheld computer to the GPS Receiver Module which is in the backpack.



Figure 4.8 FAST Terminal Handheld Computer Mounted on Rover Pole

5. Power-up the rover system

Power on the rover system by pressing the power button on the GPS Receiver Module for two seconds. The handheld computer is turned on using the power button on the keyboard. Check that all components are powered-up. The Power/SV LED on the front panel of the GPS Receiver Module will blink red to indicate that the receiver is on.

6. Configure rover system to function as a kinematic rover

As with performing a static survey, the only parameter that may need to be changed is the recording interval. The recording interval is set to 20 seconds by default. As stated earlier, an interval of 1-5 seconds is normally used for kinematic data collection. The recording interval can be set using the Front Panel User Interface or by the field application software running on the handheld computer.

NOTE: It is very important that the recording interval on the rover is set to the same interval as the base.

In addition, there are parameters that, while not required, can be very useful in executing a kinematic survey.

The Epoch Counter counts the time that each point is occupied in the kinematic survey. When the Site ID is entered, the epoch counter will automatically decrement with each epoch of GPS measurements recorded. When the counter gets to 0, an audible alarm is generated to indicate that data collection at that point is complete, and the Site ID is automatically set to question marks. Move to the next point, enter the new Site ID, and the Epoch Counter resets and again begins to decrement.

The Min SV parameter is the minimum number of locked satellites, and this parameter must be set to 4 or higher. When the number of satellites locked drops below this number, an alarm is generated to indicate that you must re-initialize the receiver (see Kinematic Survey Execution on page 138).

The recording interval, epoch counter, and Min SV can be set using the Front Panel User Interface or field application software running on the handheld computer. Refer to the Operations chapter for specific steps on how to set these parameters through the Front Panel User Interface. Refer to the user manual of the field application software for more details on setup and execution of post-processed kinematic data collection.

7. Verify operation

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

- a. Determine if the GPS receiver is observing satellites. This can be accomplished by observing the SV/Power LED on the front panel of the receiver GPS Receiver Module. It should blink green 4 or more times between each red power blink.
- b. Verify that data is being recorded. This can be accomplished by observing the Data Log LED on the front panel of the receiver GPS Receiver Module. It should blink green once at the frequency of the data recording interval.

The system is now functioning as a kinematic rover, and ready to perform a kinematic data collection. Figure 4.9 shows what the pole-mounted rover system should look like once fully configured and ready to survey.



Figure 4.9 Pole-Mounted Rover System Ready to Survey

Kinematic Survey Execution

Now that the base and rover systems are configured, point location can begin. Using the rover system, you will move about the project area collecting data on points of interest. This process involves two primary functions. These functions are Initialization and Point Observation. Each of these functions is discussed below.

Kinematic Initialization

Prior to performing any feature location with the rover system, the receiver must first go through an initialization process. The initialization process is required to produce highly precise positions. Prior to initialization, the rover system 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 of meters (several feet). The initialization process is required to fine-tune the rover system. Once initialized, the rover system will function at its specified level of accuracy until initialization is lost.

Let's devote a few sentences here to the technical aspects of the initialization process. In order to accomplish centimeter-level positioning with GPS, you must collect enough data to calculate a set of parameters termed integer ambiguities. During the initialization process, you are collecting the data required to calculate the integer ambiguities. Once the integer ambiguities have been calculated, your current location can be determined very quickly and very precisely. Once the integer ambiguities are solved, the position of your location can be computed with only an epoch or two of data. In addition, once the integer ambiguities are computed, they stay the same (fixed) as long as you maintain lock on at least five satellites. If you happen to lose lock on satellites due to an obstruction and go below the five-satellite threshold, the integer ambiguities will be lost and must be calculated again, i.e. you must initialize your kinematic survey again. All data collected prior to losing the initialization is not affected by your loss of initialization.

Once the rover is initialized, each point of interest need only be occupied for a minimum of one epoch. However, the accuracy will improve if you occupy the point for multiple epochs. For example, as the initialized rover system moves around the job site, the rover system is continually computing positions at the 0.02 - 0.05 meter (0.07 - 0.15 ft) level. If you stop in one location and observe for 8 seconds or more, your precision will improve to 0.01 - 0.03 meters (0.03 - 0.10 ft).

Initialization of your kinematic survey can be accomplished in several ways.

1. On-the-fly
2. By performing a static survey
3. On a known point

1. Initialize on-the-fly

When using a dual-frequency GPS system such as the Z-Max, there is no requirement that initializations be performed while standing still at one location. It is possible to initialize your kinematic survey while moving about the project site (thus the term on-the-fly). Initialization times are about the same as with the static survey method. The advantage of the on-the-fly method over the static method is that during the required to initialize, you can be moving about the project site productively locating points of interest. The post-processing software will use this data to initialize and, once initialized, will establish precise positions on the points observed during the initialization time period.

The trick to this method is that you must collect clean data (no loss-of-lock) during the initialization period, i.e. the first 5-10 minutes of the observation. If loss-of-lock occurs during the initialization period, you run the risk of not being able to initialize the segment of data between the start and the loss-of-lock. Any points observed during this time period will have poor precision. For this reason, this method of initialization is best left for project sites where obstructions are a minimum.

Consider a scenario where this method of initialization would be useful:

You have a landfill that you need to topographically survey. Since the project site is a landfill, most of the area has no obstructions with the possible exception of trees along the perimeter. You set up your base station in an open area. You then set up your rover system. You turn on the rover system immediately. As you finish your preparation, the rover system is collecting data for initialization on some arbitrary location. After two minutes, you are ready to begin locating topo points. You decide to start at the northeast corner of the landfill because it is wide open with no obstructions. It takes you approximately 1 minute to walk to the location of the first topo shot. By this time, you have already collected 3 minutes of data that will be used towards your initialization. You begin collecting topo points. In the next 2 minutes, you have collected 4 topo points without lose-of-lock. By this time, the system has collected 5 minutes of data, enough to initialize. Without hesitation, you continue with your survey.

When this data is processed, the kinematic survey will initialize using the data collected during the start of the survey. Even points collected prior to initialization will result in precise positions, as long as no loss-of-lock occurred.

You successfully continue to collect topo points for approximately 30 minutes without loss-of-lock. You now are in the perimeter areas where there are trees close to the edge of the landfill. While attempting to locate topo points right on the edge of the trees, the kinematic alarm in the receiver sounds indicating that you have lost your initialization. You must now re-initialize. It is good practice to establish a re-initialization point near an area where you think you may lose lock. This is done by simply driving a PK into the ground and observing this point prior to entering into the obstructed area. If loss-of-lock occurs, you can simply observe the re-initialization point for 10 seconds to regain initialization. As an alternative, once you lose lock, you can move out of the obstructed area and collect data on other points where there are no obstructions for approximately 5 minutes, giving the system enough clean data to re-initialize. Then move back into the obstructed area to collect more points.

On-the-fly initialization is an effective method for initializing your kinematic survey since there is no time wasted waiting for the system to initialize. But, you must be careful that you collect clean data during the initialization period or you run the risk of getting poor positions on some of your points.

2. Initialize by performing a static survey

Initialization of your kinematic survey can be accomplished by performing a static survey. Refer to the static survey section (Step 11 on page [129](#)) for guidelines on static occupation times.

The following scenario is an example of where this type of initialization would be used: You arrive on a new project site where you need to perform a kinematic survey. There are no known points in the vicinity so you must perform a static survey in order to initialize your kinematic survey. You set up the base station on an existing point with known coordinates or an arbitrary point where approximate coordinates will be assigned. You assign a point ID of 0001 to your base point. You drive a PK nail into the ground, approximately 10 feet from the base point, to mark your initialization point. You assign a point ID of 0100 to your initialization point. You set your rover system up over this PK nail, enter the point ID, and observe this point for 5-10 minutes. This is sufficient data to statically position this location. You are now initialized. You can pick up your rover system and begin positioning other points.

3. Initialize on a known point

Initialization of your kinematic survey can be accomplished by collecting a short amount of data on a point whose position is very well known with reference to the location of the kinematic base station. This is the quickest method for kinematic initialization, requiring approximately 10 seconds of observation time on the known point. The following scenario is an example where this type of initialization would be used:

You arrive on a new project site where you need to perform a kinematic survey. You set up the base station on an existing point with known coordinates or an arbitrary point where approximate coordinates will be assigned. You assign a point ID of 0001 to your base point. You drive a PK nail into the ground to mark your initialization point. You assign a point ID of 0100 to your initialization point. You then initialize your kinematic survey by first performing a static survey on your initialization point. Once initialized, you proceed to position new points using the kinematic mode. You successfully position 10 points when you suddenly lose lock on satellites due to an obstruction (the Z-Max receiver will sound an alarm when fewer than 5 satellites are locked). You must now re-initialize your survey.

You can re-initialize the survey by returning to your initialization point (0100) and observing it once again, but this time your observation needs to be only 10 seconds in duration because this point is now a known point. Your initialization point is a known point because you successfully performed a static survey on this point earlier. When you observe your initialization point the second time, you need to assign it the same point ID as your first observation (0100). By doing so, the post-processing software will know that these are observations on the same point.

Point Observation

When initialized, all the data collected by the rover system will produce centimeter-level results, whether walking around the project area or positioned over a feature. If your recording interval is set to 2 seconds, data samples (epochs) are written to memory every 2 seconds, all of which are processed by the post-processing software to generate centimeter-level positions. If you are walking around the project site, a position is calculated every 2 seconds producing a virtual trail of where you walked. If you stop and observe a feature of interest for 10 seconds, five data samples are observed for this feature, producing a more precise position than those produced while walking. The ability to determine positions while observing a feature for a period of time and the ability to determine positions while moving around the project site illustrates the two modes of post-processed kinematic positioning. These two modes are termed Continuous Kinematic and Stop&Go Kinematic.

Continuous Kinematic

The Continuous Kinematic mode of data collection is best used when positioning linear features such as roads. The idea is to trace the feature to be positioned or mapped. As you walk along this feature, positions are being determined at a specified interval, delineating the feature. Here is an example where this would be useful:

You have an as-built survey which includes a road approximately 30 meters (100 feet) in length. You need to position the centerline of the road and the edge of pavement on both sides. You walk out to the centerline with the rover system. Using the handheld software, you instruct the system to record data every 2 seconds. You then walk along the centerline from beginning to end. When this data is processed, you will see the centerline of the road delineated by a series of closely spaced data points that are the post-processed results of the 2 second data recording interval for the time period which you were walking along the centerline.

The Continuous Kinematic method is not as precise as the Stop&Go Kinematic method since with Continuous Kinematic, each position is determined with only one data sample. In addition, since no specific survey points are occupied, a loss-of-lock can require a re-initialization. With Continuous Kinematic, you can expect positions at the 0.03 - 0.05 meter (0.10 - 0.15 ft) level.

Stop&Go Kinematic

The Stop&Go Kinematic mode of data collection is best used when positioning point features. Here is an example of how the Stop&Go method works:

In the same as-built survey, you have a number of point features to locate, such as light poles and manhole covers. The recording interval at the base and the rover is set to 2 seconds. You position the rover pole over the point feature to be positioned and using the handheld software, assign a Site ID to the point feature. You occupy the point for 8 seconds, recording 4 epochs of data. When this data is processed, the software will compute the position of the point feature using 4 epochs of data.

The Stop&Go Kinematic method is more precise than the Continuous Kinematic method since multiple data samples are used to compute a position for each point feature. With Stop&Go Kinematic, you can expect positions at the 0.01 - 0.03 meters (0.03 - 0.10 ft) level.

If your linear features require the level of accuracy produced by the Stop&Go Kinematic method, this method can be used to position your linear features by used multiple Stop&Go observations to delineate the feature.

Congratulations! You have finished the section on data collection for Static and Kinematic GPS Surveying. Now you should have a basic understanding about how to setup a Z-Max System and collect GPS measurements in a number of different modes. Collecting GPS measurements is the first step to realizing the productivity that Z-Max surveying technology can offer. In the user documentation for GNSS Studio processing software, you will learn about how to download, process, manipulate and view the data that has been collected in order to efficiently produce professional quality surveying deliverables.

Troubleshooting

If you followed all the steps to prepare the Z-Max System to perform a survey and the system is not working, this section will provide a resource to help determine the cause of the problem. Problems usually fall into one of two categories, something was forgotten or a component was not installed properly. 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. Occasionally, components will fail, but this is rare because each part of the system that contains electronic components is factory tested prior to shipment.

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 Z-Max System to perform a static or kinematic data collection.

If the steps outlined in this troubleshooting section fail to get you up and running, there is a chance that a component in your system has failed. In case of such an event, contact your local Thales Navigation dealer or Thales Navigation Technical Support for assistance. Explain the steps you have taken to attempt to remedy the problem. They will need certain information about your Z-Max including product serial number, and receiver firmware options to help identify and solve the issue. If the problem is judged to be a hardware issue, they will arrange to have the component(s) returned for repair or replacement.

NOTE: When contacting Technical Support be prepared to provide the following information: product name, product serial number, and receiver firmware options.

You will be asked to utilize either the front panel display of the GPS receiver or the field application software running on the handheld data collector 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 Chapter 4 - **Operations** or the field application software manual for these details.

GPS Receiver Does Not Track Satellites

The SV/Power LED on the front panel of the Z-Max GPS Receiver Module blinks green for each healthy satellite supplying good data for data collection. If the LED blinks only red for more than five minutes then something is wrong. Follow the outline below to determine the cause of this problem.

Step 1. Does the GPS receiver have a clear view of the sky?

The path between the satellite and the GPS antenna should be outdoors and relatively free of obstructions. The receiver may not track satellites at all indoors.

Step 2. Is the GPS receiver powered up?

To determine if the receiver is powered up, examine the SV/Power LED on the front panel of the receiver. If the LED is on and blinks red every 1-2 seconds, the receiver is on.

Receiver not powered up

1. Turn on the receiver.

Press and hold the power switch on the Z-Max front panel. The button must be held for two 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. Assuming that you are in an area with a relatively unobstructed view to the sky, within a minute of power up, the receiver should be tracking multiple satellites.

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

2. Check the power source.

The Z-Max supports both internal (Power Module) and external power sources.

- a. If using the Power Module, press the power level indicator button. If the power level is low, replace the module with a fully-charged module 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 Thales Navigation technical 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 Thales Navigation Technical Support for assistance.

Receiver is powered up

Go to step 3 below.

Step 3. Is the GPS Antenna Module Connected to the Receiver?

The GPS Antenna Module must be securely connected to the GPS Receiver Module for the receiver to track satellites. Take a good look at the GPS Antenna Module on top of the receiver GPS Receiver Module.

Antenna Module not connected to receiver

1. Connect the GPS Antenna Module to the GPS Receiver Module.
 - a. Insert the Antenna Module into the antenna receptacle at the top of the GPS Receiver Module. Make sure the base of the Antenna Module is oriented so that the flattened side of the Antenna Module base is lined up with the flattened area of the receptacle, and the module will easily slide into place.
 - b. Once in place, twist the threaded collar on the Antenna Module until the antenna is securely locked in place.
 - c. Once connected, give the GPS receiver a few seconds to lock onto satellites.

Antenna connected to receiver

1. Ensure proper connection. The GPS Antenna Module must be securely locked into place on top of the GPS Receiver Module. Ensure this is the case.
2. Ensure the threaded collar on the Antenna Module is tight and not cross threaded.

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

CAUTION

It is important to power off the receiver using the Power key on the Front Panel before removing the SD card.

Step 4. A component may be malfunctioning.

You may have a malfunctioning GPS Antenna Module. Follow these steps to help isolate which component is causing the problem.

1. Replace the Antenna Module with one from another receiver. If the receiver now locks onto satellites, there is a problem with the first Antenna Module. Contact your local dealer or Thales Navigation Technical Support for assistance.

Step 5. You may have a malfunctioning GPS receiver.

Call your local dealer or Thales Navigation Technical Support for assistance.

GPS Receiver is Not Recording Data

The Data Log LED on the front panel of the GPS Receiver Module will blink green each time an epoch of data is recorded to memory. Examining this LED you determine that the receiver is not logging data to memory. Follow the procedures below to determine the cause of this problem.

Step 1. Is the GPS receiver tracking satellites?

The GPS receiver must first be tracking satellites before it can log data to memory. Check the SV/Power LED on the front panel of the Z-Max GPS Receiver Module to determine if the receiver is tracking satellites.

Receiver is not tracking satellites

Refer to the above troubleshooting item on satellite tracking to try and determine the problem.

Receiver is tracking satellites

Go to step 2 below.

Step 2. Is the SD memory card installed in the GPS Receiver Module?

