

Real-Time Kinematic Surveying

Training Guide



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Release Notice

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Contents

Overview

In this chapter:

- Introduction
- Course Objectives
- Course Overview
- Course Materials
- Product Overview
- GPS Receivers
- The Trimble Controller
- Processing Software
- Trimble Resources
- Other Resources
- Document Conventions

Introduction

Welcome! Trimble Navigation Limited is committed to excellence in product training services.

The overall goal of this course is for you to learn how to use the Trimble® Real-Time Kinematic Surveying (RTK) system so that you can perform your work tasks with confidence.

Course Objectives

At the end of this course, you will be able to:

- Understand GPS fundamentals and apply RTK criteria to a survey project
- Understand the RTK system and know the requirements for Real-Time Kinematic surveying
- Configure and operate RTK system components
- Apply coordinate system and GPS site calibration theory to a Real-Time Kinematic survey
- Effectively use feature codes
- Perform field data collection procedures and office data processing.
- Confidently conduct a GPS Real-Time Kinematic survey

Course Overview

The course includes an overview of GPS and RTK fundamentals. You will learn to carry out a Real-Time Kinematic surveying project, including:

- Performing field reconnaissance
- Planning a project
- Configuring the software

- Setting up equipment
- Recording, transferring, and processing data
- Exporting data in desired coordinate systems and formats
- Generating plans and reports

Review questions

Review questions in each section help you to evaluate your success in achieving the course objectives.

Course Materials

The materials provided for your Real-Time Kinematic surveying training course include this training manual, which you can use during the class and on the job. The training manual explains the fundamentals of GPS, provides classroom and field exercises, and includes a glossary of terms.

Product Overview

In this course, you will learn about and use Trimble receivers, the Trimble controllers (TSCe™ or ACU) running the Trimble Survey Controller™ software, and processing software products that are designed to work together for Real-Time Kinematic surveying.

The Trimble controllers described in this manual are the TSCe and the ACU (Attachable Control Unit). Where any information relates to only one of these controllers, it is indicated with an icon,  (TSCe) or  (ACU).

Trimble provides several solutions to your survey need: from integrated all-in-one designs and modular component design, to fully robotic optical reflectorless design. All Trimble total stations are

rugged, weather resistant, and share common options and accessories. They all use the same Trimble survey data format and supporting software.

Trimble's GPS Total Station® (RTK) system lets you precisely collect data in real-time. The GPS Total Station comes as a complete system comprising of:

- GPS Receiver
- Trimble controller running Trimble Survey Controller
- Processing software
- Radio (optional purchase)
- Accessories (optional purchase)

GPS Receivers

Table 1.1 shows how a 5700 receiver is used in a total station setup. LEDs monitor the survey in progress and the available battery capacity.

Table 1.1 Trimble GPS Total Station receivers

Receiver	Use	Operation	LEDs
5700	L1 / L2 frequency receiver GPS surveying applications One-touch data logging	Records GPS data on an internal CompactFlash card Makes all data available through serial or USB ports. (internal radio available)	5

The Trimble Controller

The Trimble controller running the Trimble Survey Controller software controls the Real-Time Kinematic systems and makes surveying a faster and more efficient process. Trimble Survey Controller is the link between all Trimble GPS receivers and the office software suites. It also links Trimble GPS/Conventional products to other existing optical total station products.

With the Trimble Survey Controller you can:

- Configure instrument settings and data collection methods to best suit your requirements.
- Collect features and attributes according to a feature and attribute library that you define in the Trimble Geomatics Office™ software or within the Trimble Survey Controller.
- Calculate areas, offsets, and intersections to points, lines, or arcs.
- Stake out design or calculated features, including road templates and DTM.
- Communicate with other optical total station products.
- Monitor the status of your RTK system.

Processing Software

Geomatics is the design, collection, storage, analysis, display, and retrieval of spatial information. The collection of spatial information can be from a variety of sources, including GPS and terrestrial methods. Geomatics integrates traditional surveying with new technology-driven approaches, making geomatics useful for a vast number of applications.

The Trimble Geomatics Office is a link and survey reduction package. It provides a seamless link between your fieldwork and design software. The software includes an extensive feature set which helps you to verify your fieldwork quickly, perform survey-related tasks easily, and export your data to a third-party design package.

Use Trimble Geomatics Office for a wide variety of tasks, including:

- Create data dictionaries or feature and attribute libraries.
- Import and export data from any GIS/CAD source.
- Import data from conventional total station products.
- Create geoid sub-grid models and transfer them to the controller.
- Edit your data graphically and textually.
- Perform multiple site calibrations and save them as unique sites.
- Communicate with other Trimble software.
- Produce scaled plots of your data.
- Process static data.
- Perform network adjustment of GPS and terrestrial data.
- Create and edit any local, global, or existing coordinate system.
- Work in a truly georeferenced global coordinate system.
- View and edit third-party road design files, and create digital terrain models (DTM).

Trimble Resources

Internet

The Trimble website provides access to Trimble's newest customer support tools. To obtain technical documents and utilities, access the website directly at <http://www.trimble.com>.

Product training

For information about training on Trimble products, check the Trimble website or contact your local dealer.

Technical assistance

If you have a problem and cannot find the information you need in the product documentation, check the Trimble website or contact your local dealer. To find your local dealer, go to www.trimble.com, then click **Where to Buy**.

Contact details

Trimble local dealer:

Company name _____

Phone number _____

Fax number _____

E-mail _____

Contact person _____

Other Resources

The following website provides GPS as well as control point information, primarily in the United States. For information about your region, ask your trainer.

U.S. Coast Guard (USCG)

This is a source for current GPS and satellite information, including information on the number of operational space vehicles (SVs), times and dates they will be available, and launch dates for new and replacement SVs.

U.S. Coast Guard web site: <http://www.navcen.uscg.gov/default.htm>

Document Conventions

The document conventions are as follows:

Convention	Definition
<i>Italics</i>	Identifies software menus, menu commands, dialog boxes, and the dialog box fields.
Helvetica Narrow	Represents messages printed on the screen.
Helvetica Bold	Identifies a software command button, or represents information that you must type in a software screen or window.
	Is an example of a hardware key (hard key) that you must press on the controller keypad.
"Select <i>Italics</i> / <i>Italics</i> "	Identifies the sequence of menus, commands, or dialog boxes that you must choose in order to reach a given screen.
	Is an example of a hardware function key that you must press on a personal computer (PC). If you must press more than one of these at the same time, this is represented by a plus sign, for example, +
	Is an example of a softkey. For more information, see, Softkeys, page 73.

GPS and Surveying

In this chapter:

- Introduction
- Session Objectives
- The Global Positioning System
- Satellite Signal Structure
- GPS Coordinate Systems
- Error Sources in GPS
- GPS Surveying Concepts
- GPS Surveying Techniques
- Techniques for Survey Tasks
- Review Questions
- Answers

Introduction

This chapter introduces you to the Global Positioning System (GPS) and the concepts related to surveying with GPS.

Session Objectives

At the end of this session, you will be able to identify and explain the following GPS elements:

- Segments
- Satellite signal structure and observables
- Coordinate systems
- Sources of error in measurements
- Surveying concepts and techniques

The Global Positioning System

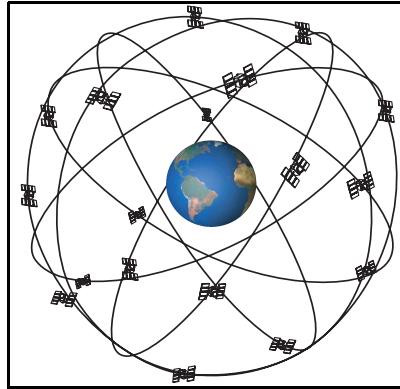
The Global Positioning System is a constellation of at least 24 satellites that act as reference points so that a GPS receiver can calculate accurate position information. GPS uses satellites and computers to compute positions anywhere on Earth. The system is owned, operated, and controlled by the United States Department of Defense (DoD). However, it can be used by any civilian worldwide, day or night, in any weather conditions, and is free of charge.

GPS segments

GPS consists of the following three segments:

Space

In the space segment there is a minimum of 24 operational NAVSTAR (NAVigation Satellite Timing And Ranging) satellites (SVs) in space. Usually there are approximately 27, but this number changes constantly as satellites are commissioned (put into operation) and decommissioned (removed from operation). They orbit the earth every twelve hours at an altitude of about 20,200 km.



The satellites are grouped into 6 orbits, each inclined at 55 degrees to the equatorial plane and evenly spaced at 60 degrees apart. Each satellite transmits radio signals that are marked with unique identifying codes.

High-precision atomic clocks on the satellites control the generation of these signals and codes.

Control

The control segment is the “brain” of GPS. The United States Department of Defense (DoD) controls the system using a master station and four ground-based monitor/upload stations. Each satellite passes over a monitoring station twice a day.

- The monitor stations continuously track the satellites and provide this data to the master station.

- The master station is located at Schriever Air Force Base in Colorado Springs, Colorado, USA. The station calculates corrections to synchronize the atomic clocks aboard the satellites, and revises orbital information. It then forwards these results to the upload stations.
- The upload stations update each individual satellite using the information provided by the master station.

The master station, and monitor/upload stations are shown in Figure 2.1.

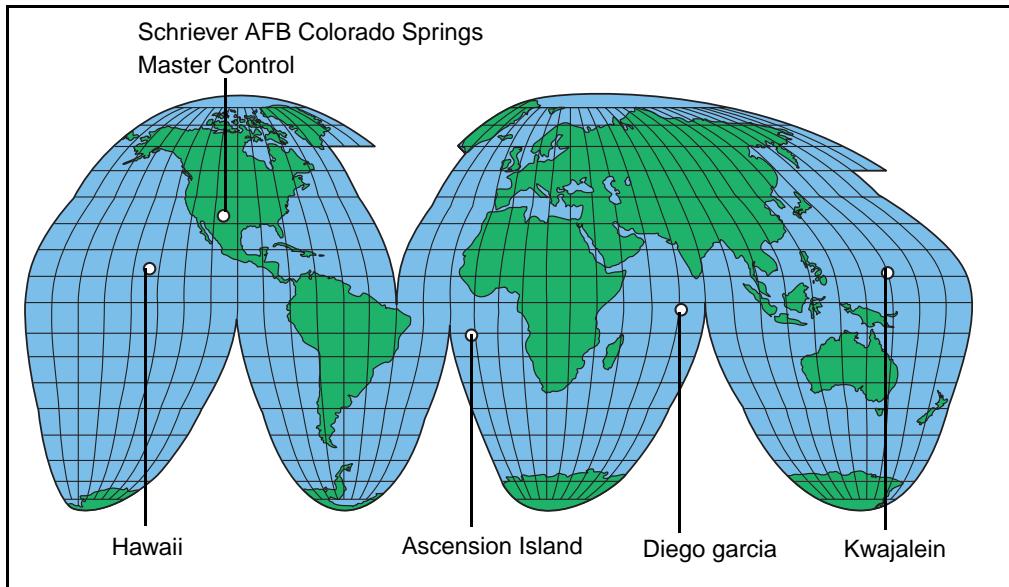


Figure 2.1 GPS master station, and the monitor/upload station network

User

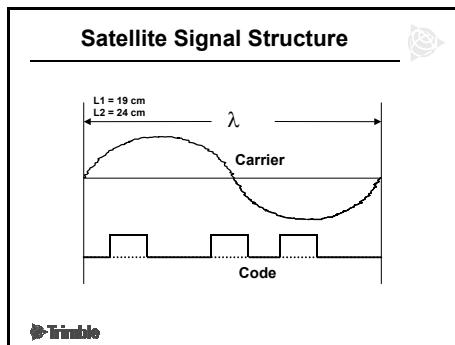
Anyone who has a GPS receiver can use GPS, and signals are used by civilians as well as by the military. Initially, GPS receivers were used mainly for position determination and navigation, but now they are used for a range of precise survey tasks on land, on sea, and in the air. Applications include surveying, agriculture, aviation, emergency services, recreation, and vehicle tracking.

For more information about GPS applications, visit the Trimble website (www.trimble.com). Civilian users currently outnumber military users.



Satellite Signal Structure

Each component of a satellite signal is called an observable, for example the L1 carrier, or C/A code are both observables.



Each satellite transmits two unique codes. The first, and more simple code is called the C/A (coarse acquisition) code. The second code is called the P (precise) code. These codes are modulated onto two carrier waves, L1 and L2.

L1 is the primary L-band carrier with a wavelength of 19 cm. The frequency is 1575.42 MHz. It is modulated by C/A code, P-code, or Y-code, and a 50 bit per second navigation message.

L2 is the secondary L-band carrier with a wavelength of 24 cm. The frequency is 1227.6 MHz. It is modulated by P-code or Y-code, and a 50 bit per second navigation message.

C/A code is modulated onto an L1 signal. The code is a string of 1023 digital bits in a pattern so complex that it looks random, and so is called pseudorandom (PRN) code or noise.

There is a different C/A code PRN for each SV. GPS satellites are often identified by their PRN number, the unique identifier for each pseudo-random-noise code.

It repeats every millisecond (1.023 MHz)

The P-Code (Precise) modulates both the L1 and L2 carrier phases. The P-Code is a very long (it takes seven days until code starts repeating itself).

When Anti-Spoofing is active, the P-Code is encrypted into the Y-Code.

GPS receivers are single-frequency or dual-frequency.

Single-frequency receivers observe the L1 carrier wave, while dual-frequency receivers observe both the L1 and L2 carrier waves.

Satellite Signal Structure		
Carrier	L1	L2
Frequency	1575.42 MHz	1227.60 MHz
Wavelength	19cm	24cm
Code Modulation	C/A-code P(Y)-code NAVDATA	- P(Y)-code NAVDATA
C/A - Coarse Acquisition Code P - Precise Code (Y-Code when encrypted) NAVDATA - Satellite health, satellite clock corrections, ephemeris parameters and SV orbital parameters.		

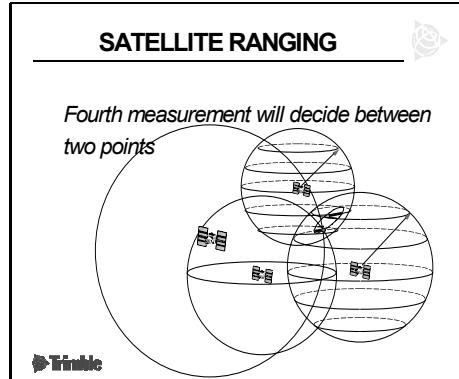
Navigation message contains system time, clock correction parameters, ionospheric delay model parameters, and details of the satellite's ephemeris and health. The information is used to process GPS signals to obtain user position and velocity.

The position of each of the satellites is precisely known at all times.

They act as “known points” in space. Knowing the distance (range) from the GPS antenna phase center (APC) to each of the satellites enables the receiver to calculate its position.

Positions are resolved by trilateration after determining the range to each visible satellite.

Ranges are measured using the code or the phase of the carrier wave.



Satellite range based on code measurements

The GPS receiver has a C/A code generator that produces the same PRN code as the satellite does. Code received from the satellite is compared with the code generated by the receiver, sliding a replica of the code in time until there is correlation with the SV code, as shown in Figure 2.2.

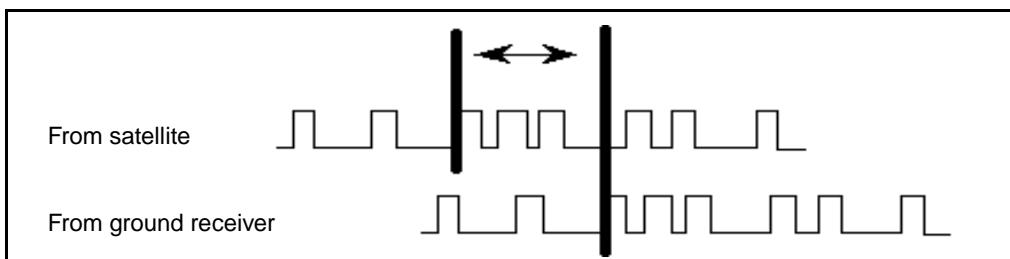


Figure 2.2 Code measurements

There is a time difference between when the same part of the code is generated in the satellite and when it is received at the GPS antenna. Code measurements make it possible to record this time difference. The measurements are multiplied by the speed of light (speed at which GPS signal travels), so range can be determined.

Code range observables provide pseudorange time differences between satellites and a single autonomous receiver.

The result of a code range is called the autonomous position. To obtain the autonomous position, only one receiver is required.

This position may be used in baseline processing as an initial receiver starting position.

Satellite range based on carrier phase measurements

Survey-grade GPS receivers measure the difference in carrier phase cycles and fractions of cycles over time.

At least two receivers track carrier signals at the same time.

Carrier phase is tracked at both receivers and the changes in tracked phase are recorded over time in both receivers.

The wavelengths of the L1 and L2 waves are known, so ranges are determined by adding the phase difference to the total number of waves that occur between each satellite and the antenna.

Carrier phase observables provide true range, the exact number of wavelengths from the antenna phase center to the satellite, between two receivers.

Determining the full number of cycles between the antenna and the satellite is referred to as the integer ambiguity search.

Resolving the integer ambiguity is essential for surveys that require centimeter-level precision.

For postprocessed surveys, the WAVE™ Baseline

processing module resolves the integer ambiguity and determines the integer during baseline postprocessing.

For Real-Time Kinematic surveys (RTK), the rover receiver resolves the integer ambiguity and determines the integer during initialization process.

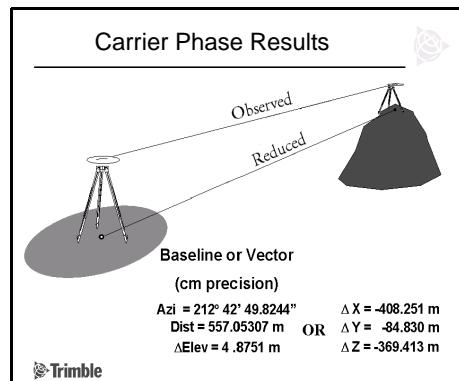
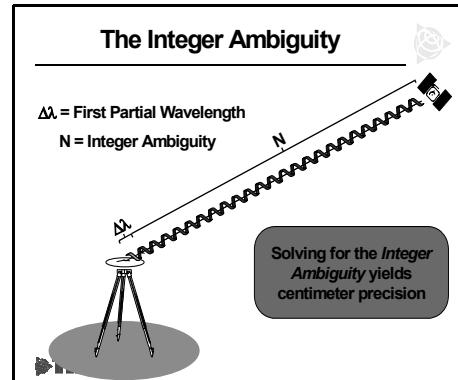
The result of a carrier phase based measurements is a baseline. It takes two receivers observing GPS signal simultaneously to produce a baseline.

When the data from these two receivers is combined, the result is a baseline comprising a 3D vector between the two stations.

The position of one GPS receiver is relative to another.

The baseline is measured from antenna phase center (APC) to antenna phase center (APC). Antenna heights are used to reduce results to ground values.

Carrier wave observations are available as real time or postprocessed results.



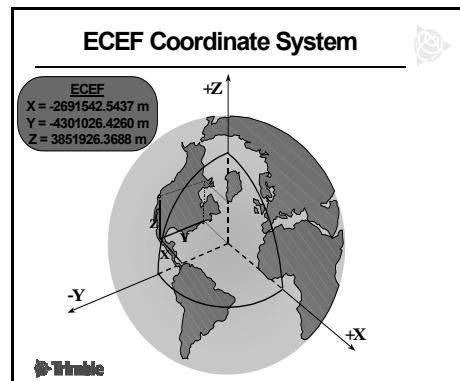
GPS Coordinate Systems

The GPS coordinate system is described in the following sections:

- Earth Centered Earth Fixed
- Reference Ellipsoid
- ECEF and WGS-84
- Geoid and GPS Height

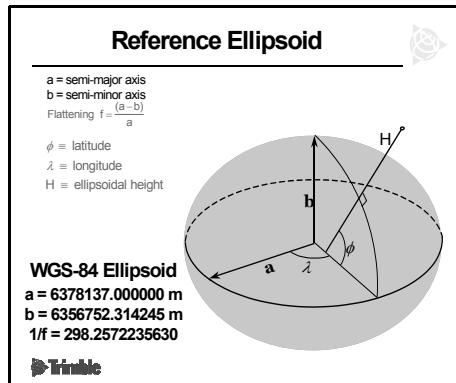
Earth-centered, earth fixed

ECEF is a cartesian coordinate system used by the WGS-84 reference frame. In this coordinate system, the center of the system is at the earth's center of mass. The *z-axis* is coincident with the mean rotational axis of the earth and the *x-axis* passes through 0° N and 0° E. The *y-axis* is perpendicular to the plane of the *x-* and *z-axes*. All axes are fixed to the earth's motion.



Reference ellipsoid

A reference ellipsoid is a mathematical model of the earth, formed by rotating an ellipse around its semi-minor axis (b). For ellipsoids that model the earth, the semi-minor axis is the polar axis (b) and the semi-major axis (a) is the equatorial axis. An ellipsoid is completely defined by specifying the lengths of both axes, or by specifying the length of the major axis and the flattening.



GPS uses the WGS-84 ellipsoid as a reference ellipsoid. Its parameters are:

- semi-major axis (a) = 6378137.000000 m
- semi-minor axis (b) = 6356752.314245 m
- inverse flattening (1/f) = 298.2572235630

Positions relative to the ellipsoid are referred to as:

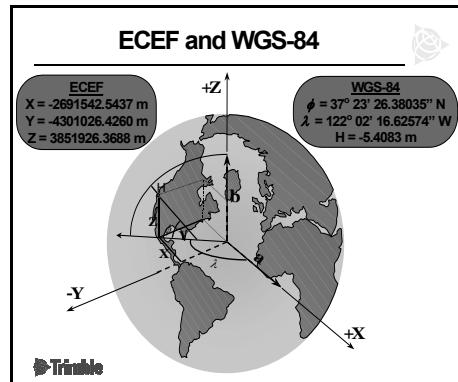
- Latitude – Angular measurement north or south of the equator
- Longitude – Angular measurement east or west of the Greenwich meridian, passing through Greenwich, England
- Height – Distance above or below the reference surface

ECEF and WGS-84

The WGS-84 geodetic datum is a mathematical model designed to fit part or all of the geoid (the physical earth's surface). A geodetic datum is defined by the relationship between an ellipsoid and the center of the earth. For ECEF and WGS-84, mathematical conversions can be calculated between the two reference systems.

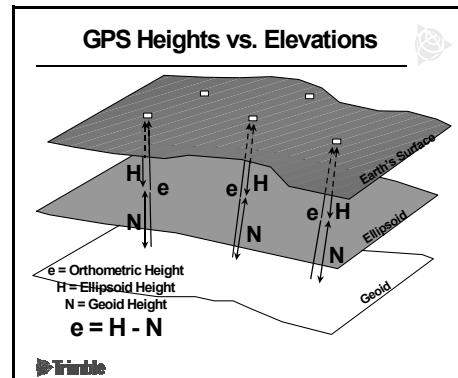
The model takes into account the size and shape of the ellipsoid, and the location of the center of the ellipsoid with respect to the center of the earth (a point on the topographic surface established as the origin of the datum).

All GPS coordinates are based on the WGS-84 datum surface.



Geoid and GPS height

The geoid is the surface of gravitational equipotential that closely approximates mean sea level. It is not a uniform mathematical shape, but is an irregular figure with an overall shape similar to an ellipsoid.



Generally, the elevations of points are measured with reference to the geoid. However, points fixed by GPS methods have heights referenced to the WGS-84 datum (a mathematical figure).

The relationship between the WGS-84 datum and the geoid must be determined by observation, as there is no single mathematical definition that can describe the relationship. You must use conventional survey methods to observe the elevation above the geoid, then compare the results with the height above the WGS-84 ellipsoid at the same point.

By gathering a large number of observations of the separation between the geoid and the WGS-84 datum (geoid separation), grid files of the separation values can be established. This allows the interpolation of the geoid separation at intermediate positions. Files containing these grids of geoid separations are referred to as geoid models. Given a WGS-84 position that falls within the extents of a geoid model, the model can return the interpolated geoidal separation at this position.

Error Sources in GPS

Measurement errors can never be completely eliminated. This section explains the following sources of errors in GPS:

- Satellite geometry
- Human error
- Selective Availability (SA) and Anti-Spoofing (AS)
- Atmospheric effects
- Multipath

Satellite geometry

Dilution of Precision (DOP) is an indicator of the quality of a GPS position.

It is a unitless figure of merit expressing the relationship between the error in user position and the error in satellite position. It takes into account the location of each satellite relative to other satellites in the constellation, as well as their geometry relative to the GPS receiver.

PDOP is inversely proportional to the volume of the pyramid formed by lines running from the receiver to four satellites observed.

Values considered good for positioning are small (for example, 3). Values greater than 7 are considered poor. Small PDOP is associated with widely separated satellites.

PDOP is related to horizontal and vertical DOP by:

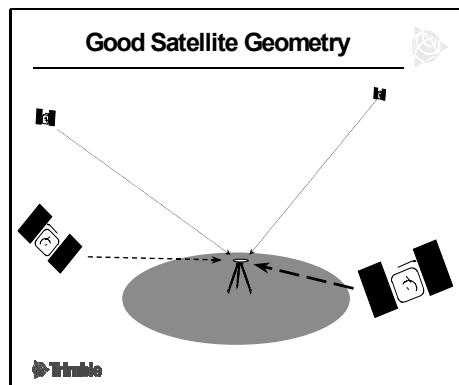
$$PDOP^2 = HDOP^2 + VDOP^2.$$

A low DOP value indicates a higher probability of accuracy.

Standard DOPs for GPS applications are:

- PDOP – Position Dilution of Precision (three coordinates)
- RDOP – Relative Dilution of Precision (Position, averaged over time)
- HDOP – Horizontal Dilution of Precision (two horizontal coordinates)
- VDOP – Vertical Dilution of Precision (height only)
- TDOP – Time Dilution of Precision (clock offset only)
- GDOP – Geometric Dilution of Precision. (The relationship between errors in user position and time, and errors in satellite range).

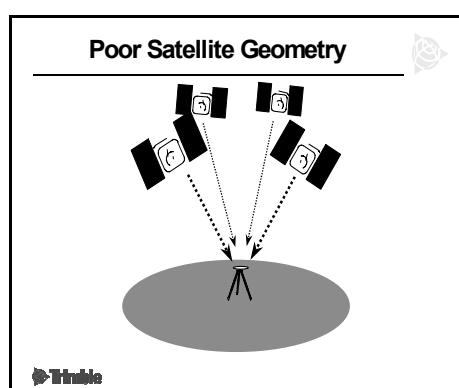
Good PDOP occurs when the satellites are geometrically balanced above your position.



GPS precision is diluted, leading to poor PDOP, when satellites are not balanced.

Poor PDOP may occur:

- even when you have a large number of satellites, if they are in a line
- when all satellites are positioned directly overhead or all are in one cluster in the sky



The PDOP mask is a user-definable setting that limits the effects of SV geometry on the accuracy of GPS position. It is the highest PDOP value at which a receiver will compute positions.

Human error

Human error is typically the greatest contributor of error. Some examples include:

- Misreading antenna height measurements
- Transposing numbers incorrectly

- Rushing observations and shortening observation times
- Poor centering and leveling over points.

SA and AS

The Department of Defense (DoD, USA) controls Selective Availability (SA) and Anti-Spoofing (AS).

Selective Availability – SA was a purposely-introduced artificial degradation of the GPS satellite signal. It involved distorting the information about SV location and time, two main components in calculating the receiver's position. The magnitude of the error in autonomous GPS introduced by the SA was 100 m (H) and 156 m (V).

Selective Availability was turned off on 1 May 2000.

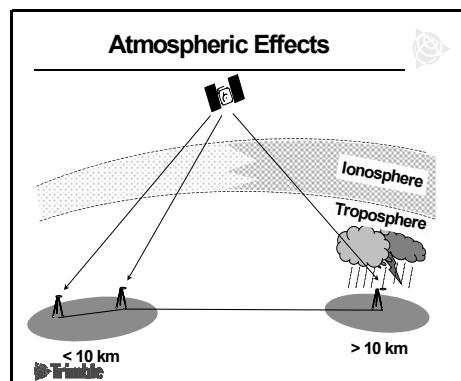
The error in autonomous GPS position since discontinuation of SA is approximately 8–10 m (H) and 10–15 m (V).

Anti-Spoofing – AS allows transmission of an encrypted Y-code in place of P-code. Y-code is intended to be useful only to authorized (primarily military) users. AS is used to deny the full precision of GPS to civilian users.

Atmospheric effects

The troposphere is a layer filled with water vapor that basically produces our local weather. Standard models are used to account for and remove this error.

The ionosphere is a layer of the atmosphere with charged particles, 80 to 120 miles



above the earth's surface. The ionosphere affects the accuracy of GPS measurements by causing a delay in GPS signal.

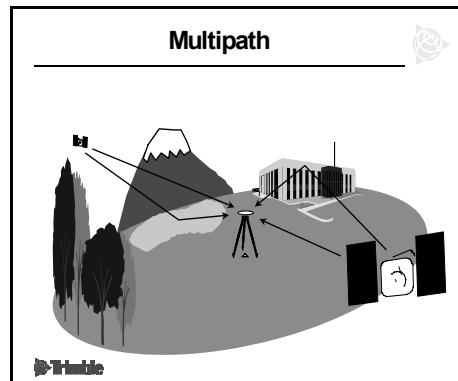
With the ionosphere, the distortion of the satellite signals varies with the thickness of the layer and the activity of charged particles. The level of activity of this layer is affected by the solar cycle. Every 11 years, the sun goes through its most active period, known as the “solar maximum”. During this time, there are many sunspots, solar flares and coronal mass ejections, which can all affect GPS systems used on Earth.

With baselines shorter than 10 km, the effects are almost equal at each receiver, therefore you do not need to use ionospheric modeling.

If long baselines are measured, you need to use ionospheric modeling in order to cancel the effects of ionosphere. It is also a limiting factor for the distance of RTK technique.

Multipath

Multipath is an interference, similar to ghosting on a television screen, and occurs when GPS signals traverse different paths before arriving at the antenna. A signal that traverses a longer path yields a larger pseudorange estimate and increases the error. If a signal reflects off a structure near the antenna, its path is longer and it reaches the receiver from multiple paths.



Structures that can reflect signals include mountains, trees, towers, buildings, bodies of water, and the surface of the ground.

GPS receivers contain multipath rejection technologies to minimize the effect of reflected signals. However, Trimble recommends that you observe in multipath-free sites if possible.

Collecting data for longer time periods or using a ground plane with your GPS antenna can help reduce the effect of multipath.

GPS Surveying Concepts

GPS surveying requires the simultaneous observation of the same four (or more) satellites by at least two GPS receivers. Although you can use more than two receivers for some surveys, this manual limits discussion to the use of two: the base receiver and a rover receiver.

The base receiver is located over a known control point for the duration of the survey. The rover receiver is moved to the points that are to be surveyed or staked out. When the data from these two receivers is combined, the result is a 3D vector (baseline) between the base antenna phase center (APC) and the rover antenna phase center (APC).

You can use different observation techniques to determine the position of the rover receiver relative to the base. These techniques are categorized according to the time at which a solution is made available:

- Real-time techniques use a radio to transmit base observations to the rover for the duration of the survey. As each measurement is completed, the solution is resolved.
- Postprocessed techniques require data to be stored and resolved some time after the survey has been completed.

Generally, the technique you choose depends on factors such as the receiver configuration, the accuracy required, time constraints, and whether or not you need real-time results.

GPS Surveying Techniques

Trimble GPS systems let you survey using the Differential, Kinematic, or Static/FastStatic survey techniques. Table 2.1 shows details of these different techniques.

Table 2.1 Survey technique details

Variable	Differential	Kinematic	Static/FastStatic
Real-time	Yes (RTDiff or DGPS)	Yes (RTK)	No
Postprocessed	No	Yes (PPKin)	Yes
Receiver	Single or dual frequency		
Measurements	C/A-code	Carrier phase	Carrier phase
Initialization	No	Yes See the following section for details.	No
Continuous SV tracking required	No	Yes 4 or more SVs common to base and rover receivers	45 minutes or longer for Static (highest precision) 8-30 minutes for FastStatic Tracking time required depends on the receiver type, baseline length, and the number and geometry of the satellites.
Precision	sub-meter	centimeter	centimeter

Kinematic survey initialization

To achieve the required precision, RTK and PPK surveys must first be initialized:

- Real-time survey – Set the rover over a known or a new point. If the rover has the on-the-fly (OTF) option installed, and there are at least five common satellites, initialization can also be achieved while the rover is moving.

- Postprocessed survey – Set the rover over a known or a new point. OTF initialization is attempted when there are five or more common satellites, whether or not the receiver has OTF option installed.

Note – If the number of common satellites falls below four while you are surveying, the survey must be reinitialized when four or more satellites are again being tracked.

Techniques for Survey Tasks

Surveyors use GPS for control surveys, topographic surveys, and stakeout.

Control surveys

Control surveys establish control points in a region of interest. Baselines are measured using careful observation techniques. These baselines form tightly braced networks, and precise coordinates result from the rigorous adjustment of the networks. Static and FastStatic observation techniques, combined with a network adjustment, are best suited to control work.

Topographic surveys

Topographic surveys determine the coordinates of significant points in a region of interest. They are usually used to produce maps.

Kinematic techniques (real-time or postprocessed) are best suited to topographic surveys because of the short occupation time required for each point.

Stakeout

Stakeout is the procedure whereby predefined points are located and marked. To stake out a point, you need results in real time. Real-Time Kinematic (RTK) is the only technique that provides centimeter-level, real-time solutions.

Figure 2.3 summarizes the different survey techniques.

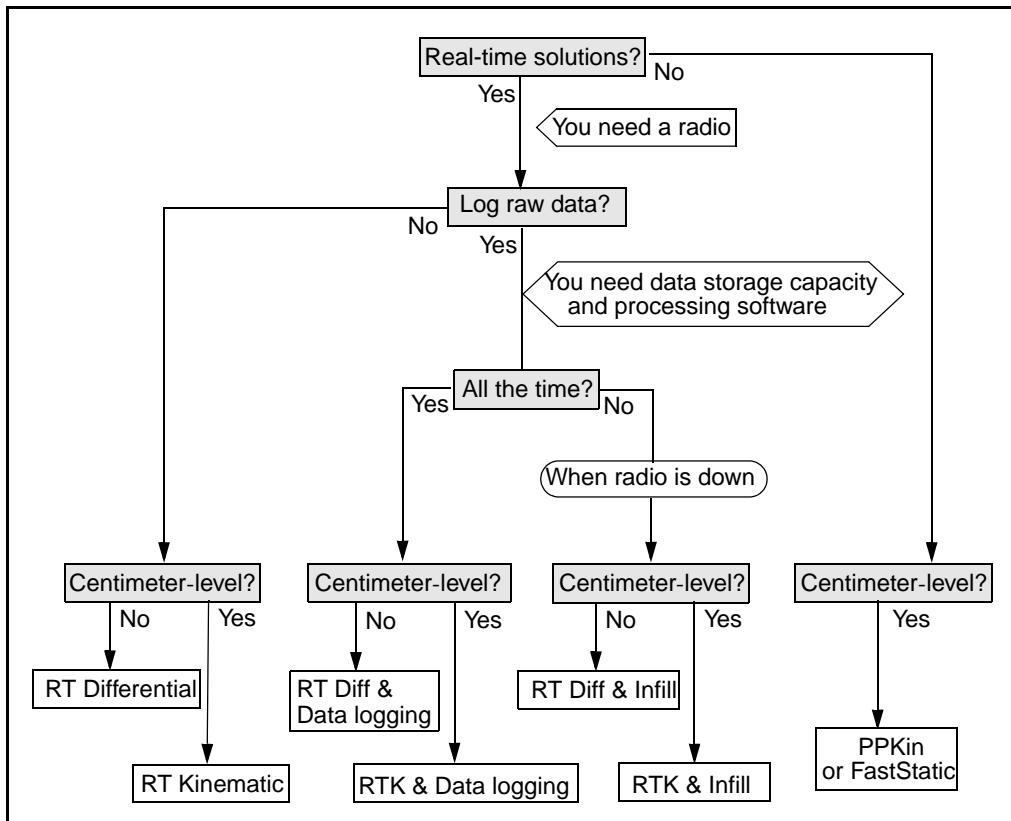


Figure 2.3 Choosing an appropriate survey technique

Review Questions

These questions test what you have learned about the Global Positioning System and GPS surveying requirements:

1. What are the three segments of GPS?
2. What is the structure of the GPS signal?
3. How is the GPS receiver position determined?
4. Determining the full number of carrier phase cycles between the GPS antenna and the SV is commonly called what?
5. Name the following: GPS coordinate system, GPS reference ellipsoid and GPS geodetic datum.
6. When measuring with GPS, to what surface are the heights referenced?
7. What are the error sources in GPS measurement?
8. How are GPS observation techniques categorized based on the time at which a solution is made available?
9. What survey tasks is GPS used for?
10. What should you consider when choosing an appropriate observation technique?

Answers

1. The three GPS segments are Space, Control, and User.
2. GPS satellites transmit two L-band radio signals, the L1 and the L2. Three binary codes are modulated on the L1 and/or L2 carrier phase:
C/A code on L1
P (Y) code on L2
The Navigation Message on both L1 and L2
3. Positions are resolved by trilateration after determining the range to each visible satellite. Ranges are measured using the code or the phase of the carrier wave.
4. The Integer Ambiguity search.
5. ECEF, WGS 84 ellipsoid and WGS 84 geodetic datum.
6. The heights are referenced to the WGS-84 datum.
7. SV geometry, human error, SA / AS, atmospheric effects and multipath.
8. Real-time and postprocessed.
9. Control survey, topographic survey and stake out.
10. Is the real-time solution necessary?
Is the raw data necessary, and when?
Is centimeter level accuracy required?