The Z-Max GPS receiver logs data to a removable SD data card. The data card must be installed in the Z-Max GPS Receiver Module for the receiver to log data. Check to ensure that the data card is properly installed. If the Z-Max is powered on without a data card, a warning message should appear across the front panel display.

Data Card Not Installed

Install an SD data card into the receiver.

Data Card Is Installed

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

Step 3. Is the data card full?

The Data log LED on the front panel of the Z-Max GPS Receiver Module will be solid red if the data card in the receiver is full. Check the LED to determine if the card is full.

Card Is Full

Delete some of the data files on the data card that have been downloaded or insert another SD card that has available memory remaining.

Card Is Not Full

Replace the current SD data card with another card. If data recording begins after replacing the data card, then there is a problem with the original data card.

Go to step 4 if the problem is not yet resolved.

Step 4. Has data recording been turned off?

The receiver contains a 'Stop Session' function that is used to suspend data recording to change data cards. Once a Stop Session has been issued, a 'Start Session' is required to resume data collection. Also, it is possible using the handheld software to turn data recording off.

Perform the following two steps to ensure data recording is enabled:

1. On the front panel display, go to the SESSIONS submenu and perform a START SESSION.
2. Using the handheld data collector and the field application software, make sure that data recording is enabled. Exactly where this is will vary depending upon which field application software you are using.

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

Step 5. A component may be malfunctioning

You may have a malfunctioning GPS receiver. Contact your local dealer or Thales Navigation Technical Support for assistance.

This concludes the troubleshooting section. If the tips given here did not help you to resolve your problem with your Z-Max System, please call your local dealer or Thales Navigation Technical Support for assistance.

SECTION 3
System Guide
to
RTK Surveying

Introduction

In the early days of surveying with GPS, data collection time on a single point was measured in hours, few was the number of points established in a day, and completion of a large project could take weeks. The results of a day's work were not known until much later when the data was finally processed at the main office. The equipment required to perform this seemingly magical task was large, heavy and came with a price tag of approximately \$300,000 for a pair of receivers.

At that time it would have been difficult to imagine that some day, data collection times would be measured in seconds, hundreds of points could be established in a single day, and large projects could be completed in hours. Results would be known immediately, in real-time. The new generation of equipment required to perform this task would be small, light enough to be carried by one person all day, and the price of the typical system would be under \$40,000.

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 data 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 have 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 the results immediately. This is Real-Time Kinematic or RTK Surveying.

The Global Positioning System (GPS)

The system that makes all this possible is the Global Positioning System or 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, 28 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, it is important to have knowledge regarding the location, geometry, and number of satellites available during data collection periods. Since the satellites are not geosynchronous, the number of satellites that are available and the satellite geometry (PDOP) at any given time will vary significantly. It is important that you are aware of the favorable times of the day and choose the times when the most satellites and the lowest PDOP are available to perform your surveys. 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 positions in various datums and grid systems, output raw data and computed position through serial ports, and display satellite availability information. 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 Surveying

RTK mode of GPS surveying requires that at least two GPS receiver systems are functioning simultaneously, as shown in Figure 1.1. In fact, this is true for any mode of GPS use where better than a few meters (SA disabled) of positional accuracy is required. In a two-receiver GPS RTK system, one receiver subsystem is usually located on a known position, i.e. a point with accurately known latitude, longitude, and height, or easting, northing, and 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 a connected 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.



RTK Base



RTK Rover

Figure 1.1 RTK Setup for GPS Surveying

The RTK rover is the mobile part of the system. The rover system is lightweight and portable, situated either in a backpack or mounted on a pole. You interface with the system through either a handheld computer/data collector or from the front panel display. 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 between the base and rover receivers is computed. Finally, the rover receiver computes the rover position using the known base position, the computed vector and station antenna heights. 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 system that can operate off of one base station.

Applications

RTK Surveying is appropriate for any application that requires both high precision and high productivity. Applications such as topography, construction, control point densification, GIS data collection, oil exploration and mining are just a few of the many applications that are good uses of RTK surveying technology. Compared to a conventional total station, an RTK system will be vastly more productive in these types of surveys and have the added benefit that an RTK system can be operated by only one person.

There are two primary survey tasks for which RTK systems are used. One method is the precise positioning of features that already exist (topography, mapping, as-built surveys). Another powerful application of RTK is navigating to features with known coordinates. This is done when recovering boundary control or while transferring a design features that exist electronically to real stakes in the ground (construction stakeout).

In feature acquisition, the rover system moves around the project area positioning and assigning attributes to features of interest. Features of any type can be positioned, such as the centerline of a road, the perimeter of a pond, light poles or corners of buildings. 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 navigating to a point or series of points that define the location of a feature. Given the coordinates of a point from another source such as an aerial photograph or a to-reach description, you are 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. This process is time consuming and requires two people. 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, and grids.

Limitations

Like other precision measurement methods, 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 limitations of RTK come from the GPS system itself, and not from GPS receivers. As discussed earlier, GPS depends on receptions of radio signals transmitted by satellites approximately 20,000 km from the earth. Being of relatively high frequency and low power, these signals are not very effective at penetrating through objects that obstruct the line of sight between the satellites and the GPS receiver. Any object that blocks 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 satellite signal. Therefore, GPS cannot be used in tunnels, under water, or any indoor space where the signal level drops below detectable levels. 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. While enough signal can often be observed to compute a rough GPS position, surveying requires a higher positional accuracy and thus, a larger quantity of clean data. RTK is usually not a tool for surveying in a dense forest, just as an optical total station is not a tool for precisely measuring angles and distances in the dark.

This does not mean that GPS RTK is only useful in areas with a wide-open view of the sky. Advanced RTK systems like the Z-Max can be used very effectively and accurately in partially obstructed areas. The critical factor is to be able to observe, at any given time, enough satellite signal to accurately and reliably compute a position. In the good parts of the satellite window (the part of the day when the most satellites are visible) 5-10 GPS satellites may be visible and available for use in RTK surveying. Accurate and reliable positions can be determined with 5 satellites distributed throughout the sky (not clustered in one part of the sky). Therefore, an obstructed location can be surveyed if at least 5 satellites can be observed. This makes RTK useful in obstructed areas such as along a tree line or against the face of a building. Advanced RTK systems such as the Z-Max report the precision of the position

solution in real-time so the user can determine if a particular observation environment is suitable for precision measurements.

Thales Navigation Z-Max

The Thales Navigation solution for RTK surveying is the Z-Max System. The Z-Max includes all required components to perform real-time GPS surveys. Powered by advanced GPS and communications technology, the Z-Max is a precision measurement tool that provides superior RTK availability, reliability and accuracy. Thales Navigation has taken a great technology platform and crafted a modular design that maximizes the return on investment for positioning professionals in a competitive business environment. The receiver is a 12-channel, dual-frequency receiver with the patented Z-Tracking technology and uses about 4 watts of power. The Z-Max RTK rover is virtually cable free, with each sealed module designed to easily and simply plug into the GPS Receiver Module. The Z-Max also uses Bluetooth short range wireless protocol to allow the handheld computer to wirelessly communicate with the receiver and wirelessly transfer data to and from the receiver and a PC. With the Z-Max System, RTK surveying is more cost-effective than it's ever been.

Thales Navigation has also developed a software suite that encompasses all phases of GPS surveying and provides connectivity with existing survey systems. Thales Navigation's focus on software has generated additional improvements in the application of the technology to real work including several key improvements in the receiver's software. The Z-Max RTK System is a compelling GPS surveying solution in today's value conscious business environment.

About The Guide to RTK Surveying

This guide is designed to help you rapidly start RTK surveying with your Z-Max. The manual assumes that you have surveying or precision measurement experience. The manual includes an overview of the RTK technology, the Z-Max modules and how to connect them, an introduction to RTK surveying modes available, a description of how to set up and execute an RTK survey. If after setting up your system you are still having trouble, this manual also provides a chapter on troubleshooting to help you determine and resolve the problem. Please refer to the Operations and Reference section of this manual for specific questions about the hardware components, the LEDs and the front panel display.

System Components

In this chapter we will provide an overview of the components that make up the Z-Max RTK System for Surveying.

The Z-Max RTK Surveying System is made up of a number of modules. If setup is taken step by step, the process of assembling a system for collecting GPS data is simple. The trick is in understanding the purpose of each module in the system and how they connect to each other. With the understanding of how to assemble the hardware and when to use the Z-Max software applications, performing real-time surveys becomes logical and straight-forward.

Compared to most RTK Surveying Systems, the Z-Max is unique in two important ways. First, most of the components of the Z-Max Surveying System are modular; they attach directly to the GPS Receiver Module without the need for cables. This greatly simplifies the configuration process. Secondly, in most of the configurations, the GPS Receiver Module attaches directly to the tripod (in the case of RTK Base) or to the survey pole (in the case of RTK Rover). Keep these concepts in mind as we explain each of the components.

The major components of an RTK System are as follows:

GPS Receiver and Antenna

The GPS receiver and the GPS antenna are responsible for collecting and processing GPS signals. There must be at least two receivers, one at the base and one at the rover. Additional receivers may be used as extra rover receivers.

Data Link

The data link is any data transmission/reception device such as a radio, a cellular modem, or even a data cable. The data link's job is to transmit and receive data and corrections. There must be a transmitter at the base and a receiver at the rover.

Power Source

The power source provides the electrical power necessary to operate the receiver and the data links.

Handheld Computer and Field Application Software

The handheld computer and the field application software provide a graphical user interface with the receiver during survey configuration and execution. Their job is to make RTK configuration and execution easier and more convenient. The handheld primarily interfaces with the rover receiver, but may also be used to configure the base receiver.

Office Software

Office software, while not technically part of the real-time surveying system, plays an important role in preparing and finalizing a survey. Office software typically includes GPS survey preparation functionality including mission planning, feature code definition and stakeout point definition. After the fieldwork is completed, the office software provides the ability to transfer data between devices, perform Q/A, generate mapping products and generate printed reports.

Now that we have a general understanding of the components that comprise an RTK surveying system, let's apply that information to the Z-Max.

While the Z-Max RTK system is comprised of several different modules, each module accomplishes one of the functions described above. In addition, the nearly cable-free design of the Z-Max makes connecting the hardware together for an RTK survey a relatively simple task. Let's take a look at the same components that comprise a generic RTK system and connect them to the specific modules of the Z-Max System.

GPS Receiver and Antenna

In the Z-Max System, the GPS receiver is part of the GPS Receiver Module. The GPS antenna is in the GPS Antenna Module.

GPS Receiver Module

The GPS Receiver Module, Figure 2.1, contains the GPS receiver electronics, the SD memory card, the Front Panel User Interface, Status LEDs, and the external communication and power ports. In addition, the GPS Receiver Module serves as the connection point for all the other modules including the Communication Module, the Power Module, and the Antenna Modules (GPS and UHF).



Figure 2.1 Z-Max GPS Receiver Module

The GPS receiver processes and stores the satellite signals. An RTK system requires at least two GPS receivers; a base receiver and a rover receiver. The base receiver is usually mounted on a tripod over the known point. The rover receiver is either mounted on a pole (Figure 2.2) or mounted on a backpack (Figure 2.3).



Figure 2.2 Pole Mounted Z-Max RTK Receiver



Figure 2.3 Backpack Z-Max RTK Receiver

The Z-Max GPS Receiver Module is a 12-channel, dual-frequency receiver. The receiver has a removable SD memory card for internal data storage and is designed to run on about 4 watts of power to maximize the amount of uninterrupted time that the receiver can be operated in the field. The receiver is capable of functioning as the base or the rover receiver in both RTK and post-processed surveys. The integrated Front Panel User Interface includes the ability to configure RTK base and rover receivers and to perform basic survey tasks without the use of a handheld computer. Most users will find the handheld computer to be more convenient for configuring and executing RTK surveys.

Z-Max GPS Antenna Module

In order for the GPS receiver to receive satellite signals, it must be connected to a GPS antenna. The GPS Antenna Module is precise and sensitive device used to receive satellite signals (Figure 2.4). It is designed to attach securely to the receiver without cables.



Figure 2.4 GPS Antenna Module

The GPS receiver antenna is the actual collection point of the satellite signals. It is also the point where the position of the rover system is computed. To determine the location of a point on the ground, the rover GPS receiver antenna must be centered and leveled over this point. 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 point. The known height is called the antenna height or the antenna HI (height of instrument).

Data Link

Data link is a general term that indicates that data is transmitted and received in some way between two devices. In RTK surveying, the data link is the mechanism through which the base and rover GPS receivers communicate over long distances. A robust data link is a critical component of RTK 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 process the data and compute the vector between the base and rover receiver in real-time. The base system transmits the data and the rover system receives the data. Typical data links for mobile RTK systems are, UHF radio, VHF radio and cellular modem.

Various different types of data links are available with the Z-Max RTK System. Distance requirements, regional regulatory statutes, local interference and available infrastructure will influence which data link to use.

Z-Max Communication Module

The Communication Module (Figure 2.5) is a flexible, modular platform designed to house a variety of data links for real-time GPS. Depending upon the option you have selected, the Communication Module may have a radio by itself, a cellular modem by itself, or both a radio and a cellular modem. The Communication Module connects directly to the Receiver GPS Receiver Module without cables.



Figure 2.5 Z-Max Communications Module

UHF Radios

The Z-Max uses data links that operate in the UHF frequency range. UHF radios can communicate over long distances. Actual radio range depends on factors including the transmitter power, the height of the transmitting antenna, the topology over the transmission path and rover sensitivity. Although UHF 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 (for example, spread spectrum radios). Because of the power levels at which these radios function and the frequency they utilize, a license is often required. In the United States, a license must be obtained from the FCC to operate UHF radios. Check the local radio transmission regulations in your region.

Because the base radio is a powerful transmitter and the remote radio is a receiver, the hardware required for each is quite different. The Z-Max RTK system uses UHF data links which look and function differently at the base and rover. Because the base radio needs to send data over long distance, it has a sizeable transmitter that is too large to fit into the Communication Module housing. It consumes much more power than the Z-Max and generally requires its own dedicated power supply. The base radio is an external device that is connected to the GPS Receiver Module serial port and is powered by a separate power supply.

The remote radio is part of the Z-Max Communication Module. The Communication Module connects directly to the GPS Receiver Module and since the rover radio receiver uses comparatively little power to operate, the Communication Module uses the GPS Receiver Module's power supply. The antenna for all UHF devices is the Vortex UHF Antenna Module which is described on page [169](#).

Thales U-Link Radio

The Thales Navigation U-Link radio, Figure 2.6, is a high performance device designed specifically for GPS RTK systems. It provides long range, low power consumption and high data quality. The U-Link rover is housed in the Z-Max Communication Module. The base transmitter is connected to the Z-Max with a cable that provides data and power for transmission. Base and rover radio channels can be changed through the Z-Max Front Panel User Interface or through application software running on a handheld computer.



Figure 2.6 Thales U-Link Radio

NOTE: When using the Thales U-Link base radio, the radio must be connect to Serial B.

Pacific Crest PDL Radio

The Pacific Crest PDL radio, Figure 2.7, is a popular data link option because of its reliable performance and range of functional options. The PDL rover is housed in the Z-Max Communication Module. Base and rover channels can be changed through the Z-Max front panel or through application software running on a handheld computer. The base radio channel can also be changed directly from a button on the front of the device.



Figure 2.7 Pacific Crest PDL Base Transmitter

Cellular Modems

Cellular communications is a relatively new option for RTK surveying. It is a system that operates using commercial cellular infrastructure and is independent of distance. Cellular communications are rarely affected by any kind of interference or movement and are robust for RTK systems. Cellular data links for RTK do have some disadvantages. In most cases, cellular RTK is limited to point-to-point operation which means that only one rover can operate from each RTK base. Cellular data links for RTK cost more per use than other systems, since the user must have be actively connected to the other side of the link while performing RTK. The phone call between RTK receivers can last for many hours a day. Cellular links work the best where there is extensive geographic coverage and flat-rate, unlimited air-time rate structures are available. When cellular data links are used for RTK surveying, base and rover receivers must use the same type of Communication Module.

When using cellular devices, the user is required to set up an account with a service provider. The service provider will supply the phone number and other information needed to access the cellular service

Motorola G18 GSM modem

GSM (Global System for Mobile communications) is a widely used cellular system that can be used to carry either voice or data communications. The GSM modems used in the Z-Max RTK system are housed in the Communication Module, Figure 2.8. Dialing of the modem can be controlled by the Front Panel User Interface of the Z-Max or through application software running on a handheld computer. GSM modems require the use of a SIM card. The SIM card helps maintain the security of a GSM user account and is inserted into the modem through an access door on the underside of the GSM enabled Communication Module. The GSM-enabled communication module includes an integrated antenna which protrudes from the top of the device.



Figure 2.8 GSM Communication Module

Data Link Configurations

While the cellular modems in the Communication Module serve as both the transmitter and the receiver (transceiver), the radios in the Communication Module are receivers only. The base receiver must have an external radio

connected that serves as the transmitter. Therefore, the Z-Max RTK System will generally use one of the following data link configurations:

- A Cellular modem at both the base and the rover. The cellular modem and antenna are inside the Communication Module for both the base and the rover receiver.
- A UHF transmitter at the base station and the Communication Module at the rover. The base transmitter is an external radio connected to one of the receiver's external serial ports and powered with an external battery. The Communication Module at the rover contains a small radio receiver.

UHF Antenna

When using a UHF radio as the data link in an RTK system, antennas must be connected at the base and rover to transmit and receive data.

The external base radio uses its own antenna that is attached to either a separate tripod or directly to the base radio. The base radio antenna is often raised as high in the air as possible to maximize transmission distance.

The rover system using a UHF Communication Module will use the Vortex UHF Antenna Module as its UHF antenna. The Vortex UHF Antenna Module is designed to connect between the GPS Receiver Module and the GPS Antenna Module as shown in Figure 2.9. There are no cables to attach. The UHF Antenna Module carries the radio signal through the GPS Receiver Module to the radio inside the Communication Module.



Figure 2.9 UHF Antenna Module and GPS Antenna Module

Power Sources

Both the base and the rover system need a source of power to operate the GPS receivers and the data links.

Because the base system is stationary, there is a lot of flexibility as to what power source to use since size and weight is not a primary consideration. The primary consideration at the base station is that there is enough power to last for the duration of the survey. The base station often runs unattended, so the user needs to be confident that there is no danger of running out of power. The base system can use one of many possible power sources as the power supply including a Z-Max Power Module or an external DC power source such as a battery, an AC/DC converter, or an auto cigarette lighter. Specially designed cables are available for using each type of external DC power source. The external battery cables connect to the Z-Max GPS Receiver Module at the power port located on the rear panel of the GPS Receiver Module. An external power source can be used at the same time as the Power Module. When both are used, the Z-Max automatically uses a suitable external source. If and when the external power source is spent, the Z-Max will automatically switch to the Power Module without any interruption in operation.

In the rover RTK system, weight and runtime are competing requirements. Since the rover is carried by the user, a heavy battery is undesirable. The Z-Max System offers the flexibility of a run-time optimized (13+ hours) and a weight optimized (6+hours) option.

Power Module

The Z-Max Power Module (Figure 2.10) is the internal battery for the Z-Max system and is the primary source of power for the Z-Max RTK rover system. The Power Module connects directly to the GPS Receiver Module without cables and contains a long lasting smart lithium ion battery. There are two types of power modules. One is optimized for runtime (13+ hours) and one is optimized for light-weight mobile operations (6+ hours). Both the Max-Run and the Max-Lite Power Modules are available as options with the Z-Max system. The Z-Max system, including the Communication Module, will use the Power Module as its main power source. An external power source must be provided for the power output on the serial port to be enabled.



Figure 2.10 Power Module

The Power Module includes a smart monitoring system that continually monitors the battery life remaining. There are two ways to monitor battery life remaining; via the LED indicators on the Power Module and using the Front Panel User Interface. The LED indicators provide a quick indication of the percentage of battery time remaining when the battery is not attached to the receiver. Each green light represents about 25% of battery life. Four green lights indicate the battery is fully charged (100%). One red light indicates that there is less than 25% of battery life left. To activate the power indicator LEDs, push the button on the back of the Power Module (the side that attaches to the GPS Receiver Module). For a more precise report of the amount of battery time remaining, use the BAT function in the SYSINFO menu of the Front Panel User Interface, or the field application software.

Mounting Accessories

When using the Z-Max system to perform RTK surveys, various accessories are required to mount the receiver to the tripod, the rover survey pole or the backpack. Each of these accessories and their purpose are described in this section. How they fit into the equipment set up will be covered in Chapter 3 - **Hardware Connectivity** and Chapter 4 - **RTK Survey Preparation**.

HI Measurement Plate - An accurate measurement of the height of the antenna above the survey mark is very important. However, when the Z-Max System is attached to a tripod there is not enough clearance to measure the antenna height from the survey mark to the GPS antenna. The HI Measurement Plate (Figure 2.11) provides a convenient location on the system to where the slant height of the antenna above the survey mark can be consistently and accurately measured. It attaches to the system between the bottom of the GPS Receiver Module and the tribrach. The HI Measurement Plate is only used when the Z-Max system is a base station receiver. The HI Measurement Plate is not necessary when using a fixed-height tripod.



Figure 2.11 HI Measurement Plate

Pole Adapter - The Pole Adapter, Figure 2.12, is used with the RTK rover system whenever the UHF Radio Antenna Module is not used. The Pole Adapter is essentially an empty UHF Antenna Module. The Pole Adapter raises the GPS Antenna module high enough on the survey pole so that the antenna's view to the satellites is not blocked by the user. The Pole Adapter attaches to the survey pole and connects between the GPS Antenna Module and the GPS Receiver Module when using a pole-mounted system, or between the GPS Antenna Module and the Range Pole RF Adapter (see below) when using a backpack-mounted system.



Figure 2.12 Pole Adapter - Pole-Mounted System

Range Pole RF Adapter - When the Z-Max system is operating as a backpack-mounted RTK rover, a cable is required to connect the GPS Receiver Module in the backpack to the GPS Antenna Module on the survey pole. The Range Pole RF Adapter (Figure 2.13) is the module where the cable physically connects to the survey pole and the GPS Antenna Module. The Range Pole RF Adapter connects between the survey pole and either the UHF Antenna Module or the Pole Adapter.



Figure 2.13 Range Pole RF Adapter - Backpack Mounted System

Max-RF Adapter - When the Z-Max system is operating as a backpack-mounted RTK rover, a cable is required to connect the GPS Receiver Module in the backpack to the GPS Antenna Module on the survey pole. The Max-RF Adapter is the module where the cable physically connects to the GPS Receiver Module. The Max- RF Adapter connects to the top of the GPS Receiver Module in the same receptacle where the GPS Antenna Module connects during a static survey (Figure 2.14).



Figure 2.14 Max-RF Adapter

Handheld Computer/Field Application Software

The user must interface with the receiver in order to configure and run an RTK survey. The device that is typically used to interface with the receiver is a handheld computer running field application software. While it is possible to configure and perform RTK surveys using the Front Panel User Interface, a handheld computer is more convenient and provides more capabilities.

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. Only one handheld computer is required in an RTK system.

FAST Terminal

The standard handheld computer used by the Z-Max Survey system is the FAST Terminal (Figure 2.15). The FAST Terminal is a lightweight, rugged handheld computer developed especially for surveying applications. It is designed to withstand conditions encountered during a variety of field scenarios. The FAST Terminal uses Bluetooth wireless technology so that no cables are required between the handheld and the receiver. Users can interface with the receiver up to 10 meters away.



Figure 2.15 FAST Terminal

The FAST Terminal features wireless communication via a Bluetooth-enabled Compact Flash card, a monochrome 320x240 display, and an RS-232 port located at the top of the unit. In addition, the unit comes with 64 MB RAM and 32 MB of ROM.

FAST Survey

Residing on the FAST Terminal data collector is the field application software FAST Survey. As with a conventional total station, this software is the user's interface to the base and rover systems, facilitating survey preparation and execution. FAST Survey software was designed by Thales Navigation specifically for use with Thales Navigation RTK systems. FAST Survey offers all the basic requirements for configuration of the Z-Max for RTK surveys such as base setup, rover setup, and control of communications devices. FAST Survey software also

offers a wide range of functionality for performing RTK applications including topography, stakeout, boundary and as-built surveys. FAST Survey is also a full functioned total station controller including COGO, graphical displays of points and locations. FAST Survey also has the ability to monitor data quality storage and coordinate system management. The software guides you through all steps required to configure and execute an RTK survey with an interface that is straightforward and easy to master.

Office Software

Although RTK surveys yield precision results in real-time, office software can still play a key roll in the preparation and finalization of survey jobs. GPS surveying typically requires office software to perform preparation tasks, including site reconnaissance, observation session planning and feature definition. Defining the attributes of real-time data is a critical function of field work. Feature codes or feature libraries are often created beforehand in an office environment. Office software also facilitates smooth RTK preparation by enabling file transfers between the PC and the handheld device. Office software can also play a pivotal role after RTK data is collected and returned from the field. Office software is useful for preparing GPS stakeout files and then for QA analysis of the collected data. Depending on the sophistication of the package, office software can generate graphical mapping products, text reports and export data into a format that assists integration into other systems. In some cases, GPS measurements collected in post-processed mode are used in conjunction with RTK.

Thales Navigation GNSS Studio

The standard office software package for the Z-Max system is Thales Navigation's GNSS Studio. GNSS Studio includes all functionality required to support processing, manipulation and output of data collected using the Z-Max RTK and post-processed surveying system. Using GNSS Studio, you can plan field operations, prepare feature codes or stakeout files prior to the field work, transfer data between the office computer and field devices, process collected data, and create your choice of detail-rich maps and reports. This is all accomplished through a user interface which is a mix of simplicity and power.

In addition to data transfers between devices using a cable, the software contains the functionality to download data using the Bluetooth wireless module in the Z-Max GPS Receiver Module, so data can be downloaded without cables.

This concludes the description of individual hardware and software modules which make up the Z-Max System for RTK surveys. Next, we will examine how the individual Z-Max hardware and software modules fit together to build a powerful system for real-time navigation and data collection.

Hardware Connectivity

If you have been reading this document sequentially, you should now have a basic understanding of the modules included with a Z-Max system for RTK surveying. In this chapter, information will be provided about how the modules fit together and how they relate to each other. In order for the different components to function as a system, they must communicate and they must be powered. This requires that the modules be connected correctly. In the following sections, we will examine the connectivity of the Z-Max modules.

Since the RTK 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, a pole-mounted configuration and a backpack configuration. Each of these configurations will be discussed separately. Lastly, remember that the Z-Max RTK system comes with a choice of data links and the data link used will have a big effect on the system configuration. Each type of data link will also be discussed separately where appropriate.

RTK Base System

The fundamental components of the RTK base system are the receiver, the GPS antenna, and the wireless data link. As discussed in chapter 2, the data link can be a radio or a cellular link. If a radio is used as the data link, an external radio with a transmitter is required at the base station. If a cellular modem is used as the data link, the integrated modem and antenna in the Communication Module are used.

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

GPS Receiver - Receiver Power System

Supplying power to the Z-Max system can be accomplished by using the Power Module or by connecting a DC power source (10-28V) to the external power port.

The Z-Max Power Module is a self-contained power source designed to be conveniently attached to the side of the GPS Receiver Module. The Max-Run Power Module can power the receiver for over 13 hours, so only one Power Module may be needed for a full day of data collection. Power Modules must be charged before being used in the field.

The Power Module does not require any cables. It simply connects to the right-hand side of the GPS Receiver Module. To connect the Power Module to the GPS Receiver Module, insert the small ledge of the Power Module into the rear of the GPS Receiver Module housing first as shown in Figure 3.1. This will correctly align the module. Using the ledge like a hinge, swing the module closed until the latch on the Power Module clicks into place.



Figure 3.1 GPS Receiver - Power Module Connection

If the Z-Max system is to collect data unattended for a period of time exceeding the capability of the Power Module, an external power source can be used. External power is applied to the Z-Max GPS Receiver Module by connecting the power source with a cable (Figure 3.2) to the external power port located on the rear panel of the GPS Receiver Module. The power port is a sealed 3-pin connector marked 'Power'.



Figure 3.2 External Power Connection

The Power Module and external power sources can be used alone or at the same time. As long as one or the other power source is plugged in, the receiver will operate without interruption. In case both the Power Module and external power source are used, the Z-Max will draw power from the external source until the voltage drops or power is interrupted. If the power from the external power source is insufficient, the Z-Max will automatically switch over to the Power Module with no interruption in operation.

GPS Receiver - GPS Antenna

The GPS Receiver Module requires that a GPS Antenna Module be connected in order to measure and record the data being transmitted by the satellites. The GPS Antenna Module connects directly to the GPS Receiver Module and does not require any cables.

At the top of the GPS Receiver Module is an antenna receptacle. The base of the GPS Antenna Module is circular except for a flattened area. To connect the GPS Antenna Module, just insert the antenna base into the receptacle at the top of the GPS Receiver Module (Figure 3.3). Make sure the base of the Antenna Module is oriented so that the flattened side of the Antenna Module is lined up with the flattened area of the receptacle, and the module will push easily into place. Once in place, twist

the threaded collar on the UHF Antenna Module until the assembly is securely locked in place.



Figure 3.3 GPS Antenna Connection

The GPS antenna can be connected to the receiver at any time before or after the receiver is powered on. Make sure the threaded collar turns easily when tightened and is not cross-threaded.

GPS Receiver - Communication Module

The Z-Max requires that a Communication Module be connected whenever the unit may be exposed to blowing dust or moisture. If the RTK base system is using UHF radios, then an empty Communication Module housing (called V-Module) is required to protect the Z-Max. If the RTK base system is using a cellular modem, then the Communication Module serves as the modem transmitter.

The Communication Module connects directly to the left-hand side of the GPS Receiver Module without cables. To connect the module, insert the small ledge of the module into the rear of the GPS Receiver Module housing first as shown in Figure 3.4. This will correctly align the module. Using the ledge like a hinge, swing the

module closed until the latch on the module clicks into place. Make sure that the module is well seated, and the latch is completely closed.



Figure 3.4 Connecting Communication Module to GPS Receiver Module

The cellular Communication Module has its own integral antenna that protrudes above the top of the module housing. Cellular Communication Modules based on GSM protocol will also have an access door on the underside of the module to enable the installation of the SIM card.

GPS Receiver - Tripod

The Z-Max RTK base system is designed to attach directly to a tripod. Center and level the tripod over the ground mark prior to attaching the receiver. On the bottom of the GPS Receiver Module is a standard 5/8" threaded receptacle that fits the tribrach adapter (Figure 3.5). Attach the tripod tribrach adapter as described below.



Figure 3.5 GPS Receiver Module and Tripod Adapter

Fixed Height Tripods

Screw the tripod adapter into the Z-Max threaded receptacle. Once the GPS Receiver Module and the tribrach adapter are attached, set the assembly onto the tripod.

When fixed height tripods are being used, the vertical height of the tripod is known. It is not necessary to measure the HI as it can be computed. To determine the total vertical height (HI) of the setup, add the vertical height of the Z-Max system to the known height of the tripod.



Figure 3.6 GPS Receiver Module Fixed Height Tripod Installation

Adjustable Height Tripods

Insert the tribrach adapter through the mounting hole of the HI Measurement Plate. Screw the adapter into the GPS Receiver Module, while holding the HI measurement plate in place. Carefully set the assembly (Z-Max, mounting plate, tribrach adapter) onto the tripod. Once the Z-Max is securely mounted to the tripod, the height of the GPS antenna must be measured. The HI measurement plate is used to measure a slant height from the receiver to the survey mark. The HI measurement plate provides a fixed radius which allows a reduction to vertical height. To determine the total height of the setup, add this reduced vertical height to the vertical height of the Z-Max which is printed on the underside of the GPS Antenna Module.



Figure 3.7 GPS Receiver Module Adjustable Tripod Installation

Radio - Radio Antenna

This section only applies if you are using a radio or a combination of radio and cellular as your data link. If you are using only a cellular modem, this section is not required.

The base radio requires an antenna to transmit GPS receiver raw data to the rover. Therefore the radio antenna must be connected to the radio. The radio and the radio antenna are generally mounted to a separate tripod. Many radio tripods are designed with a telescoping pole that can be vertically extended to improve radio range. The radio antenna connection will differ depending upon which radio you are using.

Thales U-Link Transmitter

The transmitting antenna connects directly to the Thales U-Link radio without a cable. The advantage of a direct antenna connection is that there is little signal power loss between the transmitter and the antenna. Attach the antenna by screwing the antenna to the antenna connector as shown in Figure 3.8.

The radio is mounted to the telescoping pole using the radio mounting bracket that is part of the radio system. Hook the flange on the radio into the mounting bracket, and attach the mounting bracket to the telescoping survey pole as shown

in Figure 3.9. The radio and the antenna together are raised as high as possible to maximize transmission distance.