Real-Time Kinematic (RTK) Systems

In this chapter:

- Introduction
- Session Objectives
- Real-Time Kinematic Surveying (RTK) Overview
- Initialization (Resolving the Integer Ambiguity)
- RTK System Components
- Assembling and Setting up a Real-Time Kinematic Survey System (Base)
- General Guidelines
- Setting Up a GPS Total Station 5800 Receiver (Rover)
- Measuring GPS Antenna Heights
- RTK System Equipment Checklists
- Use and Care
- General Guidelines
- Review Questions
- Answers

Introduction

This chapter gives an overview of Real-Time Kinematic Surveying (RTK), including survey concepts and requirements, equipment checklists, connection diagrams, and use and care information.

Session Objectives

At the end of this session, you will know:

- The fundamental concepts and requirements for performing a RTK survey
- How to assemble an RTK system
- The importance of proper use and care for the equipment

Real-Time Kinematic Surveying (RTK) Overview

RTK surveys are kinematic surveys with a communications link between the base receiver and rover. RTK can include stop-and-go data collection and continuous data collection.

In Real-Time Kinematic surveys, data processing occurs in the field as data is logged, providing immediate centimeter-level results in the form of coordinates in the Trimble controller.

The GPS base station is located on a known point. It takes measurements from satellites in view and then broadcasts them along with its known position to the rover receivers.

The rover receiver also collects measurements from the satellites in view and processes them with the base station data. The rover then computes its location relative to the base.

Typically, base and rover receivers take measurements at regular 1-second epochs (events in time) and produce position solutions at the same rate. If you use a radio as the communication link, one base

station can support an unlimited number of rovers. If you use a different communication method, for example, a cellular phone, you may be limited in the number of rovers the base can support.

RTK & Infill surveys are effectively a combination of Real-Time Kinematic and Postprocessed Kinematic surveys. While the communication link between base and rover is available, the survey is identical to RTK survey. Once the communication link becomes temporarily unavailable, the survey becomes PPK. For the period of communication interruption data is logged for later processing. When the communication link becomes available, survey reverts back to RTK. Depending on the mode, RTK or PPK procedures apply.

Examples of typical real-time surveying applications are: topographic surveys, construction stakeout, cadastral surveys, monument recovery, and photogrammetry control.

The benefits of real-time surveying include very fast and efficient data collection that provides results in real time and in local coordinate systems.

A Real-Time Kinematic survey requires one GPS receiver as a base station and at least one other GPS receiver as a rover. The receivers must:

- Observe and track carrier phase measurements
- Log data at common times and epochs
- Track four common SVs at each location
- Observe during good SV geometry (DOP)

The requirements for RTK surveying include:

- Initializing prior to data collection
- Maintaining lock to satellites while moving
- Maintaining lock to base station radio signal while moving

Initialization (Resolving the Integer Ambiguity)

This section explains initialization, or how to establish an exact position by calculating the difference between carrier phase signals received by the base and rover receivers.

The *carrier phase* observable of the received GPS satellite signal is used to measure satellite range, and is responsible for achieving centimeter level accuracy. These range measurements are used to compute baselines between the base antenna phase centre (APC) and the rover APC.

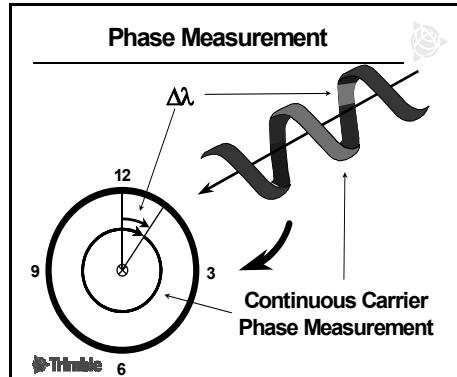
But what exactly is a carrier phase measurement? Why is it referred to as *ambiguous*? And how is the ambiguity resolved via *initialization*?

To answer these questions, see the following sections on phase measurement, carrier phase differencing, ambiguity resolution, and baseline solutions. For more information, see Initialization methods, page 39

Phase measurement

The GPS carrier wave is a right-circularly polarized wave. Phase measurements occur as follows:

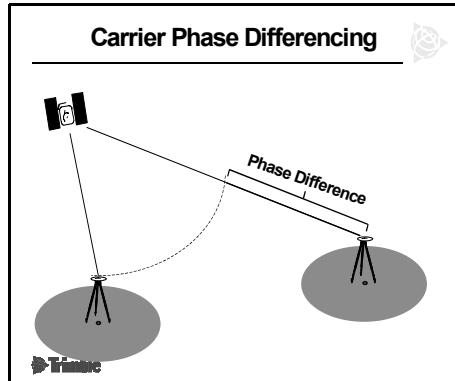
1. The first measurement observed is a partial phase of the GPS carrier.
2. After this partial phase, the receiver measures whole wavelengths of the carrier wave.
3. The receiver continuously counts whole wavelengths. The receiver does not know (ambiguous) the exact number of whole wavelengths (integer) between the SV and GPS APC.



Carrier phase differencing

How a GPS receiver measures carrier phase difference:

- Each receiver measures the same signal from a satellite.
- If the signal to one receiver is used as a reference, a phase difference between two signals can be computed.
- Phase differencing applies to all common satellites.



There is no way to determine the correct integers to match the carrier phase measurement in a standalone receiver. Two receivers simultaneously observing the same satellites are required to solve the integer ambiguity.

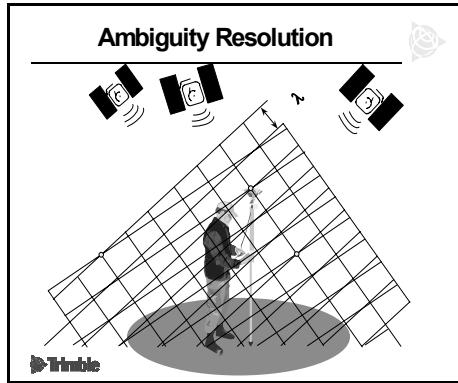
Carrier Phase Differencing is the method used to resolve integer ambiguity.

When a signal is transmitted from a satellite, it travels to all operating receivers. The signal to one of the receivers is used as a reference signal. When this reference is compared to the signal received at the other receiver, there is a signal phase difference between the two receivers. Phase differences are derived with all the other satellites in view.

Ambiguity resolution

The process to resolve the integers can be divided into the following steps:

1. **Initial estimates of the integers** – These are computed using unambiguous pseudo ranges (based on the C/A code). The expected error of these estimates defines a search volume around the unknown rover antenna position. Consider this volume to contain a 3-D matrix of points, each one associated with a combination of integers.
2. **Search for the best combination** – In its simplest form, the integer search comprises a series of computations of the rover position using every single integer combination. The correct combination will identify itself based on some statistical test defining the quality of the solution. Any such test is only possible if the solution is over-determined, which requires at least five visible satellites. Increase confidence in the selected combination by also examining close contenders—those combinations with favorable test statistics.



Float and fixed solutions

Before the integer ambiguities are resolved, the position solution type is known as a *float* solution. This implies that the ambiguity values have a fractional part (values are non-integer).

Following the integer search the integer ambiguities are resolved, and the RTK system is said to be *initialized*. The solution becomes a *fixed* solution (the integers are fixed). The position improves to centimeter level.

Initialization methods

There are three methods of initialization:

- **Known Point** – Requires a previously observed WGS-84 position or a known ground coordinate position.
- **New Point** – Allows you to calculate the initialization on a short-term static observation.
- **On-the-Fly (OTF)** – Allows you to compute the initialization while in motion.

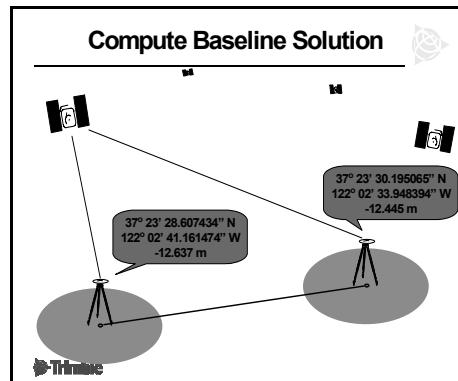
Initialization methods are discussed in detail in Chapter 12, RTK Surveys.

Compute baseline solution

Once the integer ambiguity is resolved, the baseline is computed to establish the rover's APC position in relation to the base APC.

The process of computing the baseline solutions:

1. Compute the phase differencing.
2. Solve and apply the integer ambiguity to phase differences.
3. Determine a precise range to all common satellites to provide your roving position.
4. Provide the fixed (known) base position and the base station observations.
5. Calculate the baseline and check the inverse between the base and rover positions.



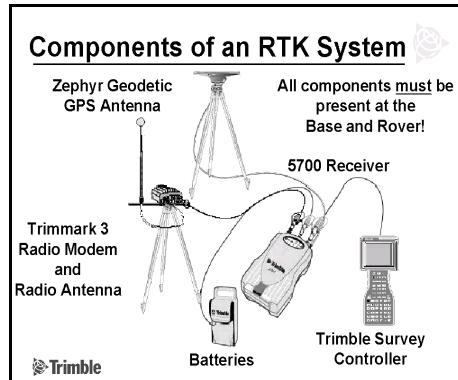
RTK System Components

An RTK system consists of these physical components:

- GPS base station
- GPS rover(s)
- Communication link between the base and the rover(s)

The GPS base station and each GPS rover must contain:

- GPS receiver
- GPS antenna
- Communication link (Radio and radio antenna or cellphone)
- Trimble Survey Controller
(Real-time surveys must have a controller at the rover receiver)
- Power supply (AC power supply or portable batteries)
- Appropriate cabling



RTK base station

A base station is set on a known point and broadcasts its reference position and observations to help compute real-time baselines.

Typically, the RTK base station consists of:

- Trimble GPS receiver and GPS antenna
- Transmitting component of the communication link (Trimble radio or suitable alternative)
- Stable observation position (tripod and tribrach or pillar)
- Power supply (AC power supply or portable batteries)
- Cables to connect the base station components

Connect a controller running Trimble Survey Controller to start the base station, or use ancillary Trimble programs, such as TRS™ (Trimble Reference Station), GPS Configurator, or Remote Controller.

RTK roving stations

Roving stations are used to locate positions relative to the base station. One base broadcast signal can be used by an unlimited number of roving stations.

A roving station consists of:

- Trimble GPS receiver and GPS antenna (5800, 5700, 4800, 4700, 4600LS)
- Receiving component of the communication link (Trimble internal / external radio or suitable alternative)
- Trimble controller running Trimble Survey Controller software
- Range pole and backpack (one of several models)
- Power supply (portable batteries)
- Cables to connect the rover components

Assembling and Setting up an RTK Survey System (Base)

This section describes how to assemble the base station and rover receiver for an RTK survey.

Using a 5700 receiver

To set up a 5700 base station for an RTK survey:

1. Set the Zephyr Geodetic GPS antenna over the ground mark using a tripod, a tribrach, and a tribrach adaptor.
2. Use the tripod clip to hang the 5700 receiver on the tripod.

3. Use the yellow GPS antenna cable to connect the Zephyr Geodetic GPS antenna to the GPS receiver yellow TNC port labeled GPS.
4. If external power is required, connect a battery with a 0-shell LEMO connection to Port 2 on the receiver.
5. Set up the radio using another tripod and place it few meters away from GPS antenna
6. Connect the radio to the GPS receiver Port 3
7. Connect the Trimble Survey Controller to the GPS receiver Port 1. Use the 0-shell LEMO to 0-shell LEMO cable.
8. Turn on the controller and go to page 240. (see Figure 3.1.)

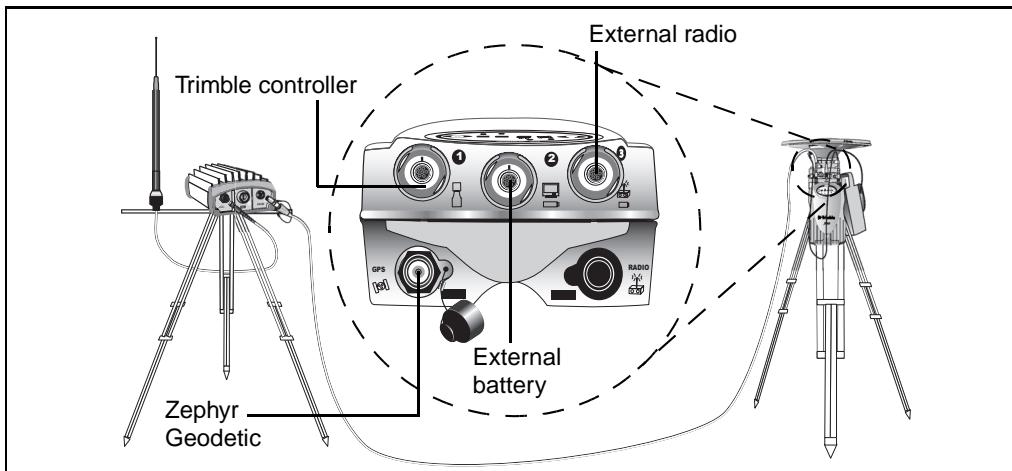


Figure 3.1 5700 RTK base station setup

To set up a 5700 rover for RTK survey:

1. Attach the Zephyr GPS antenna to the range pole.
2. Assemble 5700 GPS receiver on a pole or in a backpack.
3. Connect the Zephyr GPS antenna to the GPS receiver yellow TNC port labeled GPS.

4. Connect the RPA antenna (rubber whip or whip antenna) to the GPS receiver blue TNC port labeled RADIO.
5. Connect the Trimble Survey Controller to the GPS receiver Port 1. Use the 0-shell LEMO to 0-shell LEMO cable.
6. Turn on the controller and go to Starting the RTK Rover Survey, page 248. (see Figure 3.2.)

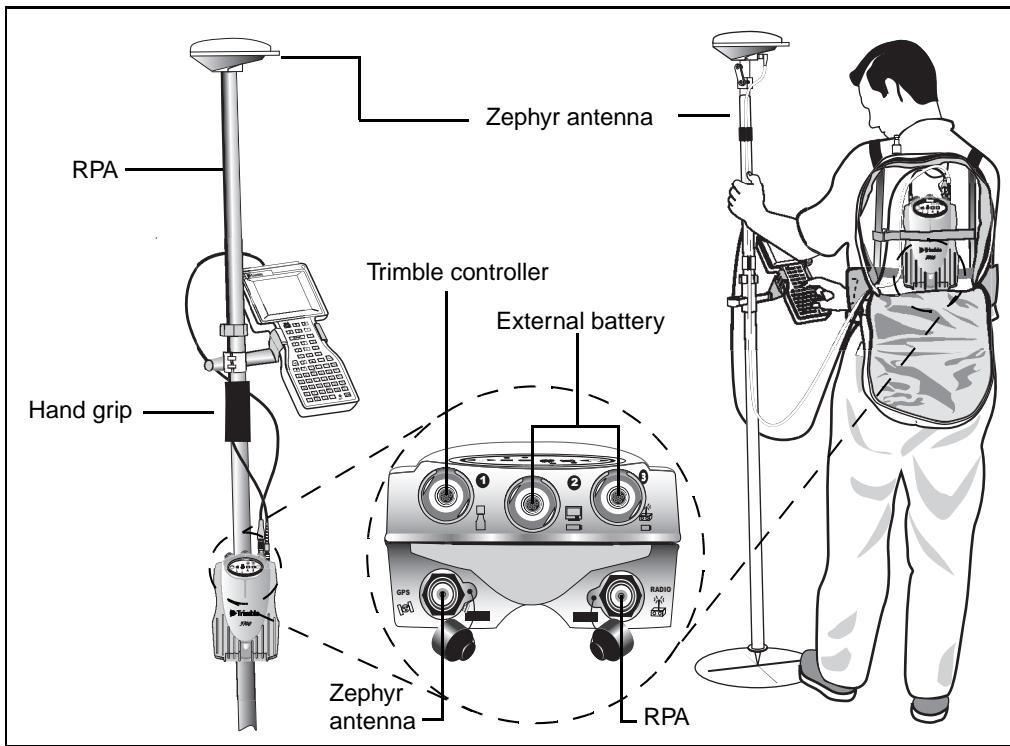


Figure 3.2 5700 RTK rover setup

General Guidelines

The following section gives guidelines for setting up an RTK system.

Setting up the base station

Locate the base station where there is a clear and unobstructed view of the sky, for example, on top of a hill or building. You should be able to see the sky all around at an elevation angle of 13° above the horizon.

The WGS-84 coordinates for the base station should be known. Every 10 m error in these coordinates can cause an error of 1 ppm in the length of the RTK baseline. Define the coordinates in one of the following ways (the most accurate methods are listed first):

- Transfer or key in published WGS-84 coordinates.
- Transfer or key in WGS-84 coordinates derived from a previous control survey.
- Transfer or key in known grid coordinates, if a projection and datum transformation are known.
- Transfer or key in local geodetic coordinates, if a datum transformation is known.
- Use the **Here** softkey to obtain a WAAS position generated by the receiver (North America only)
- Use the **Here** softkey to obtain the current approximate (autonomous) position calculated by the receiver. This position can be in error by up to 20 m, so you should perform a calibration to reduce the effect of this process.

*Note – Only use an autonomous position once for each job—to start the **first** base receiver. (An autonomous position is equivalent to an assumed coordinate in conventional surveying.) This ensures that all surveys in the same job are in terms of each other. For base set-ups after day one, select your base position from the points stored in Trimble Survey Controller.*

Setting up a GPS Total Station 5800 receiver (rover)

To set up a rover receiver for a real-time survey using a GPS Total Station 5800 receiver:

1. Mount the 5800 receiver on a range pole. The 5800 supplies its own power from an internal battery.
2. Attach the whip radio antenna to the 5800 receiver.
3. Attach the Trimble lithium-ion batteries to the ACU holder.
4. Attach the ACU holder to the range pole.
5. Attach the ACU to the holder. For more information, see page 61.
6. Turn on the 5800.
7. Turn on the ACU and start Trimble Survey Controller.
8. Connect to the 5800 receiver using Bluetooth™ wireless communications:
 - a. From the main menu, select *Configuration / Controller / Bluetooth*.
 - b. Tap **Config.** and enable *Bluetooth*. Tap .
 - c. Select *Scan* to locate the 5800 receiver.
 - d. When the scan is complete, select the 5800 receiver from the list and tap .

Optimizing field equipment setup

To become productive quickly when starting a survey, consider the following:

- **Base station environment** – Prior to setup you must be aware of the surveying environment. Whenever possible, set your base station to view the greatest amount of open sky so that it can maximize the satellite signal reception. Be aware of likely multipath sources such as buildings, wire fences, high voltage power sources, and trees.
- **Ambient orientation** – Both the base and the roving receivers require some time (approximately 2 minutes) to locate and lock onto satellite signals. This ambient time can be minimized by connecting the GPS antenna and power to the GPS receiver and allowing the antenna to view the open sky. You may simply rest your antenna equipment to one side while setting up the other necessary equipment for your base station or roving stations.
- **Base radio environment** – Use a radio scanner to confirm that your broadcast frequency is clear (not being used) before starting your base.
- **Roving station environment** – Move away from problem environments to avoid loss of lock (satellite tracking) or initialization for your roving receiver.

To detect the effects of a signal-limiting source:

- Check the number of currently tracked satellites at the rover and base using the controller *Instrument / Satellites menu*
- Monitor the root mean square (RMS) value of your present position. If the values exceed 70, attempt to move away from the problem environment. For more precise RTK work, watch out for values exceeding 35.



Tip – Although your base station will not be moving, you can detect the RMS values at your base when a job has been started with your controller. An RMS value of 30 or less indicates a low multipath environment.

Measuring GPS Antenna Heights

Once the equipment is assembled, you must measure the height of the antenna before you can start your survey.

The antenna receives GPS signals at the antenna phase center (APC), which is inside the plastic housing, so you cannot measure directly to it.

Instead, measure the height from the survey mark on the ground to a specified part of the antenna housing.

Enter the antenna height and then, in the *Measured to* field, specify the part on the housing where the measurement was taken.

Trimble Survey Controller corrects the antenna height value according to the antenna type selected and the setting in the *Measured to* field. It calculates the APC height based on the antenna type, the uncorrected height, and the value in the *Measured to* field. This APC height is used to calculate the ground height for points.

Measuring the height of an antenna on a tripod

The way to measure this depends on the equipment used.

- Zephyr antenna

If this antenna is mounted on a tripod, measure the height to the top of the notch on the side of the antenna. Enter a value in the Antenna height field, and, in the Measured to field, select Top of notch.

- Zephyr Geodetic antenna

If this antenna is mounted on a tripod, measure the height to the bottom of the notch on the side of the antenna. Enter a value in the Antenna height field, and, in the Measured to field, select Bottom of notch.



Tip – If you are using a fixed height tripod, you can measure the height to the bottom of the antenna housing and select *Bottom of antenna mount* in the *Measured to* field.

Measuring the height of an antenna on a range pole

Figure 3.3 shows how to measure the height of an antenna mounted on a range pole when the *Measured to* field is set to *Bottom of antenna* or *Bottom of antenna mount*. With a fixed height range pole, the height is a constant value.

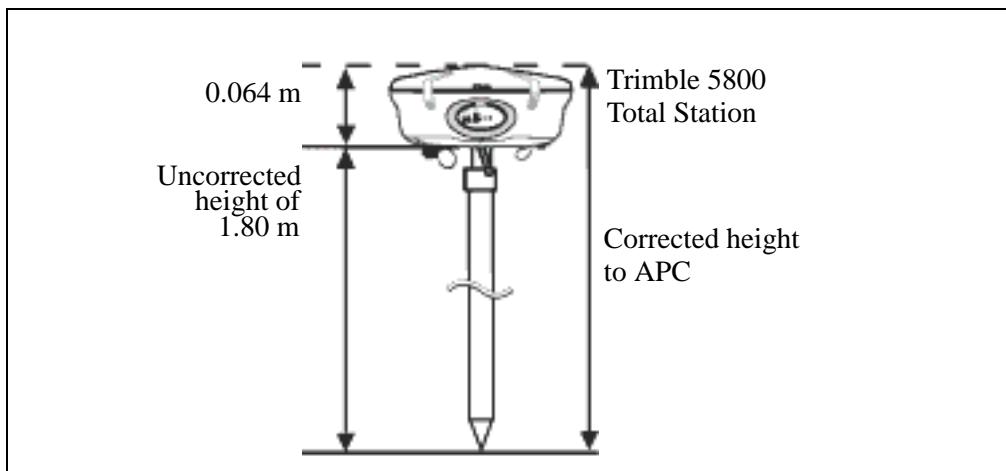


Figure 3.3 Measuring the height of a 5800 receiver on a range pole

RTK System Equipment Checklists

This section provides a checklist for the GPS Total Station (RTK).



Tip – You can photocopy this list and use it to check that all necessary components are taken to the field.

Note – Some items are optional and the final configuration may vary depending on the user requirements.

5700 GPS Total Station (RTK)

Base Station for RTK survey		
GPS Receiver #1	S/N	Firmware version
Controller #1	S/N	Software version
Controller to receiver cable		
Zephyr Geodetic antenna and GPS antenna cable		
CompactFlash Card		
Li-ion batteries (2)		
H.I. rod		
Receiver Base transport case		
Tripod, tribrach with adapter and receiver tripod clip		
COMMUNICATION LINK, see page 51		
RTK Rover (with internal radio)		
GPS Receiver #2	S/N	Firmware version
Internal Radio Frequency		
Controller #2	S/N	Software version
Controller to receiver cable		
Zephyr antenna and GPS antenna cable		
Rubber whip or eRTK range pole mount antenna and eRTK antenna cable		
CompactFlash Card and Li-ion batteries (2)		
Fixed height (or adjustable height) range pole with bipod, controller mount bracket or holder, and receiver pole mount bracket		
Backpack		
Other Accessories		
6Ah External battery and external battery to GPS receiver cable		
Magnetic mount and Quick Release Adaptor(s)		
PCMCIA card		
Office Support		
Trimble Geomatics Office software, base module		
Trimble Geomatics Office, Trimble controller, receiver manuals and software CD		
USB cable and Download cable		
Power supply for internal charger		

Communication link

RTK Base Station Radio Set Up	
RTK Rover without internal radio Set up	
Radio #1	Model
S/N	Firmware version
Radio frequency	
Standard antenna (0dB, 5dB)	
Radio Power cable and I/O cable	
Adapter cable (if required)	
Tripod, Radio tripod mount with antenna cable	
Antenna mount with 5 foot cable (Rover only)	
Other Accessories	
6Ah External battery and external battery to radio cable	
Camcorder Batteries and camcorder battery cables	
Grounding Cable	
Office Support	
TrimTalk Set Up software utility (For TT450S)	
WinFlash software utility (For TM3)	
CommSet software utility (For 4700 / 4800 internal radio)	
GPS Configurator (For 5700 internal radio)	
Configuration cable	
OSM II / OSM IV Battery charger / Computer Interface	
TT450S, TM3 Manuals	

Use and Care

Trimble Surveying Equipment tolerates the sort of rough treatment that equipment may suffer in the field. Nevertheless, they are high-precision, electronic instruments, so treat them with reasonable care. Table 3.1 lists recommended operating parameters and conditions. For more information, go to www.trimble.com

Table 3.1 Recommended operating parameters for Trimble equipment

Device	Temperature range	Shock resistance	Other
5800/R8 receiver	–40 °C to +65 °C (-40 °F to +149 °F)	2 m pole-mounted drop. Shock tested (operating) to 40 G, 10 mSec Sawtooth Vibration tested to MIL-STD-810-F, FIG.524.5C-1	Casing is dust-proof, shock- and vibration-resistant Waterproof to 1XP7 to a depth of 1 m
5700/R7 receiver	–40 °C to +65 °C (-40 °F to +149 °F)	1 m drop Shock and vibration tested to 40 G random. Passes testing per MIL-STD-810-F, FIG.524.5C-1	Waterproof to IPX7 to depth of 1 m. Fully sealed, magnesium alloy casing
ACU controller	–20°C to +55°C (-4°F to +131°F)	MIL-STD-810E drop. (Impact or pressure on the display screen can cause it to crack.)	Resistant to driving rain and dust.

Table 3.1 Recommended operating parameters for Trimble equipment

Device	Temperature range	Shock resistance	Other
TSCe controller	–25 °C to +60 °C (-13 °F to +140 °F)	MIL-STD-810E drop. (Impact or pressure on the display screen can cause it to crack.)	Immersible in up to one meter of water, for up to one hour. Ensure that the battery compartment screws are secured tightly when replacing the battery. Note: Removal of the backcase screws voids the warranty.
TRIMTALK 450S radio modem	–20 °C to +55 °C (-4°F to +131°F)		100% fully sealed, weatherproof enclosure
TRIMMARK 3 radio modem	–40 °C to +65 °C (-40 °F to 149 °F)		100% fully sealed, weatherproof enclosure



Warning – Operating or storing your equipment outside the specified temperature range can destroy the instrument or limit its life.

General Guidelines

To care for your survey equipment, follow these guidelines:

- High-power signals from a nearby radio or radar transmitter can overwhelm the receiver's circuits. This does not harm the receiver, but can prevent it from functioning. To avoid problems, try not to use the GPS receiver within 400 meters of powerful radar, television, or other transmitters. Low-power transmitters, such as the ones in portable phones and walkie-talkies, and transmission lines do not normally interfere with receiver operations.
- When plugging in a LEMO cable, make sure that the red dots on the receiver port and the cable connector line up. **Never** use force to plug cables in, as this may damage the pins of the connectors.

- When disconnecting a LEMO cable, pull the cable connector straight out of the port, using the loop provided. Do not turn it.
- To securely connect a TNC cable, push the connector into the port and turn it. TNC cables and the corresponding TNC ports on the 5700 receiver are color-coded to help you connect each cable to the correct port.
- Insert the 5700 internal batteries with the terminals facing the CompactFlash/USB door. Only new-generation Lithium ion batteries with a center groove can be used.

Review Questions

1. What key piece of communication equipment makes Real-Time Kinematic (RTK) GPS surveying possible?
2. What are the requirements in terms of equipment and conditions for conducting a Real-Time Kinematic (RTK) surveys?
3. In order to start RTK with a cm level accuracy, what needs to be resolved?
4. What is the process of resolving integer ambiguities called?
5. Explain the difference between FLOAT and FIX solutions.
6. Name three initialization methods.
7. What are the three basic components of the RTK system
8. List all necessary equipment (including the accessories) for RTK surveying.

Answers

1. Radios are the key to real-time surveying.
2. Answers:
 - Two GPS receivers
 - Communications link between base and rover
 - Tracking carrier phase measurements
 - Logging data at common times and epochs
 - Tracking four common satellites at each station and at least five total
 - Observing during good satellite geometry (DOP)
 - Initializing prior to data collection
 - Maintaining lock to satellites while moving
 - Maintaining lock to base station radio signal while moving
3. Integer Ambiguity.
4. Initialization.
5. Answers:
 - FLOAT – integer ambiguity not resolved
 - FIX – integer ambiguity resolved, RTK system initialized
6. Known point, new point, OTF
7. GPS base station, GPS Rover and radio link
8. Check your list against the one given on page 49

SECTION I — RTK SYSTEM COMPONENTS

Introduction

This section contains six chapters. The chapters describe the operation of the following Trimble Real-Time Surveying system components:

- Trimble controllers
- Trimble Survey Controller software
- Trimble GPS receivers (5800, 5700)
- Radio datalinks (TRIMTALK 450S, TRIMMARK 3)
- Trimble Geomatics Office software
- The Trimble Data Transfer utility

Session Objectives

At the end of this session, you will know:

- RTK system components features and functionalities
- Trimble Survey Controller and Trimble Geomatics Office user interfaces
- How to perform basic operations

Note – The review questions on page 181 cover all the chapters in this section.

Trimble Controllers

In this chapter:

- The ACU (Attachable Control Unit)
- The TSCe controller

Introduction

Real-time surveys are controlled by a Trimble controller (ACU or TSCe) running the Trimble Survey Controller software.

This chapter describes the ACU (Attachable Control Unit) and TSCe controllers. Where any information relates to only one of the controllers, it is indicated with an icon,  (ACU) or  (TSCe).

With a Trimble controller connected to a GPS receiver, you can log and enter data, transfer data to and from the office computer, and view data and information.

A good way to learn how to use the controller and the software is to take the controller into the field. Become familiar with the keypad, press various keys, look through the menus, and use the online Help.

Before going into the field, make sure you have everything you need.

The ACU (Attachable Control Unit)

This section describes the ACU and how to use it. Figure 4.1 shows the front of the ACU and its keys.



Figure 4.1 The ACU controller – front view

Attaching the ACU



Warning – Switch off the ACU when attaching it to the holder or when changing the batteries in the holder with the ACU attached. Otherwise, the on/off status of the ACU and the holder may become unsyncronized.

To attach the ACU:

1. Hold the controller with both hands.
2. Fit the groove on the back of the controller over the lower lip on the front of the holder.
3. Press down and rest the back of the controller flat against the holder.
4. Gently release downward pressure and guide the controller so that the teeth on the front of the holder click into the notches on top of the controller.

Figure 4.2 shows how to attach the ACU to the holder.



Figure 4.2 Attaching the ACU

ACU function keys

Table 4.1 describes Trimble Survey Controller functions that are associated with the ACU icons.

Table 4.1 ACU function keys

On this instrument or receiver ...	tap ...	to ...
Conventional or GPS	 Menu	access the main Trimble Survey Controller menu
Conventional (with Autolock™)		access the <i>Trimble function</i> screen
		switch Autolock on and start a search
		switch Autolock on or off
		take a measurement

Table 4.1 ACU function keys (continued)

On this instrument or receiver ...	tap ...	to ...
Conventional (with servos)		turn the instrument horizontally to the current point name or stakeout location
		turn the instrument vertically to the current point name or stakeout location
		turn the instrument horizontally and vertically to the current point name or stakeout location
		change face
		take a measurement
Conventional (3600)		activate the first softkey (F1)
		activate the second softkey (F2)
		activate the third softkey (F3)
		activate the fourth softkey (F4)
		take a measurement

Table 4.1 ACU function keys (continued)

On this instrument or receiver ...	tap ...	to ...
GPS		access the <i>Position</i> dialog
		access the <i>Satellites</i> dialog
		activate the first softkey (F1)
		activate the second softkey (F2)
		activate the third softkey (F3)
		activate the fourth softkey (F4)
		activate the Enter button

Preparing the ACU for a survey

To do this:

1. Set up the instrument.
2. Ensure that the ACU is turned off, and then attach it to the instrument. For more information, see page 61.
3. Press

4. Start Trimble Survey Controller. The software automatically connects to the instrument and the *Electronic level* dialog appears.

Note – If you have a Trimble 3600 instrument with a laser plummet, the laser plummet automatically turns on when this dialog appears.

5. Position and level the instrument and tap **Accept**. If you are using a Trimble 5600 instrument, the compensator is automatically initialized now.
6. When prompted by the *Corrections* dialog, enter appropriate atmospheric values and tap **Accept**.
7. The *Survey Controller Basic* dialog appears. It displays the current instrument readings.

Note – You cannot store measurements in this mode.

8. Tap **Esc** to exit Survey Controller Basic mode. The main Trimble Survey Controller menu appears, and you can then begin a survey.

If you are running a robotic survey, see the following section. Otherwise go directly to Exercise 1 Create a new job, page 88.

Using the ACU to prepare for a robotic survey

To survey using a 5600 robotic instrument:

1. From the main menu, select *Instrument / Radio*. Set the radio channel, station address and remote address and tap **Accept**.
2. From the main menu, select *Survey / Start Robotic* to prepare the 5600 for robotic connection.
3. Tap **OK** to suspend the 5600 and the ACU ready for robotic operation.
4. Remove the ACU from the 5600.

Note – If the radio settings on the 5600 instrument are already set to match the ACU, and the instrument is level, press the trigger button on the back of the 5600 to turn on the instrument for a robotic connection.

5. Ensure that the ACU is turned off, and then attach it to the ACU holder. For more information, see page 61.
6. Connect the ACU to Port A on the remote radio using the ACU holder or a 0.4m, 4 pin Hirose cable.
7. Turn on the active target or connect it to Port B on the remote radio.

Once the ACU is attached to the holder, Trimble Survey Controller connects to the remote radio and then to the 5600. The 5600 is re-initialized to compensate for the earlier removal of the controller.

You can now create a job and start the survey.

The TSCe Controller

This section describes the TSCe and how to use it. Figure 4.3 shows the front of the TSCE and its keys.

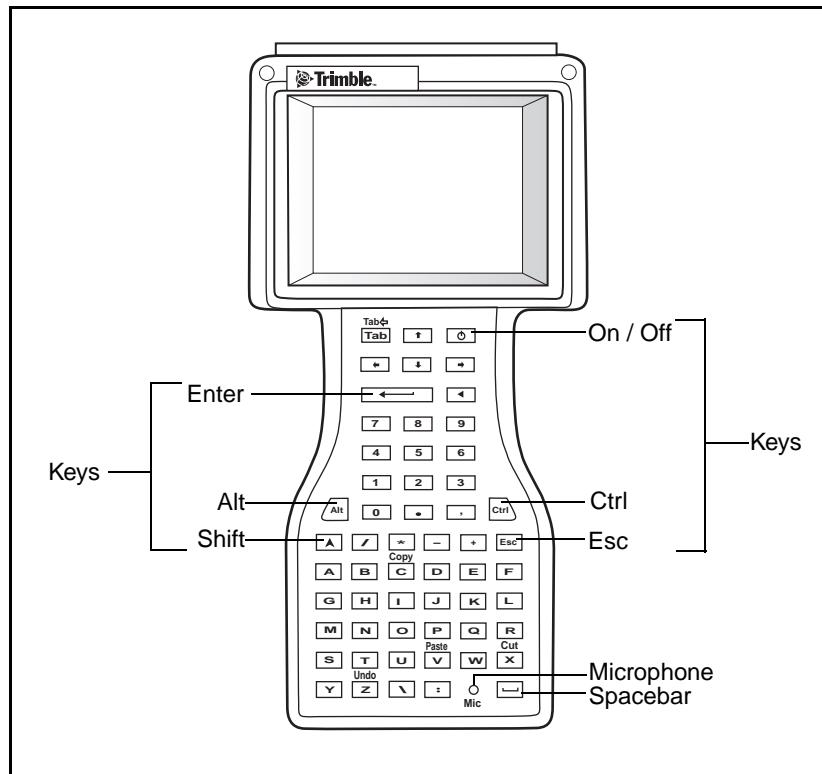


Figure 4.3 Front view of the TSCe controller

Operating the TSCe

To turn on the TSCe, make sure the battery is inserted. Press the green  key. Hold down the same key for one second to turn it off.

Keys

Hard keys are the physical keys on the TSCe keypad, for example, , , , , , , , , , , , and . Use these keys to enter data and to access screens.

Rebooting

If the controller fails to respond to keystrokes, then perform one of the following resets, which shut down the hardware and restart the Trimble Survey Controller software.

Soft reset (warm boot)

This method retains all data.

To perform a soft reset:



Hold down  and , while you press and release .



Hold down  and , while you press and release .

The controller resets to the default Microsoft Windows desktop view.

Hard reset (cold boot)

This method retains any data on the built-in storage card (the *\Disk* folder). However, a hard reset clears the contents of the RAM memory, including any desktop shortcuts that you have created.

To perform a hard reset:

1. Hold down  or .

After approximately 5 seconds, a countdown timer appears, indicating that the controller will reset.

2. Continue to hold  or  for a further 5 seconds, then release.

The controller briefly displays the boot screen and then resets to the default Microsoft Windows desktop view.

The Trimble Survey Controller Software

In this chapter:

- Introduction
- Trimble Survey Controller sample screen displays
- Trimble Survey Controller menu structure
- Entering data
- Editing data
- Reviewing Data
- Online help
- Survey styles
- Trimble GPS survey styles

Introduction

This chapter describes the Trimble Survey Controller software and how to use it with a Trimble Controller. It gives an overview of the menu structure, and shows some sample controller screens. The chapter also introduces survey styles and describes how to use them in an RTK survey.

The Trimble Survey Controller software simplifies surveying by configuring and controlling receivers for GPS surveys, and by communicating with conventional instruments for conventional surveys. Trimble Survey Controller makes surveying a faster and more efficient process because it:

- stores points
- simplifies stakeout tasks
- performs numerous calculations, including calibration and coordinate geometry (Cogo) functions
- permits two-way data transfer operations

For GPS surveys, it also:

- configures the necessary receiver parameters
- monitors the receiver and radio status

Menus

Trimble Survey Controller functions are listed in menus. When the controller is switched on, the Trimble logo screen appears, followed by the main menu.