Figure 3.8 Thales U-Link Radio Antenna

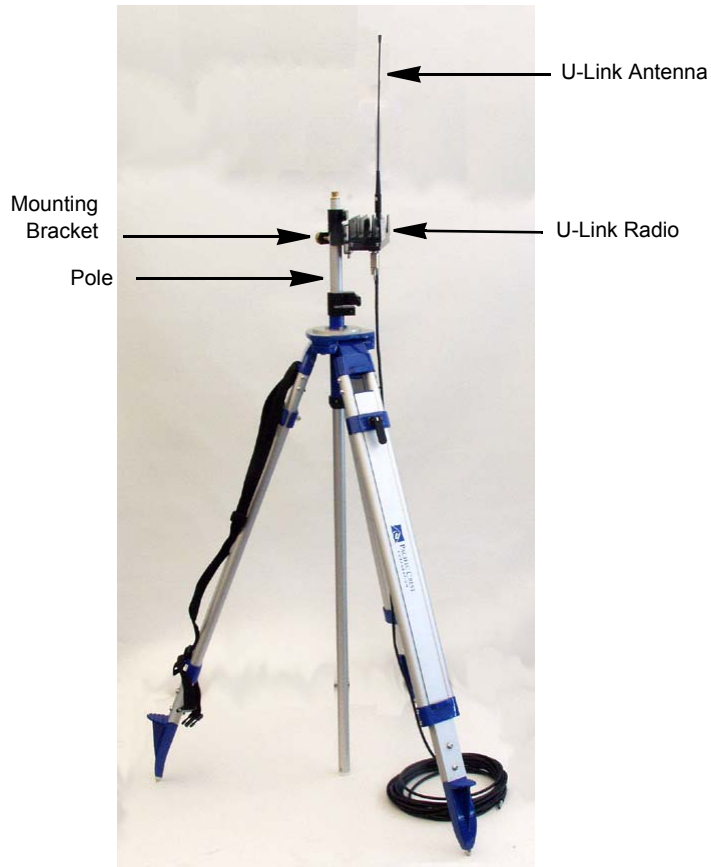


Figure 3.9 Mounting the Thales U-Link Transmitter

Pacific Crest PDL UHF Transmitter

The radio antenna for the PDL UHF Transmitter has a cable that connects to the radio. The radio antenna is connected to an antenna mount that allows the antenna to be attached to the top of a telescoping pole, or a tripod. Screw the antenna on to the top of the telescoping pole or tripod and connect the antenna cable to the radio antenna port.

The radio is generally attached to the tripod. On the radio is a built-in tripod mounting bracket. Locate the mounting flange at the top portion of one of the tripod legs and hook the radio in place as shown in Figure 3.10.



Figure 3.10 PDL Radio and Radio Antenna

CAUTION

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

GPS Receiver - Radio

This section only applies if you are using a radio as your data link. If you are using a cellular modem, skip this section.

In an RTK system using radios, data must be passed from the GPS base receiver to the transmitter for broadcast to RTK rover systems configured to receive the base transmissions. To pass the data from the GPS receiver to the radio transmitter they must be connected through a data cable. Depending on the type of radio used, this

cable may also be integrated with a power supply cable. The exact cable and connections will differ depending upon the radio and the power source used.

Base transmitters typically draw two to ten times the power of the Z-Max. Higher power consumption can require the use of an external battery with 10 Amp hours or more of capacity. Depending on the type of radio, the power for radios outputting 4 watts or less may be supplied through the serial port of the Z-Max. The Z-Max requires a DC power source to be connected to the external power port in order to power radio transmitters through the serial cable.

For radios that transmit at power levels higher than 4 watts, a Y-cable with 3 connectors must be used. Y-cable connectors consist of a receiver connector, a radio connector, and a connector used to connect to a power supply. The receiver connector of the data/power cable connects to one of the two serial ports on the rear panel of the Z-Max GPS Receiver Module. The 2 receiver ports are serial A and serial B (labeled 'SERIAL A' and 'SERIAL B'), and each port is a 7-pin Fischer connector.

Pacific Crest PDL UHF 2/35 Watt Transmitter

The RTK base configuration using a Pacific Crest 35 Watt base transmitter requires a Y-cable. The receiver end of the PDL radio data/power cable can connect to either serial port A or serial port B of the Z-Max but port B is recommended.

At the radio end of the PDL data/power cable is a 5-pin Lemo connector. The data/power connector on the radio is labeled DATA/PWR. This connection serves as both the power connector and the data cable. Connect the radio to the receiver by connecting the 5-pin end of the cable into the radio and the 7-pin end of the cable to serial port B as shown in Figure 3.11. A large battery is needed to transmit at 35 Watts and a robust power cable is needed to supply adequate

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



Figure 3.11 Connecting PDL 35-W Radio & Z-Max GPS Receiver Module

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

Pacific Crest PDL UHF Low Power Base Transmitter 2W

The RTK base configuration using a Pacific Crest 2-watt base transmitter requires a Y-cable. The receiver end of the PDL radio data/power cable can connect to either serial port A or serial port B of the Z-Max but port B is recommended.

At the radio end of the PDL data/power cable is a 5-pin right angle Lemo connector. The data/power connector on the radio is located under the LED display of the radio. This connection serves as both the power connector and the data cable. Connect the radio to the receiver by connecting the 5-pin end of the cable into the radio and the 7-pin end of the cable to serial port B as shown in Figure 3.12. A battery with a capacity greater than 10 Ah is recommended. The

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



Figure 3.12 Connecting PDL 2-W LPB Radio & Z-Max GPS Receiver Module

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

Thales U-Link Transmitter

The RTK base configuration using a Thales U-Link requires a data/power cable leading from the Z-Max to the radio. The receiver end of the Thales U-Link data/power cable must be connected to serial port B of the Z-Max. When the U-Link radio is used, the Z-Max serial port B must be configured in RS-422. This is done in the radio configuration/port setup menu of the Front Panel User Interface. When the Z-Max is setup for a Thales U-link radio on Port B, automatically changes the port protocol to RS-422.

At the radio end of the U-Link data/power cable is a 15-pin connector. The data/power connector on the radio is located under the LED display of the radio. This connection serves as both the power connector and the data cable. Connect the radio to the receiver by connecting the 15-pin end of the cable to the radio and the 7-pin end of the cable to serial port B as shown in Figure 3.13. The battery end of

the external power cable is typically fitted with alligator clips, providing the flexibility to connect to any type of battery power source.



Figure 3.13 Connecting Thales U-Link Radio & Z-Max GPS Receiver Module

It is recommended that the radio be connected to the receiver and the external battery be connected to the Z-Max external power port prior to powering up the receiver. This will ensure a clean power-up of the radio.

Handheld Computer - GPS Receiver

The base station can be configured using either a handheld computer running Field Application software or via the front panel display. The FAST Terminal handheld computer can interface with the Z-Max system without cables using Bluetooth wireless enabled devices. A Bluetooth enabled handheld can wirelessly communicate with the receiver up to 10 meters away. The Z-Max can also use a serial cable to communicate with other devices such as handheld computers and a PC. Running on the FAST Terminal is specialized software for field surveying called, FAST Survey. FAST Survey has been designed by Thales Navigation specifically for use with Z-Max RTK systems. The standard Z-Max GPS Receiver Module is equipped with an internal Bluetooth module that is on any time the receiver is powered. No further configuration is necessary.

Fully Connected RTK Base System

Depending upon the data link used, a fully connected Z-Max Base receiver will have as few as zero and as many as two cable connections.

Cellular RTK Base

The Z-Max RTK base system is practically self-contained and does not use any external cables. Simply install the Cellular Communication Module, as shown in Figure 3.14.



Figure 3.14 Z-Max RTK Base with Cellular Modem

Thales U-Link RTK Base

The U-Link connection is:

1. The radio data/power cable plugged into the radio's unlabeled 15-pin data / power port. This cable connects the radio to the Z-Max GPS Receiver Module. When using the Thales U-Link radio, power is supplied from the Z-Max serial port. In this configuration, an external power source is required for the Z-Max. Plug the external power source into the external power port of the Z-Max GPS Receiver Module.
2. The transmitting antenna attached directly to the connector on the Thales U-Link (Figure 3.15).



Figure 3.15 Thales U-Link Radio In RTK Base Configuration

The Connection to the Z-Max:

1. External power cable plugged into the port labeled "POWER". This cable connects an external power source to the Z-Max GPS Receiver Module. This is an essential connection to power the radio
2. Radio data/power cable plugged into the port labeled "SERIAL B". This cable connects the Z-Max GPS Receiver Module to the radio. This cable is mandatory.



Figure 3.16 RTK Base with Thales U-Link Radio

Pacific Crest PDL Base

The PDL connections are:

1. The radio data/power cable plugged into the radio's DATA/PWR port. This cable connects the radio to the Z-Max GPS Receiver Module and also connects the radio to an external power source.
2. The radio antenna cable plugged into the ANTENNA port that connects the radio to the radio antenna.



Figure 3.17 Pacific Crest PDL Radio with all Cable Connections

The Connection to the Z-Max:

1. External power cable plugged into the port labeled "POWER". This cable connects an external power source to the Z-Max GPS Receiver Module. This is an optional connection and is only required if the power requirements will exceed the capacity of the Power Module.
2. Radio data/power cable plugged into the port labeled "SERIAL B". This cable connects the Z-Max GPS Receiver Module to the radio.

RTK Rover System

The rover system may be mounted on a pole or placed in a backpack.

The pole-mounted rover system places the GPS receiver and all other modules directly on the rover pole. All of the components are pole-mounted, eliminating the need for cables or any physical connection between the user and the system. In the backpack rover system, the GPS receiver, power supply, and data link are all mounted in a backpack. The GPS antenna and UHF antenna are mounted together on the survey range pole and are connected by cable to the GPS Receiver Module in the backpack.

The following sections describe the connections required to use the pole-mounted and backpack rover system.

Pole-Mounted Rover System

GPS Receiver - Radio Antenna

The RTK rover requires the use of wireless communications with the base RTK receiver. The Z-Max supports different wireless communications to support differing user needs. A common type of wireless modem used for GPS RTK is UHF radio. When using UHF radio, a UHF antenna is needed. The Z-Max rover system uses the UHF Antenna Module for receiving UHF signal. Some types of wireless modems, like cellular, use antennas that are attached directly to the Communication Module. When there is no UHF modem being used, a special, empty UHF Antenna Module (called the Pole Adapter) attaches between the GPS Receiver Module and the GPS Antenna Module and maintains a constant antenna height.

The UHF Antenna Module (Figure 3.18) connects directly to the top of the GPS Receiver Module without any cables. The base of the UHF Antenna Module is circular except for a flattened area. Orient the UHF Antenna Module so that the flattened side of the Antenna Module base is lined up with the flattened area inside the antenna receptacle of the GPS Receiver Module and insert the UHF Antenna Module. If the modules are correctly aligned, the UHF Antenna Module will push easily into place. Once in place, twist the threaded collar on the module until it is securely locked in place (Figure 3.19).



Figure 3.18 UHF Antenna Module



Figure 3.19 UHF Antenna Connection to GPS Receiver Module

GPS Receiver - GPS Antenna

As with the base system, the rover GPS receiver requires an antenna in order to receive satellite signals. The rover uses the same GPS Antenna Module as the base station. Where the GPS Antenna Module is connected to the receiver depends upon the data link being used.

If the rover system is using the UHF radio in the Communication Module, the GPS Antenna Module attaches to the top of the UHF Antenna Module (Figure 3.20). If the base/rover system is using the cellular modem as the data link, the GPS Antenna Module connects directly to the Pole Adapter. The Pole Adapter is essentially an empty UHF Antenna Module.

To attach the GPS Antenna Module to the UHF Antenna Module (or Pole Adapter), note that the base of the GPS Antenna Module is circular except for a flattened area. The top of either the UHF Antenna Module or the GPS Receiver Module has a receptacle designed to hold the GPS Antenna Module. Orient the GPS Antenna Module so that the flattened side of the Antenna Module base is lined up with the flattened area inside the top of the receiving module and insert the GPS Antenna Module into the antenna receptacle. If the modules are correctly aligned, the GPS

Antenna Module will push easily into place. Once in place, twist the threaded collar on the GPS Antenna Module until the module is securely locked in place.



Figure 3.20 GPS Antenna Module - UHF Antenna Module Connection

The GPS antenna can be connected to the receiver at any time before or after the receiver is powered on. The attachments of the modules provide the water seal for the Z-Max so make sure that the connection is secure.

GPS Receiver - Communication Module

Just like the RTK base system, the Communication Module connects to the right-hand side of the GPS Receiver Module. To connect the module, align the module and the housing and insert the small ledge of the module into the rear of the GPS Receiver Module housing as shown in Figure 3.21. Swing the module closed until the latch on the module clicks into place. Make sure that the module is well seated, and the latch is completely closed.



Figure 3.21 Connecting Communication Module to GPS Receiver Module

The Communication Module is now installed and ready to be configured.

GPS Receiver - Receiver Power System

The rover system will be powered solely by the Power Module in most user scenarios. Make sure that the Power Module is fully charged before going out to the field.

The Power Module for the rover system is identical to the Power Module for the RTK base system. The Power Module connects directly to the GPS Receiver Module without cables. Just like the RTK base system, the Power Module connects to the left-hand side of the GPS Receiver Module. To connect the module, align the module and the housing and insert the small ledge of the module into the rear of the GPS Receiver Module housing as shown in Figure 3.22. Swing the module closed until the

latch on the Power Module clicks into place. Make sure that the module is well seated, and the latch is completely closed.



Figure 3.22 GPS Receiver - Power Module Connection

Connecting the battery or external power source, to the receiver is required prior to powering up the receiver.

Handheld Computer - GPS Receiver

Handheld computers (Figure 3.23) may be used to configure and control the Z-Max during RTK surveying operations. The use of a handheld computer with graphical application software can add significant utility to the system and in some cases is essential. Connection of the handheld computer is accomplished either wirelessly using the Bluetooth protocol module, or with a cable. If the handheld is going to interface with the receiver wirelessly, no physical connection is required. The Bluetooth module in the receiver is on anytime the receiver is powered on. Just make sure that the Bluetooth module is present in handheld terminal.

If you need to use a cable, the computer communication cable connects to the Z-Max via one of the two serial ports on the back panel of the receiver. These two ports are located on the rear panel of the receiver and are labeled SERIAL A and SERIAL B. The handheld can be connected to the receiver at any time during the equipment setup and data collection process.



Figure 3.23 FAST Terminal Handheld Computer

FAST Terminal

The FAST Terminal is offered as an option with the Z-Max system for RTK surveys. It is lightweight, durable and weather resistant for use in outdoor environments. The FAST Terminal allows both wireless and cabled connections from the Z-Max Receiver Module to the PC. When using a cable connection, the FAST Terminal should be connected to serial port A on the GPS Receiver Module (labeled SERIAL A). The FAST Terminal supports use of Bluetooth wireless with a module that is installed in the compact flash receptacle of the device. The compact flash receptacle is located underneath the FAST Terminal battery in a compartment located at the lower back of the device.

Mounting the System to the Pole

Now that the UHF Antenna Module, the Communication Module, and Power Module are all connected to the GPS Receiver Module, the system is ready to be mounted on the pole.

At the base of the receiver GPS Receiver Module is a 5/8" threaded receptacle. If your survey pole contains a removable brass adapter with a 5/8" bolt on top, it is easier to attach the brass adapter to the base of the receiver and then seat the

receiver onto the pole. If no adapter is available, just thread the pole directly on to the base of the receiver.

Fully Connected Z-Max Rover System

The typical pole-mounted Z-Max Rover System will not have any cable connections. All the modules will be connected directly to the GPS Receiver Module. Even the handheld computer is wireless and may be mounted on the pole with a special mounting bracket. The fully connected pole-mounted system is shown in Figure 3.24.



Figure 3.24 Fully Connected Pole-Mounted Rover System

Backpack-Mounted Rover System

The backpack-mounted rover system uses many of the same connections as the pole mounted RTK rover. The Z-Max receiver assembly, including the GPS Receiver

Module, the Communication Module and the Power Module are mounted in a backpack. To provide the capability for accurate positioning, the GPS and UHF Antenna Modules are mounted on a survey pole and are connected by the cables to the GPS Receiver Module in the backpack. The cable connectors are located on the Range Pole RF Adapter on the survey pole and on the Max-RF adapter attached to the top of the GPS Receiver Module.

GPS Receiver - Communication Module

The Communication Module connection is identical to the base and pole-mounted systems. The Communication Module connects to the right-hand side of the GPS Receiver Module. To connect the module, align the module and the housing and insert the small ledge of the module into the rear of the GPS Receiver Module housing as shown in Figure 3.25. Swing the module closed until the latch on the module clicks into place. Make sure that the module is well seated, and the latch is completely closed.



Figure 3.25 Connecting Communication Module to GPS Receiver Module

The Communication Module is now installed and ready to be configured. The Z-Max will automatically detect which type of Communication Module is present.

GPS Receiver - Receiver Power System

Under most operational conditions, the rover system will be powered solely by the Power Module. Make sure the Power Module is fully charged before leaving for the field.

The backpack-mounted Power Module is identical to the RTK base system and pole-mounted Power Module. The Power Module connects directly to the left-hand side of the GPS Receiver Module. To connect the module, align the module and the housing and insert the small ledge of the module into the rear of the GPS Receiver Module housing as shown in Figure 3.26. Swing the module closed until the latch on the Power Module clicks into place. Make sure that the module is well seated, and the latch is completely closed.



Figure 3.26 GPS Receiver - Power Module Connection

GPS Receiver - Max-RF Adapter

To provide a path for GPS and UHF RF signals to enter the Z-Max from range pole mounted antennas, the Max-RF Adapter is used (Figure 3.27). The Max-RF Adapter has a connector for UHF and GPS signal (both TNC type). Insert the Max-RF Adapter into the antenna receptacle at the top of the GPS Receiver Module. Make sure the base of the Adapter is oriented so that the flattened area is lined up with the flattened area of the receptacle, and the module can easily be pushed into place. Once in place, twist the threaded collar until the antenna is securely locked in place.



Figure 3.27 Max-RF Adapter and GPS Receiver Module

Mount the GPS Receiver Module to the Backpack

Now that the Communication Module, Power Modules and Max-RF Adapter are connected, the Z-Max assembly can be secured inside the backpack.

The Z-Max backpack is designed to allow Z-Max users to comfortably carry the unit in the pack while using a range pole to precisely center the GPS antenna over the survey point. The Z-Max backpack has adjustable shoulder and hip straps, and an adjustable torso bar. The backpack should be properly adjusted for the user. To mount the unit to the backpack, place the receiver onto the backpack and secure the unit with the Velcro strap (Figure 3.28).



Figure 3.28 Mounting the Receiver on the Backpack

Range Pole RF Adapter - Survey Pole

When a backpack is being used, a survey pole is necessary to obtain an accurate measurement from the survey mark to the GPS antenna phase center. Therefore, in the backpack configuration, components need to be mounted on both the survey pole and in the backpack. The Range Pole RF Adapter connects directly to the survey pole (Figure 3.29) and provides a cable interface for the cables that run between the Z-Max backpack and the survey range pole. The Range Pole RF Adapter is exactly the same height as the GPS Receiver Module in order to keep the same antenna HI as the Z-Max pole-mounted system.

To attach the Range Pole RF Adapter to the survey pole, simply screw it onto the top of the 5/8 inch threaded survey pole or adapter bolt.



Figure 3.29 Range Pole RF Adapter Connection

UHF Radio Antenna

The rover UHF radio requires the use of an antenna to receive the signals transmitted from the base radio. In the Z-Max, the radio antenna is called the UHF Antenna Module. The UHF Antenna Module connects directly to the Range Pole RF Adapter without cables.

When a cellular modem is being used as the data link, an empty UHF Antenna Module (called the Pole Adapter) attaches between the GPS Antenna Module and the Range Pole RF Adapter. The Pole Adapter looks the same as a UHF Antenna Module and maintains the proper height of the rover pole.

The UHF Antenna Module connects directly to the top of Range Pole RF Adapter (Figure 3.30). Note that the base of the Antenna Module is circular except for a flattened area. Orient the UHF Antenna Module so that the flattened side of the antenna module is lined up with the flattened area of the receptacle in the Pole extension. Insert the UHF Antenna Module into the top of the Range Pole RF Adapter. If the modules are correctly oriented, the UHF Antenna Module will push easily into place. Once in place, twist the threaded collar until the antenna is securely locked in place.



Figure 3.30 UHF Antenna/Range Pole RF Adapter Connection

GPS Antenna

All GPS receivers require a GPS antenna to receive satellite signals. The rover uses the same GPS Antenna Module as the base station.

The GPS Antenna Module attaches to the top of the UHF Antenna Module or the Pole Adapter (Figure 3.31).

Attaching the GPS Antenna Module to either the UHF Antenna Module or the Pole Adapter is very similar. Note that the base of the GPS Antenna Module is circular except for a flattened area. The top of either the UHF Antenna Module or the Pole Adapter has a receptacle designed to hold the GPS Antenna Module. Orient the GPS Antenna Module so that the flattened side of the Antenna Module base is lined up with the flattened area inside the top of the UHF Antenna Module or Pole Adapter, and insert the GPS Antenna Module into the antenna receptacle. If the modules are correctly aligned, the GPS Antenna Module will push easily into place. Once in place,

twist the threaded collar on the GPS Antenna Module until the module is securely locked in place.



Figure 3.31 GPS Antenna Module - UHF Antenna Module Connection

GPS Receiver - Range Pole RF Adapter

From previous steps, the Max-RF Adapter has been installed on the GPS Receiver Module and the Range Pole RF Adapter is connected to the survey pole. The GPS Antenna and the UHF Antenna (or Pole Adapter) are attached to the top of the Range Pole RF Adapter. The GPS Receiver Module is connected to the survey pole by connecting the Max-RF cable between the Range Pole RF Adapter and the Max-RF Adapter as shown in Figure 3.32. Make sure that the correct cable is attached to the correct connection and check that the cable connections are secure.



Figure 3.32 GPS Receiver Module/Range Pole RF Adapter Cable Connection

Handheld Computer - GPS Receiver

Handheld computers may be used to control the Z-Max during RTK surveying operations. The use of a handheld computer with graphical application software can add significant utility to the system and in some cases is essential. Connection of the handheld computer in the backpack configuration is accomplished with a cable. One end of the serial cable connects to the handheld computer and the other side connects to the Z-Max via one of the two serial ports on the back panel of the receiver. These two ports are located on the rear panel of the receiver and are labeled SERIAL A and SERIAL B (serial A is recommended). The handheld can be connected to the receiver at any time during the equipment setup and data collection process.

FAST Terminal

The FAST Terminal (Figure 3.33) is offered as an option with the Z-Max system for RTK surveys. It is lightweight, durable and weather resistant for use in outdoor environments. The FAST Terminal allows both wireless and cable connections between the Z-Max Receiver Module and the PC. When using a cable connection, the FAST Terminal should be connected to serial port A on the GPS Receiver Module (labeled SERIAL A).



Figure 3.33 FAST Terminal Handheld Computer

Fully Connected Z-Max Backpack Rover System

The fully connected backpack-mounted Z-Max Rover System is shown in Figure 3.34.



Figure 3.34 Fully Connected Backpack-Mounted Rover Systems

Depending on the type of wireless modem being used, a fully connected backpack-mounted Z-Max Rover will have one cable from the Range Pole RF Adapter to the Z-Max assembly.

RTK Survey Preparation

The previous two chapters laid the groundwork for understanding the purpose of each component of the Z-Max RTK System and the relationship between the 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 present a brief overview of the RTK surveying parameters that must be chosen during the RTK setup, and then go through the steps required to set up the base and rover systems to perform an RTK survey.

RTK Parameters

When configuring the receiver to perform an RTK survey, you will have access to many parameters that affect the survey that is executed. While we have made every attempt to minimize the parameters that must be changed by setting them to the most common default values, we will review them and provide some guidance as to what the choices mean. In addition, there are several issues related to RTK surveying of which you should be aware that are presented briefly.

Data Formats

From previous discussions, it should now be clear that RTK surveying involves the transmission of data from the base station to the rover station. The format of the data that is transferred by the base station and received by the rover is selectable. The Z-Max base station can be set to transmit in one of three data formats, and the base and the rover must be set to use the same format. The following is a list and a brief description of each format.

DBEN: a compressed company-proprietary data format that includes GPS pseudo-range and carrier phase measurements. This is the default data format.

RTCM: the data transmitted will be in the RTCM-104 version 2.3 format. The RTCM format has a number of message types that are used with RTK and DGPS. The message types for RTK are Type 18/19 and Type 20/21.

CMR: Compact Measurement Record or CMR format is a non-proprietary RTK format that uses data compression techniques to reduce the bandwidth required to transmit RTK data from the base to the rover receiver. In other words, the amount of data that must be transmitted on the data link to perform RTK operations is less with CMR than with other formats. There is also an enhanced format called CMR+.

The default data format in the base station is DBEN. To select another data format, use either the base station configuration in the FAST Survey handheld computer software or the PORT/TYPE submenu in the front panel display.

The rover by default will accept either DBEN or CMR message formats, no additional settings are necessary. To set the rover to receive RTCM messages, use either the rover station configuration in the FAST Survey handheld computer software or the PORT/TYPE submenu in the front panel display.

NOTE: The Z-Max rover receiver will also accept DSNP format output by other Thales Navigation receivers. The Z-Max does not transmit DSNP format.

RTK Positioning Modes

The Z-Max RTK System is designed to be flexible and robust over a number of different conditions. The firmware comes equipped with RTK algorithms that will compute an RTK position with only a single epoch in certain conditions, as well as those that will compute RTK positions over distances of up to 50 kilometers. The receiver will automatically determine the correct algorithm to use given the current conditions. As a user, there is nothing that must be done to take advantage of these performance-enhancing modes.

The only RTK mode that you need to be aware of is the RTK positioning mode. The RTK positioning mode you choose will determine the available frequency of position output, and will also have some effect on the accuracy of the position. The RTK positioning mode is selected in the rover receiver and can either be set in the Field Application software or via the front panel display. There are two available modes:

- Synchronized RTK (1 Hz and 5 Hz); and
- Fast RTK

Synchronized RTK (also called matched time tag RTK or Fine Positioning) will compute and output one rover position for each epoch of base station data that has been received. Fast RTK (also called Coarse Positioning or Fast CPD) works by

using a single epoch of base station data to compute multiple rover RTK positions. The default is Coarse Positioning.

Choosing between Fast RTK and Synchronized RTK

Choosing between Fast (Coarse) and Synchronized (Fine) RTK can be confusing. This section will explain how Synchronized and Fast RTK work, and provide applications where you might choose one over the other. Choosing the right mode for your application is a decision based on a trade-off between frequency of the position output, and the accuracy of the position.

Synchronized RTK

Synchronized RTK or Fine Positioning is generally less consistent in its output but more consistent in its accuracy than Fast RTK or Coarse Positioning. Synchronized RTK is used when consistent accuracy is more important than the frequency of position output.

In Synchronized RTK, the rover receiver will compute and output a single RTK rover position for each DBEN, RTCM, or CMR message it receives from the base receiver. In synchronized RTK, the maximum transmission rate from the base receiver is 1 Hz (once per second). If the H option is enabled the maximum transmission rate can be set to 5 Hz (5 times per second). The maximum position output rate at the remote receiver is equal to the data transmission rate at the base station. In other words, if the base station data is transmitting data at 1 Hz, then the rover can output RTK positions at a maximum rate of 1 Hz.

Fine positioning is less consistent in its output because any interruption in the rover station's reception of base data will cause the rover to cease outputting positions. An interruption could be caused by a problem at the base receiver or interference in the data link between the base and the rover. Regardless of the cause, the rover will only provide an RTK position when it receives data from the base receiver. So if base data is blocked for 5 seconds, then the rover will cease to output a position for 5 seconds.

Synchronized RTK is generally more accurate because of the issue of latency. Latency is the delay between when raw base data is transmitted from the base, and when the data is used in a rover position computation. Latency degrades position accuracy so the higher the latency, the less accurate the RTK position. With synchronized RTK, the latency of the rover position is very small so the positions are consistently very accurate. The accuracy of synchronized RTK positions is typically 0.5 cm + 1ppm.

Fast RTK

Fast RTK should be used when consistent and high frequency position updates are required (such as in machine control), and when consistent position accuracy is not the highest priority. The [F] option must be enabled to perform Fast RTK.

In Fast RTK mode (Coarse Positioning), the rover receiver can output centimeter level RTK positions at rates up to 10 Hz. Fast RTK works by using a single base station message to compute multiple rover RTK positions. In this mode, positions are more independent of the rate at which it receives DBEN, RTCM, or CMR messages from the base receiver. For example, if the base station is transmitting data at 1 Hz (once per second), the rover (in Coarse mode) can output up to ten RTK positions at 0.1-second intervals, using the one base station epoch to compute one matched time-tagged and nine unmatched time-tagged RTK positions.

The inconsistent accuracy is a function of the latency. If the base station is transmitting data at 1 Hz (once per second) intervals and rover is computing RTK positions at 10 Hz (10 times per second), the last RTK position computed before a new base station epoch arrives will have a latency of almost one full second longer than the first position. Therefore, the accuracy of the last position is generally lower than the first position computed after the arrival of base station data. The degradation of accuracy is very slight (if latency is kept to less than 1 second) and is often inconsequential for many applications.

One big advantage of Coarse positioning is that RTK will continue to be computed even if there is a minor interruption in the base station data. Under good conditions, centimeter-level accuracy can be maintained for data latencies up to 10 seconds. Any degradation in position, either because of latency or cycle slips can be monitored in the Field Application software or by using the NMEA RRE message. Because Fast RTK is running synchronized RTK in the background, any degradation is usually temporary. Cycle slips are typically fixed at the next synchronized epoch.

RTK Logging Modes

The Z-Max RTK System is designed to operate in one of three logging modes: Manual, Auto Point, and Trajectory. The logging mode is set in the rover receiver using the Field Application software or the front panel display. (Logging mode is referred to as LOG TYPE on the front panel display.)

MANUAL: In Manual logging, the user initiates RTK data logging by inputting a site ID and selecting START. The receiver will collect data at that point until the user selects STOP.

AUTO POINT: Auto Point logging is ideal when you have a series of closely related sites that you wish to occupy for a certain period of time. In Auto Point

logging, the user sets a 'Time To Stay' parameter in seconds. RTK data logging is initiated by entering a Site ID. The receiver will collect data at that point for the duration set in the 'Time To Stay' parameter. After data collection has stopped, the Site ID will automatically increment by 1, and RTK data logging continues upon confirmation of the Site ID. To automatically increment the last character of the Site ID must be numeric.

TRAJECTORY: Trajectory logging is ideal for setting stakeouts, or other surveys where data is collected at fixed distance intervals. In Trajectory logging, the user sets a 'Distance Interval' parameter in meters. RTK data logging is initiated by entering a numeric Site ID. As the user traverses across the site, the receiver will monitor the distance covered and collect data at each interval set in the Distance Interval parameter. The Site ID will automatically increment each time RTK data is logged to the receiver.

RTK Position Output

The output rate of RTK positions is controlled by the Recording Interval parameter in the rover receiver. As we discussed in the Positioning Modes section, the maximum output frequency is higher when in Fast RTK (Coarse positioning) mode than with Synchronized RTK (Fine positioning) mode. The maximum output rate is also directly affected by the firmware options that are set.

- If the [F] option is enabled and the receiver is in Fast RTK mode, output can be set from 0.1 – 999 seconds.
- If the [H] option is enabled and the receiver is in Synchronized RTK mode, then the RTK output can be set from 0.2 – 999 seconds. Remember that in Fine positioning mode, the output of the rover will equal to the transmission rate of the base receiver. So to output RTK positions at 0.2 seconds, the base must be transmitting at 0.2 seconds.

Base Station Position

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 to accurately compute the rover position. Any inaccuracy in the base station position is transferred to the computed rover position.

Most frequently, the base station will occupy an accurately known position. That known position is entered into the base receiver. However, it is possible to perform an RTK survey using an unknown point as the base station using approximate coordinates determined by the base receiver.

If you plan to set the base system on an unknown point, 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 relative error will be introduced into the computed vector between the base and rover system, plus the absolute difference between the computed base station position and the real base station position. 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 (0.002 m per 1 kilometer or 0.010 ft 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 its 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.

Antenna Reduction

A concept related to the Base Station position is Antenna Reduction. In RTK, the rover receiver computes the vector from the phase center of the base station antenna to the phase center of the rover station antenna. Usually, the real position of interest is not the phase center of the antenna, but the survey mark (or other landmark) over which the antenna is set up. To compute the position of the mark instead of the antenna, it is necessary to instruct the receiver to perform an antenna reduction. In an antenna reduction, the antenna heights are included when computing and outputting the rover position. Antenna reduction is set using the handheld computer and the field application software. When using RTK and performing an antenna reduction, the antenna height of both the base and the rover must be entered (assuming that they are both over survey marks).

Base System Setup

Now that we have covered some basic RTK concepts, keep them in mind as we set up and configure a base station.

Prior to departing for the field, it is recommended that the base system is examined to ensure that all required components are indeed in the transport case. Also, verify that all batteries and Power Modules are fully charged. Once 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. Ideally, there are 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 with which to work.
2. The site should be on a high point in relation to surrounding terrain. This is to facilitate 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. This is not important if you are using GSM modems, although with GSM modems you must have access to the service.

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 surveying (assuming the site is not too heavily obstructed).