*Note – To return to the main menu at any time, tap **Menu**.*

To select a main menu option, tap its icon on the screen.

In the list of menu options, tap the required menu item or highlight it using the Up or Down arrow key. If necessary, navigate to the item using the Up or Down arrow keys, or the scroll bar.

Tap **Enter** or **Accept** to accept the option, depending on the dialog that you have accessed.

Favorites menu

The *Favorites* menu provides quick access to commonly used screens (dialogs). You can access a screen from the Favorites list or use **Switch to** to move between active screens.

To access a screen from the Favorites list, tap **Favorites** and select the screen that you want to access.

To add a screen to the Favorites list, view the screen you want to add and tap *Favorites / Add to favorites*. To remove a screen, view the screen and tap *Favorites / Remove from favorites*.

Enter button

The **Enter** button performs the same action as pressing  on the controller keypad. The action of the **Enter** button relates to particular screens, and in some screens, the caption on the button changes to describe the action for that screen. For example, **Enter** changes to **Measure** when you are in the *Measure points* screen.

Softkeys

Softkeys (software keys) are displayed on the bottom line of the Trimble Survey Controller screen. Softkeys relate to particular screens and only appear when these screens are accessed. For example, the **Units** softkey appears when you access the *Antenna height* field.

Tap a softkey to access the required function. For example, in the *Map of current job* screen, to zoom in on an area, tap .

Note – The  softkey appears if there are more than four softkeys associated with a screen. Tap it to see the others. Alternatively, press the  (Shift) key to access the other softkeys.

Shortcut keys

Shortcut keys (also known as access keys or hotkeys) provide a quick way of using the keypad to access menus and commonly used options. They appear as an underlined letter in the menu or option description. Hold down the **Alt** key and press the appropriate letter key to use them.

Table 1.2 shows the shortcut keys that are commonly used in the Trimble Survey Controller software.

Table 5.1 Trimble Survey Controller shortcut keys

Use Alt plus this key...	to access the...
F	Files menu
K	Key in menu
S	Survey menu
C	Cogo menu
O	Configuration menu
I	Instrument menu
M	Map of current job
E	Main menu
A	Favorites menu
W	Switch to list
H	Online Help

Trimble Survey Controller Sample Screen Displays

Press the power key to switch on the controller. The Trimble logo screen appears, followed by the main menu.

Trimble Survey Controller is menu driven, which means that you select an item from a list to perform a function. The main menu consists of six icons. All other menus appear as lists.

Most of the details in the status line appear only when the controller is connected to either a GPS receiver or a conventional instrument.

If the controller is connected to a GPS receiver, a screen similar to that shown in Figure 5.1 appears.

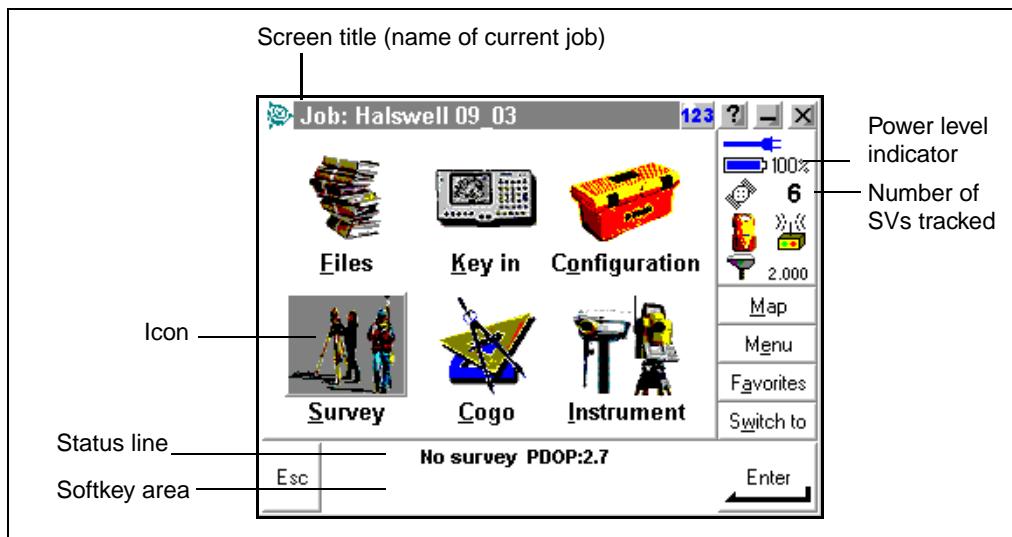


Figure 5.1 Trimble controller connected to a GPS receiver

If the controller is connected to a conventional instrument, a screen similar to that shown in Figure 5.2 appears.

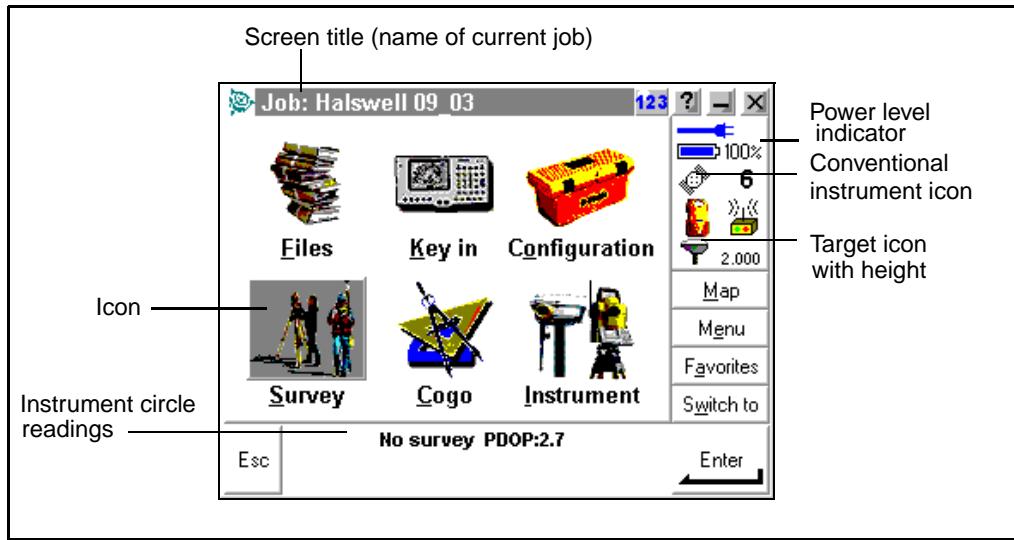


Figure 5.2 Controller connected to a conventional instrument

Trimble Survey Controller Menu Structure

Table 5.2 shows the Trimble Survey Controller main menu structure.

Table 5.2 Main menu structure

Name / Icon	Menu / Sub-menu
Files 	New job Open job Review current job Map of current job Properties of current job Copy between jobs Import/Export Trimble PC communications Send ASCII data Receive ASCII data Windows Explorer
Key in 	Points Lines Arcs Boundary Roads Templates Notes

Table 5.2 Main menu structure (Continued)

Name / Icon	Menu / Sub-menu
Survey 	Start base receiver Station setup Start survey Measure points Measure rounds Continuous topo Station and offset Measure Stakeout Stakeout Points Lines Arcs DTMs Roads Site calibration Swap base Receiver Start Robotic End survey
Items depend on the type of survey you are doing	

Table 5.2 Main menu structure (Continued)

Name / Icon	Menu / Sub-menu
Configuration 	Controller Time/date Language Sound events Bluetooth Feature and attribute libraries Survey Styles Rover options Topo points Rover radio Base options Base radio Laser rangefinder FastStatic point Observed control point Rapid point Continuous points Stakeout Instrument Rounds Site calibration PP initialization times Duplicate point tolerances Traverse options Options Directory Options
Items depend on the survey style you select	

Table 5.2 Main menu structure (Continued)

Name / Icon	Menu / Sub-menu
Cogo 	Compute inverse Compute point Compute area Compute azimuth Compute distance Compute average Subdivide a line Subdivide an arc Traverse Calculator
Instrument 	Satellites Receiver files Import from receiver Export to receiver Position Receiver status Options Navigate to point Electronic level Direct Reflex Instrument controls Tracklight Autolock Radio Settings Instrument Settings Adjust Instrument Survey Controller Basic Trimble functions
Items depend on the type of instrument the Trimble controller is connected to.	

Keep this table handy as a reference until you are familiar with the menu structure.

Entering Data

You must enter data before Trimble Survey Controller can perform most of its functions. A typical screen has several fields into which you can enter data. For some fields, you select an option from a list. For other fields, you key in alphanumeric details.

Choosing an option

Fields which offer a list of options have a drop-down arrow on the right.

Tap the required option or highlight it using the Up or Down arrow key. If necessary, navigate to the item using the Up or Down arrow keys, or the scroll bar.

Tap **Enter** or **Accept** to accept the option, depending on the dialog that you have accessed.

Keying in data

Tap the required field or highlight it using the Up or Down arrow key. Enter the details, then tap **Enter** or **Accept**, according to the dialog that you have accessed.

Editing Data

Tap the required field or highlight it using the Up or Down arrow key. Enter the new details, then tap **Enter** or **Accept**, according to the dialog that you have accessed.

Reviewing Data

You can review the data in the Trimble Survey Controller database at any time.

To review data, select *Files* from the main menu. Then select *Review current job*.

Records are stored in chronological order. The last (most recent) page of the database appears first when you access the database.

Press the **Page ↑** and **Page ↓** softkeys to move up and down in the database one page at a time. Press the Up or Down arrow keys to move up or down one record at a time.

Use the **Search** softkey to find records elsewhere in the database. For example, to search for points surveyed several hours ago. To do this, tap **Search**. Then select the type of search (current record type, name, code, or class).

For more information about a record, highlight it, then double tap it or tap **Details**. To return to the database list, tap **Esc**.

If required, you can edit some fields, for example, *Code* and *Antenna height*.

Note – If point coordinates appear as ‘?’, see the Note on page 83.

Coordinate view setting

The setting in the *Coordinate view* field (for example, WGS-84, or Local) determines which values appear in the point record. You can change the coordinate view setting for an entire job, or just when viewing a point.

To change the *Coordinate view* setting for a point that you want to view:

1. Tap *Files / Review current job*.
2. Highlight the point record, then tap **Details**.
3. Tap **Options**.

4. Select another option from the drop-down list in the *Coordinate view* field.

Note – If no datum transformation and no projection are defined and the Coordinate view field is set to Local or Grid, the coordinate values for GPS points will be ‘?’. Change the Coordinate view setting to WGS-84.

Online Help

Online help for the Trimble Survey Controller software is displayed in Hyper-text Markup Language (HTML) pages. Tap any underlined text (link) to move to the page it describes.

To access the help, do one of the following:

- Tap  in the top left corner of the controller screen. Then tap Help.
- Tap  in the top right corner of the controller screen.
- Press  +  on the keypad.

An index of all the topics appears, with the default topic for the current screen highlighted. Do one of the following:

- To view this topic, tap the topic.
- To search for a different topic, enter a new keyword or scroll through the list.



Tip – To move quickly to a Help topic, type the first few letters of the topic. Then use the arrow keys if necessary.

Survey Styles

There are two kinds of survey style: GPS and Conventional. They appear together in the *Select Survey Style* list.

When using Trimble Survey Controller for a GPS survey, choose from one of nine survey types. These types are based on the kinematic, differential, and FastStatic techniques. To select the survey type you need, select an appropriate Survey Style.

The concept of survey styles

Survey Styles make Trimble Survey Controller easier to use. Use them to change the configuration of Trimble Survey Controller quickly and easily for different types of survey.

In a GPS survey, the Survey Style instructs the base and rover receivers to perform the functions required for a specific survey type. It also defines the parameters for measuring and storing points. This whole set of information is stored as a template that can be called up and reused when necessary.

A GPS Survey Style defines the survey type, antenna information, elevation mask, PDOP mask, and point occupation times. If applicable, it also defines the following:

- Logging intervals
- Initialization times
- Site calibration defaults
- GPS file storage location
- Real-time broadcast message format
- Radio communication parameters

Choosing a survey style

Trimble provides four GPS Survey Styles that cover four of the nine possible survey types. To use any survey type not covered by the Trimble Survey Styles, you must create your own Survey Style. This is described in Create an RTK & data logging survey style, page 90.

Trimble GPS Survey Styles

The four standard Trimble GPS survey styles supplied with the Trimble Survey Controller system are:

- RTK
- RTK & Infill
- PPK
- FastStatic

These styles cover the four most popular centimeter-level survey types. To use the default settings for a survey type, select the appropriate style and use it as it is.

Note – This training manual addresses Trimble RTK and Trimble RTK & Infill Survey Styles only.

Trimble RTK survey style

The Trimble RTK survey style prepares Trimble Survey Controller for an RTK survey. Use this style for centimeter-level stakeout as well as topographic and control surveying.

Note – Survey styles (such as Trimble RTK) that employ the real-time kinematic survey type rely on a trouble-free radio solution.

By default, the base receiver is instructed to generate RTK corrections at one-second intervals.

Trimble RTK & Infill survey style

The Trimble RTK & infill survey style prepares Trimble Survey Controller for an RTK survey, with postprocessed support when base radio corrections are not available.

Use this style for real-time topographic or control surveys if there is a risk of radio link interruption. Use it if obstructions or interference are a problem, or if the operational range of the radio could be exceeded.

By default, the base receiver is instructed to generate real-time kinematic message at one-second intervals and to simultaneously log raw data at five-second intervals for the duration of the base survey.

Default settings

The default elevation mask for the base receiver and the rover receiver is 13°. The default PDOP mask setting is 6. Other default settings define how point measurements are made.

Note – When editing an option, you cannot access every field in the screen that appears. For example, the setting in the Survey type field is fixed for each Trimble survey style.

Options in a Trimble GPS survey style

A group of options is associated with each survey type. The selected GPS survey style determines which survey type is used, and which options are available. Once you can use survey styles, you can edit many of the options to further customize individual surveys. For example, you can edit the default setting for the minimum occupation time of a topo point.

Table 5.3 shows the options associated with Trimble RTK GPS survey styles.

Table 5.3 Options in Trimble RTK GPS survey styles

Option	Trimble GPS survey styles	
	Trimble RTK	Trimble RTK & infill
Rover options	✓	✓
Rover radio	✓	✓
Base options	✓	✓
Base radio	✓	✓
Laser rangefinder	✓	✓
FastStatic point		
Topo point	✓	✓
Observed control point	✓	✓
Rapid point	✓	✓
Continuous points	✓	✓
Stakeout	✓	✓
Site calibration	✓	✓
PP initialization times		✓
Duplicate point actions	✓	✓

Exercise 1: Create a new job

To create a job:

1. Turn on the controller.
2. From the main menu, select *Files / New job*. The *New job* dialog appears.
3. Enter the job name 1212. Tap **Enter**.
4. Tap the **Coord Sys** button in the *Properties* group.

The *Select coordinate system* screen appears. Select one of the following options:

- Scale factor only.
Select this option for a conventional total station survey.
- Select from library.
Then tap **Next**. Select the required system and zone. Enter the project height. Then tap **Accept**. Tap **Store** when completed.
- Key in parameters
Then tap **Accept**. Enter the required details for the site. Tap **Store** when completed.

- No projection/no datum.

Set the *Coordinates* field to Ground. Enter the project height. Alternatively, set the *Coordinate* field to Grid.

Select the *Use geoid model* check box. Select a geoid model to calculate a Geoid/Inclined plane vertical adjustment after a site calibration. Tap **Store** when completed.

For a survey where GPS measurements are to be combined with conventional observations later, choose a coordinate system now. For more information, refer to the *Trimble Survey Controller User Guide*.

Note – If you are not sure of the coordinate system, select No projection/no datum. Set the Coordinates field to Ground and enter the average site elevation in the Project height field. When you redefine these parameters later in the job, all points will be updated. (To change the coordinate system, select Files / Properties of current job. Tap the Coord Sys button and make any necessary changes.)

If no datum transformation and no projection are defined, any points measured using GPS are displayed as WGS-84 coordinates. Any points measured using a conventional instrument are displayed with null (?) coordinates.

If you require coordinates to be at ground level instead of projection level, use a ground coordinate system. For more information, refer to the Trimble Survey Controller Help.

5. After selecting or keying in a coordinate system, tap **Store**.
6. Edit the other properties of the new job as required.

Note – To return to this dialog later, select Files / Properties of current job from the main menu.

7. Tap **Accept** when completed.

The job is created.

Exercise 2: Create an RTK & logging survey style

Trimble Survey Controller provides Trimble Survey Styles that configure the hardware for four of the nine possible GPS survey types—RTK, RTK & infill, FastStatic, and PPK.

The other available survey types are:

- RTK & logging
- RT diff & infill
- RT diff & logging

The RTK & logging survey type is similar to RTK except that raw GPS data is recorded for the entire survey. This method is useful if raw data is required for quality assurance purposes.

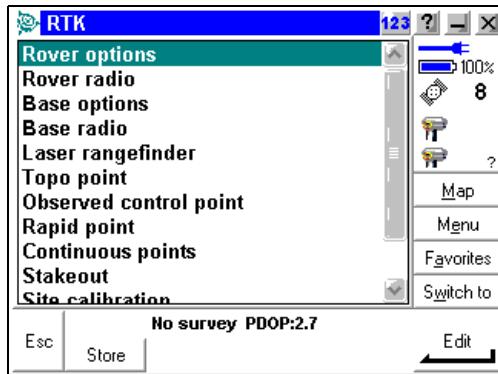
To survey using any of these types, first create a new survey style.

To do this:

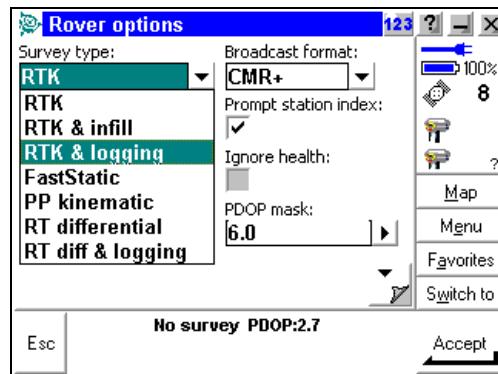
1. From the main menu, select *Configuration / Survey Style*.
2. Tap .
3. Enter a name in the *Style name* field and tap .
4. In the *Style type* field select GPS.
5. Tap .

Note – When you create a new GPS Survey Style, it is configured as an RTK survey that you must edit.

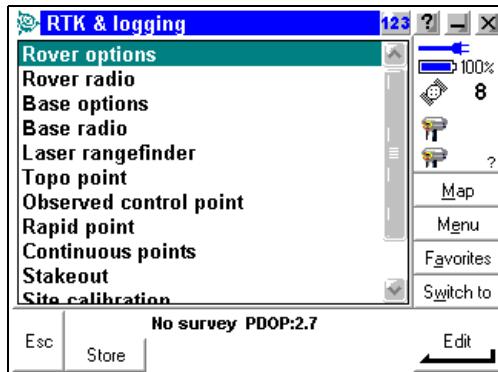
Some of the available survey style items are shown in the following screen:



If you select *Rover options* or *Base options* and change the setting in the *Type* field, the list of Survey Style options is rebuilt so that it is appropriate to that survey type.



For example, if the survey type is changed to RTK & Logging, the list shown in the following screen appears:



Select each menu item in turn. In the screen that appears, set the fields to specify your equipment and preferences.

Editing a Survey Style

Trimble survey styles can be edited.

Edit a survey style to define new field observation procedures or to set options for new hardware, such as radios and receivers.

Any survey style that you create by copying an original or edited Trimble survey style is also locked in this way. If you create your own survey styles, however, you can copy and edit them without limitation.

To edit a survey style:

1. End the current survey.
2. From the main menu select *Configuration / Survey Styles*. The list of survey styles appears. Highlight the name of the style to be edited and press **Edit**. The list of options for that survey style appears.
3. Change the settings in each option as required.

GPS Receivers

In this chapter:

- Introduction
- LED behavior
- Communication ports
- Starting and stopping the receiver
- Logging data
- Resetting to defaults
- Formatting a CompactFlash card (5700/R7 only)

Introduction

This chapter describes the Trimble R7, Trimble R8, 5700, and 5800 GPS receivers. All of these receivers can be configured as a rover or as an autonomous base station.

For real-time kinematic surveys, these receivers use a Trimble controller as an interface. For general operation, all the receiver controls are located on the front panel, as shown in the following figures.

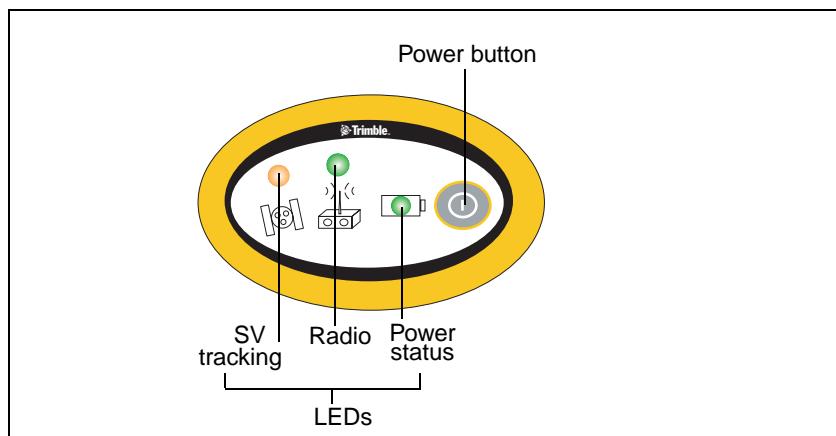


Figure 6.1 5800/R8 receiver front panel

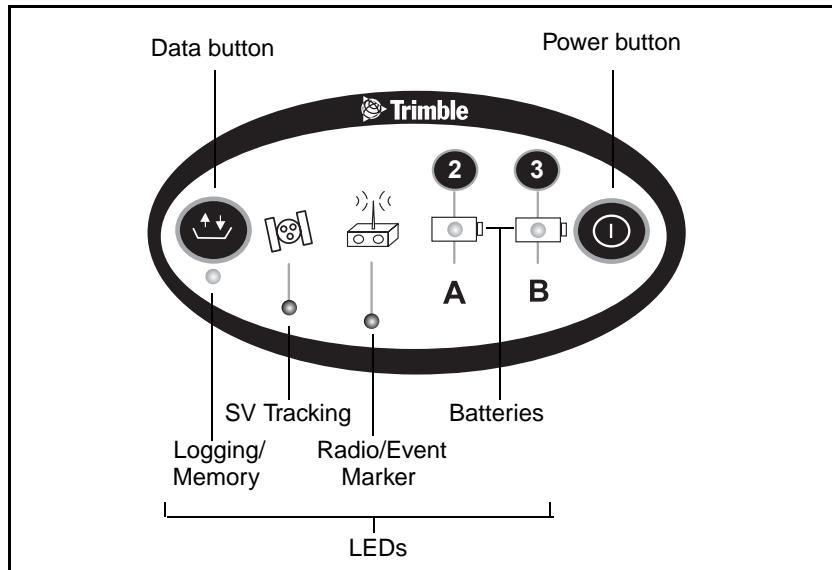


Figure 6.2 5700/R7 receiver front panel

Button functions

Each receiver has a power button (represented in this manual by **P**). The 5700 and R7 receivers also have a data button (**D**).

Use **P** to switch the receiver on or off, and to perform data management functions such as deleting files or resetting the receiver.

Use **D** to start or stop logging. This button is only effective when the receiver is switched on and has completed any power-up and initialization tasks.

Table 6.1 describes the main functions of the GPS receiver buttons.

Table 6.1 Button functions

Action	Power button	Data button (5700/R7 only)
Turn the receiver on	Press	
Turn the receiver off	Hold for 2 seconds	
Start logging data internally		Press
Stop logging data internally		Hold for 2 seconds
Delete the ephemeris file	Hold for 15 seconds	
Reset the receiver to factory defaults	Hold for 15 seconds	
Delete application files	Hold for 30 seconds	
Format the CompactFlash card (5700 only)	Hold for 30 seconds	

Note – The term “press” indicates that you should press the button down and release it immediately. The term “hold” indicates that you should press the button down and hold it down until the time indicated has elapsed.

LED Behavior

The LEDs on the receiver indicate various operating conditions. Generally, a lit or slowly flashing LED indicates normal operation, a LED that is flashing quickly indicates a condition that may require attention, and an unlit LED indicates that no operation is occurring. Table 6.2 defines each possible LED state.

Table 6.2 LED terms

The term ...	means that the LED ...
Flash	is lit briefly every second
Slow flash	alternates slowly between being lit and unlit
Fast flash	alternates rapidly between being lit and unlit

Table 6.2 LED terms (continued)

The term ...	means that the LED ...
On	is lit steadily
Off	is unlit

Logging/memory LED

The yellow Logging/Memory LED below the  button indicates the status of data logging and memory usage, as shown in Table 6.3.

Table 6.3 LED behavior

Behavior	Meaning
On	Data is being logged
Slow flash	Enough FastStatic data has been logged. Alternatively, if the red SV Tracking LED is on at the same time, the receiver is in Monitor mode, and is checking for new firmware to install.
Fast flash	Data is being logged but memory is low
Flash	The receiver is in Sleep mode, and will wake up five minutes before the scheduled start time of a timed application file
Off	Data is not being logged, or the CompactFlash card is full

SV tracking LED

The red SV Tracking LED below the SV icon  indicates the status of satellite tracking, as shown in Table 6.4.

Table 6.4 SV tracking LED status

Behavior	Meaning
Slow flash	Tracking four or more satellites
Fast flash	Tracking three or fewer satellites

Table 6.4 SV tracking LED status

Behavior	Meaning
Off	Not tracking any satellites
On	The receiver is in Monitor mode, and is checking for new firmware to install

Battery LEDs

By default, each battery LED  indicates the status of the external power source on Port 1 (5800/R8) or Ports 2 and 3 (5700/R7). If no external source is detected, each LED indicates the status of an internal battery. The color of the LED indicates whether the power source is currently in use (green) or is on standby (yellow), as shown in Table 6.5.

Table 6.5 LED indicator usage

Color	Meaning	Behavior	Meaning
Green	Power source is in use	On	Healthy
		Fast flash	Low power
		Off	No power source is present
Yellow	Power source is on standby	On	Healthy
		Fast flash	Low power
		Flash	Dead
		Off	No power source is present

Radio LED

The Radio LED  indicates the status of data input and output. Slow flash indicates that an information packet or event marker has been received.

Communication Ports

Figure 6.3 and Figure 6.4 below show the receiver communication ports.

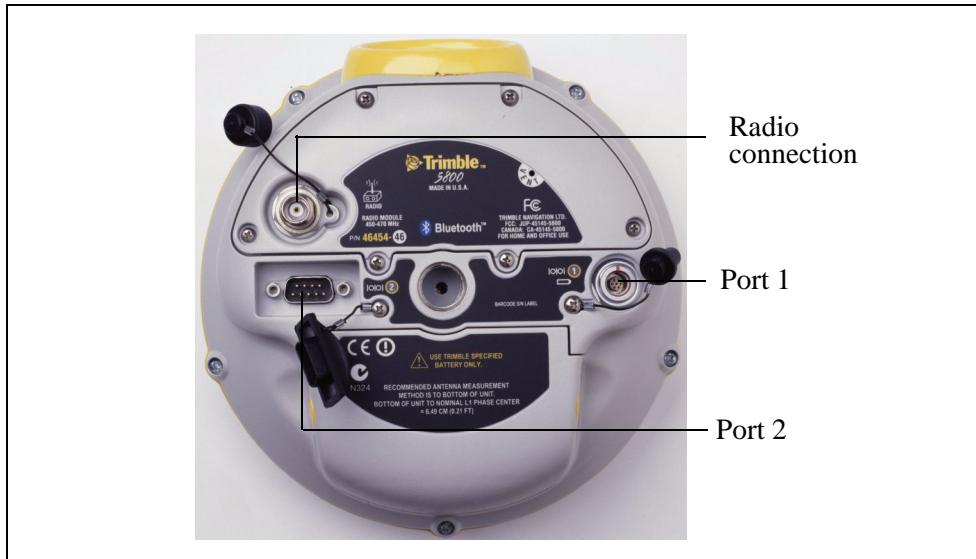


Figure 6.3 5800 receiver ports (R8 ports are identical)

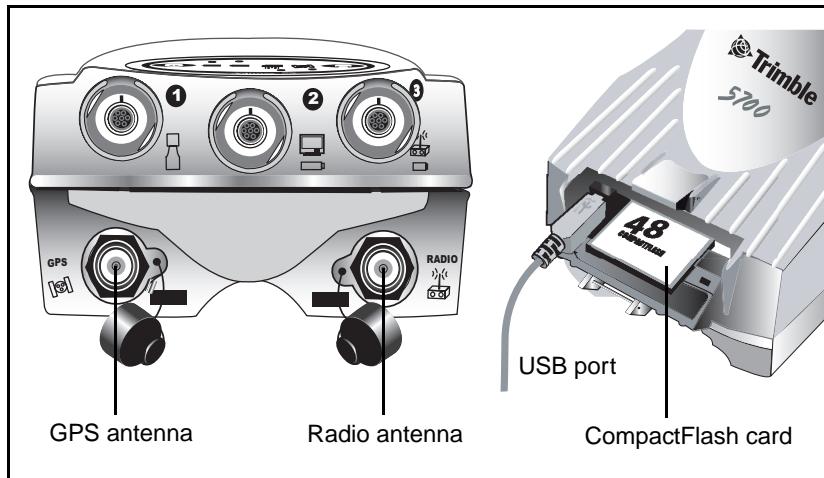


Figure 6.4 5700 receiver ports (R7 ports are identical)

Table 6.6 shows the icons available for the 5700/R7 receiver ports

Table 6.6 5700/R7 receiver ports

Icon	Name	Connections
	Port 1	Controller, event marker, or computer
	Port 2	Power in, computer, 1PPS, or event marker
	Port 3	External radio, power in
	ANT	GPS antenna
	RADIO	Radio communications antenna

Starting and Stopping the Receiver

To turn on the receiver, press **P**.

To turn off the receiver, hold down **P** for two seconds.

In RTK surveys, starting and stopping the receiver is controlled by Trimble Survey Controller.

Logging Data

You can log data on the GPS receiver, or you can use the receiver to generate GPS data, which is logged to a controller.

Logging to Trimble Survey Controller

When the receiver is connected to a controller running Trimble Survey Controller, you can log GPS data from the receiver to the controller.

When you use Trimble Survey Controller, you do not use the receiver's controls. Instead, you use Trimble Survey Controller functions to set logging options, specify filenames, and control when logging occurs.

Data is stored in job files, which can be transferred to your office computer using Trimble's Data Transfer utility.

Logging internally

The 5700/R7 receivers can log GPS data internally on a CompactFlash card. The 5800/R8 receivers have internal memory for storing data. You can then use Data Transfer to transfer logged data files to your office computer. The transferred files are in Trimble DAT (.dat) format.

Data is logged using the current logging settings configured in the receiver. Data files logged internally are named automatically.

For the 5700/R7 receivers:

- To begin internal logging, press **[D]**. The Logging/Memory LED lights up.
- To stop logging, hold down **[D]** for at least two seconds. The Logging/Memory LED turns off.

For the 5800/R8 receivers:

- To begin logging data, you must have a Trimble controller attached.

Note – When the CompactFlash card is full, the receiver stops logging data, and the Logging/Memory LED switches off. Existing data files are not overwritten.

Approximate storage requirements for different logging rates are shown in Table 6.7. The values shown are for a one-hour logging session with six satellites visible.

Table 6.7 Storage requirements

Logging rate	Memory required
10 Hz	2,588 KB
1 Hz	335 KB
5 seconds	87 KB
15 seconds	37 KB

Note – If power is lost, or the CompactFlash card is removed while logging, the file system is designed so that a maximum of ten seconds of data will be lost, regardless of the logging rate. To ensure that this behavior occurs, use the GPS Configurator software to perform a quick format of the CompactFlash card before logging data to the card for the first time.

Resetting to Defaults

To reset the receiver to its factory default settings, hold down **P** for at least 15 seconds.



Warning – Make sure that you do not hold down the Power button for more than 30 seconds. After 30 seconds, any application files stored in the receiver are deleted and any memory, including a CompactFlash card, is reformatted.

Resetting the receiver to its factory defaults also deletes any almanac file in the receiver.

Formatting a CompactFlash Card (5700/R7 Only)

To format a CompactFlash card for use in a 5700 or R7 receiver, insert the card in the CompactFlash port, then hold down **P** for at least 30 seconds. After 15 seconds, the receiver is reset to its factory defaults, and any almanac file is deleted. After 30 seconds, any files stored on the card are deleted and the CompactFlash card is reformatted.



Warning – Formatting a CompactFlash card while it is in the receiver deletes all the data files on the card and all the application files in the receiver.

*Note – When you use **P** to format the CompactFlash card, a quick format is performed. A quick format reformats the card for use with a 5700/R7 receiver and deletes all data on the card. A full format also checks the card for errors and bad sectors. A full format is only necessary if the card is corrupted. To perform a full format, use the GPS Configurator software.*

Embedded software

A receiver's *embedded software* is the program inside the receiver that makes the receiver run and controls the hardware. Use WinFlash to upgrade the embedded software.

Alternatively, for the 5700/R7 receiver, to upgrade the embedded software, copy the .elf file to the CompactFlash card:

1. Connect the CompactFlash card to your desktop computer.
2. Using Microsoft Windows Explorer, copy the .elf file from your computer to the CompactFlash card.
3. Disconnect the CompactFlash card from your computer and insert it into the receiver.
4. Turn the 5700/R7 receiver off.
5. Hold down **[D]** and press **[P]**.

The receiver starts up in Monitor mode, automatically detects the newer version of the firmware, and installs it. In Monitor mode, the red SV Tracking LED is lit solidly and the yellow Logging/Memory LED flashes slowly.

The upgrade takes about two minutes. Once the upgrade procedure is complete, the receiver restarts automatically.



Warning – Upgrading the embedded software deletes all application files on the receiver.

Radio Data Links

In this chapter:

- General guidelines
- The TRIMTALK 450S radio modem
- The TRIMMARK 3 radio modem
- Configuring the radio modem

Introduction

This chapter describes how to use a radio to carry out an RTK survey.

General Guidelines

Before setting up the equipment in the field, verify that each radio modem is set to the same channel and wireless data rate. Also verify that the radio modem's *Data Port* settings are *38400 Baud Rate* and *Parity None* by using the WinFlash utility. Set the serial port settings for both base and rover GPS receivers to 38400 bps, 8 bits, parity none, and 1 stop bit. Refer to the GPS receiver manual for general GPS receiver setup information. If these settings are not available, use either the WinFlash or TTSetup utility, or Trimble Survey Controller to set the radio modem's serial port settings to those of the GPS receiver.

Note – High-power signals from a nearby high-power radio station or radar transmitter can overwhelm the radio modem circuits. This does not harm the instruments, but can prevent them from functioning correctly. To avoid problems, try not to use the radio modems within 400 meters (1300 feet) of powerful radar, television, or other transmitters. Low-power transmitters such as those in portable phones and walkie-talkies normally do not interfere with TrimTalk 450S or TRIMMARK 3 radio modem operations unless they are tuned to the same channel. Always monitor frequency before and during operation. Transmit only on a clear channel.

To avoid possible interference with GPS reception, keep the base radio modem antenna as far as possible—at least 3 m (10 ft)—from the GPS antenna.

The TRIMTALK 450S Radio Modem

The TRIMTALK 450S radio modem is packaged in a weatherproof, yellow metal box. The front panel has two indicator lights for power and data, Figure 4.10.

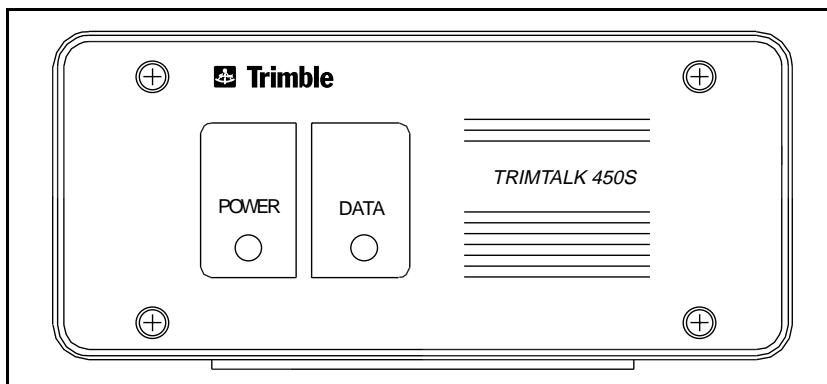


Figure 7.1 TRIMTALK 450S front panel

Controls and indicators

The TRIMTALK 450S radio modem front panel has two lights. The data light blinks whenever the receiver successfully sends or receives a data packet. The blink is slightly longer when sending a packet than when receiving one. The power light turns on whenever adequate power is supplied to the receiver. In the case of low power supply voltage or current, the power light may blink or remain off to indicate the fault condition. When the power light is off, the TRIMTALK 450S radio modem tries to maintain receiver operation. For example, the receiver may be able to respond to the serial port, or even receive incoming packets while the power light is off due to a partially discharged battery. However, trying to transmit with a partially discharged battery results in decreased or zero transmitter power.

Note – Change rechargeable batteries when the POWER light turns off. Continuing to operate from a discharged battery decreases battery life.

Figure 4.11 shows the rear panel.