Position Tripod Over Base Point

Prior to mounting the RTK base system on the tripod, set up and carefully position and level the tripod over the survey mark. 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 4.1). 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 4.1 Conventional and GPS Tripods

Mount the Base Radio and Antenna

This applies only if you are using a radio for your data link.

There are many possible configurations for the base radio. In the described configuration, we will use a separate tripod for the radio. The radio and the radio antenna can be mounted in any location on the base site. The only consideration is cable length. Remember that the radio, the antenna, and the GPS receiver must all be connected using the available cables. The length of the cables will dictate the possible locations of the radio antenna.

Thales U-Link Transmitter

Set up the radio tripod on a stable site within the data cable distance of the GPS tripod. The Thales radio system comes with a mounting bracket. Use the mounting bracket to attach the radio to the telescoping pole on the radio tripod, as shown in Figure 4.2. The U-Link radio antenna connects directly to the radio.



Figure 4.2 Mounted Thales Base Radio and Antenna

Pacific Crest PDL Transmitter

Set up the radio tripod on a stable site within the data cable distance of the GPS tripod. The PDL radio has a flange that allows the radio to hook to the side of the radio tripod. Screw the radio antenna onto the telescoping survey pole. The radio tripod set up is shown in Figure 4.3. Connect the radio antenna cable to the radio.



Figure 4.3 Mounted PDL Base Radio Antenna

Connect System Components

Connect the base station modules and components as listed below. Some of these connections may have already been made. Remember that if you are using the GSM modem as your data link, then the radio components are not used. Likewise, if you are using a radio, then the Communication Module is not used, but remember to use the V-Module to protect the Communication Module interface. Check that all modules and connections are seated properly. Refer to the previous chapter on how to connect these components.

- GPS Receiver ↔ Receiver Power System
- GPS Receiver ↔ GPS Antenna
- GPS Receiver ↔ Communication Module (or V-Module)
- Radio ↔ Radio Antenna (if using radio)
- GPS Receiver ↔ Radio (if using radio)
- Radio ↔ Radio Power System (if using radio)

Mount the Base System

Insert the tribrach adapter into the center hole of the HI Measurement Plate. Screw the HI Measurement Plate/tribrach adapter assembly to the bottom of the GPS Receiver Module. Carefully set the GPS Receiver Module with the attached components into the top of the tribrach. While placing the module into the tribrach, take care not to jar the tripod out of alignment in any way. You may find it more convenient to temporarily disconnect the external power cable and the radio cable (if used) from the module. Be sure to reconnect them when you are finished.

Measure Instrument Height (HI) of GPS Antenna

Remember the 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 point. It is critical that the HI of the antenna above the monument is measured accurately. A tool to measure the HI is included with the base system (Figure 4.4). Measure from the survey point to the edge of the HI Measurement Plate.



Figure 4.4 Measuring HI (Height of Instrument) of Base GPS Antenna

Power Up Base System

Power up the system by pressing the power button on the front panel of the GPS Receiver Module. Power on the radio. (Note that the Thales Max UHF radio and the Communication Module do not have a power button. The radio and the GSM modem will power on during configuration.) Check that all components are powered up. The GPS receiver and the PDL radio have an LED to indicate that power has been applied and the component is on.

Configure Base GPS Receiver to Function as RTK Base

This task is usually accomplished using the handheld computer running the Field Application software. However, the Z-Max base station can also be configured through the front panel display. If you are using the handheld computer to configure the base system, refer to the Field Application software documentation for specific steps. If using the front panel of the Z-Max, refer to Chapter 4 of the **Operations and Reference** section of this manual.

Regardless of which method you choose, perform the following steps:

1. Set the receiver to RTK Base mode.
2. Set the port to which the radio is connected. 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 UHF radio will be connected to serial port B of the receiver. The GSM modem will use port D, which is the default.
3. Select the data format. This sets the format in which raw data is being transmitted by the base. The options are RTCM, CMR, and DBEN. The default is DBEN.
4. Select the frequency of raw data transmissions. This sets how frequently raw data is transmitted by the base radio. The default is 1 Hz (1 second).

By default, you will also collect raw data for post-processing.

Enter Base Station Site ID, Coordinates, and HI Into Base Receiver

From the discussion of base station position earlier in this chapter it should be clear that an accurate base station position is critical for an accurate RTK survey. In addition, to accurately compute the rover position, the rover also needs to know the accurate base station antenna HI to perform an antenna reduction. Both the base station coordinates and the antenna HI are transmitted to the rover along with the base receiver's satellite data or corrections. It is very important that these values are accurate, and have been accurately entered into the base receiver during setup. Entering the base station Site ID will help the rover to identify from which base receiver it is receiving data.

This task can either be accomplished using the handheld computer running the Field Application software or the front panel display.

Regardless of which method you choose, perform the following steps:

1. Enter the 4-character Site ID.
2. Enter the antenna height in meters.
3. Enter the antenna radius in meters.
4. Enter the known position of the base station survey mark.

Configure the Base Data Link

The procedure for configuring the data link depends which data link you are using, a UHF radio or a GSM modem. Either task can be accomplished using the Front Panel User Interface or the Field Application software on the handheld computer.

Thales U-Link and PDL Radio

The radios have several parameters that must be configured. While most of the parameters apply to both the Thales and the PDL radios, there are some differences that are noted below.

Perform the following steps:

1. Set the radio port.
This is the serial port to which the radio is connected. If you followed the recommendations in the previous chapter, the radio will be connected to port B.
2. Set the port baud rate.
The baud rate is the port speed of the serial port to which the radio is connected. The default is 19200 and generally should not be changed.
3. Load radio parameters into the receiver.
This is done to ensure that any other active data links are fully turned off and the receiver is ready to use the radio.
4. Set the Sensitivity to LOW. (PDL radio only)
5. Set the Link Speed. (PDL radio only)
The default is 9600.
6. Set the channel number for transmission frequency.
Channel numbers range from 00 to 15 and each channel number is linked to a particular radio frequency set at the factory.
7. Send user-selected radio parameters to the receiver.
Program the user-selected radio parameters (port, channel, sensitivity, link speed) to the receiver. Any errors in sending the parameters will trigger a message that will be displayed on the front panel display.

GSM Modem

The GSM modem has several set up parameters that must be configured before the modem can be used. If the set up parameters are saved to receiver memory, they will not have to be set the next time the modem is used.

Set up the GSM modem by performing the following steps:

1. Set the GSM band. (BAND).
The band parameter sets the operable frequency band. In general, set this parameter to 1900 in North America or 900/1800 elsewhere, but verify this with your GSM service provider.
2. Set the PIN number.
This number is available from your GSM service provider.
3. Power on the modem.

Verify Base Receiver Function

Determine if the base system is functioning properly as follows:

- Determine if the base receiver is tracking satellites. This can be accomplished by either using the Power/SV LED on the front panel of the receiver, or by using the FAST Survey software
- Determine if the base radio is transmitting data, as indicated by the COMMUNICATION LED on the front panel of the receiver (the second LED from the left). This LED should flash once every time the base radio transmits a packet of data. The default transmission frequency is 1 second. If you are using the GSM modem as the data link, transmission will not occur until the rover modem connects (calls) the base modem, so the COMMUNICATION LED will not be active until the rover is set up.

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 4.5 shows the base system fully configured and ready to survey.



Figure 4.5 Base System Ready to Survey

Rover System Setup

As described in Chapter 3, the rover system can either be pole-mounted or backpack mounted. The choice will determine which modules and accessories are required. As with the base station, prior to departing for the field, examine the rover system to ensure that all required components are in the transport case. Also, verify that the Power Module is fully charged. When all required rover system components are accounted for, execute the following steps to set up a RTK rover system:

Connect System Components

Connecting the system components will be different depending upon if you are using a pole or a backpack to mount the receiver, and if you are using a radio or the GSM modem. Below is a brief summary of each configuration. For a more detailed description of how the components connect and their purpose, refer back to Chapter 3 – *Hardware Connectivity*.

Pole-Mounted Rover System

Attach Radio Antenna Module

Perform this step only if you are using the UHF radio as your data link. Connect the UHF Antenna Module to the top of the GPS Receiver Module. Ensure the antenna is securely locked in place. 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.

Attach GPS Antenna Module

Attach the GPS Antenna. Where the GPS Antenna Module connects depends upon the data link being used. When the rover system is using the UHF radio in the Communication Module, the GPS Antenna Module attaches to the top of the UHF Antenna Module. When the rover system is using the GSM modem as the data link, the GPS Antenna Module connects directly to the GPS Receiver Module. Make sure that the connection is secure.

Attach Communication Module

Attach the Communication Module containing the GSM modem and/or UHF radio to the right-hand side of the GPS Receiver Module. Make sure that the module is secure, and the latch is completely closed. The GSM modem or UHF radio is now installed and ready to be configured.

Attach Power Module

The Power Module connects to the left-hand side of the GPS Receiver Module. Make sure that the module is secure, and the latch is completely closed

Mount the System to the Pole

Now that the Antenna, Communication and Power Modules are all connected to the GPS Receiver Module, the system is ready to be mounted on the pole

Backpack Mounted Rover System

Attach Communication Module

Attach the Communication Module containing the GSM modem and/or UHF radio to the right-hand side of the GPS Receiver Module.

Attach Power Module

The Power Module connects to the left-hand side of the GPS Receiver Module. Make sure that the module is well seated, and the latch is completely closed

Mount the GPS Receiver Module to the Backpack

Now that the Communication and Power Modules are connected, the GPS Receiver Module can be mounted to the backpack. Make sure the receiver is securely mounted to the backpack.

Attach Range Pole RF Adapter Module

Attach the Range Pole RF Adapter Module directly to the survey pole. The Pole RF Adapter screws onto the survey pole and provides an interface for the GPS/UHF cable coming from the backpack. The RF Pole Adapter also provides a receptacle for the UHF Antenna Module.

Attach UHF Antenna Module or Pole Adapter Module

Connect the UHF Antenna Module directly to the top of the Range Pole RF Adapter. If using the GSM modem as your data link, connect the Pole Adapter Module to the Range Pole RF Adapter.

Attach GPS Antenna Module

Attach the GPS Antenna Module to the UHF Antenna Module. If using the GSM modem as your data link, attach the GPS Antenna Module to the Pole Adapter Module. Make sure that the connection is secure.

Attach Max-RF Adapter

Attach the Max-RF Adapter to the top of the GPS Receiver Module. Insert the Max-RF Adapter into the antenna receptacle at the top of the GPS Receiver Module.

Attach Cable to Range Pole RF Adapter

Connect the Max-RF cable between the Range Pole RF Adapter and the Max-RF Adapter. Make sure that the connectors are correctly attached and check that the cable connections are secure.

Compute the GPS Antenna Instrument Height (HI)

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 survey mark on the ground. It's critical that the height of the antenna above the ground (HI) is computed accurately.

Because of the design of the Z-Max System the HI can always be a constant. This helps you completely eliminate antenna measurement error. To compute the HI with a fixed-height survey pole, simply add the height of the pole and the height of the components on the pole to get the total HI.

Power Up Rover System

Power up the system by pressing the power button on the front panel of the GPS Receiver Module. Turn on the handheld computer using the power button on the keyboard. The radios and the GSM Module will be powered when the data links are configured. Check that all components are powered up.

Configure Rover Receiver to Function as RTK Rover

This task is usually accomplished using the Field Application software running on the handheld computer. However, the front panel display can be used for rover configuration if necessary.

Configure the Rover by performing the following steps:

1. Set the receiver to RTK Rover mode.
2. Inform the receiver which data format will be transmitted from the base receiver.

3. Inform the receiver which port the radio is connected to.
If you are using the Communication Module, this is port D, which is the default.
4. Select the desired RTK positioning algorithm.
Coarse will output Fast RTK positions. Fine will output synchronized RTK positions. The default is Coarse.
5. Select the RTK logging method.
If you plan to do Auto Point or Trajectory logging, set this parameter. Also set the Time To Stay parameter for Auto Point or the Distance Interval parameter for Trajectory.
6. Set the recording interval.
The recording interval will determine the output frequency of the RTK positions. See the RTK Position Output section on page [221](#) if you have questions about the valid values.

Configure the Rover Data Link

The procedure for configuring the data link depends which data link you are using, a UHF radio or a GSM modem. Either task can be accomplished using the Front Panel User Interface or the Field Application software on the handheld computer.

Thales U-Link and PDL Radio

The radios have several parameters that must be configured. While most of the parameters apply to both the Thales and the PDL radios, there are some differences that are noted below.

Perform the following steps:

1. Set the radio port.
This is the serial port to which the radio is connected. If you are using the Communication Module, the radio will be connected to port D (default).
2. Set the port baud rate.
The baud rate is the port speed of the serial port to which the radio is connected. The default is 19200 and should not be changed.
3. Load radio parameters to the receiver.
This is done to ensure that any other active data links are fully turned off and the receiver is ready to use the PDL radio.
4. Set the Sensitivity. (PDL radio only)

The best sensitivity setting depends upon a) the distance of the transmitter from the receiver and b) the amount of interference present on your frequency.

5. Set the Link Speed. (PDL radio only)
The default is 9600.
6. Set the channel number for the receiver frequency.
Channel numbers range from 00 to 15 and each channel number is linked to a particular radio frequency set at the factory. The base and the rover must be on the same frequency.
7. Send user-selected radio parameters to the receiver.
Program the user-selected radio parameters (port, channel, sensitivity, link speed) to the receiver. Any errors in sending the parameters will trigger a message that will be displayed on the front panel display.

GSM Modem

The GSM modem has several set up parameters that must be configured before the modem can be used.

Set up the GSM modem by performing the following steps:

1. Set the GSM mode.
Set this parameter to AUTO if you want to automatically dial the base modem, or MANUAL to manually dial the base modem.
2. Set the GSM band. (BAND).
The band parameter sets the operable frequency band. In general, set this parameter to 1900 in North America or 900/1800 elsewhere, but verify this with your GSM service provider. The base and rover must be using the same band.
3. Set the base phone number.
Enter the phone number of the base receiver. This is the number that the modem will dial when the DIAL function is activated.
4. Set the PIN number.
This number is available from your GSM service provider.
5. Set the number of retries.
This is the number of times the rover will attempt to call the base modem. The default is 2.
6. Once the setup parameters are entered, power on the modem using either the Field Application software or the front panel display.

7. Dial the base modem. From the Front Panel User Interface, perform the DIAL function from the COM OPTN/GSM Rover submenu.
8. Verify that the GSM state is ONLINE. From the Front Panel User Interface, check the STATE status in the COM OPTN/GSM Rover submenu

Verify Function

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

- Determine if the rover receiver is tracking satellites. This can be accomplished by either using the Power/SV LED on the front panel of the receiver, or by using the Field Application software
- Determine if the data link is receiving data, as indicated by the COMMUNICATION LED on the front panel of the receiver (the second LED from the left). This LED should flash green every time the rover receives a packet of good quality data.

The system is now functioning as an RTK rover and is ready to perform an RTK survey. With the backpack rover configuration, the GPS receiver, data link, and optional external power source remain in the backpack. Figure 4.6 shows the backpack rover system fully configured and 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. Figure 4.7 shows the pole-mounted configuration.



Figure 4.6 Backpack Rover System Ready to Survey



Figure 4.7 Pole-Mounted Rover System Ready to Survey

Executing an RTK Survey

After connecting the hardware and configuring the receivers as described in the previous two chapters, your Z-Max RTK System is now operational, and almost ready to execute an RTK survey.

In this chapter we:

- discuss the important concept of Rover Initialization,
- provide step-by-step instructions on executing different types of RTK surveys using the Front Panel User Interface, and
- provide procedures on downloading data from the SD memory card once the survey is complete.

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 has been given several different names including fixing biases, ambiguity resolution and fixing integers. All of these terms refer to the same process. Being aware of this process will help ensure a successful RTK survey.

Prior to initialization, the rover system 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 several meters. The initialization process is required to maximize the accuracy of the rover system. Once initialized, the rover system will function at its specified level of accuracy until initialization is lost.

The initialization status of the rover can be determined by looking at the RTK SOLUTION LED on the front panel of the GPS Receiver Module. If the LED is blinking green, the receiver is initialized and computing fixed-integer, centimeter-level RTK positions. If the LED is blinking yellow, then the receiver is not initialized, and the accuracy of RTK positions will be degraded. If the LED is blinking red or if the LED is not blinking at all, then the receiver is not computing RTK positions. In this case, the problem is most likely a setup or configuration problem at the base or rover receiver.

When the rover system detects that it is not initialized, it will automatically execute the initialization process. No interaction by the user is required to instruct the rover system to initialize. The initialization process is dependent on several factors including site obstructions, satellite visibility at both the base and the rover site, and the separation (distance) between the base and the rover receiver.

For initialization to occur, the base and the rover RTK systems must be observing at least 5 common satellites. If the number of common visible satellites is less than 5, or if either the base or the rover site is obstructed causing either system to see less than 5 satellites, the system will not initialize. Either survey at a time when more satellites are visible, or in the case of an obstructed site, move the obstructed receiver system to a more suitable location.

The time required to initialize the rover system is also dependent upon the distance between the rover and the base. The closer the rover system is to the base, the faster the initialization process. As the rover moves further away from the base system, initialization times will increase. If the base and the rover systems are observing at least 5 common satellites and the base-rover separation is less than 15 km, initialization is often instantaneous, i.e. less than 5 seconds. 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 and the rover system will automatically execute the initialization process again.

Receiver initialization is most crucial when you are ready to store the position of a point of interest or about to stake out a point. If the rover system is not initialized when a data point is stored, accuracy will be poor. If you are performing an Auto Point RTK Survey (see page [244](#)), the rover must be initialized to store an RTK position. Again, the RTK SOLUTION LED on the Front Panel User Interface will display the current state of initialization at any given time.

The RTK rover system must remain in constant communication with the base system in order to compute accurate positions. As the rover system approaches the range of the data link used, communication will begin to get un dependable. 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 COMMUNICATION LED on the front panel of the rover system will provide you with information on the status of the data link. If the COMMUNICATION LED is blinking green, then the incoming data quality is good. If the COMMUNICATION LED is blinking red, then the incoming data quality is not good. While there may be other reasons for poor quality transmitted data besides distance, before doing extensive troubleshooting ensure the receiver separation is within the range of the data link.

Lastly, be aware that 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).

Performing an RTK Survey

Prior to performing an RTK survey, the base and rover receivers must be properly setup, configured, operational, and initialized. Getting to this point has been covered in detail in chapters 3 and 4, but the following is a quick review of the steps involved.

- The base receiver is set up on a tripod over the control point and is configured as an RTK base.
- The tripod has been centered and leveled, and an accurate antenna HI has been measured.
- A precise base station position has been entered into the base receiver along with the antenna height information.
- The base data link (UHF radio or GSM modem) has been configured and is transmitting base station data to the rover.
- The rover receiver is either pole-mounted or backpack-mounted, and is configured as an RTK rover.
- The rover data link (UHF radio or GSM modem) has been configured and is receiving data from the base receiver. This is confirmed by the COMMUNICATION LED status light which is blinking green.
- The RTK SOLUTION LED status light on the rover system is blinking green indicating that the rover has been initialized and is outputting centimeter level positions.

You are ready to perform an RTK survey.

Performing an RTK survey requires interfacing with the Rover receiver. Once the base station is set up and configured, it can run unattended. Interfacing with the Rover receiver can be done either with the handheld data collector/field application software or by using the Front Panel User Interface. If you are using the data collector, refer to the Field Application software manual for information on performing RTK surveys.

If you are using the Front Panel User Interface, you have the choice of three types of RTK surveys:

- **Auto Point**
- **Trajectory**
- **Manual**

Auto Point surveys are used when you have a series of closely related sites that you wish to occupy for the same period of time. Trajectory surveys are used for setting stakeouts, or other surveys where data is collected at fixed distance or time intervals. Manual RTK surveys are performed when points are randomly occupied for different periods of time.

The following is a step-by-step procedure on how to set up and perform each type of RTK survey. Note that these RTK surveys are executed using the Front Panel User Interface and the User Interface control keys. If you need more information about using the Front Panel User Interface, see Chapter 4 - **Operations** in the Operation and Reference section of this manual. These procedures do not apply if you are using the handheld data collector. To perform RTK surveys with the data collector, see the Field Application software manual.

AUTO POINT RTK SURVEY

Auto Point surveys are used when you have a series of closely related sites that you wish to survey for the same period of time. In Auto Point RTK, a 'Time To Stay' parameter is set in seconds. The receiver will collect data at each point for the duration of the 'Time To Stay' parameter. After data collection has stopped the SITE ID automatically increments by 1.

Auto Point Set Up

1. Verify the SURVCONF menu is in RTK ROVER mode.
From the SURVCONF menu, use the UP/DOWN control keys until the MODE is displayed. Verify that the mode is MODE:RTK ROVER. If it is not, press the ENTER key and select RTK ROVER.
2. Set the positioning algorithm.
From the SURVCONF menu, access the POSITIONING submenu. Select the desired RTK positioning algorithm. COARSE will output Fast RTK positions. FINE will output synchronized RTK positions. Either type is acceptable. The default is COARSE. To change this parameter, press the ENTER key and select the desired algorithm.
3. Set the logging method.
From the SURVCONF menu, use the UP/DOWN control keys until the LOG TYPE is displayed. Select the logging method AUTO PT to do an Auto Point RTK survey.

4. Set the Time to Stay parameter.
From the SURVCONF menu, access the TIME TO STAY submenu. Enter the amount of time in seconds for which you intend to occupy each point. The range of this parameter is 0.0 to 999 seconds, but reasonable values are between 5 and 60 seconds.
5. Set the recording interval.
From the SURVCONF menu, use the UP/DOWN control keys until the REC INI is displayed. The recording interval will determine the output frequency of the RTK positions. The range is dependent upon the firmware options enabled in your receiver, the output frequency of the base station data and the positioning algorithm selected in step 2. In general, the recording interval should be set to a value of 1 second or less.

Auto Point Survey Execution

1. Move the rover system to the first point to be surveyed.
Set and level the survey pole on the point. Verify that the RTK SOLUTION LED is blinking green (the system is initialized).
2. Enter the antenna height.
Access the SURVEY:RTK ROVER submenu. Enter the ANT HT submenu and input the accurate vertical antenna height from the mark to the GPS Antenna Module. This parameter will stay constant for the duration of the survey.
3. Enter the Site ID.
The Site ID submenu is in the 3rd level of the SURVEY:RTK ROVER menu. To access the 3rd level, display the LOGGING submenu and press the ENTER key. Select AUTO POINT and press the ENTER key. Enter the SITE submenu and input a 4-character ID that is unique to that site, for example PT01. This will start RTK data logging.

NOTE: For the Site ID to automatically increment at the end of site occupation, the last character in the Site ID must be numeric.

4. Occupy point.
The receiver will log RTK position and vector data for the duration set in the Time to Stay parameter and at the frequency set in the Recording Interval parameter.
5. Monitor the data logging.
There are three submenus to help you to monitor the site data logging. Use the LOG submenu to display the amount of time elapsed since the start of data logging. Use the HRMS and the VRMS submenus to monitor the horizontal and vertical positional accuracy. Also, verify that the RTK SOLUTION LED is still blinking green.

6. Move to next point.
When data collection is complete, a message is displayed in the front panel display and the receiver stops logging data. Move to the next point and set up the survey pole in the new point.
7. Confirm new Site ID.
If the last character of the Site ID is numeric, the Site ID will automatically increment by 1 (for example to PT02). If this Site ID is correct, press the ENTER key. If the Site ID is not correct, enter the correct Site ID and press the ENTER key. Data logging will start at the new point.

Repeat steps 3 through 8 until all points in the survey have been observed. You are now ready to return to the office and download the data.

If during the survey, the RTK SOLUTION LED blinks YELLOW wait until the receiver re-initializes and the LED blinks green again before occupying a point. If the LED does not become green again, you will have to troubleshoot the system to determine the problem. See Chapter 6 - **Troubleshooting** for more information about troubleshooting your system.

TRAJECTORY RTK SURVEY

Trajectory surveys are used for setting stakeouts, or other surveys where data is collected at fixed distance intervals. In Trajectory RTK surveys, a 'Distance Interval' parameter is set in meters. As you traverse across the site, the receiver will monitor the distance covered and log data at each interval set in the Distance Interval parameter. You can also collect trajectory data at set time intervals by setting the Distance Interval parameter to 0 and setting the Recording Interval parameter to the desired time interval.

Trajectory Set Up

1. Verify the SURVCONF menu is in RTK ROVER mode.
From the SURVCONF menu, use the UP/DOWN control keys until the MODE is displayed. Verify that the mode is MODE:RTK ROVER. If it is not, press the ENTER key and select RTK ROVER.
2. Set the positioning algorithm.
From the SURVCONF menu, access the POSITIONING submenu. Select the desired RTK positioning algorithm. COARSE will output Fast RTK positions. FINE will output synchronized RTK positions. Either type is acceptable. The default is COARSE. To change this parameter, press the ENTER key and select the desired algorithm.
3. Set the logging method.
From the SURVCONF menu, use the UP/DOWN control keys until the

LOG TYPE is displayed. Press ENTER and use the UP/DOWN control keys until TRAJEECT is displayed. Press ENTER to select the logging method TRAJEECT to do a Trajectory RTK survey.

4. Set the Distance Interval parameter.
From the SURVCONF menu, use the UP/DOWN control keys until DISTANCE INTERVAL is displayed. Press ENTER and input the desired distance between each point. The range of this parameter is 0 to 999 meters. To perform a Trajectory RTK survey at a fixed time interval, set the Distance Interval to 0 and set the Recording Interval (step 5) to the desired time interval.
5. Set the recording interval.
From the SURVCONF menu, use the UP/DOWN control keys until the REC INI is displayed. Press ENTER and input the recording interval in seconds. The recording interval will determine the output frequency of the RTK positions in seconds. The range is dependent upon the firmware options enabled in your receiver, the output frequency of the base station data and the positioning algorithm selected in step 2. In general, the recording interval should be set to a value of 1 second or less. If the Distance Interval is set to 0 meters, set the Recording Interval to the desired time interval between RTK position logging for the trajectory.

Trajectory Survey Execution

1. Move the rover system to the start of the trajectory. Verify that the RTK SOLUTION LED is blinking green (the system is initialized).
2. Enter the antenna height.
Access the SURVEY:RTK ROVER submenu and use the UP/DOWN control keys until ANT HT is displayed. Press ENTER and input the accurate antenna height from the mark to the GPS Antenna Module. This parameter will stay constant for the duration of the survey.
3. Enter the Site ID.
The Site ID submenu is in the 3rd level of the SURVEY:RTK ROVER menu. To access the 3rd level, display the LOGGING submenu and press the ENTER key. Select TRAJEECTORY and press the ENTER key. Enter the SITE submenu and input a 4-character site ID. This will start RTK data logging.
4. Move along the traverse.
As you move along your traverse, the receiver will log RTK position and vector data each time the amount of distance set in the Distance Interval parameter has been covered.
5. Monitor data quality.
There are two submenus to help you to monitor the data collection. Use the HRMS and the VRMS submenus to monitor the horizontal and vertical

positional accuracy. Check the RTK SOLUTION LED to verify that the LED is blinking green.

Continue to travel the traverse until the entire course has been observed. You can now return to the office and download the data.

If during the survey, the RTK SOLUTION LED blinks YELLOW, wait until the receiver re-initializes and the LED blinks green again before occupying a point. If the LED does not become green again, you will have to troubleshoot the system to determine the problem. See Chapter 6 - **Troubleshooting** for more information about troubleshooting your system.

MANUAL RTK SURVEYS

In Manual surveys, there are no special parameters to set. The Site ID is manually entered and you can collect data on any point for as long as you wish. Data is collected until you manually instruct the receiver to stop.

Manual RTK Set Up

1. Verify the SURVCONF menu is in RTK ROVER mode.
From the SURVCONF menu, use the UP/DOWN control keys until the MODE is displayed. Verify that the mode is MODE:RTK ROVER. If it is not, press the ENTER key and select RTK ROVER.
2. Set the positioning algorithm.
From the SURVCONF menu, access the POSITIONING submenu. Select the desired RTK positioning algorithm. COARSE will output Fast RTK positions. FINE will output synchronized RTK positions. Either type is acceptable. The default is COARSE. To change this parameter, press the ENTER key and select the desired algorithm.
3. Set the recording interval.
From the SURVCONF menu, use the UP/DOWN control keys until the REC INI submenu is displayed. The recording interval will determine the output frequency of the RTK positions. The range is dependent upon the firmware options enabled in your receiver, the output frequency of the base station data and the positioning algorithm selected in step 2. In general, the recording interval should be set to a value or 1 second or less.

Manual RTK Survey Execution

1. At the first point to be surveyed, set and level the survey pole on the point.
Verify that the RTK SOLUTION LED is blinking green.
2. Enter the antenna height.
Access the SURVEY:RTK ROVER submenu and use the UP/DOWN

control keys until ANT HT is displayed. Press ENTER and input the accurate antenna height from the mark to the GPS Antenna Module. This parameter will stay constant for the duration of the survey.

3. Enter the Site ID.

The Site ID submenu is in the 3rd level of the SURVEY:RTK ROVER menu. To access the 3rd level, display the LOGGING submenu and press the ENTER key. Select MANUAL and press the ENTER key. Enter the SITE submenu and input a 4-character ID that is unique to that site, for example PT01.

4. Start data logging.

Data logging is initiated by the START function. Once the Site ID is entered, use the UP/DOWN keys until START is displayed. Press ENTER to start data logging.

5. Monitor site occupation.

There are three submenus to help you to monitor the data collection. Use the TE (time elapsed) submenu to display how much time has elapsed since the start of data logging. Use the HRMS and the VRMS submenus to monitor the horizontal and vertical positional accuracy. Also, verify that the RTK SOLUTION LED is blinking green.

6. Stop data logging.

When enough data has been collected at this point, use the UP/DOWN keys until the STOP? function is displayed. Press the ENTER key and the query "Stop data logging?" will appear on the display. Press ENTER to confirm.

7. Move to next point.

Move to the next point to be surveyed and repeat steps 3-6.

Continue to occupy and monitor each point until all points in the survey have been observed. You can now return to the office and download the data.

If during the survey, the RTK SOLUTION LED blinks RED, wait until the receiver re-initializes and the LED blinks green again before occupying a point. If the LED does not become green again, you will have to troubleshoot the system to determine the problem. See Chapter 6 - **Troubleshooting** for more information about troubleshooting your system.

Downloading the Data

Downloading data involves the transfer of data from the SD memory card to the PC for subsequent processing. During the downloading process, the session file on the SD memory card is decoded and converted into the epoch solution files (CBEN data), vector solution files (OBEN files) and raw data files (B-file, E-files, and S-files). The decoded files are stored in the desired directory of the PC.

This section covers downloading data from the receiver only. If the handheld data collector is used during RTK operations, vector and solution files are stored in the data collector. Procedures for downloading data from the data collector are found in Chapter 4 - **Operations** of the Operation and Applications section in this manual and in the GNSS Studio software manual.

There are several ways to download data from the SD memory card to the PC. This section will cover downloading data directly from the SD card. This process will use the Download utility of the GNSS Studio software suite. For other methods of downloading data from the receiver, see Chapter 4 - **Operations** of the Operation and Reference section in this manual.

Downloading Directly From the SD MemoryCard

Downloading directly from the SD memory card is the fastest way to download data, since the data does not need to be transferred from the receiver to the PC. To use this method, an SD card reader must be connected to the PC.

To download data directly from the SD card:

1. Manually move the SD card from the SD card slot in the receiver to the SD card reader in the PC.
2. From the PC, run GNSS Studio software.
3. If a project has not already been created, create a project. This project should be open.
4. From the Project menu, select '**Download Data from External Device**'.
5. Select '**Raw Data**' from the list on the left. This will open the Download utility and the Download main window appears. The left pane is the source directory (currently blank) and the right pane is the currently selected destination directory.
6. From the File menu, select '**Connect**' - '**Receiver**' - '**PC Drive**'
7. From the left pane of the Download main window, select the drive letter of the connected SD card reader port.
8. Download reads the contents of the SD card (this may take 1-2 minutes) and then displays the list of session files on the SD card.
9. In the right pane of the Download main window, change the destination directory to either the project directory or the directory where you want the data files to be stored.
10. Select the desired session data file(s) from the SD card pane that you want to download and drag them to the PC pane.
11. The selected files will be downloaded and converted into individual data files and placed in the selected destination directory. A progress dialog box

indicates the status of the download. The files on the SD card will not be erased after download is complete.

If you need instructions on how to remove the SD card from the receiver, refer to Chapter 3 - **Getting Started**, Step 4.

Troubleshooting

So, you followed all the steps to prepare the Z-Max to perform an RTK survey and the system is not working. Why? 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. 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 Z-Max system to perform a survey.

If the steps outlined in this troubleshooting section fail to get you up and operational, there is a good chance that a component in your system has failed. In such an event, contact your local Thales Navigation dealer or Thales Navigation technical 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 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 Z-Max 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-Max 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 handheld computer. Refer to the field application software documentation 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-Max 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-Max supports both internal (Power Module) and external power sources.