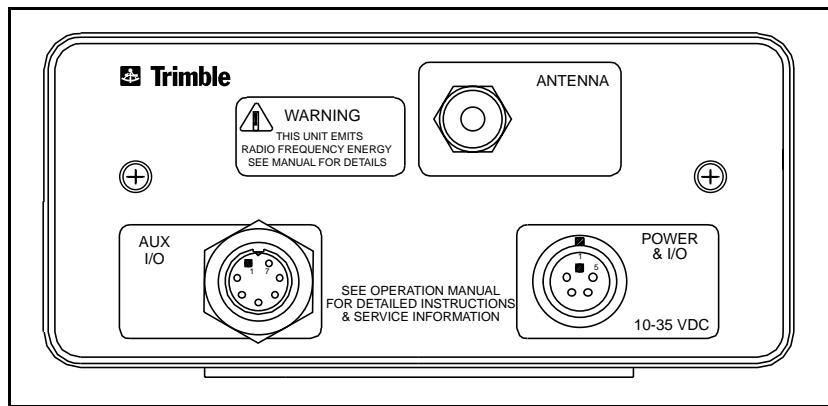


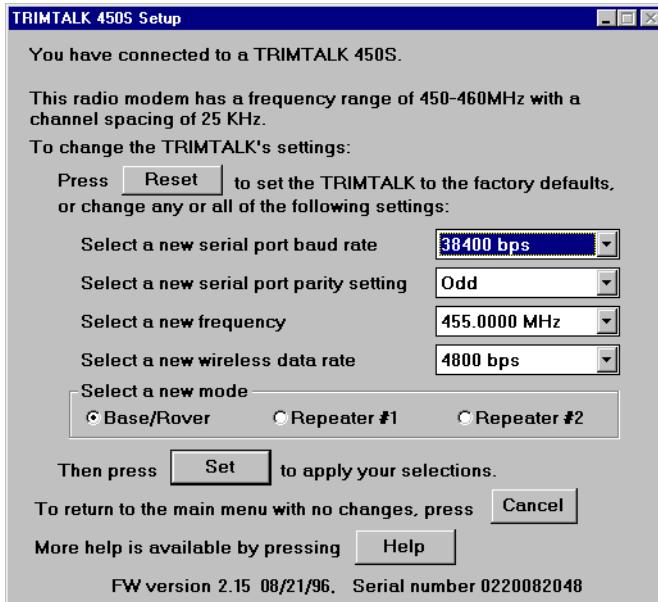
Figure 7.2 TRIMTALK 450S rear panel

The rear panel has three electrical connectors:

- POWER & I/O connector (five-pin female LEMO)
- AUX I/O connector (seven-pin male CONXALL)
- ANTENNA connector (female TNC)

Exercise 3: Configure the TRIMTALK 450S radio modem

When a successful connection is established, the *TRIMTALK Setup* window is replaced by the *TRIMTALK 450S Setup* window:



Note – From the *TRIMTALK 450S Setup* window you can select the receiver's operating frequency from the factory programmed list of available frequencies.

Follow these steps to modify the serial port parameters, radio frequency and wireless data link parameters:

1. Change the serial port baud rate and parity, if necessary.

Note – Change the receiver's serial port settings only if you plan on connecting the *TRIMTALK 450S* radio modem to a GPS receiver with serial port settings different than 38400 bps and odd parity.

2. Select the radio frequency you want from the list of available frequencies in the *Select a new radio frequency* list box. All frequencies are displayed from lowest to highest in the list box. The program cannot accept an invalid setting.
3. Select the wireless data rate from the list in *Select a new wireless data rate* list window. The program cannot accept an invalid setting.

Note – All TRIMTALK 450S radio modems in a wireless data network must be configured to the same frequency and wireless data rate.

4. In the *New Mode* list box, select the radio modem's mode: *Base/Rover, Repeater #1 or Repeater #2*.
5. Click on **Set** to load them into the receiver's non-volatile memory. These parameters are retrieved each time the TRIMTALK 450S radio modem is powered-up.

Cancel allows you to leave the *TRIMTALK 450S Setup* window without making any changes.

Reset resets all of the receiver's configuration parameters to the factory defaults. The TRIMTALK 450S radio modem's serial I/O factory default settings are 38400 bps, 8 data bits, odd parity and 1 stop bit. The wireless data link factory default settings are Channel 1, 4800 bps and Base/Rover mode.

Note – If a TRIMTALK 450S radio modem is reset, make sure that its settings are updated to match the other units in the network before trying to use it in the network.

The TRIMMARK 3 Radio Modem

The radio modem is packaged in a weatherproof housing. The front panel, as shown in Figure 4.12 has a VFD display to indicate channel frequency, radio status, and error messages. The following menus are available through the front panel:

- Channel – channel number and operating frequency.
- Mode – base, repeater or rover modes
- Channel sharing – carrier detect settings
- Transmit power – 2, 10, or 25 watts

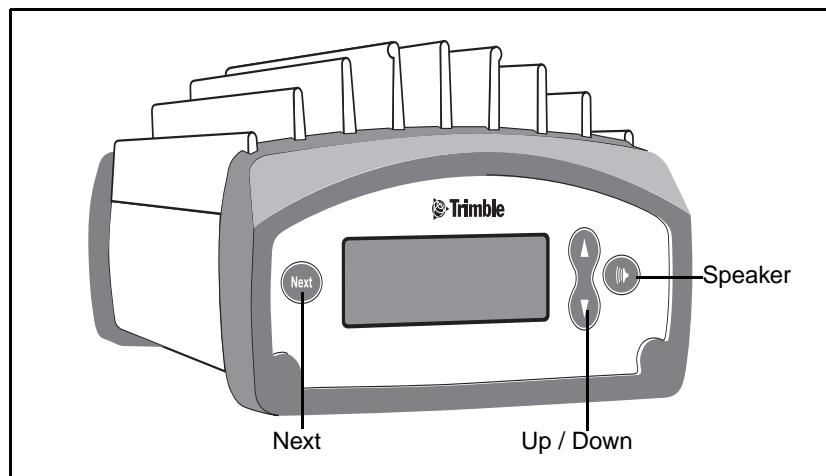


Figure 7.3 TRIMMARK 3 front panel

- Speaker – Control the volume of the received audio signal on the currently selected channel. If the volume is adjusted high enough, you will hear any traffic present.
- Up / Down – Scroll through the available menu options.
- Next – Browse through the menu screens.

The rear panel, as shown in Figure 4.13, has the following electrical connectors:

- Antenna – Female TNC
- Power – Two-pin LEMO
- Data – Seven-pin LEMO, 0-shell

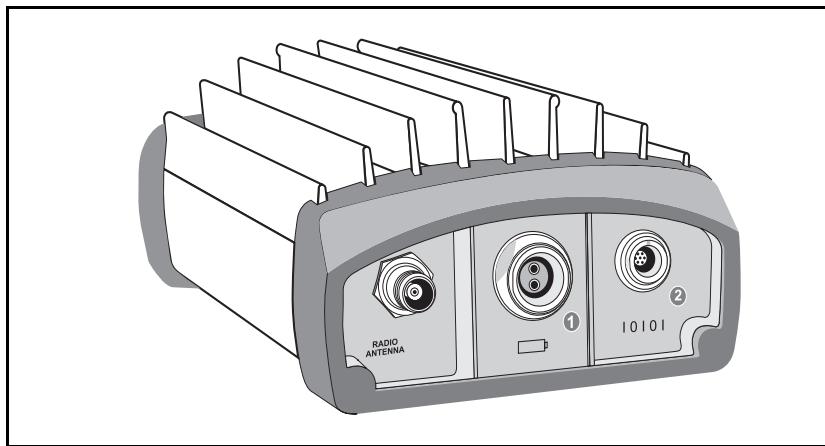


Figure 7.4 TRIMMARK 3 rear panel

When you turn the modem on, the Channel menu appears by default. Select other menus with the front panel control keys, as shown in Figure 4.12.

Figure 4.14 shows the menu hierarchy.

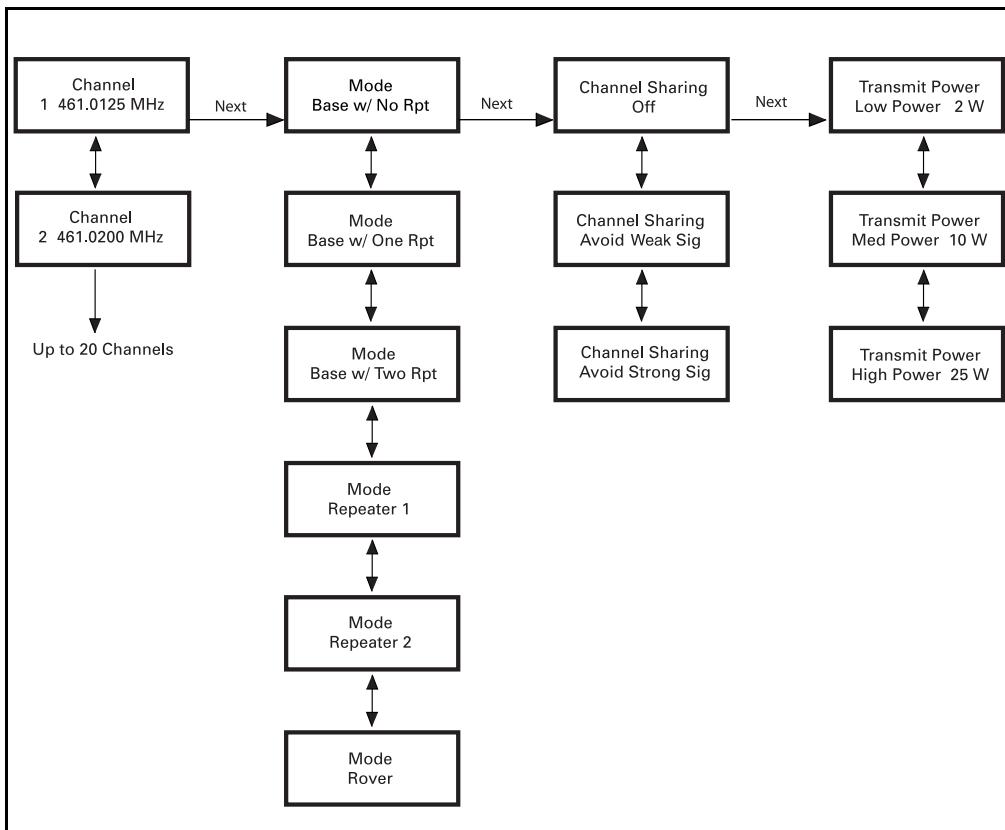


Figure 7.5 TRIMMARK 3 menu hierarchy

Power and I/O cables

The TRIMMARK 3 base equipment set includes a radio-to-receiver Input/Output cable (not provided in the repeater equipment set), an antenna cable with integrated antenna mount, a power cable, and a configuration cable (PC to radio modem). The configuration cable lets you modify the radio modem configuration using the WinFlash utility.

When configured as a base, the modem receives data at the data connector through a single LEMO-to-LEMO cable that plugs into a Trimble GPS receiver. When the receiver is configured as a repeater, no data connection is required.

Power is connected to the receiver at the power connector from a stable power supply or a battery.

Defaults

The TRIMMARK 3 radio modem is shipped from the factory with the serial I/O port configured for 38400 bps, 8 data bits, parity none, and wireless mode set to TRIMMARK II mode at 4800 bps. Channel sharing is set to *Avoid Weak Signals*.

All modems are shipped from the factory configured as Base with no Repeaters. Use WinFlash, the front panel, or the controller to configure the modem for your specific application.

When power is applied to the modem, the front panel briefly displays the firmware version and then cycles to the main menu, which displays channel and frequency information. If the GPS receiver is providing data to the modem, it will immediately begin transmitting data as indicated by “TRAN” flashing at the selected transmit rate in the upper right corner of the display.



Warning – Before applying power, ensure that the antenna cable and antenna are properly connected to the radio. If the radio transmits without the antenna attached it may cause damage to the radio amplifier.

Configuring the Radio Modem

Each TRIMMARK 3 radio modem comes from the factory with its serial I/O port configured for 38400 bps, 8 data bits, parity none, and 1 stop bit. The modem is preconfigured for Base without a Repeater mode. Use WinFlash, Trimble Survey Controller, or the front panel to configure the modem for operations in other modes.

The factory default parameters are stored in nonvolatile memory and serve as the initial power-up settings for the radio modems. The modem retrieves the parameters stored in non-volatile memory at each power-up. The power-up settings can be changed as often as necessary using the WinFlash utility.

Configuring the serial I/O port

Note – The BAUD RATE, FORMAT, and CTS parameters for the GPS receiver must be configured to transfer data properly between the receiver and the radio modem. BAUD RATE must be set to match the maximum serial I/O rate of the radio modem (38400 bps) and FORMAT is always set to 8-NONE-1. CTS flow control is disabled.

See the following sections for procedures to connect the modem to your computer, install the WinFlash Utility under Windows, and set up the serial I/O parameters.

Note – Your computer must be able to support a 38400 bps serial port data rate.

Connecting to a computer

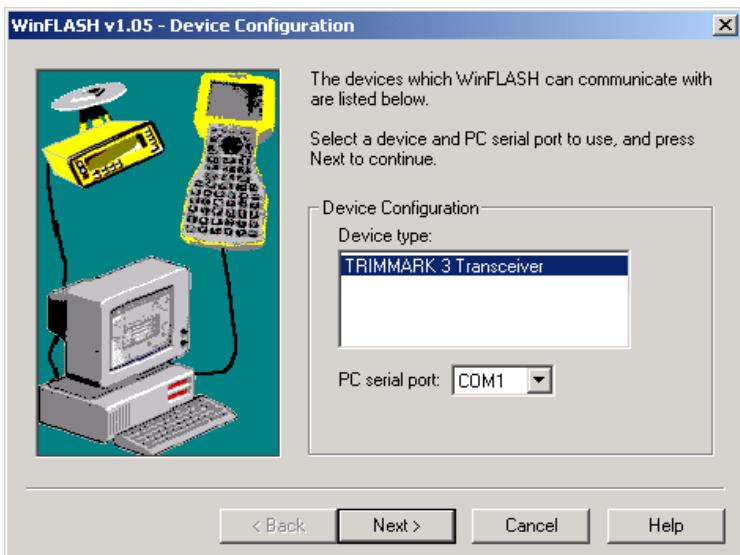
Connect the radio modem programming cable (P/N 32960) to the serial COM port on the computer and the I/O port on the radio. Connect power cable (P/N 40356) to the power connector from a suitable power source.

Exercise 4: Configure the TRIMMARK 3 radio using WinFlash

WinFlash is a communications setup utility used to configure the radio. For information on the installation of WinFlash and an icon on your desktop, read the README.TXT file provided on the WinFlash diskette or use the Microsoft Windows documentation.

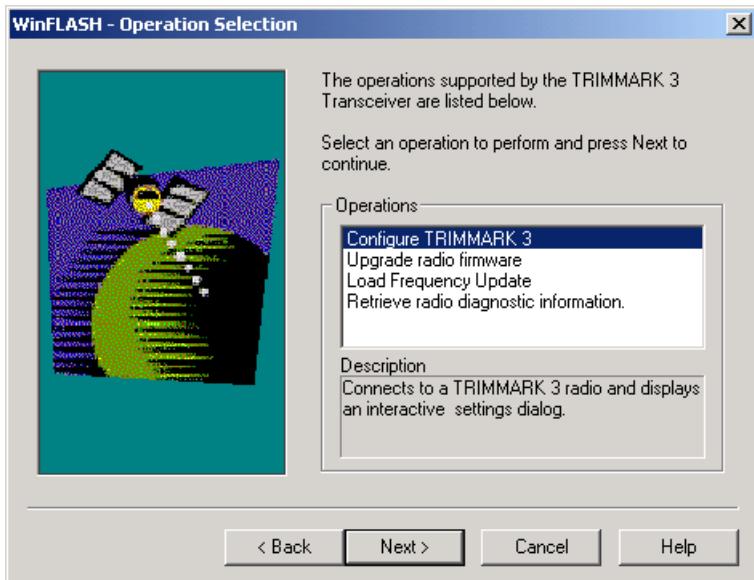
To use WinFlash:

1. Select and open the WinFlash icon to start WinFlash:



2. Follow the directions in the WinFlash window to make a logical connection to the radio modem.
 - a. Select the appropriate PC serial port (COM port).
 - b. Select the appropriate device, TRIMMARK 3 transceiver, and press **Next**.

The *Operation Selection* window appears:



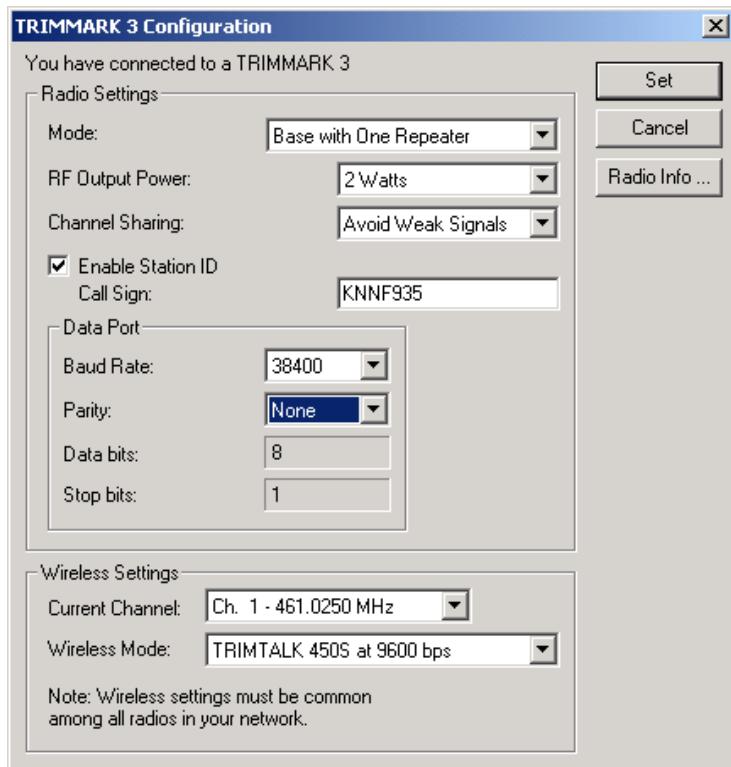
3. Select the appropriate operation in the *Operations* window, Configure TRIMMARK 3, and press **Next**.

The *Settings Review* window appears to confirm that you selected operation.

4. Press **Finish**.

A connection status window appears, counts to 100%, and then displays the TRIMMARK 3 configuration menu.

When a successful connection is established, the *TRIMMARK 3 Configuration* window replaces the *WinFlash* window:



Use the dialogs in the *TRIMMARK 3 Configuration* window to modify configuration parameters.

To configure the modem:

1. Select the appropriate operating *Mode* depending on intended use, for example, Base with No Repeaters.
2. Select the appropriate *RF Output Power*: 2, 10, or 25 watts. The permissible output power may be limited in your region.
3. Select the *Channel Sharing* configuration (base modes only, not selectable for a repeater or rover):

Off – The carrier detect mode is off. The radio will ignore other transmissions on your frequency and continue to transmit data.

Note – *Channel Sharing set to Off may be illegal in your country of use. You may be subject to penalties or fines based upon the specific licensing requirements for your country of use. Please consult your radio license documentation or licensing agency for operational guidelines.*

Avoid Weak Signals – The carrier detect mode is on. The radio will cease transmitting if it detects another radio transmission on its frequency. It will resume transmission when the channel is free of radio traffic.

Avoid Strong Signals – The carrier detect mode is on, but the radio will stop transmitting only when there is a strong signal present. (Receive level > -90 dBm)

4. Check the *Enable Station ID* box and enter your call sign into the box. This is a Federal Communications Commission requirement for U.S. licensed users, and sets your radio to transmit your call sign in Morse code every 15 minutes.
5. In the *Data Port* dialog, enter the *Baud Rate* and *Parity*. These are the communications parameters between the receiver and radio.

Note – *The factory default GPS port parameters for the TRIMMARK 3 radio are 38400 baud rate with parity none. The factory default mode is Base with no Repeater with Channel Sharing set to Avoid Weak Signals (ON).*

6. In the *Wireless Settings* dialog, select the appropriate *Current Channel*, which determines the radio operating frequency. Next, select the desired *Wireless Mode*, which determines the over-the-air communications parameters.
7. To update the configuration, click the **Set** button.

The *Status* dialog appears. You can return to the main menu, or exit WinFlash.

Note – All radios in the network must be configured with the same wireless setting.



Tip – Setting the wireless mode to the highest possible setting reduces battery consumption on your base or repeater. For example, 9600 bps consumes half the power of 4800 bps for the same data format and time of operation.

-
8. The **Radio Info** button allows you to view a text listing of all radio information, including its current configuration.



Tip – You can print or save to file the radio configuration information for future reference. This saved file can be printed and then faxed or e-mailed to Trimble Support to aid in troubleshooting radio problems.

Frequency list updates

The TRIMMARK 3 radio modem can be programmed with a list of up to 20 frequencies, stored in non-volatile memory. This list is preconfigured based on the frequencies requested when the modem was ordered. Governmental regulations require that only manufacturers or authorized dealers be allowed to create this frequency list. All frequencies programmed into a modem must comply with the host country regulations.

When you need to change the frequency list (add, delete, or replace frequencies), contact your Trimble dealer and provide the radio modem's serial number and an updated list of the frequencies you require. Once you are provided with the frequency file, you may upgrade the radio using the WinFlash utility.

Firmware updates

TRIMMARK 3 firmware upgrades will be available periodically for download at the Trimble World Wide Web (www.trimble.com) or FTP site (ftp.trimble.com). The radio firmware can be upgraded using the WinFlash utility program.

The Trimble Geomatics Office Software

In this chapter:

- Introduction
- Starting Trimble Geomatics Office
- The Survey view
- Other modules
- The Plan view
- Properties window overview
- Viewing survey data in the Properties window
- Viewing and editing points
- Viewing observations
- Using project templates

Introduction

This chapter describes the Trimble Geomatics Office software and how to use it to process the data from an RTK survey.

Starting Trimble Geomatics Office

To start the software:

- Click  and then select *Programs / Trimble Geomatics Office / Trimble Geomatics Office*.

The Trimble Geomatics Office window appears.

The Trimble Geomatics Office window

The Trimble Geomatics Office window includes the main graphics window (which displays project data), menus, and toolbars.

There are two views—Survey and Plan. In each view the available menus, menu commands, and toolbars are different.

To switch between the Survey and Plan views, do one of the following:

- In the toolbar, select the *Survey View*  tool or the *Plan View*  tool.
- Select *View / Survey* or *View / Plan*.

Figure 8.1 shows the parts of the Trimble Geomatics Office window that are common to both views.

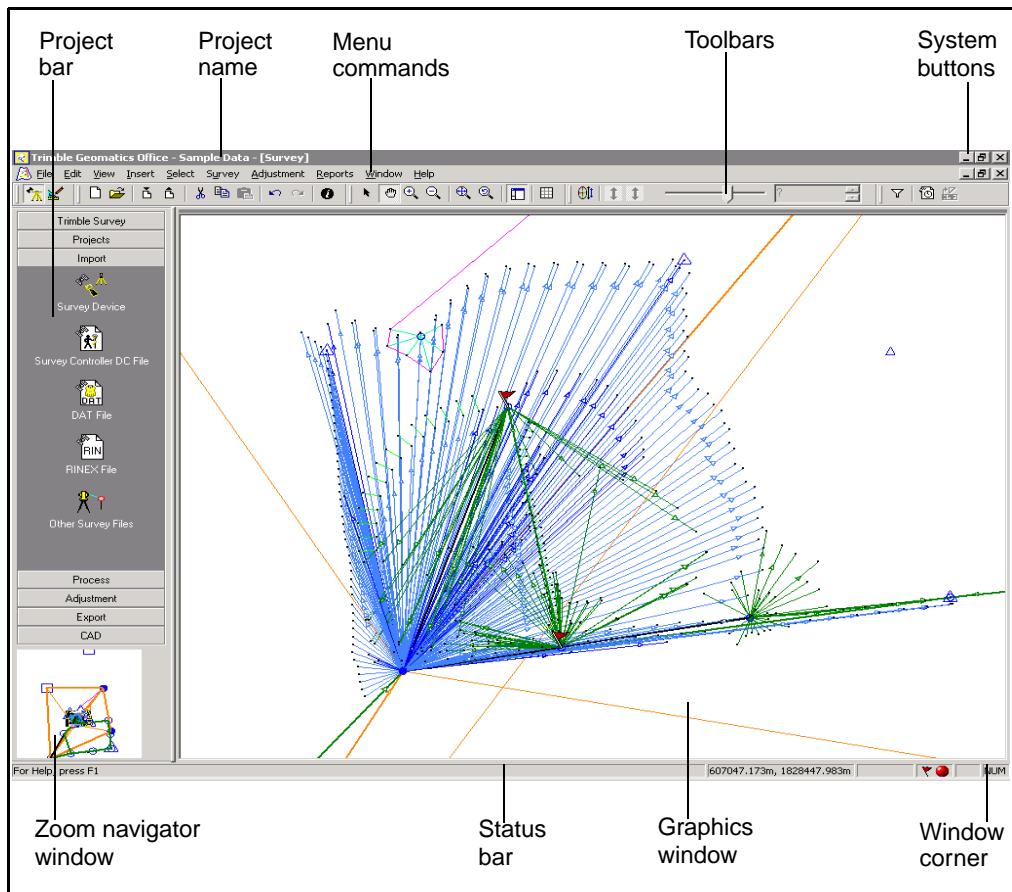


Figure 8.1 Parts of the graphics window common to both views

The project bar

The project bar is located on the left side of the Trimble Geomatics Office window. It contains named groups (for example, the *Trimble Survey* group) that list shortcuts to commonly performed tasks. These groups follow a general work flow.

Figure 8.2 shows the parts of the project bar. You can click the drop-down arrow to show the rest of the shortcuts in a group. Click a shortcut to perform a task. For example, click the Survey Device shortcut to transfer data from a device to the Trimble Geomatics Office project.

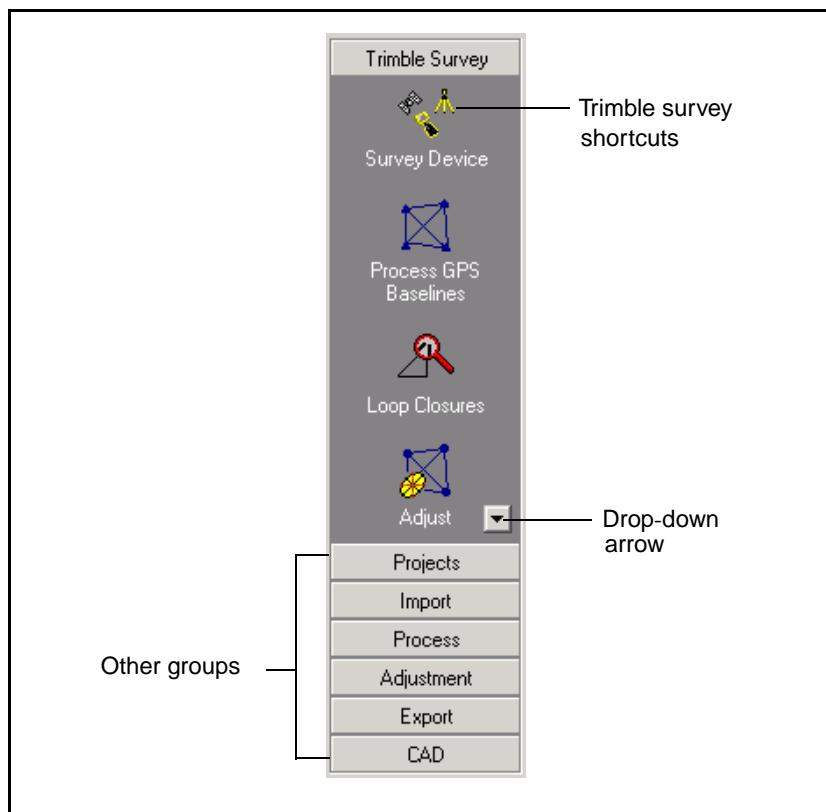


Figure 8.2 Items in the project bar

To show or hide the project bar, do one of the following:

- In the toolbar, click the *Project Bar*  icon.
- Select *View / Project Bar*.

When there is no project open, the *Projects* and *Utilities* groups are available. When a project is open, only the *Utilities* group is unavailable.

The zoom navigator



The zoom navigator is a small window located at the bottom of the project bar. It reflects the data displayed in the main Trimble Geomatics Office graphics window. If you use any of the zoom tools in the main window, the zoom navigator changes to reflect this. It is a convenient display of the extents of your project.

You can show or hide the zoom navigator within the project bar. To do this:

- In the project bar, right-click to access the shortcut menu and then select *Zoom Navigator*.

To use the zoom navigator:

- Click an area of the project in the zoom navigator. This area becomes the center of the main graphics window.

To use the zoom navigator to zoom:

- In the zoom navigator, drag a box around the area of interest. The main graphics window displays the same data.

When you point to the middle of the box in the zoom navigator, the pointer becomes a . This means that you can drag the box over the project area without changing the zoom. The view of the project in the main graphics window reflects these movements.



Tip – If you have a mouse with a wheel, you can use the wheel to change the size of the zoom navigator box.

The status bar

The status bar is located at the bottom of the Trimble Geomatics Office graphics window (see Figure 8.1, page 127). It displays icons that show the current status of the project. To perform the action indicated by an icon, double-click it. Table 8.1 shows the icons that are displayed in the status bar.

Table 8.1 Icons in the status bar

Icon	View	Is displayed when ...
	Both	a recomputation is required to update the coordinates for points fixed by GPS and terrestrial observations. To perform a recomputation, double-click this icon.
	Survey	there is a misclosure between two or more observations to the same point, or a GPS observation has failed the rejection criteria. To select all of the points and observations which are flagged, double-click this icon. The <i>Properties</i> window opens. You can view the points and observations. If you suppress a flag for a point or an observation, the flag is white.
	Plan	one or more layers have their Visible property set to false. To edit the Visible property of layers, double-click this icon. The <i>Layers</i> dialog appears.
	Plan	one or more layers have their Locked property set to true. To edit the Locked property of layers, double-click this icon. The <i>Layers</i> dialog appears.
	Survey	one or more view filters are applied. To edit the view filters, double-click this icon. The <i>View Filters</i> dialog appears.
	Both	grid lines are displayed. The grid interval is also shown.
	Both	the mouse is outside of the graphics window.

The Survey View

In the Survey view, GPS and terrestrial observations are displayed as colored lines. Control points and network adjusted points also have special displays.

If Trimble Geomatics Office finds any problematic observations (for example, a misclosure outside the tolerance specified in the *Horizontal* or *Vertical* fields of the *Recompute* tab in the *Project Properties* dialog), error flags appear at the point where the misclosure occurs. Use the Survey view to perform survey-related tasks such as:

- checking GPS and conventional observations
- correcting erroneous data
- GPS processing (if you have the WAVE Baseline Processing module installed)
- GPS site calibration
- GPS loop closures
- inverse calculations
- Network Adjustment (if you have the Network Adjustment module installed)

For more information, refer to the Trimble Geomatics Office Help.

Figure 8.3 shows a project in the Survey view.

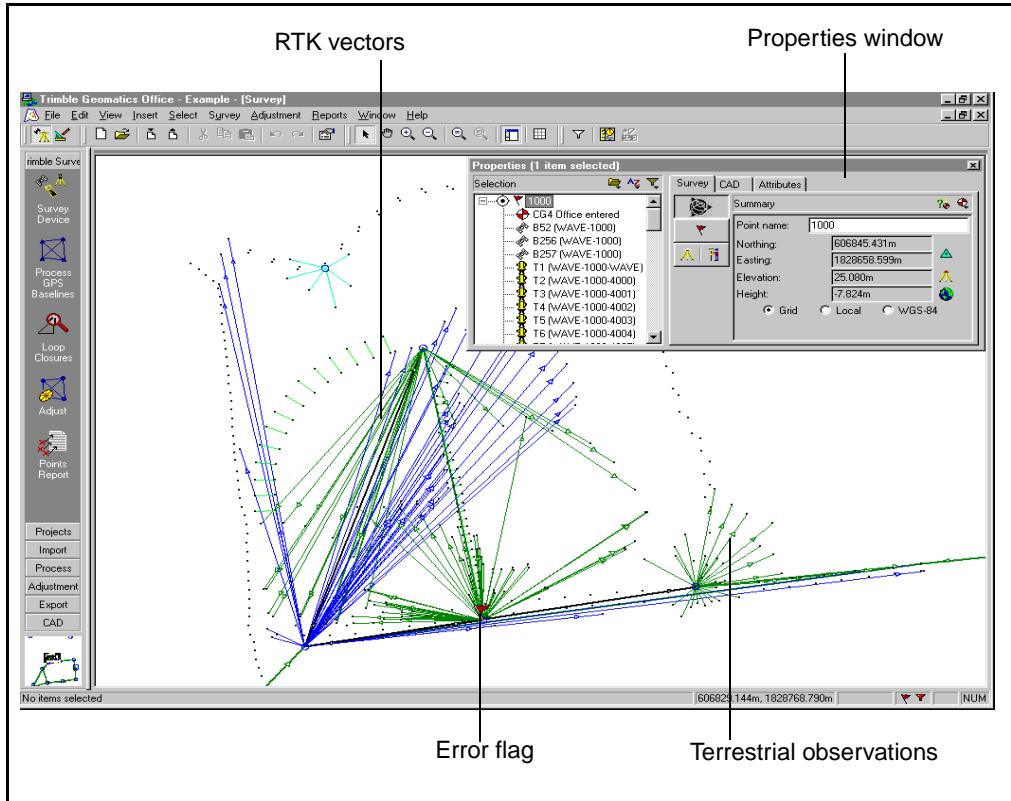


Figure 8.3 A project in the Survey view

Other Modules

Once the Trimble Geomatics Office base module is installed the following additional modules can be added.

Note – Additional modules will appear under Survey view.

WAVE baseline processing module

Table 8.2 shows the functionality that is available in the Trimble Geomatics Office – WAVE Baseline Processing module.

Table 8.2 The WAVE baseline processing module

Name	Use
WAVE Baseline processor (available from the Survey menu or the project bar)	To process raw GPS observations, including kinematic, continuous kinematic, static/FastStatic and infill data.
WAVE processing styles	To specify different processing controls for the WAVE baseline processor, and to save the control sets as named styles.
Timeline window	To view and edit raw GPS measurements and survey information. Displays GPS data in a chronological view. The close integration of the Timeline window with the graphics window makes this a powerful quality control tool.
GPS Baseline Processing Report (HTML)	To display detailed information about postprocessed baseline solutions. These reports are available both during processing and also later from the Reports menu.
Process group in the project bar	For quick access to commonly used baseline processing tasks.

Network adjustment module

Table 8.3 shows the functionality that is available in the Trimble Geomatics Office – Network Adjustment module.

Table 8.3 The Network Adjustment module

Name	Use
Network Adjustment (available from the <i>Adjustment</i> menu or the project bar).	To adjust your GPS and terrestrial networks, analyze the results, edit the network parameters, and readjust.
Allowing you to fix points, load observations for Network Adjustment, determine observation outliers, and weight the observation errors.	
Network Adjustment styles	To specify different adjustment controls for the Network Adjustment software, and to save the control sets as named styles.
<i>Network Adjustment Report</i> (HTML)	To review the results of the adjustment and perform quality control checks.
<i>Adjustment</i> group in project bar	For quick access to commonly-used network adjustment processing tasks.
Ellipse Controls toolbar	To configure the appearance of error ellipses in the graphics window after a network adjustment.

Note – For RTK surveys, only base module is required.

For RTK & Infill surveys, WAVE module is required for processing Infill data.

If you wish to include RTK baselines into a network adjustment, the Network Adjustment module is required. Make sure QC2 records are collected in the field.

The Plan View

In the Plan view, entities are displayed according to the style given to them, so use the Plan view to view the topographic features observed during the field survey. You can add entities—points, lines, arcs, curves, text styles, and annotations—to the project.

You can change the style of an entity by using the *Properties* window or the *Multiple Edit* dialog, or by processing feature codes. Any changes that you make do not affect the underlying survey observations.

Use the Plan view to prepare a topographic survey for export to your design software package. You can do the following:

- process feature codes
- manage layers and styles
- access the DTMLink and RoadLink software

For more information, refer to the Trimble Geomatics Office Help.

Figure 8.4 shows a project in the Plan view.

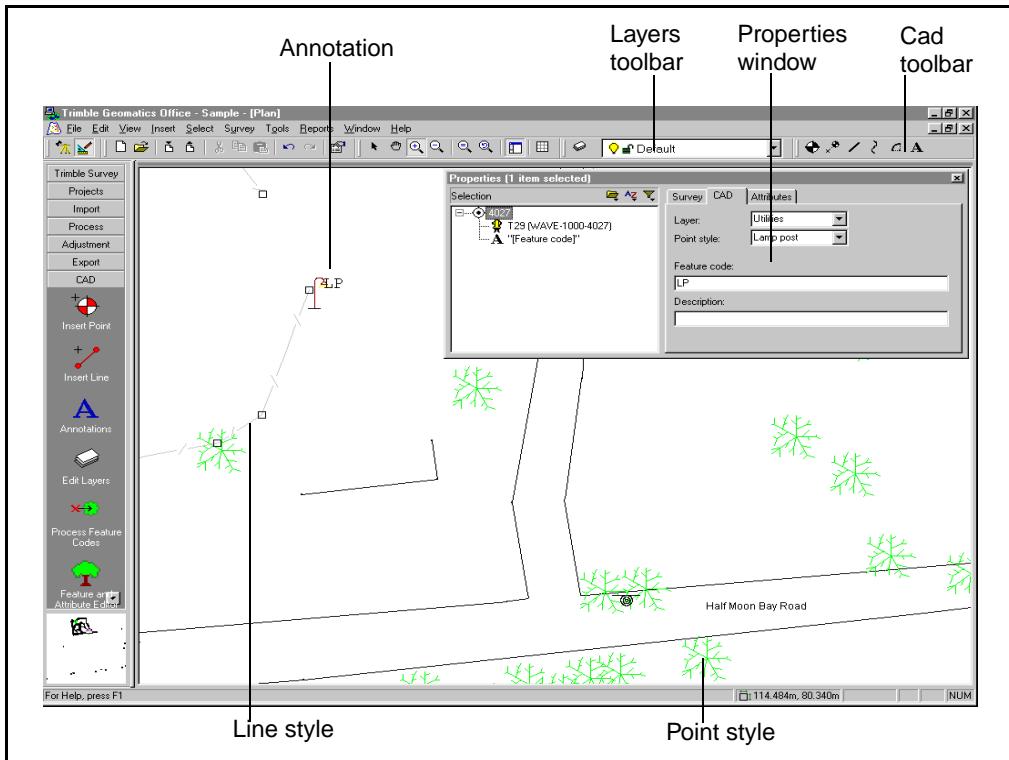


Figure 8.4 A project in the Plan view

ToolTips

ToolTips are a quick way to learn about, or recall the function of, a button, box, or tool. They also provide useful information about entities in the graphics window. To use ToolTips:

- Position the pointer over a button, box, or tool in the toolbar; or an entity (observation, point, line, arc, curve, text, or annotation) in the graphics window.