- a. If using the Power Module, press the power level indicator button. If low, replace the module 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 charged battery 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 Thales Navigation technical support for assistance.

c. You may have a malfunctioning GPS receiver. Call your local dealer or Thales Navigation technical support for assistance.

Receiver is powered up

Go to Step 2 below.

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

Look at the GPS Antenna Module on top of the GPS Receiver Module.

Antenna Module not connected to receiver

1. Connect the GPS Antenna Module to the GPS Receiver Module.
 - a. Insert the Antenna Module into the antenna receptacle at the top of the GPS Receiver Module. Make sure the base of the Antenna Module is oriented so that the flattened area is lined up with the flattened area of the receptacle, and the module will easily slide into place.
 - b. Once in place, twist the threaded collar on the Antenna Module until the antenna is securely locked in place.
 - c. Once connected, give the GPS receiver a few seconds to lock onto satellites.

Antenna connected to receiver

1. Ensure proper connection. The GPS Antenna Module must be securely locked into place on top of the GPS Receiver Module. Ensure this is the case.
2. Ensure the threaded collar on the Antenna Module 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.

You may have a malfunctioning Antenna Module. Follow these steps to help isolate which component is causing the problem.

1. Replace the GPS Antenna Module with the one from the rover system. If the receiver locks onto satellites, there is a problem with the Antenna Module. Contact your local dealer or Thales Navigation technical support for assistance.

Step 4. You may have a malfunctioning GPS receiver.

Call your local dealer or Thales Navigation technical support for assistance.

Base System Does Not Transmit Data

The transmit LED on the front panel of the base radio will blink green each time a packet of good quality 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. Note that the Thales radio does not have an LED.

Base radio is not powered up

1. Both the Thales and the PDL radios automatically turn on once power is applied.
 - a. If using one of the UHF radios, 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.
 - 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-Max.
 - e. If the cable is properly connected, check that the receiver is turned on.
 - f. If still no power, disconnect the cable at the receiver and connect to another RS-232 port. If the radio powers up, there is a problem with the

RS-232 port you were previously connected. Avoid this port until you can arrange to have it fixed.

- g. You may have a malfunctioning radio or radio power cable. If using the Pacific Crest UHF radio, it is not possible to further isolate the problem. Contact your local dealer or Thales Navigation technical 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-Max, connect the radio cable to port **B**.
3. Connect the radio cable to the radio connector labeled DATA/PWR or SERIAL.

Radio connected to receiver

1. Ensure proper connection
2. Ensure that the radio cable is connected to port B on the back panel of the receiver.
3. Ensure the connection between the receiver and the radio is well-seated.

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 serial port for transmission by the radio. Use the field application software or front panel of the Z-Max to determine if the receiver is set to RTK base mode.

Receiver not configured as RTK base

1. Set receiver to RTK base mode.

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 serial port labeled 'B' on the back of the Z-Max. 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.

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 its 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-Max 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 correct 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 Power/SV LED on the front panel of

the receiver or the field application software to determine if the base receiver is tracking 4 or more 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 you have another radio to try, swap in the new radio and see if it makes a difference. Otherwise, contact your local dealer or Thales Navigation technical support for assistance.

Your base GPS receiver may be malfunctioning. Follow these steps to determine if the base receiver is the problem.

1. Replace the base GPS receiver with rover GPS receiver.
2. Follow the steps outlined above to set up the rover receiver as an RTK base.
3. If the base radio begins to transmit data, there is a problem with the base GPS receiver. Contact your local dealer or Thales Navigation technical support for assistance.

Rover System Troubleshooting

The Z-Max rover system has three basic functions: track satellites in order to collect raw satellite data at its position, receive base position satellite data transmitted by the base system radio, and finally, process the rover satellite data and the base satellite data together to compute the 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 green each time a packet of good quality 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 the Communication Module with the UHF radio, 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 the Communication Module, go to step 2 below.

Step 2. Is the UHF Antenna Module 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 UHF Antenna Module to the GPS Receiver Module. Ensure that the connection to the GPS Receiver Module is secure and the threaded collar that secures the module is snug and not cross-threaded.

Antenna is connected

Ensure the connection to the Communication Module radio is secure and the latch is completely closed.

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

Step 3. 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 or the front panel display to set the frequency of the rover radio to match the frequency of the base radio.

Radio set to same frequency as base

Go to step 4 below.

Step 4. Is line-of-sight between base and rover antennae obstructed?

Although UHF radios are fairly robust, an excessive amount of obstructions can block out the signal.

Line of sight not obstructed

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

Step 5. 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 UHF system can function with tens of miles of separation.

Unfortunately, these are ideal situations seldom found. In most situations, the range of UHF radio will be limited 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 the base receiver to test the system. Since radio range is difficult to predict due to 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 6 below if the problem is not yet resolved.

Step 6. Are you being jammed?

When working with UHF 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 can be a problem with UHF 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 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 about 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 7 below.

Being jammed

1. Lower sensitivity of rover radio. The field application software packages let you change the sensitivity of the rover radio, and you can also lower the sensitivity of the PDL radio via the front panel display. 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 7. You may have a malfunctioning component in your system

Your rover radio or UHF Antenna Module may be malfunctioning. There is no way to further isolate this problem unless you have spares for these components. Call your local dealer or Thales Navigation technical 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 its 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 green 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 Communication Module connected to the GPS receiver?

The rover radio in the Communication Module must send the base satellite data it receives to the rover GPS receiver in order for the rover receiver to compute a position. For this to happen, the Communication Module, the connection between the Communication Module and the GPS Receiver Module must be correct and secure.

Module not connected

Connect the Communication Module to the GPS Receiver Module. To connect the module, insert the small ledge of the Power Module into the rear of the GPS Receiver Module housing first. This will correctly align the module. Using the ledge like a hinge, swing the module closed until the latch on the Power Module clicks into place. Make sure that the Module is well seated, and the latch is completely closed.

Module connected

Ensure that the module is securely connected. Ensure the connections at the Communication Module and the GPS Receiver Module are fully seated.

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

Step 3. Is the Communication Module using 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. When using the Communication Module, the port is Port D. Use the field application software to verify that port D is set to be the radio port.

Not connected to correct port

Change the port setting to Port 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 its 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*” on page [254](#) 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, 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 has any obstructions 15° above the horizon, the obstructions may be blocking essential satellites. If obstructions exist at the base or the rover, move 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 Thales Navigation technical support for assistance.

Rover Computing Positions 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 to compute accurate RTK positions. If the rover receiver is 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 the receiver to function as an 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.
 - e. 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, move 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 Thales Navigation technical support for assistance.

This concludes the troubleshooting section. If the tips given here did not help you to resolve your problem with your Z-Max System, please call your local dealer or Thales Navigation technical support for assistance.

Serial & Power Port Pinouts

This appendix supplies the pinout specifications for the external power, USB, and serial ports in the GPS Receiver Module.

Power Port

The rear panel of the GPS Receiver Module has one connector for external power. External power is supplied through a 3-pin Fischer connector, Figure A.1. This connector also provides one pin for a boot signal (Table A.1).

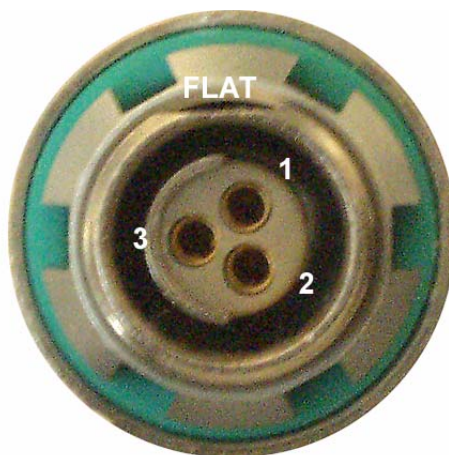


Figure A.1. Power Receptacle Front View

Table A.1 Power Connector Pinouts

Pin Number	Signal Name	Description
1	GND	External Power Ground
2	VEXT	External Power Input, 9-28V DC
3	Reserved	Leave unconnected

Serial Ports

The rear panel of the GPS Receiver Module has two external serial connectors – Serial A and Serial B. Serial A is an RS-232-only port. Port B can be configured at the factory to have either RS-232 or RS-422 levels. Serial A shares the internal logical port A with the USB port. Two devices cannot share this port at the same time. Figure A.2 shows the pin layout for Serial A and Serial B. Table A.2 and Table A.3 show the pinout descriptions. Note that the pinout descriptions will be depend on if the port is configured as an RS-232 or RS-422.

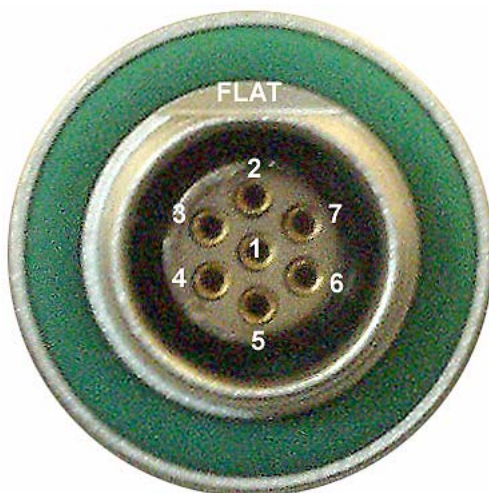


Figure A.2. Serial Port Pin Layout

Table A.2 Pinout of Serial Port A

Pin	Signal	Description
1	+12V	DC voltage +12V
2	GND	Ground
3	CTSA	Serial port A, clear to send
4	RTSA	Serial port A, request to send
5	RXDA	Serial port A, receive data
6	TXDA	Serial port A, transmit data
7	1PPS_OUT	One-pulse-per-second output

Table A.3 Pinout of Serial Port B

Pin	Signal	Description
1	+12V	DC voltage +12V
2	GND	Ground
3	CTSB/RX-	Serial port B, clear to send/RS422 inverting input
4	RTSB/TX+	Serial port B, request to send/RS422 non-inverting output
5	RXDB/RX+	Serial port B, receive data/RS422 non-inverting input
6	TXDB/TX-	Serial port B, transmit data/RS422 inverting output
7	EVENT	Event marker input

USB Port

The high-speed USB port is located in the compartment of the front panel. The connector is a type-B USB connector with the following pin-outs (Table A.4).

Table A.4 Pinout of USB Connector

Pin	Signal	Description
1	VBus	USB bus power input powers the USB transceiver
2	D-	D- line
3	D+	D+ line
4	GND	Ground
5	GND	Ground
6	GND	Ground

User Parameters

Table B.1 lists the more common user parameters. This table also indicates where to change the parameter and if applicable, the default value. If the parameter is available from the front panel display, the Front Panel column indicates the submenu where the parameter can be found. If the parameter is available using a serial command, the Serial Command column lists the command name.

Table B.1User Parameters

Description	Front Panel	Default
Antenna offsets	SURVEY: <i>mode</i>	0.0
Base station position	SURVEY: <i>mode</i>	n/a
Baud rate	SETTINGS	9600
Beep setting	SETTINGS	ON
Close session	SESSIONS	n/a
Data recording/ output interval	SURVCONV	20.0
Delete files	SESSIONS	n/a
Elevation mask	SURVCONF	10
Epoch counter	SURVCONF	0
Memory reset	SETTINGS	n/a
Minimum number of satellites for data recording/output	SURVCONF	3
Minimum number of satellites for kinematic surveying	SURVCONF	0
Reset factory defaults	SETTINGS	n/a
Restart session	SESSION	
RTK base port	SURVCONF	
RTK rover port	SURVCONF	
Save user parameters	SETTINGS	n/a
Site ID	SURVEY: <i>mode</i>	
Stop session	SESSION	

Uploading New Firmware

Occasionally, Thales Navigation will make available new versions of the receiver firmware that contain feature changes and general improvements to the Z-Max receiver. This appendix covers how to upload new firmware to your receiver. Using the following procedures, uploading firmware is an easy and straightforward process.

Step 1 - Acquire the New Firmware

New firmware is available by contacting Thales Navigation Technical Support. Notifications that an upgrade is available can be found on our web site at:

technical@thalesnavigation.com.

New firmware is acquired in one of two ways:

- - the new firmware file can be downloaded to your PC from the Thales Navigation FTP site. The firmware file must then be copied from your PC on to an SD card using an SD card reader attached to your PC.
- - an SD card containing the new firmware file can be purchased from Thales Navigation Technical Support.

Step 2 - Insert the SD Card into the Receiver

With the receiver powered off, insert the SD card containing the new firmware file in to the SD card slot of the GPS Receiver Module. If the SD card slot in the receiver contains an SD card for recording data, remove the data SD card and insert the firmware SD card. Remember to replace the data SD card after firmware uploading is complete.

Note that data SD card and the firmware SD card can be the same card. There is no problem with using the same card for both purposes. To use the same card, copy the firmware file onto the data card using the SD card reader. When the data card is read through the SD card reader it will contain a file named Micro-Z.bin. This is the receiver's file system where data files are stored. This file is required by the receiver to record data. **Do not delete this file.**

Step 3 - Connect Communication and Power Modules

Firmware upgrades also include firmware that operates the Communication and Power Modules. If these modules are part of your system, attach them to the GPS Receiver Module prior to uploading the firmware to ensure that all modules are at the same level of firmware. To do so, power off the unit then attach the modules to it, insert the SD card in the receiver with it still powered off, then proceed to the next step.

If for some reason these modules are unavailable at this time, the new firmware can be loaded to the receiver now and reloaded a second time once the modules become available.

Step 4 - Initiate Firmware Upload

With the receiver powered off, initiate the firmware upgrade process by pushing the UP arrow key and the Power button at the same time. The unit will beep after about 3 seconds, release the key and wait. The receiver will check the SD card to ensure that the firmware file is on the card and that the file is not corrupted. If a good file is found on the SD card, the receiver will start the upgrade. Go to Step 5.

If the firmware file is not found on the SD card, the front panel display will show the message **"No firmware to upgrade"** and all 4 indicator LEDs will blink red. Power cycle the receiver to clear this state, and then insert an SD card with valid firmware.

If the firmware file is corrupted, the front panel display will show the message **"Bad image checksum, will not upgrade"** and all 4 indicator LEDs will blink red. Power cycle the receiver to clear this state, and then acquire another copy of the firmware from Technical Support.

Step 5 - Monitor the Upgrade

The firmware upgrade is executed in five stages, and each stage will show a message on the front panel display. As the upgrade proceeds, you should see the following messages:

- "Loading Thales firmware stage #1"
- "Loading Thales firmware stage #2"
- "Loading Thales firmware stage #3"
- "Loading Thales firmware stage #4"
- "Loading Thales firmware stage #5"

If the Power Module is not connected to the GPS Receiver Module, Step 1 is skipped and the message "No answer from the BATT Module stage #1 skipped" is displayed. If a Communication Module is not attached, Step 2 is skipped and the message "No answer from comm module stage #2 skipped" is displayed.

The entire upload process should take around five minutes to complete. If all the active modules been upgraded successfully, the system will automatically reboot itself, and will power up in normal operating mode with the new firmware.

If there is a problem with any stage of the upgrade, a warning message will appear on the front panel display in the form "**Step X failed**" and the 4 LEDs will blink red. Power cycle the system to clear this state and repeat steps 4 and 5. If after one or two attempts this problem continues, contact Technical Support.

Step 6 - Verify the New Version

Verify that the correct version of firmware was loaded by going to the SYSINFO / VER submenu on the front panel display. If the new version is correct, then the firmware upload is complete. Repeat Steps 2-6 for all other receivers in your possession.

Once all receivers are upgraded, the firmware file can be deleted from the SD card, or else saved as a backup. It is recommended to delete the firmware file from the SD card after the firmware upload, however the receiver will operate properly if the firmware file is left on the SD card.

Technical Support

If you have any problems or require further assistance, you can contact Technical Support by telephone, email, or Internet.

Please refer to the documentation before contacting Technical Support. Many common problems are identified within the documentation and suggestions are offered for solving them.

Thales Navigation Professional Products Technical Support

Santa Clara CA USA (For North, Central, and South America plus International)

800 Number: 800-229-2400 (US only)

Direct Dial: (408) 615-3980

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FAX Line: (408) 615-5200

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Internet: <http://www.thalesnavigation.com>

Nantes, France: (For Europe, Middle East, and Africa plus International)

Direct Dial: 33 2 2809 3934

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e-mail: technical@thalesnavigation.com

Internet: <http://www.thalesnavigation.com>

When contacting Technical Support, the following minimum information is required:

Receiver serial number

Software version number

Software key serial number, if applicable

Firmware version number

A clear, concise description of the problem.

Also visit the Thales Navigation ftp site at <ftp://ftp.thalesnavigation.com> for updates to current firmware, software, product release notices, PDF versions of manuals, training materials, and FAQs.

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