After a few seconds, a small pop-up window appears and identifies the item. This is a ToolTip.

For example, when you position the pointer over the *Import* tool in the standard toolbar, the following ToolTip appears:



For more information about what each tool does, refer to the Help.

Shortcut menus

Shortcut menus are context-sensitive menus with commands that vary depending on where you position the pointer.

You can use shortcut menus for common tasks such as:

- accessing commonly-used menu commands and dialogs
- toggling display settings
- inserting field codes

To access a shortcut menu:

1. In the appropriate area, click the right mouse button (right-click). A shortcut menu appears.
2. Select the appropriate menu command.

Pointers

When you use a mouse, you use a pointer to select objects and choose menu commands. This pointer changes shape according to its position, the mode you are in (for example, the Select or Field fill-in modes), or the tool that has been selected. Table 8.4 shows some pointers.

Table 8.4 Pointer shapes

Pointer	Use
	When it is in the graphics window in Select mode, or when it is to be used for selecting menu items or toolbar icons.
	When it is over a text box—used for inserting text.
	When it is in Field fill-in mode.
	When it is in Pan mode—used for shifting the center of the zoom area in the graphics window to display a different area of the screen view.
	When defining a selection set.
	When moving selected entities.

Color and symbol schemes

Table 8.5 shows the available colors and symbols.

Table 8.5 Colors and symbols

Item	Default legend	Black legend
Default color for text	Window text color in Control Panel	White
Trimble Geomatics Office graphics window	Window color in Control Panel	Black
Color of selected entities	Selected items color in Control Panel	Red
More than one type of observation (for example a terrestrial and an RTK observation between two points)	Black	White
RTK vectors	Blue	Blue
Postprocessed static baselines	Orange	Yellow
Conventional observations	Dark green	Dark green
Laser rangefinder observations	Light green	Light green
Reduced observations	Green	Green
Potential baselines (overlapping GPS data between two points)	Grey	Grey
Disabled baselines	Dark red	Dark red
Any observation enabled as a check	Dashed line in the color set for the observation type	Dashed line in the color set for the observation type
Flagged observations	Red	Red
RTK Continuous vectors	Light blue	Light blue
Postprocessed Kinematic (PPK) vectors	Blue	Blue
PPK Continuous vectors	Light blue	Light blue
Normal point	Black dot	White dot

Table 8.5 Colors and symbols (Continued)

Item	Default legend	Black legend
Station	Blue circle	White circle
3D control point	Blue triangle with dot	White triangle with dot
Horizontal control point	Blue single triangle	White single triangle
Vertical control point	Blue box	White box
Network-adjusted point	White solid circle	White solid circle
Event marker	Blue solid circle	Blue solid circle

Properties Window Overview

The *Properties* window lets you view the details of all entities (points, observations, lines, arcs, curves, text, annotations). Use it whenever you want to view and edit entity details. The software immediately applies any changes that you make to entities in the *Properties* window.

You can keep the *Properties* window open while you use other parts of Trimble Geomatics Office. The *Properties* window is automatically updated to show the correct information about the currently selected entities.

The tree view in the *Properties* window shows the names and values of the selected item, and the relationship between the entities. For example, to view the *from* and *to* points for any observation or linetype entity, click the plus (+) icon and select the point that you want to view and edit.

You can select one or more entities to view in the *Properties* window at the same time. When you have defined a current selection set and selected an entity to view from the *Properties* window selection list, the current selection in the graphics window is updated to include only the entity that you are viewing. The *Properties* window selection list

retains the original selection set. Any entities highlighted in the *Properties* window selection list become the current selection set in the graphics window.

To open the *Properties* window, do one of the following:

- Select *Edit / Properties*.
- In the standard toolbar, select the Edit Properties  tool.
- Double-click a graphical entity.

Figure 8.5 shows the *Properties* window, and the table following it describes each part.

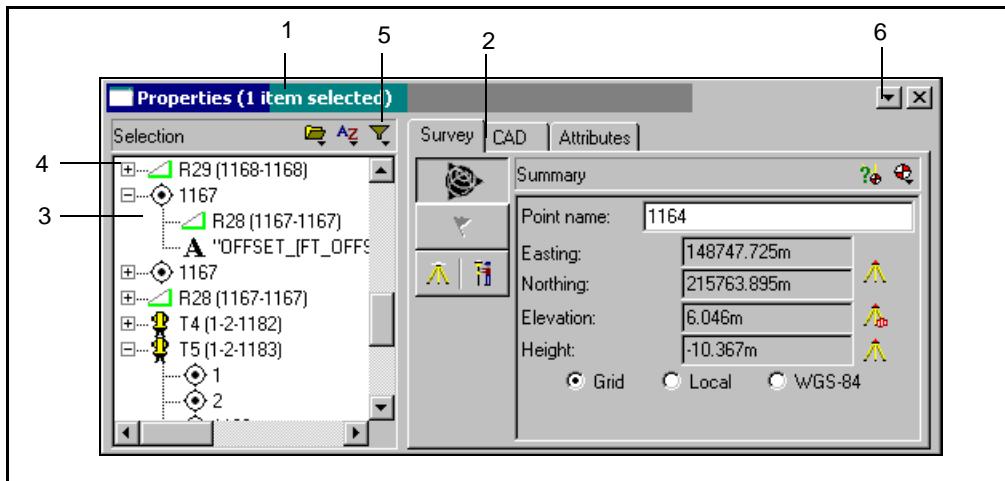


Figure 8.5 The Properties window

Part	Function
1	Shows the number of items selected.
2	The tabs organize data into groups. The availability of the tabs depends on the type of entity selected.
3	Lists the entities in your current selection set. You can only view the details of one entity at a time. If you have more than one entity selected, from the list select the entity you want to look at.
4	Lets you expand and collapse the tree view outline.

Part	Function
5	Selection tools
	 The <i>Group Survey Data</i> tool groups data by source or type.
	 The <i>Sort</i> tool sorts the selected entities. To do this, select the option you want.
	 The <i>Filter</i> tool only keeps an entity type in the current selection set.
6	 The Auto roll-up tool minimizes the <i>Properties</i> window when the mouse pointer moves from the area of the <i>Properties</i> window.

The information and tabs available on the right side of the *Properties* window depend on the entity type currently selected. The following sections describe how to use the *Properties* window to view and edit data for each type.

Viewing Survey Data in the Properties window

Use the *Survey* tab of the *Properties* window to view and edit the survey-related properties of an entity in the selection. You can view the properties of entities that appear in the *Survey* view, such as:

- points
- GPS observations
- conventional observations
- level observations
- laser rangefinder observations
- azimuth observations
- reduced observations
- staked-out point information
- events data

Using pages to view survey details

Survey details in the *Properties* window are organized into pages. You can only view one page at a time. Access the pages using the available page buttons. They depend on the entity type that is currently selected.

Figure 8.6 shows the typical parts of a page in the *Survey* tab.

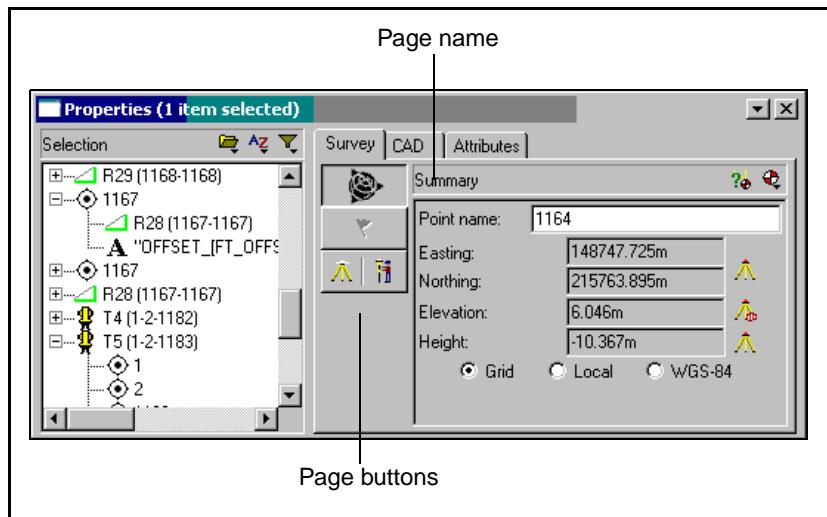


Figure 8.6 The Survey tab

Viewing and Editing Points

Point details in the *Properties* window are organized into the following tabs:

- Use the *Survey* tab to view and edit the survey-related details of a selected point.
- Use the *Stakeout* tab to view details about staked out points.
- Use the *CAD* tab to view and edit the CAD-related details of a selected point.

- If a selected point contains attribute information and you have set up the project for attributes, use the *Attributes* tab to view this information.

To view and edit the details of a point, select the appropriate tab in the *Properties* window.

The following sections describe the details of a point that you can view, using the *Properties* window.

Viewing survey details

Use the *Survey* tab in the *Properties* window to view and edit the survey-related details of the selected point (for example, the derived position, warning messages, occupation and setup details, coordinates, and observation statistics).

To view the survey details for a point:

1. In the *Properties* window, do one of the following:
 - From the *Properties* window selection list, select a point.
 - In the graphics window, select a point.
2. Select the *Survey* tab.

To select the types of survey details that you want to view, click a page button.



Tip – To view the *from* and *to* points for any observation, click the plus (+) icon beside the observation. Then, click the point that you want to view and edit.

The following *Properties* window shows a typical page for a point:

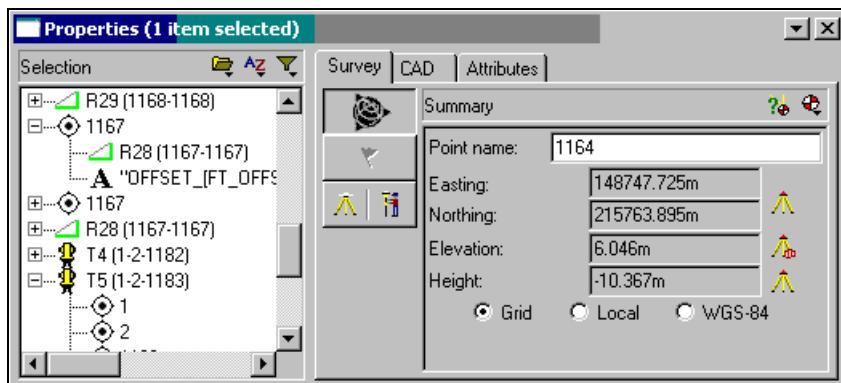


Table 8.6 summarizes the pages for points in the *Properties* window. For more information on each page, refer to the appropriate Help topics.

Table 8.6 Pages for points in the Properties window

Button	Page name	What it shows
	Summary	<p>The point name, the derived position, and qualities for a point.</p> <p>Use this page to view the qualities of the position components or report on how the point was derived.</p>
	Warning	<p>A warning message indicating that a misclosure has been detected on the point, or that a high RMS was detected.</p> <p>Use this page to view the error message and to suppress the warning flags displayed in the graphics window if the error is acceptable for the project.</p>
	Occupations and Setups	<p>Details of any GPS occupation or terrestrial setup from or to the point.</p> <p>Use this page to view and correct the details for the GPS occupation or terrestrial setup details, for example, antenna and target heights. If there is more than one occupation or setup for the point, a shortcut menu appears. As you hold the pointer over different occupations and setups in the shortcut menu, the occupation and setup details are updated in the page.</p>

Table 8.6 Pages for points in the Properties window (Continued)

Button	Page name	What it shows
	Error Estimate	The estimated errors for the point's position after a network adjustment, if you have the Network Adjustment module installed.
N/A	Coordinate	The underlying coordinates and qualities for a point. Use this page to change the coordinate qualities and status of the point.
N/A	GPS Solution (APC)	The position solution of a GPS point including the time of occupation, WGS-84 coordinates, and precisions. Use this page to view the position solution and to change the status of the point.

Note – If the Summary page is set to display the point as a WGS-84 position, the fields displayed will depend on what is set for the Display WGS-84 as setting in the Units and Format tab of the Project Properties dialog. For example, if the Display WGS-84 as field is set to X,Y,Z, the WGS-84 fields in the Summary page are labeled X,Y,Z. If the Display WGS-84 as field is set to L,L,H, the WGS-84 fields are labeled Latitude, Longitude, and Height.

Point quality indicators

The *Properties* window shows the quality of each coordinate component. Table 8.7 describes these qualities.

Table 8.7 Point quality indicators

Symbol	Quality
	Fixed Control (yellow)
	Adjusted
	Control (blue)

Table 8.7 Point quality indicators

Symbol	Quality
	Survey
	Mapping
	Unknown



Tip – The geoid indicator is used in the *Properties* window to show if the elevation or height was derived from a geoid. For example, if an RTK point is measured, it will have a height on WGS-84 and an elevation derived from the geoid. Conversely, if a terrestrial point is collected, it will have an elevation and a WGS-84 height derived from the geoid. These indicators are also used in the Point Derivation report and the Recompute report.

Viewing Observations

You can view the survey details of any observation type, such as:

- GPS observations
- Conventional observations
- Level observations
- Laser rangefinder observations
- Azimuth observations
- Reduced observations

The following sections describe how to use the *Properties* window to view the survey details for each observation type.

GPS observations

Use the *Properties* window to view the details of any GPS observation type such as RTK, Static, FastStatic and postprocessed kinematic baselines.

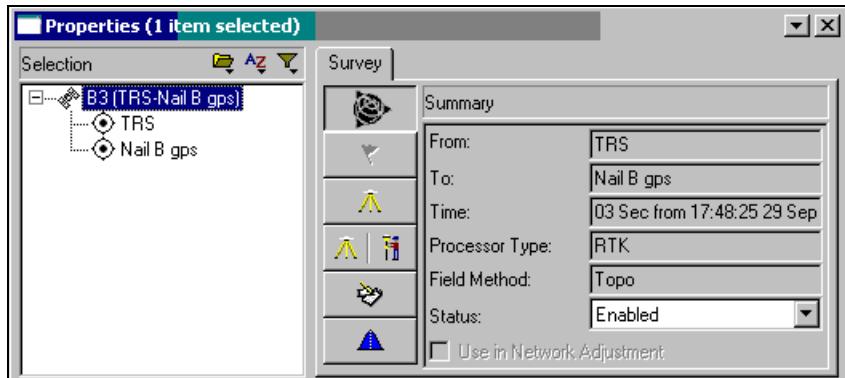
To view the survey details of an observation:

1. In the *Properties* window, do one of the following:
 - From the *Properties* window selection list, select a GPS observation.
 - In the graphics window, select a GPS observation.
2. To select the types of survey details that you want to view, click a page button.



Tip – To view an observation from or to a point, click the plus (+) icon beside the point. Then, click the observation that you want to view.

The following *Properties* window shows a typical page selected for a Real-Time Kinematic (RTK) GPS observation. The page buttons shown are the same for all GPS observation types:



Conventional observations

Use the *Properties* window to view the details of any terrestrial observation measured in the field using a conventional instrument.

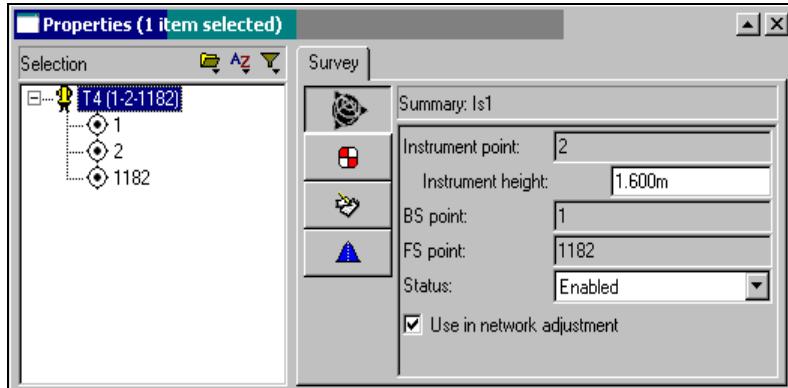
To view the survey details of an observation:

1. In the *Properties* window, do one of the following:
 - From the *Properties* window selection list, select a conventional observation.
 - In the graphics window, select a conventional observation.
2. To select the types of survey details that you want to view, click a page button.



Tip – To view an observation from or to a point, click the plus (+) icon beside the point. Then, click the observation that you want to view.

The following *Properties* window shows a typical page selected for a conventional observation:



For more information about viewing other observation types, refer to the Trimble Geomatics Office help or manuals.

Exercise 5: Create and configure a project

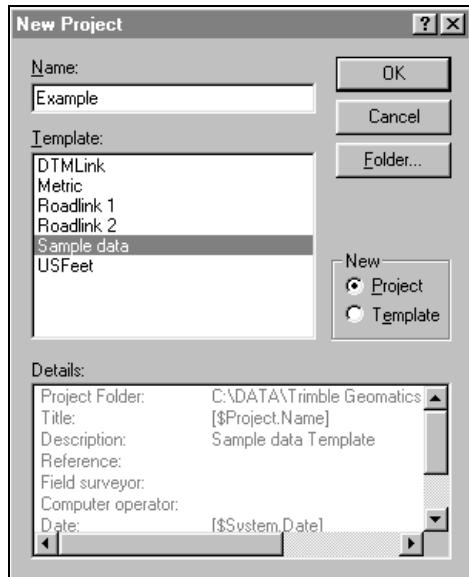
Trimble Geomatics Office organizes your data in projects. A project usually covers one site and may contain several days' data collected using different equipment.

When you create a project, you begin by choosing a template for it. This template provides your project with the basic general information necessary for setting it up; that is, the units, coordinate system, and display settings.

To create a project:

1. Do one of the following:
 - In the standard toolbar, click the *New Project*  tool.
 - Select *File / New Project*.
 - In the project bar, click the *New Project*  shortcut.

The following dialog appears:



2. In the *Name* field, enter a name for the project.

3. In the *Template* list, select a template. This determines the initial state of the project. The details of the selected template are displayed in the details list.
4. In the *New* group, make sure that the *Project* option is selected.
5. If you want the project files stored in a particular folder (other than that specified during installation), do the following:
 - a. Click **Folder**.
 - b. Specify the appropriate folder and then click **OK**.
The folder name appears in the *Details* list.
6. Click **OK**.

The project is created and the *Project Properties* dialog appears. The settings in this dialog are from the template selected for the project.

Changing the project properties

Use the tabs in the *Project Properties* dialog to change a project's properties, if necessary.

To access this dialog:

- Select *File / Project Properties*.

The following dialog appears:

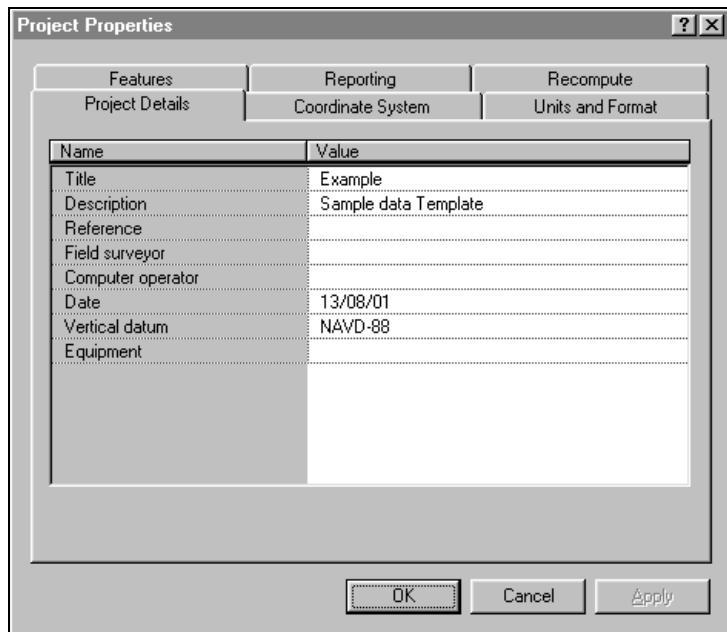


Table 8.8 describes the six tabs in the *Project Properties* dialog:

Table 8.8 Tabs in the Project Properties dialog

Tab	Description
Project Details	Use the <i>Project Details</i> tab to enter the project information that you want included in reports and plots.
Coordinate System	Use the <i>Coordinate System</i> tab to view the current coordinate system and, if necessary, change the coordinate system for the project.
Units and Format	Use the <i>Units and Format</i> tab to set Trimble Geomatics Office unit values for the current project.
Features	Use the <i>Features</i> tab to specify the feature and attribute settings for the Trimble Geomatics Office project.

Table 8.8 Tabs in the Project Properties dialog (Continued)

Tab	Description
Reporting	Use the <i>Reporting</i> tab to control how you are notified when a system-generated report has been created.
Recompute	Use the <i>Recompute</i> tab to specify how Trimble Geomatics Office determines the calculated positions for all points in the project.

For more information, refer to the *Trimble Geomatics Office User Guide*.

Using Project Templates

To configure the initial state of a project, you must select a project template. To reduce the time required to configure new projects, create your own templates with the properties and data that are common to all of your projects.

Selecting a template for a project

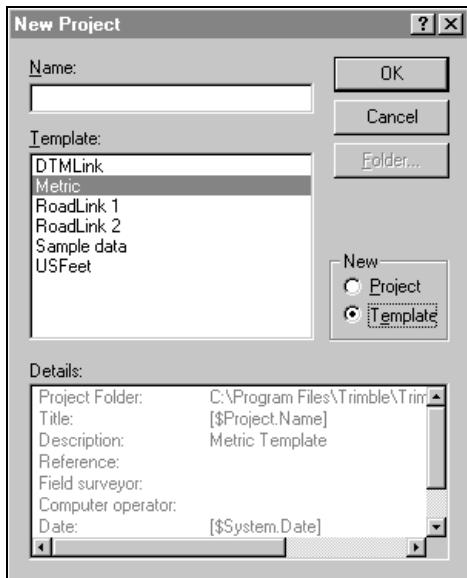
When you create a new project, you must select a template. Using templates in Trimble Geomatics Office is similar to using template documents in Microsoft Word, or prototype drawings in AutoCAD. Trimble Geomatics Office templates are stored in C:\Program Files\Trimble\Trimble Geomatics Office\Template.

When a project is created, the whole template—including the template folders—is copied to the new project. For example, if an ASCII file containing control points exists in the template *Checkin* folder, the same file is copied to the *Checkin* folder of the project. The template you use stays the same. That is, any edits made to the project are not made to the template.

Creating a template

To create a project template:

1. Select *File / New Project*. The *New Project* dialog appears.
2. In the *New* group, select the *Template* option. *Project Folder* in the *Details* list changes to *Templates Folder*, as shown below:



3. Enter a name for the new template.
4. Select an existing template on which to base the new one and then click **OK**. The *Project Properties* dialog appears.
5. Use the tabs in the *Project Properties* dialog to edit the default settings that trimble Geomatics Office uses when creating a project based on the template.
6. Click **OK**. A message appears. It asks if you want to continue editing the template.
7. Do one of the following:

- To continue editing the template, click **Yes**. You can edit the template using parts of trimble Geomatics Office other than the *Project Properties* dialog, for example, to enter common control points.
- To close the template, click **No**.

Note – *You do not have to manually save a template. All changes to a template are automatically saved as they occur.*

The new template appears in the *Templates* list when you create a new project. You can open a template in the same way that you would a project.

Exercise 6: Enter coordinates for a point

You can enter control coordinates for a point into Trimble Geomatics Office by:

- importing a Trimble Survey Controller job with keyed-in control coordinates entered in the field. For more information, refer to the Trimble Survey Controller documentation.
- importing an ASCII file with control points. For more information, refer to the *Trimble Geomatics Office User Guide*.
- entering known coordinates for an existing point using the *Properties* window or the *Points* dialog (if you have the Network Adjustment module installed). For information on using the *Points* dialog, refer to the Network Adjustment module Help.
- entering known coordinates for a new point using the *Insert Points* dialog. For more information, refer to the *Trimble Geomatics Office User Guide*.

Any coordinates entered receive an *office-entered coordinate* source. This is shown in the *Properties* window.

Note – Each point in Trimble Geomatics Office can only have one keyed-in WGS-84 coordinate and one keyed-in grid/local coordinate.

The following section describes how to use the *Properties* window to enter known coordinates for an existing point.

Using the Properties window to enter coordinates for a point

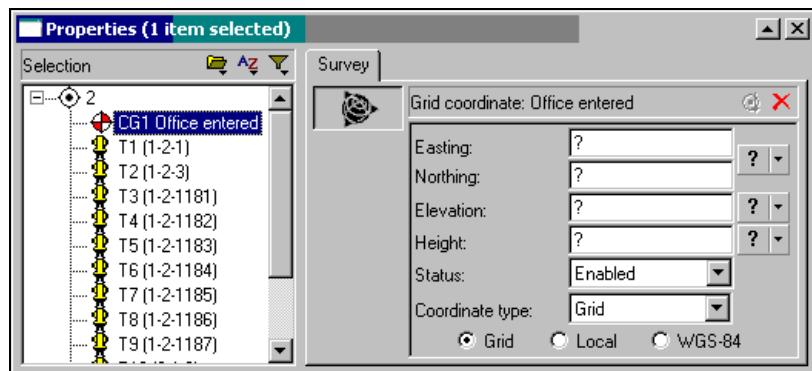
You can key in coordinates for a point using the *Properties* window. However, only do this when you want the software to use your keyed-in coordinate in preference to the coordinates derived from observations. The keyed-in coordinate will have an office-entered source.

To key in coordinates using the *Properties* window:

1. Select the point that you want to add coordinates for.
2. To open the *Properties* window, select the *Edit Properties*  tool.
3. To open the *Summary* page, click the *Summary*  page button.
4. Select the *Add coordinate*  tool.

Select the coordinate type to be added from the drop-down list (WGS-84, Grid or Local). You can only enter one grid/local and one WGS-84 coordinate for each point, so if a WGS-84 coordinate already exists, then you cannot add another.

5. A keyed-in coordinate appears in the point tree, as shown below:



6. In the coordinate fields, enter the known coordinates.

When you add a new coordinate, all of the fields are null (?). Use the *Insert Current Value*  tool to enter the current point position and quality. You must select each field before the *Add current value* field is available.

7. To set the quality for the point, select the *Quality Selector Control* tool and the coordinate(s) that you want to change. Select the quality from the list.

8. Use the *Coordinate Type* option to store the data in the database in the format specified. The software saves the coordinate in the coordinate view selected.

Note – You can only edit the coordinates in the display format that is stored in the database.

Note – If you have a keyed-in grid coordinate and a keyed-in WGS-84 coordinate, you cannot save the keyed-in grid coordinate as a WGS-84 coordinate.

Changing the status of coordinates

To change the status of an underlying coordinate using the *Properties* window, in a *Coordinate* page:

1. In the *Status* field, select the appropriate option. Do one of the following:
 - If you want the coordinate used to derive the position of the point, select *Enabled*.
 - If you do not want the coordinate used to derive the position of the point, select *Disabled*.
 - If you only want the coordinate used if there are no other enabled observations or coordinates that can be used to derive the position of the point, select *Enabled as check*.
2. Click **OK**.

The software performs a recomputation, and you can view the new derived position for the point in the *Summary* page of the *Properties* window.

Note – The Recompute report reports on coordinates enabled as *check*, but not on disabled coordinates.

The Trimble Data Transfer Utility

In this chapter:

- Introduction
- Using Data Transfer from Trimble Geomatics Office
- Using the standalone Data Transfer utility
- Setting up devices using the Data Transfer utility
- Managing devices
- Importing ASCII data files

Introduction



Trimble Geomatics Office uses the Trimble Data Transfer utility to transfer data to or from devices, such as:

- a controller running Trimble Survey Controller
- a survey data card
- a Trimble GPS receiver
- a Trimble total station
- an SDR data recorder

You can also use the Data Transfer utility as standalone software to transfer data without using Trimble Geomatics Office.

To use the Data Transfer utility, you need the correct cables for connecting your device to your computer. For information about the cables you need, refer to the documentation for the device you are using.

The following sections describe the basic functions of the Data Transfer utility when accessed from Trimble Geomatics Office. For more information, refer to the Data Transfer Help.

For information about using the Data Transfer utility to transfer files, refer to the *Trimble Survey Controller* or *Geomatics Office User Guides*.

Using Data Transfer from Trimble Geomatics Office

The Data Transfer utility starts whenever you use the *Export* or *Import* dialogs to transfer files to or from a Trimble device. For example, to open the utility you can select the *Feature and Attribute Library (*.fcl) to Survey Controller* option in the *Export* dialog.

Using the Standalone Data Transfer Utility

You can use the Data Transfer utility as a standalone utility. Do one of the following:

- Click  and then select *Programs / Trimble Geomatics Office / Trimble Utilities / Data Transfer*.
- When there is no project open, select *Utilities / Data Transfer*.
- When there is no project open, in the project bar, click the *Utilities* group and then click the *Data Transfer* shortcut.

This lets you transfer any file type to any device.

Setting up Devices Using the Data Transfer Utility

Before using Data Transfer to transfer files between Trimble Geomatics Office and a device, you may need to set up a device.

Devices are system wide—once you have set up a device, it is available in all projects.

The following sections show you how to set up a Trimble Survey Controller device, a GPS receiver device and a survey data card device.

Setting up a Trimble Survey Controller device

Set up a Trimble Survey Controller device before transferring files to or from Trimble Survey Controller. When you have added a Trimble Survey Controller device, you can connect to Trimble Survey Controller during import or export. Trimble Geomatics Office already has a device for a Trimble Survey Controller defined. This section shows how to create your own custom device if necessary.

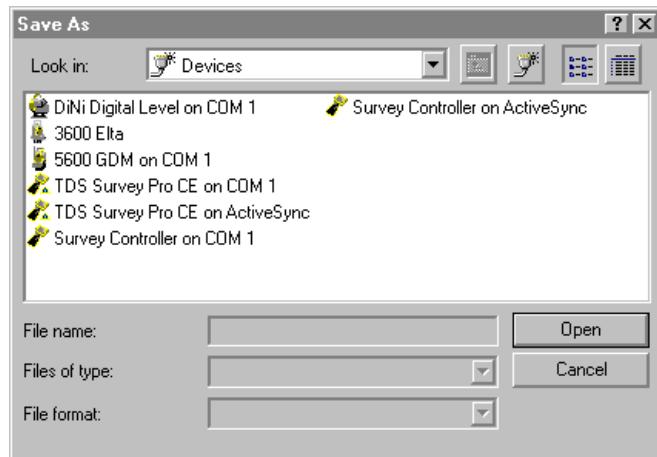
To set up a Trimble Survey Controller device:

1. Do one of the following:
 - Select the *Export*  tool.

- Select *File / Export*.
- Select the *Import*  tool.
- Select *File / Import*.

The appropriate dialog appears.

2. In the *Survey* tab, select the *Survey devices* option.
3. Click **OK**. The *Save As* or *Open* dialog appears:



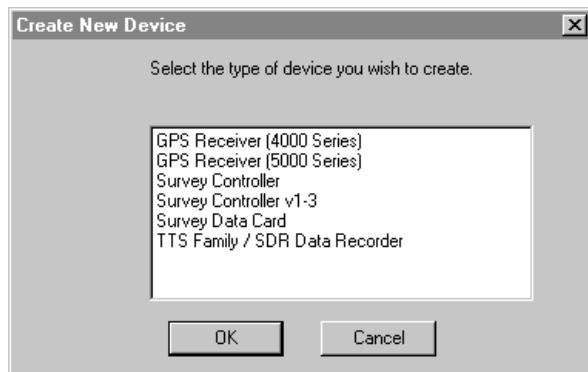
The *Look in* field is set to Devices. Previously created device definitions appear in the window.



Tip – In the project bar, click the *Survey Device* shortcut in the *Trimble Survey*, *Import*, or *Export* groups as a shortcut to the *Open* or *Save As* dialog.

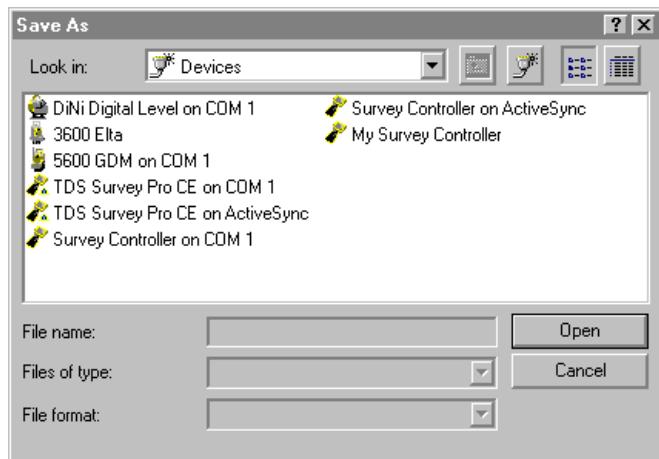
4. Do one of the following:
 - Right-click to access the shortcut menu, and then select *New*.
 - Click the *Create new device*  button.

The following dialog appears:



5. Select the *Survey Controller* option and click **OK**. The *Create Remote Device* dialog appears.
6. In the *Port* field, select the computer port that will be connected to the Trimble Survey Controller and then click **Next**. The *Enter Device Name* dialog appears.
7. In the *Name* field, enter a name for the new Trimble Survey Controller device. This is the name that appears in the *Save As* dialog. For example, enter **My Survey Controller**.

8. Click **Finish**. The following dialog appears:



It displays the new Trimble Survey Controller device.

The Trimble Survey Controller device is now set up. You can transfer data between your computer and Trimble Survey Controller.

Setting up a GPS receiver device

Set up a GPS receiver device before transferring files from a GPS receiver. Once you add a GPS receiver device, you can connect to a GPS receiver device when you import.

To set up a GPS receiver device:

1. Do one of the following:
 - Select the *Import* tool.
 - Select *File / Import*.
2. In the *Survey* tab, select the *Survey devices* option and click **OK**.
The *Open* dialog appears. The *Look in* field is set to Devices and previously created devices appear in the window.

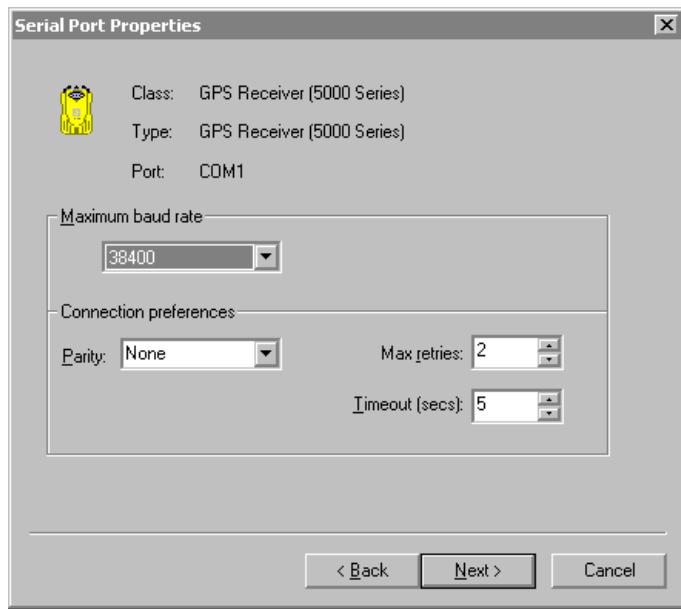


Tip – In the project bar, you can also click the *Survey Device* shortcut in the *Trimble Survey* or *Import* groups to display the *Open* dialog.

3. Do one of the following:
 - Right-click to access the shortcut menu, and select *New*.
 - Click the *Create new device*  button.The *Create New Device* dialog appears.
4. Select the GPS receiver (5000 Series) option and click **OK**. The *Create Remote Device* dialog appears.

Note – You can only use the GPS Receiver 5000 option to connect to a 5000 series receiver, that is, the 5800 or 5700. To connect to a 4000 series receiver, use the GPS Receiver 4000 option.
5. In the *Port* field, select the computer port you use to connect to your GPS receiver and then click **Next**. The *Enter Device Name* dialog appears.
6. In the *Name* field, enter a name for the new GPS receiver device. This is the name that appears in the *Save As* dialog. For example, enter **My GPS receiver**.

7. Click **Next**. The following dialog appears:



8. Select the appropriate serial port settings to allow your computer to communicate with the GPS receiver and then click **Next**. The *Download Properties* dialog appears.
9. Click **Finish**. The *Open* dialog appears. The new GPS receiver device appears in the window.

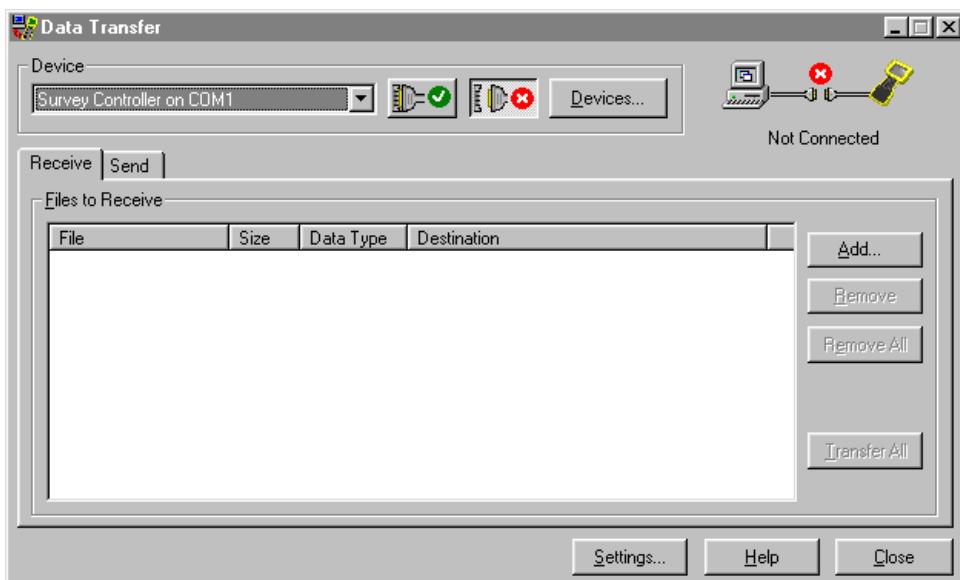
The GPS receiver device is now set up. You can transfer data to your computer from a GPS receiver.

Exercise 7: Creating a device that uses Microsoft ActiveSync

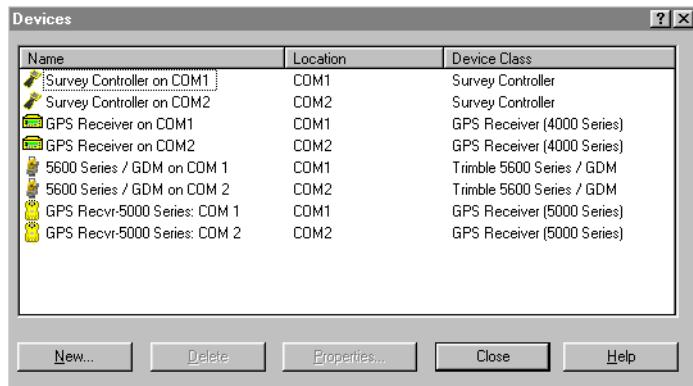
If your computer has Microsoft ActiveSync installed you can use it to transfer data to or from Trimble Geomatics Office. Set up a survey device using Microsoft ActiveSync before transferring files.

To do this using standalone Data Transfer Utility:

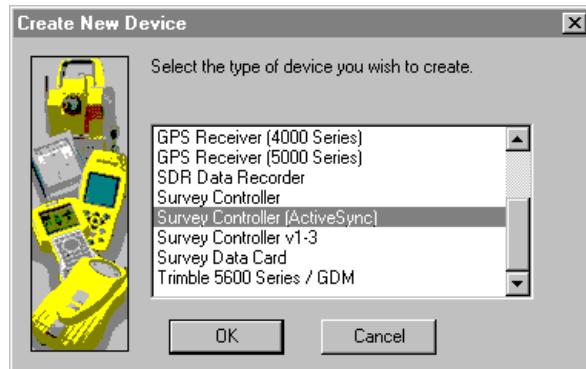
1. Start the Data Transfer Utility. The following dialog appears.



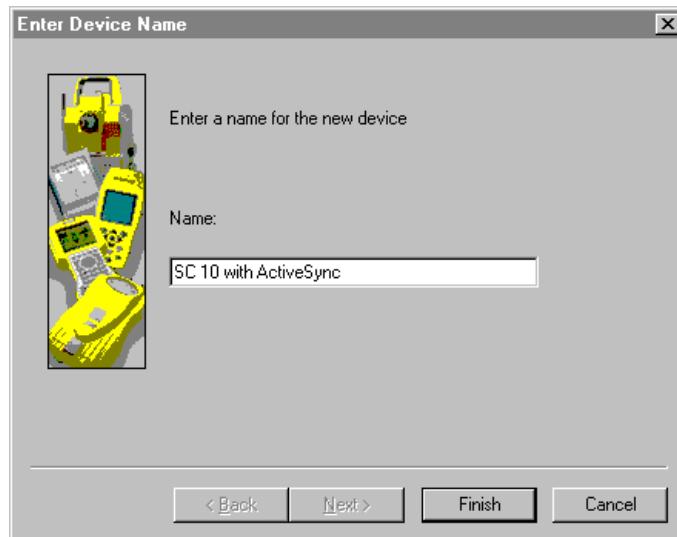
2. Click the **Devices** button. The following dialog appears.



3. Click the **New** button. The *Create New Device* dialog appears.

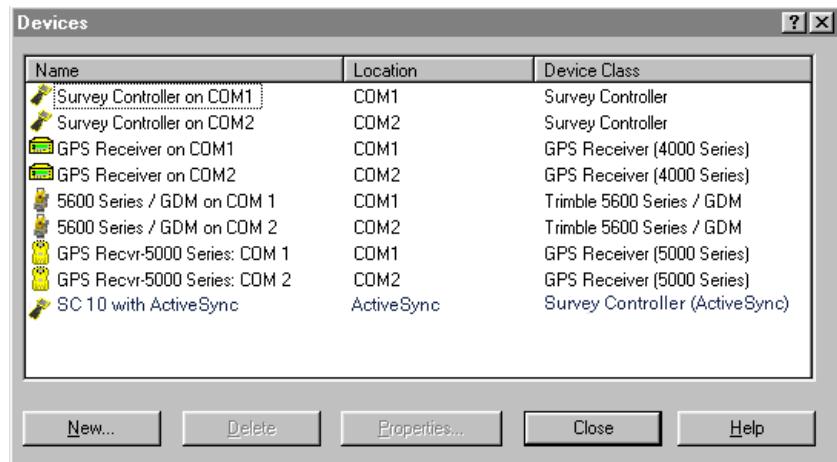


4. Select the *Survey Controller (ActiveSync)* option and click **OK**.
The *Enter Device Name* dialog appears.



5. In the *Name* field, enter a name for the new survey data card device. This is the name that appears in the *Save As* dialog. For example, enter **SC 10 with ActiveSync**.

6. Click **Finish**. The *Save As* or *Open* dialog appears. The new survey controller device appears in the window.



The ActiveSync device is now set up. You can now transfer data between your computer and a controller using Data Transfer and ActiveSync.

Managing Devices

You can create several devices if you have more than one connection to the same device. For example, you can set up more than one Trimble Survey Controller device.

Viewing the properties of a device

To view the properties of a device:

1. Access the *Open* or *Save As* dialogs. For information on how to open these dialogs, see Setting up a Trimble Survey Controller device, page 161.
2. Select the appropriate device.

3. Right-click to access the shortcut menu, and select *Properties*. The appropriate *Properties* dialog appears. If a field is unavailable, that setting is not applicable for the device.
4. Edit the *Properties* dialog as required and click **OK** to apply your changes. The *Open* or *Save As* dialog returns.

Deleting a device

To delete a device at any time:

1. Access the *Open* or *Save As* dialogs. For information on how to open these dialogs, see Setting up a Trimble Survey Controller device, page 161.
2. Select the appropriate device and press **Delete**.

The following message appears:

Are you sure you want to delete '<device name>'?

3. Do one of the following:
 - To delete the device, click **Yes**. The device is removed from the list in the dialog.
 - To cancel the delete, click **No**. You are returned to the dialog.

Importing ASCII data files

This section describes how to import an ASCII file into a Trimble Geomatics Office project.

You can import a variety of data file formats into Trimble Geomatics Office, as well as define your own custom ASCII formats to import. For example, you may have a data file containing control points that you want to import into Trimble Geomatics Office. If you have a data file containing design points that you want to stake out using

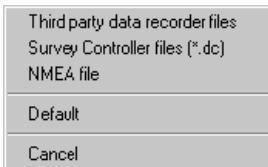
Trimble Survey Controller, you need to import the data file into your Trimble Geomatics Office project, then transfer the points in a Trimble Survey Controller (*.dc) file to Trimble Survey Controller.

Using drag-and-drop

You can use Windows Explorer and the Microsoft Windows drag-and-drop functionality to import data files from a folder on your computer into a project.

To do this:

1. Open Windows Explorer. For more information, refer to your Windows operating system documentation.
2. Locate the folder containing the file that you want to import.
3. Use the right mouse button to drag the file onto the Trimble Geomatics Office graphics window. The shortcut menu appears, as shown below:



4. Select the option that matches the file format that you are importing. If the file format you require does not appear in the list, then Trimble Geomatics Office does not recognize the file format.

To import a file of this type, do one of the following:

- Define a custom import format.
- Use an import filter.

The software imports the file. For more information, refer to the *Trimble Geomatics Office User Guide*.

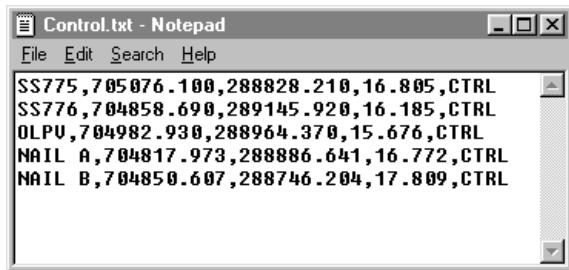


Tip – If you use the left mouse button to drag-and-drop a file, Trimble Geomatics Office uses the extension of the file to determine the file that you are importing. If the file extension is used for more than one import format, the software uses the default format. If you do not know what the default format is, use the right mouse button and select the correct file format.

Exercise 8: Create and import a PacSoft file containing control points

To create a PacSoft file, open a text editor and key in information in the following format:

Point Name,Northing,Easting,Elevation,Feature Code



The screenshot shows a Windows Notepad window with the title bar 'Control.txt - Notepad'. The menu bar includes 'File', 'Edit', 'Search', and 'Help'. The main text area contains five lines of data, each representing a control point in PacSoft format:

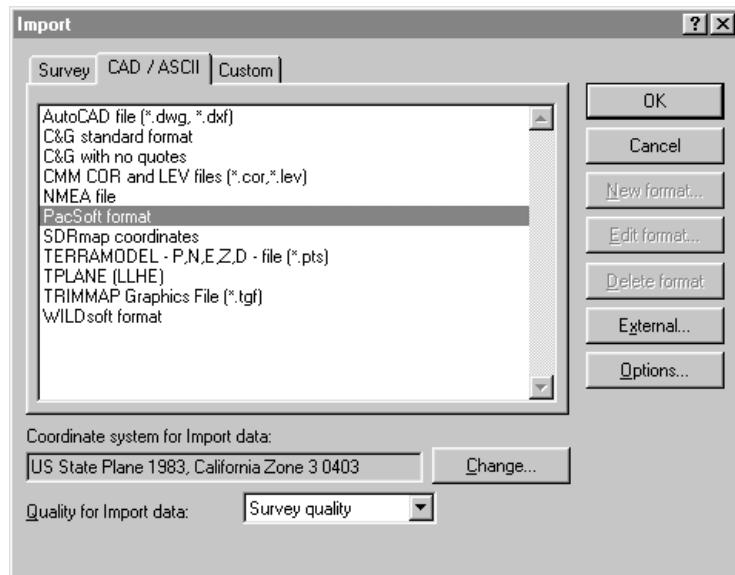
```
SS775,705076.100,288828.210,16.805,CTRL
SS776,704858.690,289145.920,16.185,CTRL
OLPV,704982.930,288964.370,15.676,CTRL
NAIL A,704817.973,288886.641,16.772,CTRL
NAIL B,704850.607,288746.204,17.809,CTRL
```

To import a data file to a project:

1. Do one of the following:
 - Select *File / Import*.
 - Click the *Import*  tool.

The *Import* dialog appears.

2. Select the *CAD / ASCII* or *Custom* tab that contains the appropriate import format, as shown below:



3. Select the file format that you want to import.

If the format does not contain coordinate system information, click **Change** to select the coordinate system for the file to be imported. You only need to use this option if you know that the file you want to import is in a different coordinate system than the project.

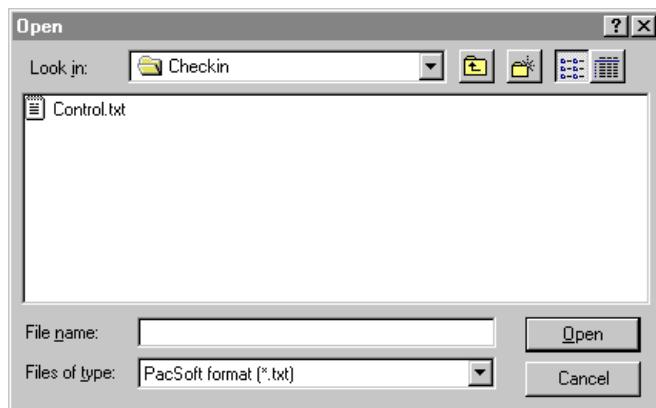
4. In the *Quality for Import data* field, select the point quality for the points in the file.

The quality that you select is assigned to both horizontal and vertical components of the points in the file. You can change the quality of the coordinate components later using the *Properties* window. For example, if the northings and eastings of points are of control quality, but the elevations are *not* of control quality, you can import the points as control quality, then use the *Properties* window to change the elevation qualities.

Do one of the following:

- If the file contains control points for your project, select the *Control* option.
- If the file contains survey quality points (for example, centimeter precision), but are not control, select the *Surveying* option.
- If the file contains mapping quality points (for example, meter precision), select the *Mapping* option.
- If you do not know the quality of the points, select the *Unknown* option.

5. Click **OK**. The following dialog appears:



6. Navigate to the folder where the file you want to import is stored.
7. Select the file and click **Open**.

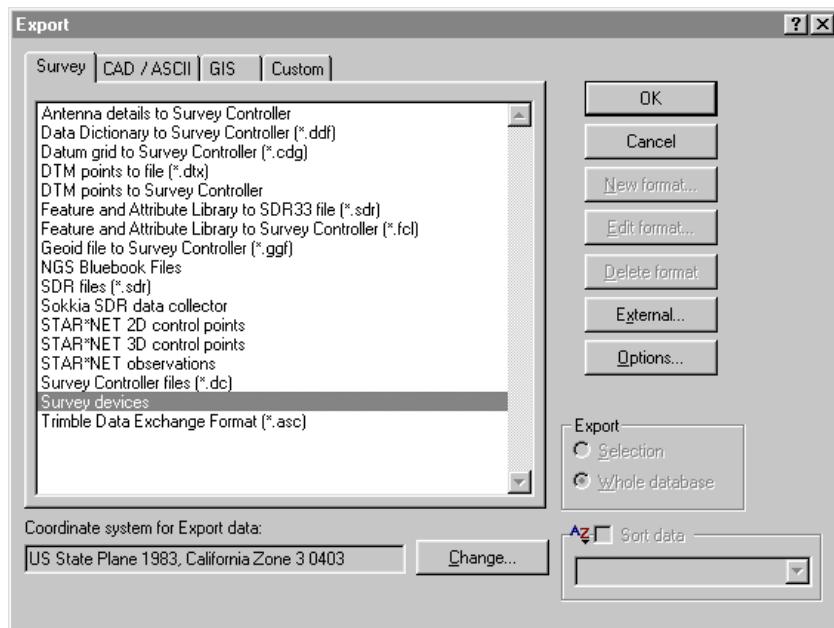
The software imports the file to the Trimble Geomatics Office project.

Exercise 9: Transfer files to Trimble Survey Controller

To transfer files to Trimble Survey Controller:

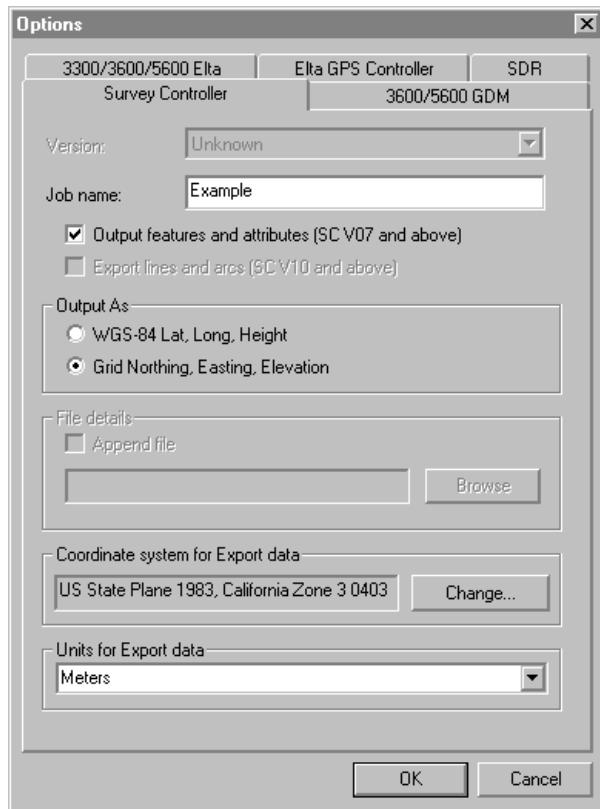
1. Do one of the following:
 - Select the *Export*  tool.
 - Select *File / Export*.

The following dialog appears:



2. In the *Survey* tab, select *Survey Devices* option.

3. Click **Options**. (This button is only available for some export formats.) The following dialog appears:

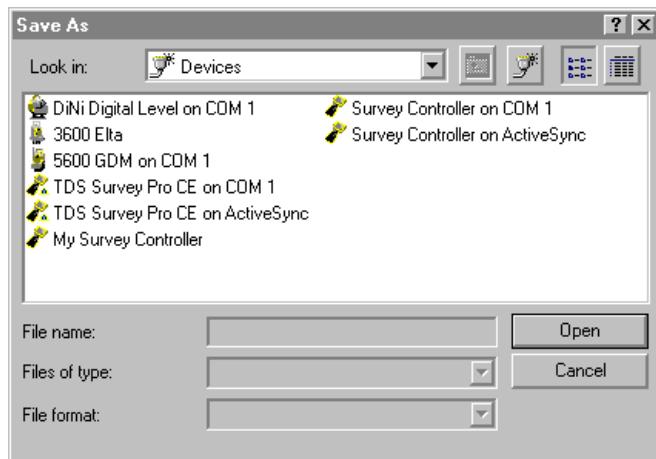


4. Use this dialog to configure the format of the .dc file to be created and whether WGS-84 or Local grid coordinates are to be exported.

Note – Trimble Survey Controller files have a .dc file extension.

5. When you have completed your settings, click **OK** to return to the *Export* dialog.

6. Click **OK**. The following dialog appears:



Once you have checked that Trimble Survey Controller is connected to the correct COM port and is in the appropriate data transfer mode, you can export the data.

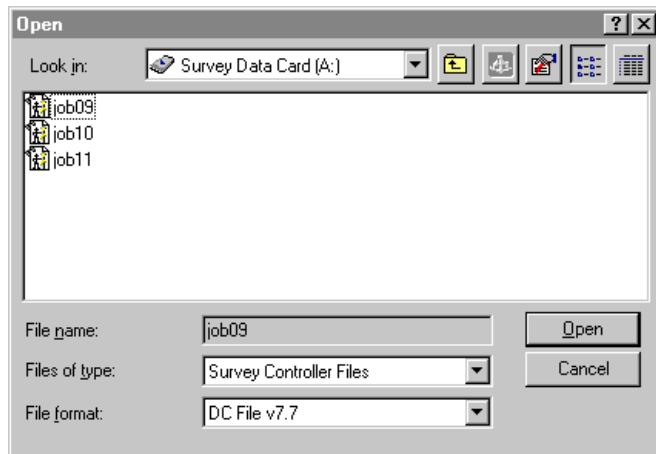
To transfer the .dc file:

1. In the *Open* dialog, select a Trimble Survey Controller device.
2. Click **Open**. The following dialog appears as the computer connects to Trimble Survey Controller:



When the computer makes a connection, the *Save As* dialog returns. The *Look in* field is set to the Trimble Survey Controller device that you are connected to.

3. The software displays all of the Trimble Survey Controller jobs in the memory, as shown below:



4. In the *File name* field, enter a name for the new .dc file. The default name comes from the *Job name* field specified in the *Data Collector Options* dialog from Step 5, page 178.
5. Click **Save** to create the .dc file and transfer it to Trimble Survey Controller.

The *Sending* dialog appears. It shows the progress of the transfer. When the .dc file has transferred, you return to the graphics window.

The .dc file is now in Trimble Survey Controller.

Section 1 — RTK System Components Review

Questions

1. What is the easiest way to configure Trimble Survey Controller?
2. In Trimble Survey Controller, what parameters must be defined before you start any project or job?
3. What is the easiest way to obtain information about Trimble Survey Controller operations when you are in the field?
4. What is an excellent source of information for processes in Trimble Geomatics Office?
5. Name two views in Trimble Geomatics Office.
6. In Trimble Geomatics Office, what is a template?
7. What menu options are used for bringing data into or out of your project database in Trimble Geomatics Office?
8. What is the difference between *Data Transfer* and *Import/Export*?
9. If Trimble Geomatics Office does not support your ASCII file format, what *Import/Export* option can you use to bring that file's data into your project?

Answers

1. Use *Survey Styles*, either Trimble's or your own.
2. Define a map projection, local or published, datum transformation, horizontal and vertical adjustments, and geoid model.
3. Use the Trimble Survey Controller Help.
4. Use the *Help* menu.
5. Plan and Survey view.
6. A template is a definable set of parameters that can be reused when starting a new project. The parameters include: units and format, coordinate system, and general settings.
7. Use the *Import* or *Export* options to bring data into or send it out of your project database.
8. *Data Transfer* is used to transfer data from or to your Trimble Survey Controller/PC card or receiver to your computer.
Import/Export allows you to do the same and import or export data to or from your project database.
9. Use the *Custom* tab and generate your own import/export file format.

Coordinate Systems and GPS Site Calibration Theory

In this chapter:

- Introduction
- Session objectives
- Site calibration overview
- Datum transformation
- The mapping projection
- The horizontal adjustment
- Geoid undulation models
- The vertical adjustment
- Review questions
- Answers

Introduction

This chapter provides an overview of GPS site calibration, including discussions of datum transformations, map projections, horizontal and vertical adjustments and geoidal undulation models. The goal of this lesson is to outline the concepts critical to performing a GPS site calibration.

Session Objectives

At the end of this session, you will be able to:

- Define the following concepts:
 - Datum transformation
 - Map projection
 - Horizontal adjustment
 - Geoidal undulation model
 - Vertical adjustment
- Outline the procedures for a GPS site calibration.

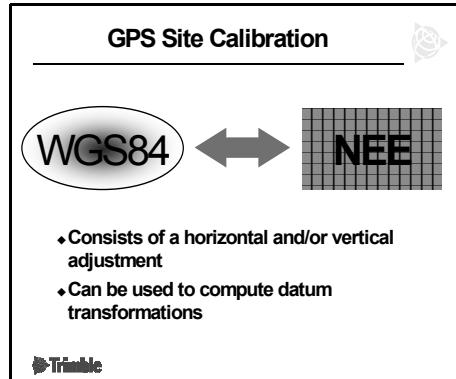
Site Calibration Overview

The GPS site calibration process establishes the relationship between the WGS-84 positions determined by GPS observations and the local coordinates defined by a local map grid with elevations above sea level. A local map grid can be a published one, such as a UTM zone or a US State Plane Coordinate System.

A local map grid may also be an assumed local system defined by the user. This type of grid can have an arbitrary value for the Northing and Easting set at the origin. For example, the value for the origin could be 10,000 North and 50,000 East.

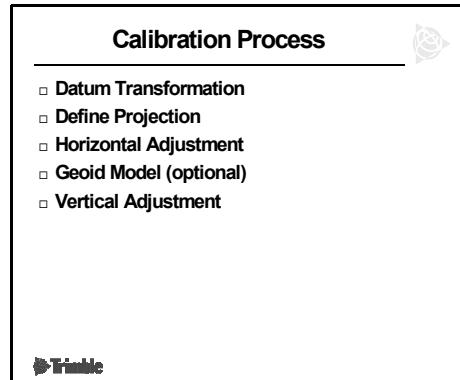
The relationship between WGS-84 and the local coordinates is defined by a series of mathematical parameters. Mathematical transformations and conversions are applied in order to convert WGS-84 positions to grid coordinates.

Note – Before you proceed: In order to understand the GPS site calibration, you must be familiar with the ellipsoid, the geoid, ellipsoid heights, orthometric heights (elevations), geoid height or undulation, datum transformations, and mapping projections.



The calibration process comprises:

- A ***datum transformation*** to convert the WGS-84 latitude, longitude, and ellipsoidal height to the latitude, longitude, and ellipsoidal height relative to the local ellipsoid used in the country where the survey work is taking place. This step is required when the local map grid is projected from an ellipsoid other than WGS-84.



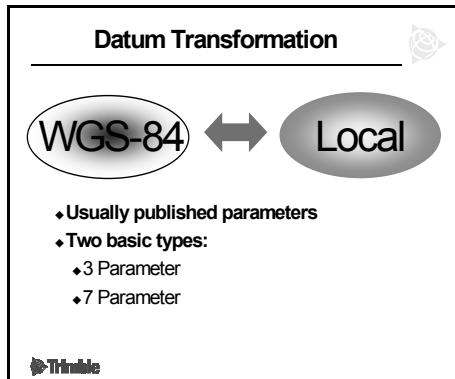
A ***map projection*** to project the local ellipsoid latitude and longitude coordinates onto the local map grid as northing and easting coordinates.

- A ***horizontal adjustment*** of the projected grid coordinates to best fit the local control values. This adjustment allows for any local variations in the projection system that are not treated by the datum transformation. These variations may include orientation and scale.
- A ***geoidal undulation model*** (optional) to mathematically mimic the true geoidal surface.
- A ***vertical adjustment*** to convert the heights referenced to the local ellipsoid to elevations above sea level or to some vertical datum.

We will examine each of the calibration steps listed above in greater detail in the following sections.

Datum Transformation

Simply stated, a datum transformation is a set of mathematical parameters that transform a point's coordinates defined on one datum to the same point's coordinates defined on another datum. The physical point does not change or move. It is the coordinates of the point that will change depending upon the datum in which the coordinates are expressed.



In real-time surveying, positions are determined with respect to the WGS-84 datum. But, very often we work with coordinates that are defined on a datum that may be quite different from the WGS-84 datum. The differences between the WGS-84 datum and the many local and regional datums can be expressed in several ways. The major differences are:

- the location of the origin of each datum and the size
- the shape of the ellipsoid with which each datum is defined

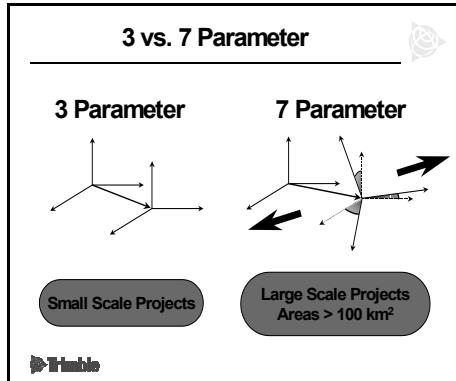
In order to work in local coordinates on local datums, you must account for these differences by employing the use of a datum transformation. There are numerous existing datum transformations. They are published by various governments and agencies all over the world for use in their respective regions. A datum transformation may also be derived for an area by the user.

If there is an existing published datum transformation for the area where you are working, it is best to use it rather than deriving one. If you must derive a datum transformation, Trimble Geomatics Office and the controller provide you with two options. They are the three- and seven-parameter datum transformations.

Three-parameter datum transformation

A three-parameter datum transformation accounts for the difference in the location of the origins of two datums. These differences are expressed as linear shifts along the x -, y -, and z -axes of the 3D Cartesian coordinate system of one datum to the other.

Since the origin of the WGS-84 3D Cartesian coordinate system is at the earth's center of mass, this coordinate system can be an Earth Centered, Earth Fixed (ECEF) Cartesian Coordinate System. This makes it convenient to display the shifts as being from the origin of the WGS-84 ECEF coordinate system to the origin of the local datum.



Seven-parameter datum transformation

A seven-parameter datum transformation accounts for the difference in the location and orientation of axes of two datums, and scale. These differences are expressed as linear shifts along the x -, y -, and z -axes along with rotations around the x -, y -, and z -axes. The scale factor accounts for the ratio of all distances from one datum to another datum.

As in the three-parameter transformation, the shifts are along the WGS-84 x -, y -, and z -axes from WGS-84 origin to the local datum origin. The rotations are determined by calculating the rotation in arc seconds needed for each axis in the WGS-84 ECEF coordinate system to correspond of each of the respective axes in the local Cartesian coordinate system. The scale factor is displayed in parts per million (ppm) from one datum to a second datum.

Datum grid files

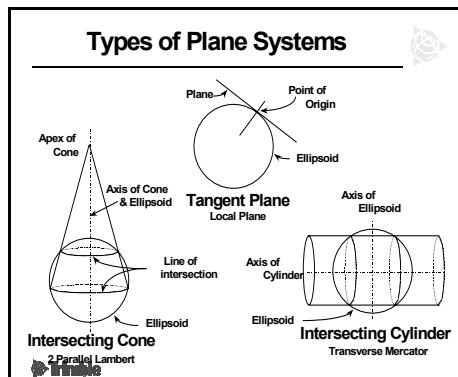
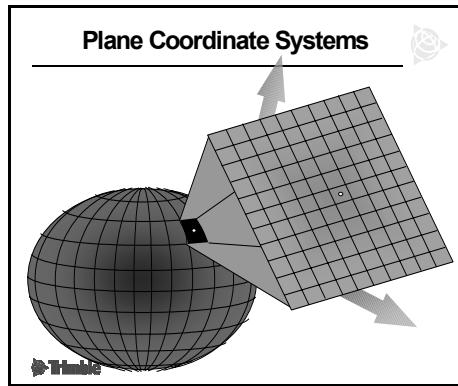
A datum grid file may be used to interpolate the coordinate value between datum transformations for any horizontal point on a grid. NADCON files are supported for users in North America.

The Mapping Projection

Mapping projections are used to represent positions on the curved surface of the earth as points on a *flat* surface or plane. Mapping projection surfaces used in surveying are designed to minimize the distortion that can occur when a curved surface is flattened.

Note – If you are using a local plane, use an estimated elevation value that closely matches the true elevation of the area. This will minimize the distance corrections required due to the elevation above sea level.

A map projection can be described as a function that creates a one-to-one correspondence between points related to the curved ellipsoid and points on the map projection. The parameters defining the relationship between ellipsoidal coordinates and



grid coordinates will include, the latitude and longitude of the origin, the northing and easting at the origin, and scale, among other things.

Some of the most common map projections in the world make use of a conic or a cylindrical shape to develop into conformal mapping surfaces.

There are many existing mapping projections published by the various countries and states throughout the world. For example, in the United States, each state has its own mapping projection.

You may also create localized mapping projections using assumed grid coordinates. For example, a tangent plane projection is a very simple mapping projection requiring only the latitude and longitude and ellipsoid height of the origin, along with corresponding grid coordinates at the origin. A rotation and scale may also be defined for the projection.

The Horizontal Adjustment

After the WGS-84 positions have been transformed and projected as described above, there may still exist some inconsistencies between the grid coordinates produced from the GPS measurements and the grid coordinates that are accepted as true values for the respective points.

To resolve these inconsistencies a horizontal adjustment can be applied to the GPS grid coordinates. The best adjustment of survey data employs the principle of least squares.

The horizontal adjustment is an unweighted least squares best fit of the coordinates for the points determined by GPS to the coordinates of the points accepted as true. In the calibration, a grid coordinate obtained from GPS measurements is paired to a control grid coordinate for each calibration point.

Calibration Process

- Datum Transformation**
- Define Projection**
- Horizontal Adjustment**
 - ◆ Rotation
 - ◆ Translation
 - ◆ Scale

► Trinble

The result of the least squares best fit is a single set of parameters that describe how to make the GPS derived coordinates fit, as closely as possible, to the control coordinates. The parameters are:

- **Rotation** of the GPS coordinates around the project centroid.
- **Translation** of the GPS coordinates in the north (\pm) and east (\pm) directions.
- **Scale** factor for the GPS coordinates to make them fit the control coordinates as closely as possible.

These parameters are derived simultaneously during the horizontal adjustment portion of the GPS site calibration.

To perform the horizontal adjustment, at least three control points are needed. Each of these points must be observed with GPS as well as possess control coordinate values. Three points are required for the horizontal adjustment because it takes two points to derive the adjustment parameters and one

Horizontal Adjustment

- ◆ At least 3 horizontal control points are required
- ◆ 5 points are recommended

► Trinble

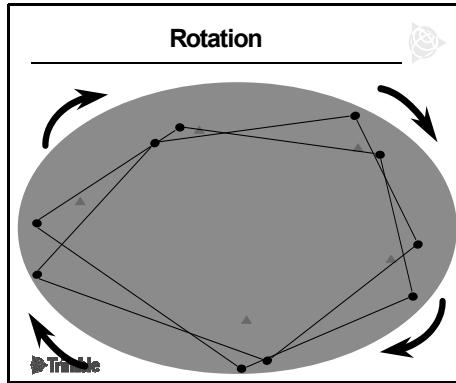
additional point to provide a **check** on the fit obtained from those parameters. This check appears as residuals for each point in the calibration.



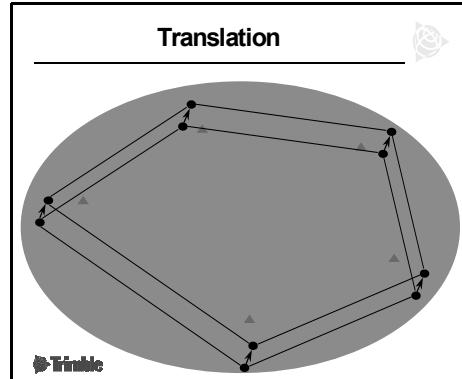
Tip – Trimble recommends that you use more than the minimum number of control points in a GPS site calibration, and also use control coordinates that originated from the same control adjustment. This ensures that datum and adjustment differences do not introduce significant error into the site calibration.

The parameters resulting from the horizontal adjustment are described below.

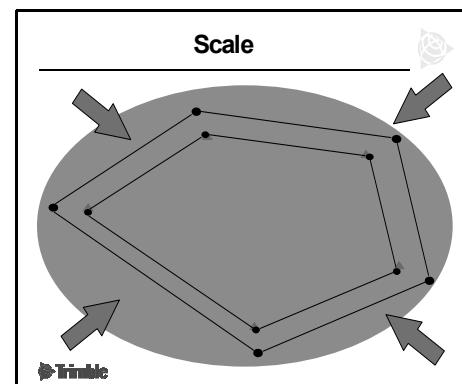
All of the horizontal points in the calibration are used to calculate a centroid (geographic center) about which a rotation of the GPS grid coordinates is applied. All of the observed GPS points in the project, even those not used in the calibration, will be rotated by the same angular amount. A minimum of two horizontal calibration point pairs are required to calculate a rotation parameter.



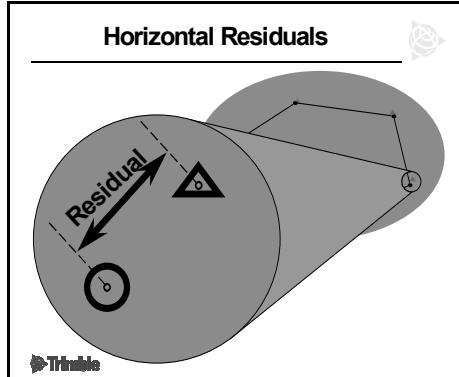
A translation moves all of the observed GPS coordinates in the same direction and by the same distance, so that they lie closer to the control coordinates. The translation parameter will be applied to all of the observed GPS (WGS-84) positions in the project. A translation parameter will be calculated with as few as one horizontal point pair used in the calibration.



A scale factor is determined using a ratio of the *true* distances, calculated between horizontal control coordinates, and the distances calculated between the GPS grid positions for the same points. This ratio of these two distances is the scale factor. The scale factor is applied to all of the GPS coordinates to obtain the best possible fit to the control coordinates. At least two point pairs must be used in the calibration to calculate a scale factor.



After the best fit is obtained and the GPS points are moved using the single set of parameters, there are still minor discrepancies between the GPS derived coordinates and the control coordinates. These discrepancies are called **horizontal residuals**. They should be relatively small. They are used to determine the quality of fit that results from the least squares adjustment.



If the quality of the control coordinates was uniform and the GPS observations were all performed in the same way, then the residuals should all be roughly the same size.

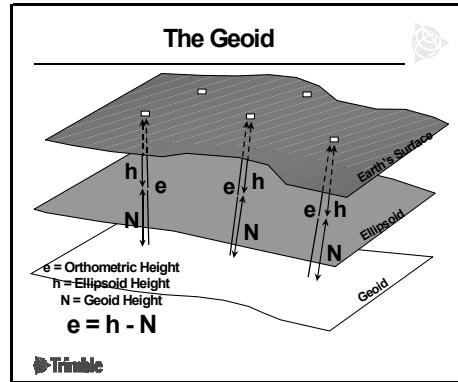
Note – The site calibration is performed to obtain the parameters that allow conversions from the local coordinate system to WGS-84 coordinates and back again. The final coordinate values for the GPS-derived observations of the control marks are used to generate residuals. The GPS derived control coordinates will not be used because known control values already exist for those points.

As part of any proper least squares adjustment, information for analyzing the results is produced as output. After the calibration is computed, a report can be generated. The report will indicate the point having the largest horizontal residual and the root mean square (RMS) of the residuals used in the site calibration network. This is very helpful in deciding whether the site calibration is satisfactory or not.

More details about the calibration report can be found in the examples of calibrations in the following chapters.

Geoid Undulation Models

The geoid is an equipotential gravity surface for the earth which, on average, coincides with mean sea level in the open oceans. It is influenced by large masses on, or beneath, the Earth's surface. The effect of these masses is to warp the shape of the geoid. This uneven shape is called **geoid undulation**.



Because of the irregularity of the earth's surface, the ellipsoid is not always beneath the earth's surface.

Orthometric heights (elevations) (**e**) relate the geoid to the surface of the Earth. These heights are commonly referred to as heights above sea level.

Geoid separations (**N**) relate the geoid to a reference ellipsoid, for example, the WGS-84 ellipsoid.

The basic relationship that exists between these quantities is:

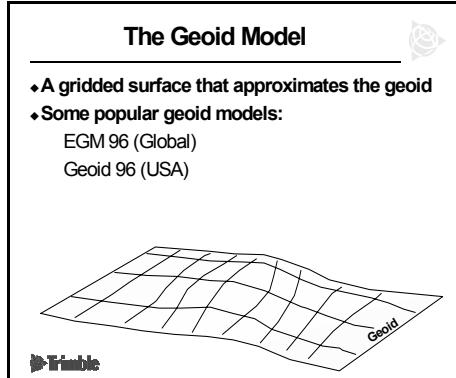
$$e = h - N$$

Where:

- **e** = orthometric height (from levels or other sources)
- **N** = geoid separation (from geoid model, if available)
- **h** = ellipsoidal height (from GPS)

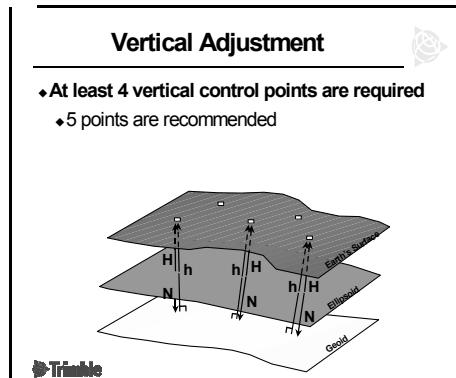
Geodesists try to model the geoid by estimating the amount of separation between the geoid and ellipsoid at particular locations. This separation goes by several names: geoid separation, geoid undulation, and geoid height. (**Geoid height** is very misleading. The geoid height is NOT a height above the geoid, rather it is the distance from the ellipsoid to the geoid.)

EGM96 (Global) and Geoid99 (Conus) are geoid models designed for the world and North America, respectively. Each model consists of a grid and an interpolation scheme. They provide us with an estimate for the separation, called N_m , between the two reference surfaces when given a particular latitude and longitude.



The Vertical Adjustment

The vertical adjustment is the last part of the calibration to be computed. This part of the calibration is where the orthometric elevations for all of the points are made to agree, as closely as possible, with the control benchmark elevations. If no geoid model is provided, then the



undulation of the geoid with respect to the ellipsoid must be resolved. This will produce a simple planar geoid model for the project area.

The source of the control elevation values could be from benchmarks established and published by a government agency, or they could be established by the user from differential leveling or precise trigonometric leveling.

For the vertical adjustment:

- Three fixed points uniquely define an inclined plane.
- Four fixed points uniquely define an inclined plane with measurable residuals.

Note – Calibrating to only one known vertical point will maintain the shape of the geoid model, resulting in a vertical shift in the model's position. Using two or more calibrated points results in a slope or plane computed by the observed points, rather than the undulating geoid model.



Tip – If necessary, you can complete a survey which relies solely on the geoid model. However, if you do so, you should always check at least two known elevations to confirm that the geoid model truly fits your survey site.

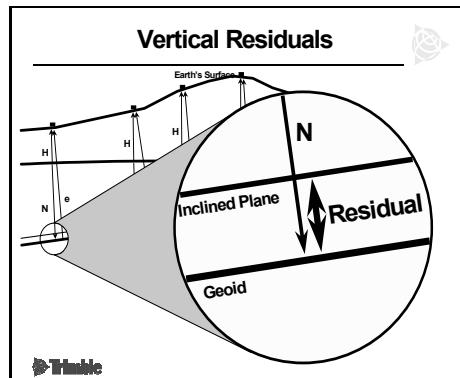
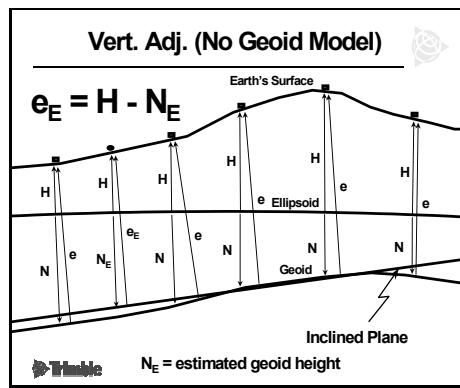
The vertical adjustment with no geoid model

When no geoid model is present, the vertical adjustment provides a simple planar geoid model using a least squares best fit of the geoid separations (N) that are calculated using the known orthometric elevations on the benchmarks (e) and the ellipsoid heights (H) obtained for the benchmarks using GPS.

The result of the least squares best fit is an inclined plane that approximates the geoid.

At each calibration benchmark, the difference between the calculated geoid separation and the approximate value derived from the inclined plane can be calculated. These differences are called residuals. Contrast these residuals to those calculated using a known geoid model.

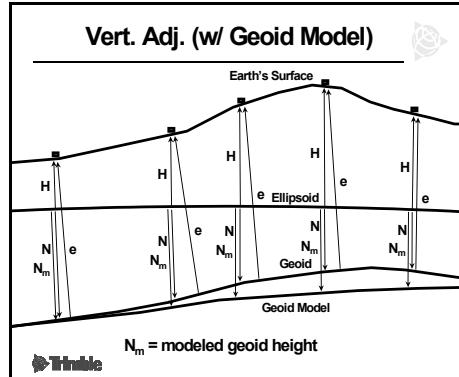
As part of any proper least squares adjustment, information for analyzing the results is produced as output. After the calibration is computed, you can generate a report that indicates the point having the largest vertical error and the RMS of all the residuals in the site calibration network. This is very helpful in deciding whether the calibration is satisfactory or not.



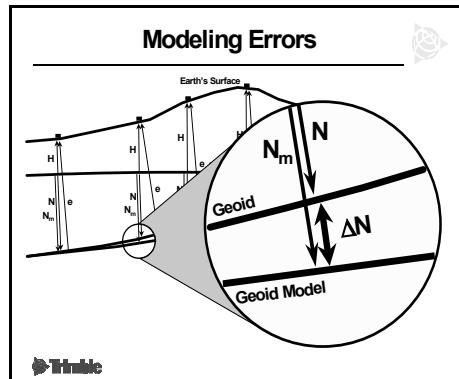
The vertical adjustment with a geoid model

Note – You do not have to reference to the Geoid as your vertical datum. The height adjustment can be made to any vertical datum.

As shown in the slide, the gridded geoid model may not accurately describe the true geoid undulation in the project area. There will be small differences between the geoid shape described by the benchmarks and the modeled geoid.



For each of the vertical site calibration points, the observed ellipsoid height (N) and the orthometric elevation (e) can be used to calculate a value for the geoid separation. This calculated value for N can then be compared to the N_m value, obtained from the geoid model. The comparison provides a ΔN value for each calibration benchmark.



These ΔN values can be used in a least squares best fit to provide **corrections** to the separations provided by the geoid model (N_m). This is accomplished by making a plot of the ΔN 's positioned at each benchmark northing and easting. An inclined plane is fit to the ΔN values. The plane will not fit perfectly through all of the

ΔN values. Differences between the plane and each ΔN is the vertical residual for that point. Vertical **residuals** will be computed for each calibration benchmark.

The inclined plane provides geoid model correction values (N_c) for all of the points that are not calibration benchmarks. The correction at each point (N_c) is subtracted from the separation obtained from the geoid model (N_m) to produce a better estimate for the orthometric elevation (e_E).

Elevations are calculated for these points using the adjusted separations and observed ellipsoid heights from RTK. The results are elevations for the survey points that agree with the local controlling benchmarks.

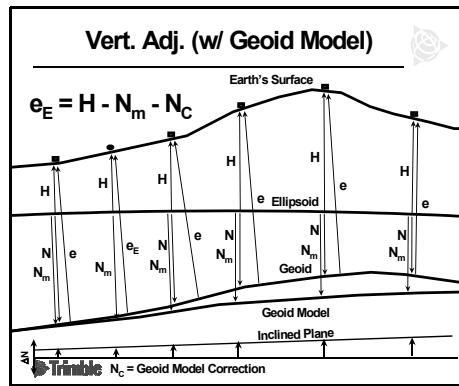
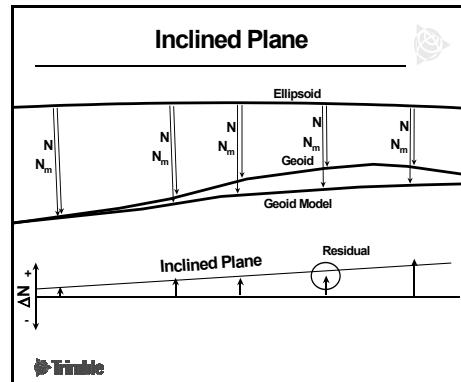


Figure 10.1 shows the calibration process.

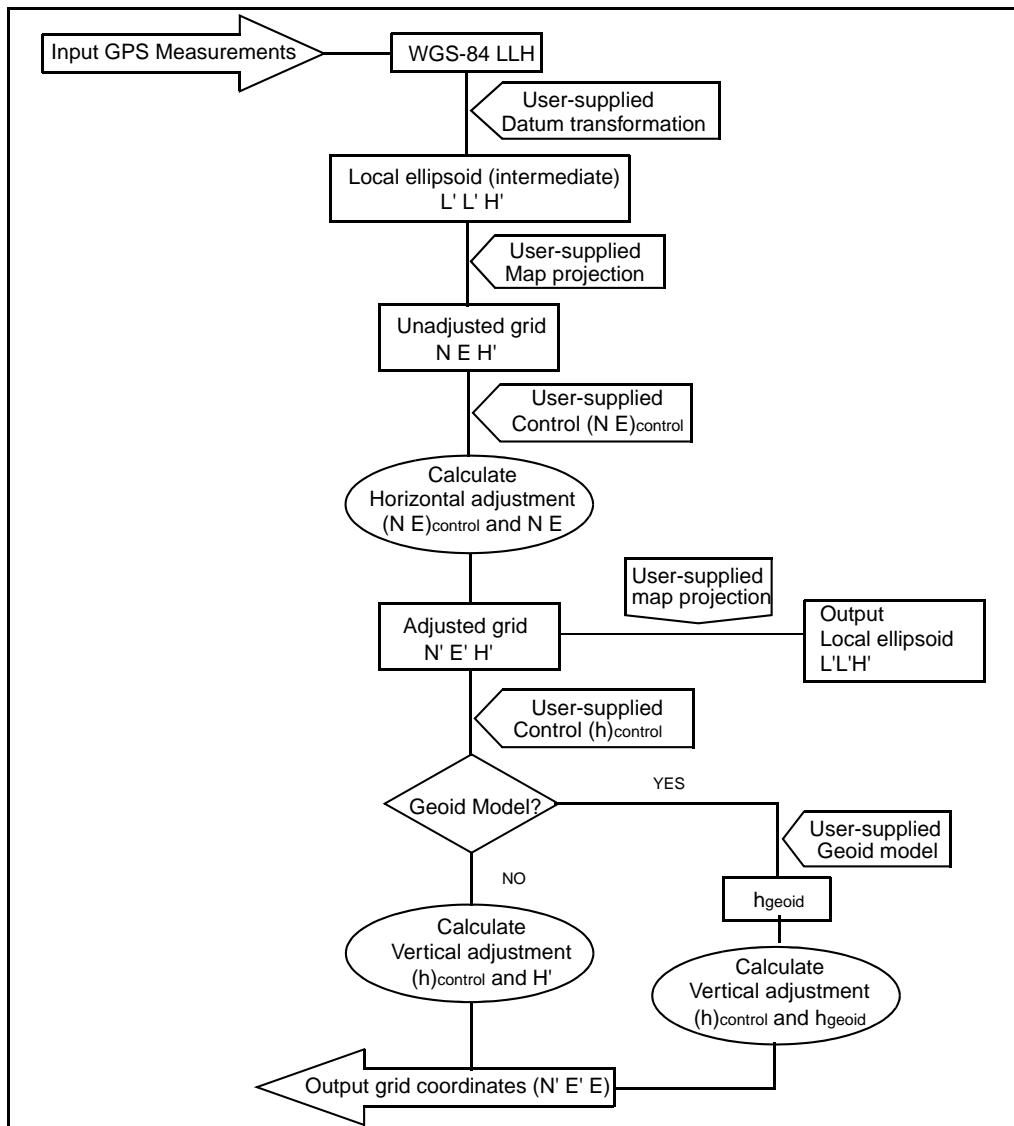


Figure 10.1 Calibration calculation process

When to calibrate

For a GPS survey or a survey that combines GPS measurements and conventional measurements with local control points, always complete a calibration **before** staking out any points, or computing offset or intersection points.

For a survey that uses conventional measurements only, no calibration is required.

Notes and recommendations

- You can perform a calibration using one of the real-time GPS Survey Styles in Trimble Survey Controller. Do a manual calibration, or let Trimble Survey Controller do it automatically. If all the points have been measured, there is no need to connect the controller to a receiver during a manual calibration.
- Multiple calibrations can be performed in one job. The last calibration performed and applied is used to convert the coordinates of all previously surveyed points in the database.
- You can use up to 20 points for a calibration. Trimble strongly recommends a minimum of four 3D local grid coordinates (N, E, E) and four observed WGS-84 coordinates, with the local projection and datum transformation parameters (the coordinate system). This should provide adequate redundancy.

Note – You can use a combination of 1D, 2D, and 3D local grid coordinates. If no projection and no datum transformation are defined, you must have at least one 2D grid point.

Note – If the coordinate system is not specified, Trimble Survey Controller calculates a Transverse Mercator projection and a three-parameter datum transformation.

- Use Trimble Geomatics Office, Data Transfer, GPSurvey, or ASCII transfer to transfer control points.

- When naming points, use different names for Grid and WGS-84 coordinates, for example, *Grid 100* for a Grid point and *WGS 100_GPS* for a WGS-84 point. For more information about data search rules, refer to the *Trimble Survey Controller User Guide*
- The set of WGS-84 coordinates must be independent of the set of grid coordinates.
- You select the grid coordinates. Select the vertical coordinates (Elevation), the horizontal coordinates (Northing and Easting values), or all of these together.
- Place the calibration points around the perimeter of the site. Do not survey outside of the area enclosed by the calibration points, as the calibration is not valid beyond this perimeter.
- The origin of the horizontal adjustment in a calibration is the centroid of the measured calibration points. The origin of the vertical adjustment is the first point in the calibration that has an elevation.
- When reviewing a calibration point in the database, notice that the WGS-84 values are the **measured** coordinates. The grid values are derived from these, using the current calibration.

The original keyed-in coordinates remain unchanged. (They are stored elsewhere in the database as a point with the *Type* field showing Keyed in coordinates and the *Stored as* field showing Grid.)

- When you are calibrating a no projection, no datum job, (where Ground coordinates are required after calibration) you must define the reference elevation (average site elevation). When the job is calibrated, the reference elevation is used to compute the scale factor for the projection, using the inverse of the ellipsoid correction.

When Grid coordinates are specified, the scale factor in the projection is set to one after a site calibration.

- When you are calibrating a Scale-only job, the scale factor specified in the Scale-only job is used as the scale factor in the projection after calibration.

Review Questions

1. What is the purpose of the GPS Site Calibration process?
2. What are the five steps in the site calibration process?
3. What data is required to perform a GPS Site Calibration?
4. What does a Datum Transformation accomplish?
5. What three parameters are defined in the Horizontal Adjustment?
6. What term defines the difference between the known coordinate and the computed coordinate of a point, once the horizontal parameters have been applied to the measurement?
7. Is it necessary to use a geoid model in the GPS Site Calibration?
8. What is the minimum number of horizontal and vertical control points required to perform a *good* calibration?
9. When selecting control for your calibration, what two constraints should you keep in mind?
10. What naming convention could you use during a site calibration?
11. What are the three main components of site calibration?
12. What are the four summaries you can review after you compute a GPS site calibration?

13. How do you obtain more details about your site calibration results?
14. If the calibrated site is acceptable, and you wish to use it for several different projects, what is an efficient method for saving the site calibration?
15. When should you fix your horizontal scale factor to 1.0 during the site calibration?

Answers

1. You are determining the parameters necessary to relate measurements made on the WGS-84 datum to local coordinates defined by a map projection and elevations related to some vertical datum.
2. The five steps in the calibration process are: Datum Transformation, Define Projection, Horizontal Adjustment, Geoid Model and Vertical Adjustment
3. To perform a GPS Site Calibration, you must have known control points in your local coordinate system and measurements of those control points in WGS-84
4. A Datum Transformation is the parameters and mathematical computations required to translate coordinates on one datum to another datum. These parameters are normally defined and published.
5. The three parameters defined in the horizontal adjustment are: Rotation, Translation, and Scale factor of the local coordinate system anomalies.
6. The term is residual (horizontal).
7. No, the vertical adjustment can be made on any vertical datum.
8. The minimum number is: three horizontal and four vertical.
9. Your control encloses the project area, and you must maintain good network geometry (horizontal and vertical spread throughout your project, and vertical not in a line).
10. Placing a prefix, such as G, before the original grid name of the observed GPS positions
11. Datum transformation, horizontal adjustment, and vertical adjustment.
12. Horizontal adjustment scale factor, maximum vertical adjustment inclination, maximum horizontal residual, and maximum vertical residual.

13. Select **Report**.
14. You can save the calibration as a site. When you start a new project, you can use that site to quickly configure your coordinate system.
15. To check how robust your GPS distances are.

Feature Codes

In this chapter:

- Introduction
- Session objectives
- Feature codes and attributes
- Topographic surveying overview
- Collecting a code and attribute in the field
- Types of feature codes and attributes
- Feature code list and data dictionary
- Default feature code list
- Review questions
- Answers

Introduction

This chapter describes how to extend and improve your field data collection by incorporating feature codes and attributes. It outlines the procedures required to create and export a feature and attribute library, as well as the procedure to review and utilize the exported feature code list and data dictionary in Trimble Survey Controller.

A default Feature Code list is included on page 230.

Session Objectives

At the end of this session, you will know:

- The types of feature codes and attributes
- Topographic surveying fundamentals
- The methods of feature code collection
- How to create and export a feature code list
- How to process feature codes

Feature Codes and Attributes

Survey Controller allows you to assign feature codes to the points you are collecting, along with attributes that define the characteristics of the point.

A feature code:

- is an alphanumeric code that describes the point you are collecting.
- can be used to automatically generate plans.

An attribute:

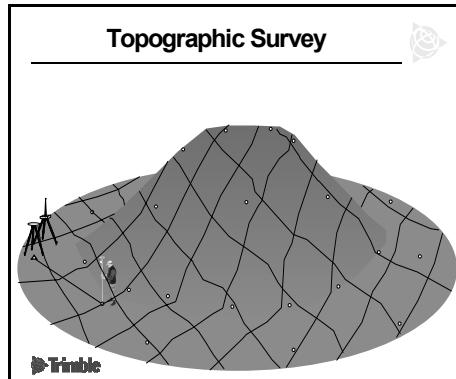
- describes the characteristics of a point you are collecting.

- can be thought of as questions about a feature that you want answered during data collection. For example, *Surface Type* would be the appropriate attribute for the question, “What is the surface of the road?”
- has assigned values which can be thought of as answers to the question about the feature. For example, attribute values for a *Surface Type* attribute include dirt, gravel and asphalt. When collecting a feature, enter the appropriate attribute value.

Topographic Surveying Overview

Many points can be observed in a short period of time. These data can be used for:

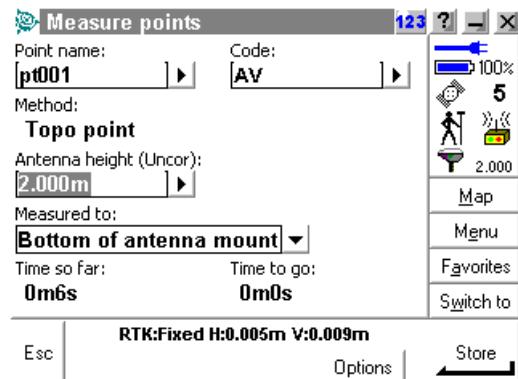
- Engineering design work
- As-built surveys
- Digital Terrain Models (DTMs)
- Triangulated Irregular Networks (TINs)
- Geographic Information System (GIS) data collection



Collecting a Code and Attribute in the Field

A *Feature Code* and *Attribute* may be entered from any *Measurement* screen, as the Topo point with code *SIB*, shows in the following screen:

You can extend the usefulness of GPS positioning by attaching a feature code, attribute, and attribute value to describe the nature of points observed in the field.



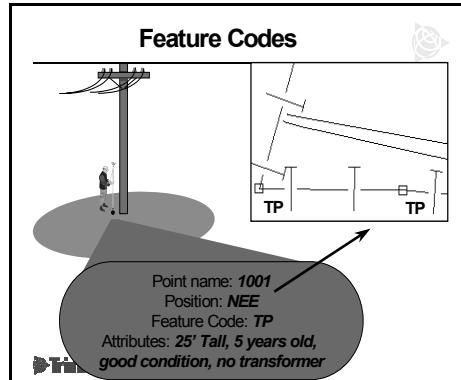
- Each code is attached to a point to represent a feature you wish to measure in the field.
- By selecting **Attrib** you can add point attributes (as established by a feature and attribute library or a data dictionary currently loaded into the controller).
- Codes can be alpha, numeric, or alphanumeric.
- Trimble Geomatics Office processes feature codes using an appropriate Library.

Note – Feature Codes can be stored in the controller and can be exported through Trimble Geomatics Office to a third-party software package for further use.

Telephone pole example

Feature codes and attributes can be used to describe the points observed in the field, as described below:

- You can locate a telephone pole with the GPS rover, and enter a Feature Code (such as *TP*) to represent a telephone pole. Additional attribute information or notes about the pole can also be stored in the .dc file.
- When the code *TP* is processed in Trimble Geomatics Office software, the code from the field observation is matched with a processor code of the same name. The symbol for the telephone pole (\square) is then displayed in the Trimble Geomatics Office DB at the exact recorded position.
- After processing, all stored features with the same feature code name display the same symbol.
- The attribute information is stored as a record in the .dc file. To access to the attribute information in Trimble Geomatics Office:
 - Use the mouse or selection options to select any point.
 - Then select the point *Properties* dialog and edit the *CAD* tab.



For more information on features, attributes, and data dictionaries, refer to the *Trimble Geomatics Office User Guide*.

In Trimble Geomatics Office, a table of processor codes is called a Feature Code Library. Use this to produce a Feature Code List in the controller.

Note – If you do not have any points in the database that contain feature codes, you can change the feature and attribute library associated with the project. However, once you import a controller file containing features and attributes, or add a feature using the Properties dialog in the Trimble Geomatics Office, the feature and attribute library associated with the project becomes fixed, and you cannot change feature and attribute libraries for that project. This ensures that you have consistent feature and attribute data throughout the project.

Types of Feature Codes and Attributes

There are three basic types of feature codes:

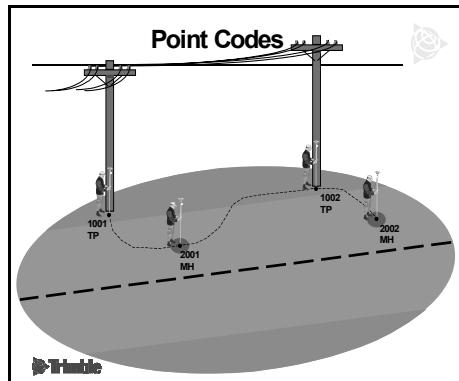
- Point
- Control
- Control with Parameters

There are also three types of attributes:

- Menu
- Text/Numeric
- Date/Time

Point code

A Point Code represents a single point feature and displays a singular feature symbol or line style to represent it—as in the previous example of a telephone pole.

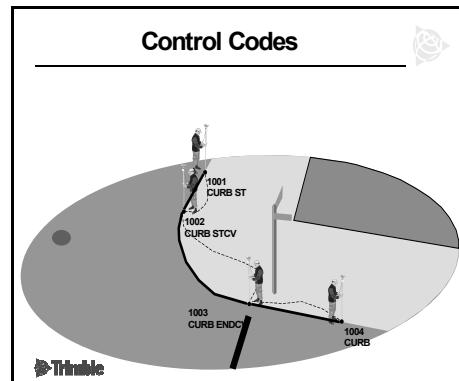


Tip – You can efficiently manage points by distributing codes into predefined layers.

Control code

A Control Code uses the flow of data storage of point names. The processor searches for the previous numerical point name that has the same Feature Code and joins the two or more points with a line.

The example indicates a curb's curved line, using the control codes CURB ST, CURB STCV, CURB ENDCV, and CURB.

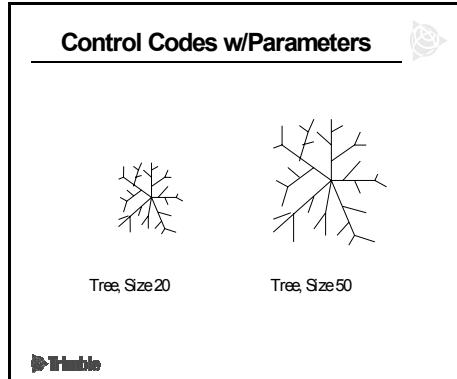




Tip – To meet your requirements, you can customize control codes for the description of curved roadways to meet your requirements. For example, use PT for point of tangent and PC for point of curvature on a curve.

Control code with parameters

A Control Code with Parameters is a more advanced Control code. It allows you to join line work to points across pathways that you do not physically cross during the data collection. Or, it allows you to increase the size of a feature so that, after processing, it displays more to the true scale of the object.



The example illustrates the true size of a tree (to better represent the symbol on the map or plan), after the control code with parameters has been processed in the office.



Tip – For more information on feature coding and creating feature code libraries, consult the Help information in Trimble Geomatics Office.

Attribute values

When collecting data in the field, each set of ***attribute values*** may be characterized by one of the following on-screen formats:

- ***Menu Attributes*** – a predefined list consisting of the possible ***attribute values*** from which you choose. If you do not select a value, the default is entered automatically.

- **Text and Numeric Attributes** – a text-entry field into which you can type the *attribute value*. For a *numeric attribute*, you enter a number.
If you do not enter a value, the default value is entered automatically.
- **Date and Time Attributes** – a text-entry field with *Today* (for dates) and *Now* (for times) already entered.
 - If you accept *Today*, the current date is entered.
 - If you accept *Now*, the current time is entered.If appropriate, you can manually enter date and time attributes.
- **File Name Attributes** – a text-entry field. This attribute allows you to input a directory and filename of a graphic file, such as a bitmap, for reference.

Methods of feature code collection

There are two basic methods for collecting data using feature codes:

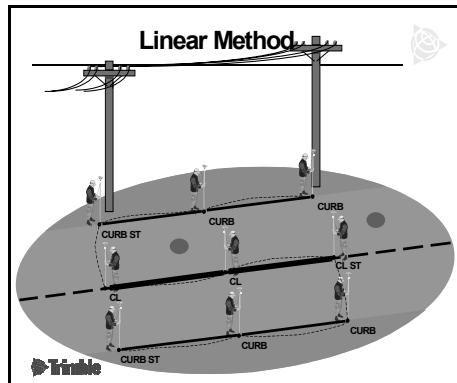
- Linear
- Cross-sectional

You can use either method, or a combination of both, but be aware of your point number generation order, especially when collecting line features.

Linear method

Consider using a linear method of data collection when:

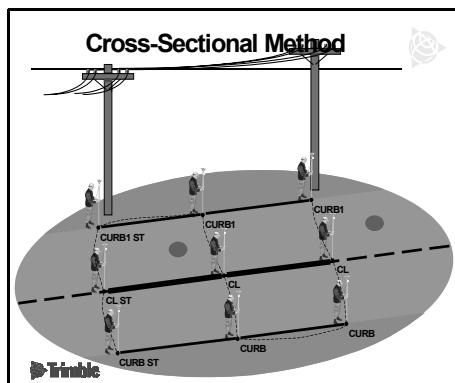
- the scale of your topo survey is large
- you are collecting a number of features with the same code
- for safety reasons



Cross-sectional method

Consider using a cross-sectional method of data collection when collecting:

- a large number of features
- road-design survey data.



Feature Code List and Data Dictionary

The following sections give a description of the feature code list and data dictionary.

What is a feature code list?

A *feature code list* is derived from the *feature and attribute library* created in Trimble Geomatics Office software. The feature code list is the alphanumeric code descriptors transferred from Trimble Geomatics Office to the controller, using the Data Transfer program.

The list can be transferred to your controller to reduce the amount of typing required in the field.

A feature code list can also be created in the field by entering and editing the codes in the controller.



Tip – The feature code processing in Trimble Geomatics Office works properly only if the feature codes used in the field exactly match with the feature codes in Trimble Geomatics Office. Using a feature code list standardizes the use of these codes.

What is a data dictionary?

A data dictionary:

- defines the types of features that you can capture in the field, along with attributes relevant to a particular project or job. It is used in the field to control the capture of features (objects) and attributes (information about those objects).
- includes a list of features that are captured in the field and, for each feature, a list of attributes that describe the feature.
- is created according to your intended applications. Since different users have differing collection requirements, each user or group of users can design data dictionaries to suit their needs.

Note – *Data dictionaries are used for GIS data collection. A feature and attribute library (feature code list) is synonymous with data dictionary.*

Exercise 10: Creating the Feature Codes with Attributes

The following exercise shows how to create a feature code called *Lamp Post*. This example also shows how to assign attribute definitions to a feature.

Note – You can also edit the properties of an existing library which already contains codes and attributes.

To create the lamp post feature code:

1. To access the *Feature and Attribute Editor*, click  .
2. Select *Programs / Trimble Geomatics Office / Trimble Utilities, or click  Feature and Attribute Editor* .
3. To display the default library, select *File / Open*.
4. Select and open the default library.
5. To build a new feature code with attributes, select *Edit / New*.

To define your feature code, from the *New Feature Code* properties:

1. In the *Feature Code* field, enter *LP2* for a lamp post.
This will be exported to the controller as part of the feature code list.
2. In the *Description* field, enter the full description of the feature: *Lamp Post 2*.
3. Click the *Point* tab.
This is where you define how points with a code of *Lamp Post* display in the Plan View of Trimble Geomatics Office.
4. Highlight the *point style* you want to use (in this case, *Lamp Post*).

The symbol on which the style is based appears. In the *Layer* field, [*Default layer*] is selected automatically.

If you want to put all Lamp Post points into a particular layer, select that layer. This is useful if you are handling large amounts of data that you want to display in different views.

1. Enter the layer or select from the list.
2. Use the *Annotation* field, to select an annotation style.

We will not use this field. However, if an annotation style exists, all points coded with *Lamp Post 2* are annotated according to the defined style.

Note – To learn more about how to create annotation styles, use the Feature and Attribute Editor / Help topics.

3. Define a line. In this case, focus only on lamp posts and select: *No line style*.

Linework could be used to connect all of the lamp posts together with a line.



Tip – You may create your own symbols and line work using  *Symbol Editor* and  *Line Type Editor* icons from the Trimble utilities programs.

Now work with the *Attributes* tab to define a set of attributes for the *Lamp Post 2* feature code.

1. Click **New**.

The *New Attribute* dialog appears.

2. Define a numeric attribute named *age* for the feature code Lamp Post.
 - a. In the *Name* field, enter *Age*.
 - b. Select the *Numeric* option.
 - c. Click **OK**.

The attribute details appear. The items that display in the *Attribute Properties* group depend upon the currently highlighted attribute type.

For this example, enter these *Field Values*:

- a. **Minimum 1**
- b. **Maximum 50**

- c. *Decimal Places 0*
- d. *Default 5*
- e. ***Field Entry Required***

Field Entry is available for all attribute types. This setting is used during entry of attribute data in Survey Controller.

3. Click **OK**.

The feature code *Lamp Post 2* now appears when you select the *Feature Codes* tab.

Note – At this point, we have created a feature code and assigned attributes. As a feature and attribute library, only the feature code and attributes can be assigned to the position in the field. All the other parameters such as point styles, line styles, annotation styles, and layers are resident only in Trimble Geomatics Office.

Save the feature and attribute library:

1. From the menu bar, select *File / Save*.
2. In the *File name* field, enter a name for your feature and attribute library.

The default file extension is .fcl.

Exercise 11: Exporting a Feature and Attribute Library

To use a Feature and Attribute Library (*.fcl) file in the field, you must export it from within a Trimble Geomatics Office project to a controller running Trimble Survey Controller. You can use a feature and attribute library to select feature codes for points and to store attribute definitions.

Before you transfer the library:

1. In the *Export* dialog, select the *Survey* tab.
2. Select the *Feature and Attribute Library to Survey Controller (*.fcl)* option.
3. Click **Options**. The *Feature and Attribute Library Options* dialog appears.
4. In the *Version* field, select the Trimble Survey Controller version that you are exporting to and then click **OK** to return to the *Export* dialog.
5. Click **OK**. The *Select feature and attribute library* dialog appears.
6. In the *File* field, select the library you want to export:
 - Click **Browse** to navigate to the library.
7. Do one of the following:
 - If you want to export attribute definitions in the library, select the *Export Attributes* check box.
 - If you do **not** want to export attribute definitions, clear this check box.
8. Click **OK**.

The Data Transfer *Save As* dialog appears.

Once you have checked that Trimble Survey Controller is connected to the correct COM port and is in the appropriate data transfer mode, you can export the data.

To transfer the feature and attribute library:

1. In the *Save As* dialog, select a survey controller device. Make sure that it is the same version that is specified in the *Feature and Attribute Library Options* dialog (see Step 4).
2. Click **Open**. The *Connecting* dialog appears as the computer connects to Trimble Survey Controller.

When a connection is established, the *Save As* dialog returns. The *Look in* field is set to the survey controller device that you are connected to

3. In the *File name* field, the library description of the library appears. (This is the library name unless you have edited it in the Feature and Attribute Editor utility.) You cannot change the name.
4. Click **Save** to transfer the library. The *Sending* dialog appears. It shows the progress of the transfer.

When the feature and attribute library file has transferred, you return to the graphics window.

The Feature and Attribute Library file is now in Trimble Survey Controller. Any control codes defined in the feature and attribute library are also transferred. For more information, refer to the Trimble Survey Controller documentation.

Exercise 12: Viewing the Feature and Attribute Library in the controller

After transferring a feature and attribute library to the controller, check that the contents of the file have been transferred correctly.

1. Tap  to switch to the Trimble Survey Controller main menu.
2. Select  and then *Feature and attribute libraries*.
3. Verify that your library (list) has been loaded.

Note – You can access the feature and attribute library once you have started a job and you are collecting your first point. When the *Code* field of the *Survey / Measure points* screen is highlighted, tap  to select the feature code list or data dictionary to be used in your survey. Alternatively, when you set up a new job, choose a feature and attribute library from the *New job* screen.

Exercise 13: Feature Code Processing

Create a new project using the sample data template:

1. Do one of the following:
 - Select *File / New Project*.
 - In the standard toolbar, select the *New Project*  tool.
 - In the project bar, click the *New Project*  shortcut.
2. In the *Name* field, enter a name for the project.
3. From the *Template* list, select the *Sample Data* option.
4. In the *New* group, make sure that the *Project* option is selected and then click **OK**.

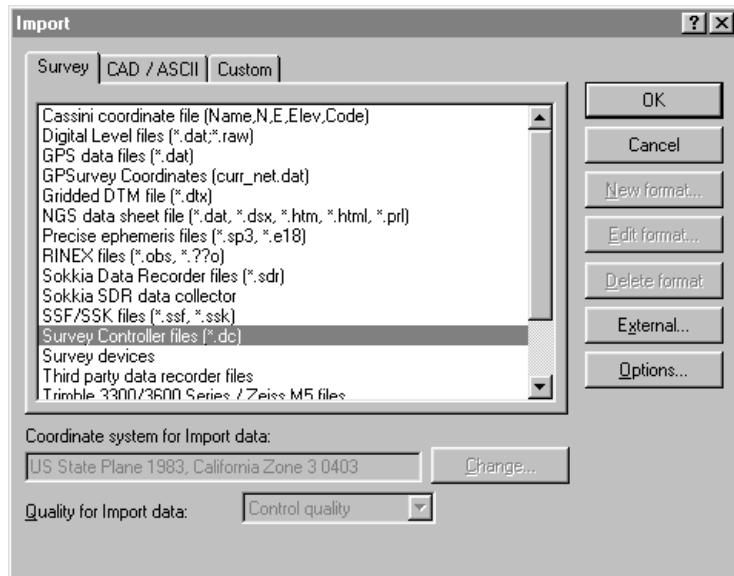
The project is created and the *Project Properties* dialog appears. The values in the fields in each tab are derived from the sample data template.

5. To close the *Project Properties* dialog, click **OK**.

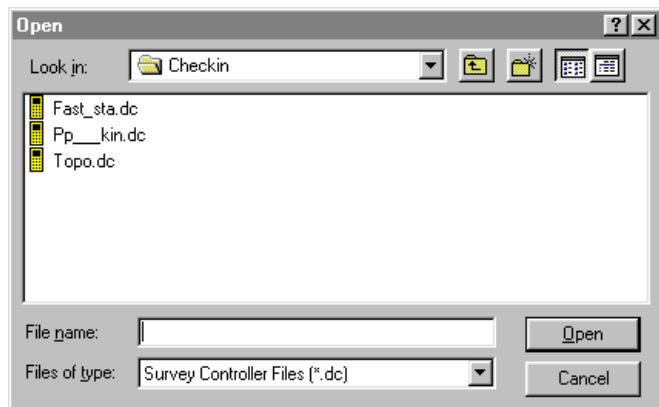
To import files into your sample data project:

1. Open the *Import* dialog. To do this, do one of the following:
 - Select *File / Import*.
 - Select the *Import*  tool.

The following dialog appears:



2. In the *Survey* tab, select the Survey Controller files (*.dc) option.
3. Click **OK**. The following dialog appears:

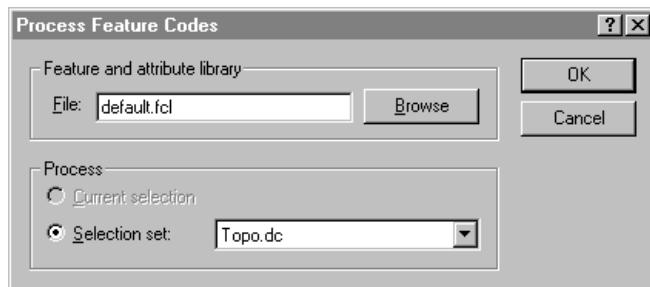


The *Look in* field defaults to the project's *Checkin* folder.

4. Highlight the Topo.dc
5. Click **Open**.

To process feature codes:

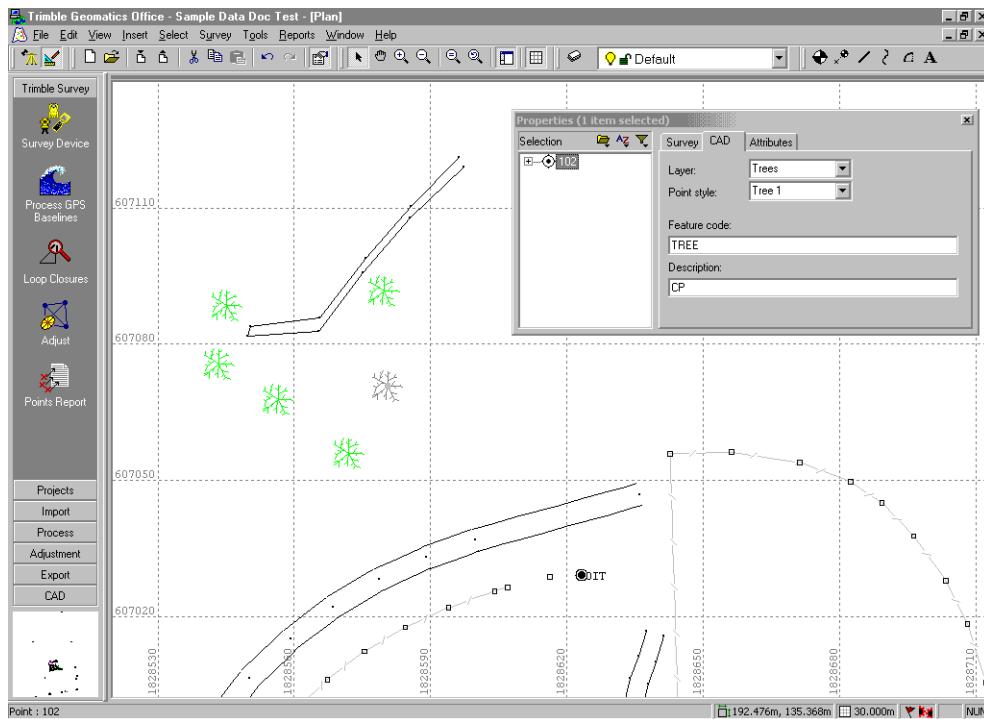
1. Switch to the Plan view. To do this, do one of the following:
 - In the toolbar, select the *Plan View* tool.
 - Select *View / Plan*.
2. In the Plan view, select *Tools / Process Feature Codes*. The following dialog appears:



3. In this example, use the Default.fcl feature and attribute library that appears in the dialog. However, you can click **Browse** and use the *Browse* dialog to locate and select the feature and attribute library with which you want to process feature codes.
4. In the *Process* group, select the Topo.dc selection set.

Note – You must choose a selection set created from the imported .dc file, not the current group of selected points. This ensures that the points are processed in the order in which they are collected. If you select points using any other selection method, unexpected feature code processing can occur.
5. Click **OK** to start processing feature codes.

The following window shows the zoomed results of the feature code processing:



After feature code processing, the Plan view graphically shows the area that was surveyed. (Note that conventional observations were made in an area where there are a lot of trees.)

The sample data also has feature and attribute information.

To view attributes:

1. Double-click a point feature. The *Properties* window appears.
2. Select the *Attributes* tab. It shows the attributes for the currently selected feature.

You can export attributes to a number of popular GIS software formats. For more information, refer to the Help.

In the Plan view you can also do the following:

- Create, edit, and delete:
 - Layers
 - CAD styles
 - Annotation templates
- Add lines, curves, arcs, text, and annotations

For more information on using the Plan view, refer to the Help.

Default Feature Code List

Table 11.1 gives the default codes for commonly used features.

Table 11.1 Default feature code list

Feature Code	Description
AV	Air valve
BANK1	River bank
BCABLE	Buried cable
BDY1	Cadastral boundary
BH	Bore hole
BLDG	Building point
BRICK	Use to modify line types
BUS	Bus shelter
CABLE	Cable (power, telephone)
CL	Road center line
CLSRECT	Close rectangle using 3 previous points
CURB2	Roadside curb

Feature Code	Description
BANK	River bank
BANK2	River bank
BDY	Cadastral boundary
BDY2	Cadastral boundary
BLD	Building point
BOB	Bottom of bank
BRIDGE	Bridge side
BUSH	Bush
CHECK	Check jobs (not plotted - no actions)
CLOSE	Closes to first point in sequence
CURB	Roadside curb
CURB3	Roadside curb

Table 11.1 Default feature code list (Continued)

Feature Code	Description	Feature Code	Description
CURB4	Roadside curb	CVEND	End of curve (non-tangential)
CVST	Start of curve (not tangential)	DIST	Provides for entry of measured dimensions
DISTADJ	Provides for entry of measured dimensions with adjusted closure	DRAIN	Drain line
DUCT	Duct	ENDARC	End of arc (tangential)
ENDCV	End of curve (tangential)	ENDLOOP	End of a closed loop - closes to first point in sequence
ENDONARC	End of arc (non-tangential)	ENDONCV	End of curve (non-tangential)
EOA	Edge of asphalt	EOA1	Edge of asphalt
EOA2	Edge of asphalt	EOB	Edge of bush
EOB1	Edge of bush	EOB2	Edge of bush
EP	Electric post	FCE	Fence
FH	Fire hydrant	FINCV	End of curve (non-tangential)
FP	Footpath	FP1	Footpath
FP2	Footpath	GAS	Gas Valve
GATE	Gate with "two-point symbol" effect	GULLY	Gully
GUTTER	Gutter or roadside channel	GUTTER1	Gutter or roadside channel
GUTTER2	Gutter or roadside channel	HEDGE	Hedge
IG	Sump/catch pit (Iron grate)	INVERT	Invert level
IS	Iron spike	ISLAND	Traffic Island

Table 11.1 Default feature code list (Continued)

Feature Code	Description	Feature Code	Description
IT	Iron Tube (survey mark)	JP	Joins to previous point in selection set
KERB	Roadside kerb	KERB1	Roadside kerb
KERB2	Roadside kerb	KERB3	Roadside kerb
KERB4	Roadside kerb	LAKE	Lake edge
LG	Lip of gutter	LG1	Lip of gutter
LG2	Lip of gutter	LINE	General purpose line
LP	Lamp post	MH	Manhole
OIS	Old iron spike (survey mark)	OP	Old peg (survey mark)
PC	Start of curve (tangential)	PEG	Wooden peg (survey mark)
PHONE	Phone line	PIN	Pin line (road survey Line)
POND	Pond edge	POST	Post
PP	Power pole	RAIL	Railway line
RAIL1	Railway line	RAIL2	Railway line
RDBDY	Road boundary	RDBDY1	Road boundary
RDBDY2	Road boundary	RSH	Road spot height
RWALL	Retaining wall	SGAT	Public Scating
SH	Surveyed spot height point - annotated with height	SIGN	Road Sign
SIZE	Sets symbol size in ground units	SS	Survey standard
SSMH	Sanitary sewer manhole	SUMP	Drain catchpoint
SW	Sidewalk	SW1	Sidewalk1
SW2	Sidewalk	SWMH	Stormwater manhole
TOB	Top of bank	TOBL	Top of bank

Table 11.1 Default feature code list (Continued)

Feature Code	Description	Feature Code	Description
TOBR	Top of bank	TP	Telephone pole
TREE	Tree	TREE2	Deciduous tree (type 2)
TRIG	Trig station (survey mark)	WALL	Wall
WS	Water supply		

Review Questions

1. Define a feature code and attribute library and explain how it is used in Trimble Geomatics Office.
2. List the three basic types of feature codes and give examples of each.
3. List the three basic types of attribute values and give examples of each.
4. While collecting data, what controller screen do you use to enter a feature code?
5. Describe the two basic methods collecting line data with feature codes.
6. On what does reliable feature code processing depend?
7. How do you edit or correct errors you encounter with a processed code?
8. What is the easiest way to display only one type of coded data?
9. In which view do feature codes appear once processed by Trimble Geomatics Office?

Answers

1. A feature and attribute library contains alphanumeric codes that describe the point you are collecting; an attribute answers questions about your point.
2. Point, control, and control with parameters.
3. Menu. For example: tree, healthy or unhealthy.
Text/numeric. For example: tree #12345.
Date/time. For example: 01/06/00.
4. *Measure points* screen.
5. Linear or cross-sectional.
6. The feature and attribute library associated with the project in Trimble Geomatics Office must match the feature code list associated with the job in the Survey Controller.
7. You can select the point in question, then use the *Properties* dialog CAD tab to change the codes.
8. The easiest way to display only one type of coded data is to put that code into a layer.
9. Plan View.

SECTION 2 — FIELD AND OFFICE PROCEDURES

Introduction

This section contains four chapters. The chapters provide a step-by-step guide to the field and office procedures that make up a real-time survey.

Session Objectives

At the end of this session, you will be able to confidently:

- Start the base station and rover for RTK survey
- Start the base station and rover for RTK & Infill survey
- Calibrate a GPS site with a Trimble controller
- Calibrate a GPS site with Trimble Geomatics Office
- Collect data with the RTK and RTK & Infill survey style
- Use COGO functions
- Stakeout points
- Process RTK & Infill data
- Evaluate and accept results
- End a survey
- Produce reports

Note – The review questions on page 321 cover all the chapters in this section.

RTK Surveys

In this chapter:

- Introduction
- Starting the RTK base survey
- Starting the RTK & Infill base survey
- Starting the RTK rover survey
- Starting the RTK & Infill rover survey
- Initializing the survey
- Recommended RTK initialization procedure

Introduction

This chapter describes how to use survey styles in a variety of RTK surveys, and how to initialize an RTK survey.

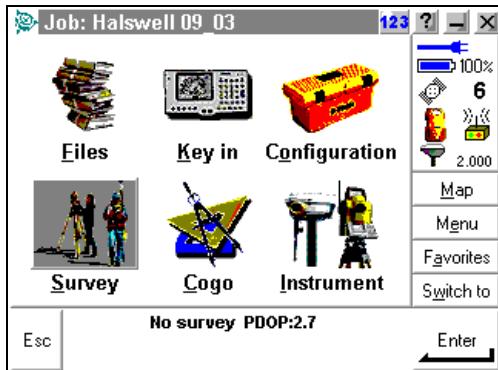
A Survey Style is a set of configurations that apply to one particular type of survey. Each Survey Style provides a template that you can use when you perform a survey of that type. A GPS Survey Style instructs the base and rover receivers to perform compatible types of measurements. It also defines the parameters needed for measuring and storing points. For more information, see Assembling and Setting up an RTK Survey System (Base), page 41.

Starting the RTK Base Survey

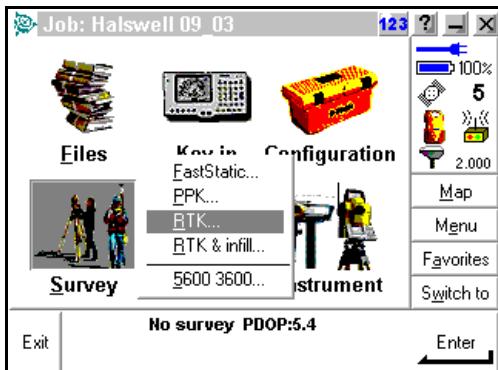
If you have not yet created and configured a job, do so now. For more information, see Survey Styles, page 84 and Exercise 1.

Then do the following:

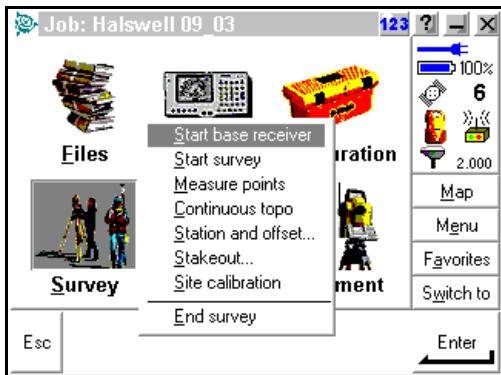
- From the main menu, select *Survey*.



- From the list that appears, select the name of the survey style created for the particular setup.

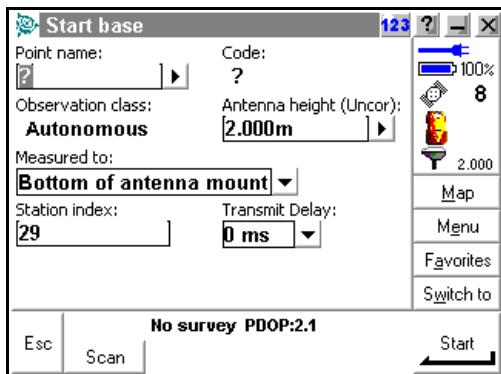


The *Survey* menu appears.

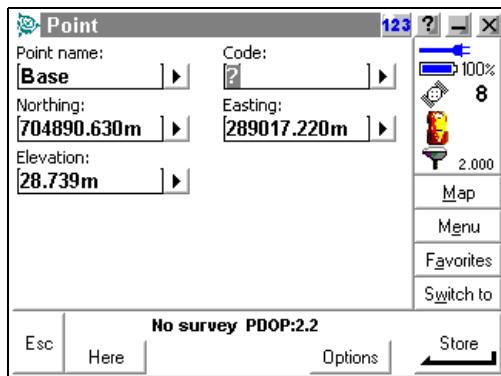


3. Select *Start base receiver*.

The *Survey / Start base* screen appears.

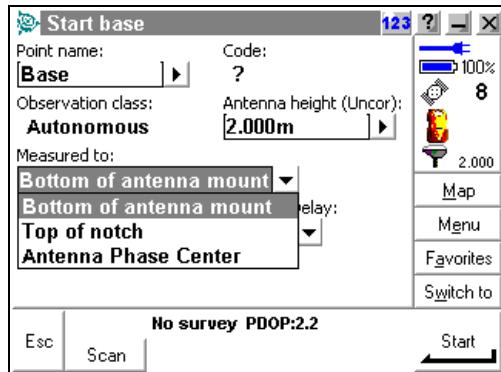


4. In the *Point name* field, select the point name from the previously defined list, or key in the coordinates from the Key-in menu. Alternatively, enter the point name in the *Key in* screen, then tap the softkey. The current position is displayed. Press to accept and store it.



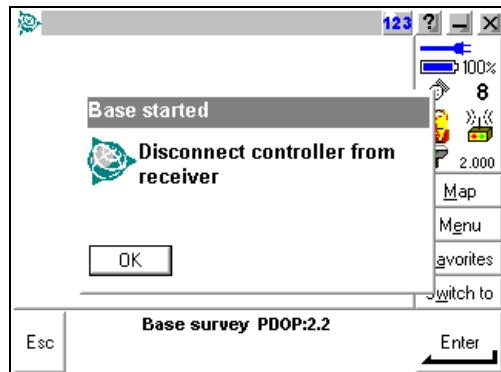
Note – When you press as instructed above, the base receiver starts using an autonomous position generated by the receiver. This is the least accurate method of establishing the base station WGS-84 coordinates, but it does let you start surveying immediately. For every 10 m of error in the base coordinate, you could introduce up to 1 ppm scale error on every measured baseline. To improve the quality of the survey when you use the key method, carry out a GPS site calibration. For more information, see Chapter 13, Site Calibration. If the receiver is tracking WAAS satellites, press the softkey to return a WAAS position generated by the receiver. A WAAS position is better than an autonomous position. WAAS is available only in North America.

5. Highlight the *Antenna height* field and enter the base station antenna height. Make sure that the *Measured to* field is correct.



Warning – To avoid serious errors in your survey, you must measure the height of the antenna correctly and accurately. See Measuring GPS Antenna Heights, page 47.

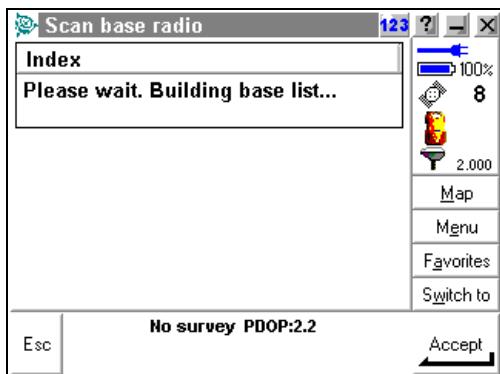
6. Make sure the radio antenna is connected to the radio then press the **Start** softkey. The following screen appears:



Note – The Data LED on the external radio will start flashing at a regular interval.

7. Disconnect the controller but **do not** turn off the receiver.
Then tap **OK**.

Note – When you press the Scan softkey, the following screen appears: The system will automatically scan the radio frequency and report if any other base station is operating on the same frequency.



Starting the RTK & Infill Base Survey

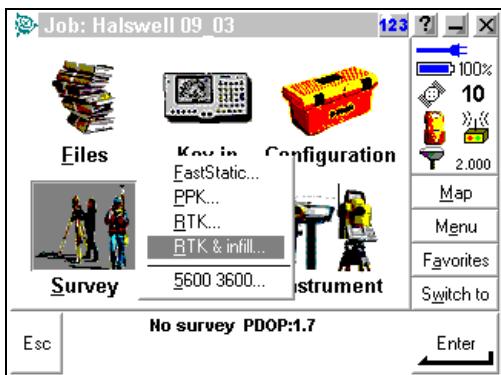
A Survey Style is a set of configurations that apply to one particular type of survey. Each Survey Style provides a template that you can use when you perform a survey of that type. A GPS Survey Style instructs the base and rover receivers to perform compatible types of measurements. It also defines the parameters needed for measuring and storing points.

For more information, see Assembling and Setting up an RTK Survey System (Base), page 41.

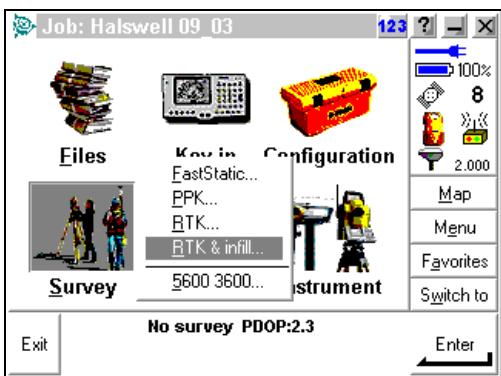
If you have not yet created and configured a job, do so now. For more information, see Survey Styles, page 84 and Exercise 1.

Then do the following:

1. From the main menu, select *Survey*.

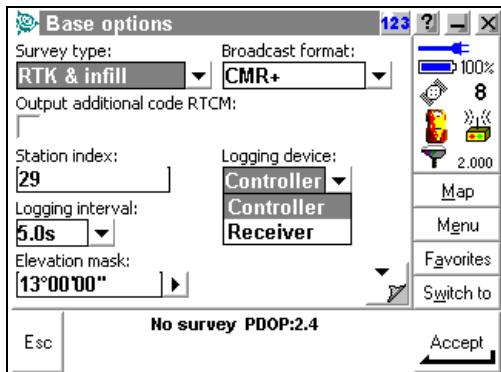


2. From the list that appears, select the name of the survey style created for the particular setup.



3. For details, see Step 3 on page 242.
4. For details, see Step 4 on page 243.
5. For details, see Step 5 on page 244.
6. For details, see Step 6 on page 244.
7. Disconnect the controller but **do not** turn off the receiver.

Note – RTK & Infill survey requires data logging at the base and rover during the “radio link down” period. Make sure that you specify the logging device in your Survey Style / Base-Rover Options. If you are logging data to the controller, the system does not prompt you to remove the controller. Do not disconnect the controller from the base. However, if you are logging data to the receiver, you can now remove the controller.



Starting the RTK Rover Survey

Note – For more information, see Assembling and Setting up an RTK Survey System (Base), page 41.

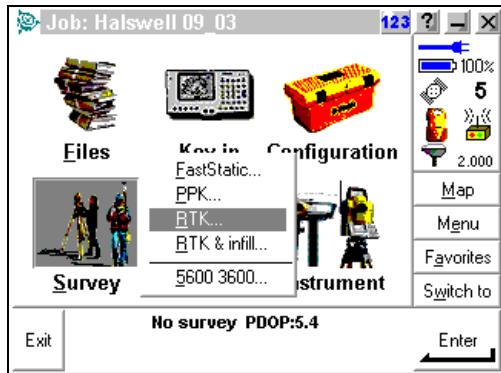
If you have not yet created and configured a job, do so now. For more information, see Survey Styles, page 84 and Exercise 1.

Then do the following:

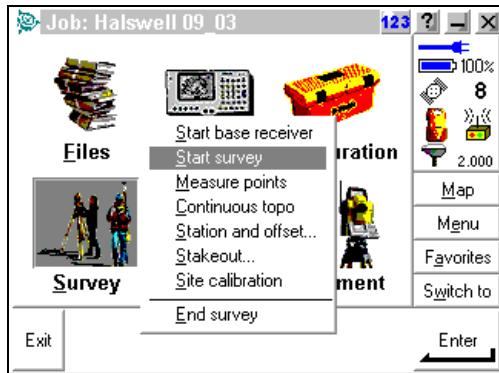
1. From the main menu, select *Survey*.



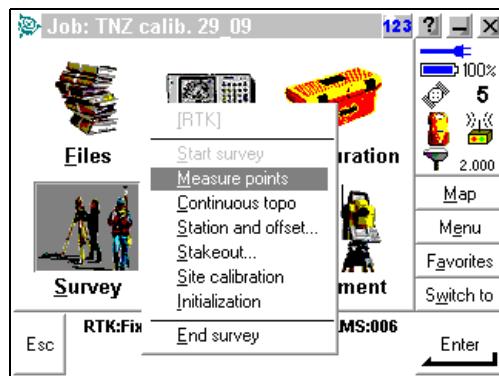
2. From the list that appears, select the new RTK survey style.



3. From the RTK screen that appears, select *Start survey*.



4. OTF initialization is gained automatically through the receiver. The following screen appears:



For more information on initialization methods, see *Initializing the Survey*, page 251.

Starting the RTK & Infill Rover Survey

Note – For more information, see Assembling and Setting up an RTK Survey System (Base), page 41.

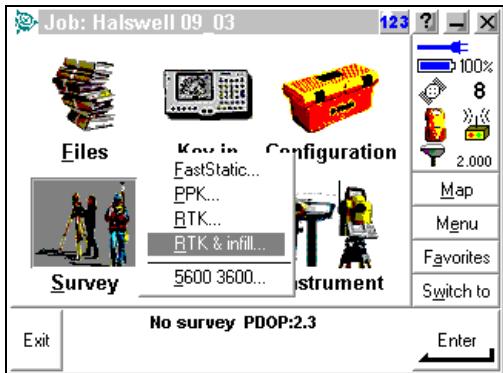
If you have not yet created and configured a job, do so now. For more information, see Survey Styles, page 84 and Exercise 1.

Then do the following:

1. From the main menu, select *Survey*.



2. From the list that appears, select the new RTK survey style.



3. For details, see Step 3 on page 242.
4. For details, see Step 4 on page 243.

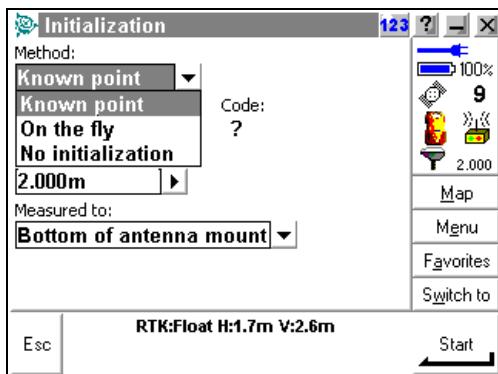
Initializing the Survey

You must initialize a survey before you can begin centimeter-level surveying. Initialization can occur only if the rover is receiving corrections from the base station. The base station must be tracking four or more satellites.

Note – At least five L1/L2 satellites are required for OTF initialization. After initialization, at least four satellites must be tracked. If the number of satellites drops below four, the survey must be reinitialized.

When performing an RTK survey with a dual-frequency receiver, select *Survey / Initialization* to access the Initialization screen. Tap to change the initialization.

Note – The Initialization menu is not available until you select *Survey / Start survey*.



Use one of the following methods to initialize dual frequency RTK surveys:

- Known Point
- On-the-Fly (OTF)

In the Trimble R7, Trimble R8, 5700, or 5800 receiver, OTF initialization is performed automatically. The New Point method is not available, but you can initialize on a known point. To do this, select *Survey / Initialization* and press .

Table 12.1 summarizes methods of initializing a real-time kinematic survey with an R7, R8, 5700, or 5800 receiver, and the time required for each method.

Table 12.1 Initializing a Real-Time Kinematic survey

Receiver	Time required for each initialization method		
	Known Point	New Point	OTF
R7, R8, 5700, or 5800	~15 s (5+ SVs) ~30 s (4 SVs)	Not available	~60 s (5+ SVs)

Note – Initialization must be maintained throughout the survey by continuously tracking a minimum of four satellites. If initialization is lost at any time, reinitialize and then continue the survey. Table 12.1 shows Trimble’s recommended times. In a high multipath environment, initialization can take much longer or even never occur.

Note – After initialization, the survey mode changes from Float to Fixed. The mode remains Fixed if the receiver continuously tracks at least four satellites. If the mode changes to Float, reinitialize the survey.

Multipath

Initialization reliability depends on the initialization method used and on whether or not multipath occurred during the initialization phase. (Multipath occurs when GPS signals are reflected off objects such as the ground or a building).

The occurrence of multipath at the GPS antenna adversely affects GPS initializations and solutions:

- If initialization is by the Known Point method, multipath can cause an initialization attempt to fail.

- If initialization is by the OTF or New Point method, it is difficult to detect the presence of multipath during the initialization. If there is multipath, the receiver may take a long time to initialize or it may not initialize at all. See Recommended RTK Initialization Procedure, page 255.

The initialization process in Trimble receivers is very reliable, but if an incorrect initialization does occur, Trimble's RTK processing routines detect it within 15 minutes (if the mode has remained Fixed). When the error is detected, the receiver automatically discards the initialization and issues a warning.

Note – If you survey points with a bad initialization, position errors result. To minimize the effect of multipath during an OTF initialization, move around.

On-the-Fly (OTF) initialization

An R7, R8, 5700, or 5800 receiver has On-the-Fly (OTF) capability and initialization is automatic. Wait for the system to initialize. When the status line shows RTK=Fixed, the survey is initialized and you can start to measure points.

Known point initialization

To perform a Known Point initialization:

1. Position the rover antenna over a known point.
2. From the *Survey* menu, choose *Initialization*.
3. Tap  **Init**.
4. Set the *Method* field to Known Point and tap  **Enter**.
5. In the *Point name* field, tap  **List**. Select from the list of known points.
6. Enter values in the *Code* and *Antenna height* fields. Make sure that the *Measured to* field is correct.

7. When the antenna is centered and vertical over the point, press **Start** or **Enter**.

The controller starts to record data, and the static icon () appears in the status line.

Keep the antenna vertical and stationary while data is recorded.

8. When the receiver is initialized, the results are displayed and the **OK** softkey appears. Press it to accept the initialization.
9. If the initialization fails, the results are displayed. Trimble Survey Controller asks if you want to retry. Press **Yes** or **No**.

New point initialization (no OTF)

You cannot carry out a New Point initialization on an R7, R8, 5700, or 5800 receiver.

To perform a New Point initialization:

1. Position the rover antenna a distance away from the base receiver.



Tip – Trimble recommends that you use a bipod attached to the range pole when using this method.

2. From the *Survey* menu, choose *Initialization*.
3. Set the Method field to New Point and press \.
4. Enter values for the *Point name*, *Code*, and *Antenna height* fields.
5. When the antenna is centered and vertical over the point, press **Start** or **Enter**.

The controller starts to record data, and the static icon appears in the status line.

Keep the antenna vertical and stationary while data is recorded.

-
6. When the receiver has initialized, the **Store** softkey appears. Press it to store the point.

Recommended RTK Initialization Procedure

This section describes the procedure that Trimble recommends for performing a check on a New Point or an OTF RTK initialization.

Adopt good survey techniques to minimize the chance of surveying with a bad initialization. A bad initialization occurs when the integer ambiguities are not correctly resolved. Trimble Survey Controller automatically reinitializes when this is detected, but cannot do so if you end the survey too soon. As a precaution, always perform the initialization described below.

When initializing, always choose a site that has a clear view of the sky and is free of obstructions that could cause multipath.

Note – Known Point is the quickest method of initialization when known points exist.

To perform a check on a New Point or OTF initialization:

1. Initialize the survey using the New Point or OTF method.



Tip – When performing an OTF initialization, move the antenna around. This reduces the effect of multipath.

2. When the system is initialized, establish a mark about 9 meters (30 feet) from where the initialization occurred.
3. Observe a topo point measurement over the mark. Once this is done, discard the current initialization.
4. If using an adjustable height range pole, change the height of the antenna by approximately 20 cm (8 in).
5. Reoccupy the mark observed in Step 2, and reinitialize the survey using the Known Point method of initialization. Remember to enter the new antenna height details.

Site Calibration

In this chapter:

- Introduction
- Performing a manual site calibration (field)
- Performing an automatic site calibration (field)
- Performing a site calibration (office)
- Selecting the calibration point pairs
- Computing the calibration parameters
- Analyzing the calibration parameters
- Viewing a report
- Applying the calibration
- Using a GPS site calibration in future projects

Introduction

This chapter describes how to perform a site calibration in the field and in the office.

Performing a Manual Site Calibration (Field)

To calibrate a survey manually, follow this general procedure:

1. Key in, transfer, or use a conventional instrument to measure the grid coordinates of the control (calibration) points.
2. Check or set the calibration tolerances. For more information, see Chapter 10, Coordinate Systems and GPS Site Calibration Theory.
3. Measure the control points using GPS.
4. Name or select the pairs of points to be used for the calibration. A pair of points consists of the grid coordinates and the WGS-84 coordinates for the same point.
5. Perform the calibration.
6. Check residuals, and recalibrate if necessary.
7. Apply the calibration.

*Note – Carry out the complete calibration **before** staking out any points, computing offset and/or intersection points, or computing a resection from GPS points.*

Keying in grid coordinates

To key in grid coordinates:

1. From the main menu, select *Key in / Points*. The *Key in/Point* screen appears.
2. Check that the coordinate fields are *Northing*, *Easting*, and *Elevation*. (If they are not, press **Options** and change the *Coordinate view* setting to Grid).

3. Enter a name in the *Point name* field. Tap .
4. Enter details or features of the point in the *Code* field. Tap .
5. Key in the known grid coordinates. Tap .
6. Select the *Control point* check box. This ensures that the point is not overwritten by a measured point. For more information on Control points (Search class rules), refer to the *Trimble Survey Controller Help*.
7. Repeat Step 3 through Step 6 for each grid coordinate point to be keyed in.
8. Tap .
9. Tap to return to the main menu.

Transferring grid coordinates

Transfer coordinates using Trimble Geomatics Office, Data Transfer, or ASCII transfer.

Make sure that these coordinates are:

- Transferred as grid coordinates (N, E, E), not as WGS-84 coordinates (L, L, H)
- Control class points

Using GPS to measure calibration points

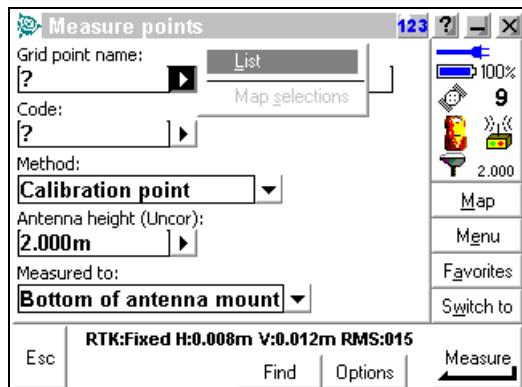
Use GPS to survey the points. Trimble Survey Controller automatically matches the grid points to the WGS-84 values and then calculates, stores, and applies the calibration.

When one point has been calibrated, or a projection and datum transformation have been defined, the softkey appears. You can use this to navigate to the next point.

As you measure another calibration point, the new calibration is calculated, stored, and applied to the job.

To measure a calibration point:

1. From the main menu, choose *Survey*.
2. Select the required RTK survey style.
3. Select *Measure points*. In the dialog that appears, change the *Type* field to Calibration point.
4. Access the *Grid point name* field and press . A list of keyed in grid coordinates appears. Highlight the point to be measured and press . The point name appears in the *Grid point name* field:



The *GPS point name* field is filled in by Trimble Survey Controller depending on the settings in the *Calibration point name* field in the *Site calibration* option in the Survey Style.

5. Enter values for the *Code* and *Antenna height* fields. Tap to accept the screen.
6. When the antenna is centered and vertical over the control point, tap or . The controller starts to record data.

Keep the antenna vertical and stationary while data is recorded.

7. When the preset required time has elapsed, the **Store** softkey appears. Inspect the precisions. If they are satisfactory, tap **Store** to store the point.
8. The calculations are then done automatically and the results are stored. While this is happening, the following messages appear:
Please wait. Storing point
Calculating calibration
Storing calibration

Note – When Trimble Survey Controller is performing an automatic calibration, the results of the calibration are not normally displayed. However, if a calibration exceeds the tolerances that have been set, the residuals are displayed. For more information, see the next section.

9. Enter the next calibration point name in the *Point name* field and press **Find**. The graphical display screen appears, with the azimuth and distance to the next point displayed on the right.

To use the arrow display, start moving with the controller held in front of you as normal. The arrow points in the direction of the next calibration point. Walk towards the point. About 3 meters (10 feet) from the point, the arrow disappears and the point is displayed.

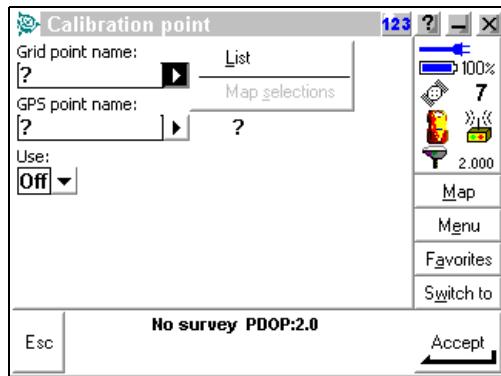
When the point is located, Tap **Back**.

10. Repeat Step 4 through Step 9 until all the calibration points are measured.

Selecting the points pairs and performing the calibration

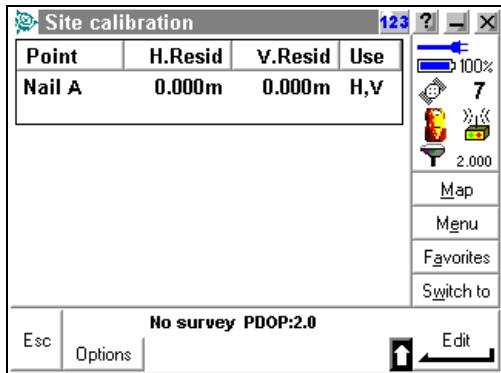
The following steps describe how to select the points for a calibration and then perform the calibration using Trimble Survey Controller. Do this once you have entered grid coordinates, checked the settings in the survey style, and measured the points using GPS.

1. From the main menu, select *Survey*. Then select a real-time survey style.
2. From the list that appears, select *Site calibration*. The *Site calibration* screen appears.
3. Tap **Add**. The following dialog appears:



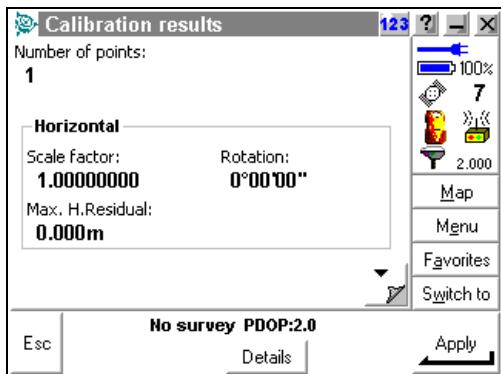
4. To enter the name of the grid point, tap next to the *Grid point* field, then tap **List**. Select a point that you have keyed in, transferred, or measured using a conventional instrument.
5. Highlight the *GPS point* field and enter the point name as described in Step 4. The two point names do not have to be the same, but they must refer to the same physical point.
6. In the *Use* field, select whether to use the vertical coordinate of the grid point, the horizontal coordinates, or both horizontal and vertical coordinates.

7. Tap **Accept**. The following dialog appears:



The residuals for each point are not displayed until at least three 3D points are included in the calibration to provide redundancy.

8. Press **Results** to see the horizontal and vertical shifts that the calibration has calculated. The following dialog appears:



9. To add more points, tap **Apply** to return to the *Calibration* screen.
 10. Repeat Step 3 through Step 9 until all the points are added.

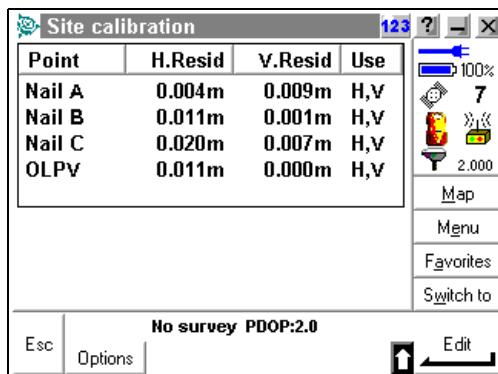
11. Do one of the following:

- If the residuals are acceptable, press **Apply** to store the calibration.
- If the residuals are not acceptable, recalculate the calibration.

Checking the residuals

When you use auto-calibrate, the calibration residuals appear only if the calibration tolerances are exceeded.

When you calibrate manually , the residuals appear in the following dialog:



If the residuals are excessive, as shown above, consider removing the point with the most extreme residuals. Then do one of the following:

- If four or more points remain after removing that point, recalibrate using the remaining points.
- If fewer than four points remain after removing that point, measure the point again and recalibrate.

You may need to remove (and measure again) more than one point.

To remove a point from the calibration calculations:

1. Tap the point name.
 2. Set the *Use* check box to *Off*. Tap .
- The calibration is recalculated and the new residuals are displayed.
3. Tap to accept the calibration.

Recalculating a calibration

Recalculate a calibration if the residuals are not acceptable, or if you want to add or delete points. Recalculate using one of the following:

- Some of the points
- Only the horizontal component of a point
- Only the vertical component of a point

To recalculate a calibration:

1. From the main menu, select *Survey*. Select a real-time Survey Style.
2. From the *Survey* menu, choose *Site calibration*.
3. Do one of the following:
 - To remove (exclude) a point, highlight the point name and press .
 - To add a point, press . For more information, see Step 4 on page 262.
 - To change the components used for a point, tap the point name. In the *Use* field select, whether to use the vertical coordinate of the grid point, the horizontal coordinates, or both horizontal and vertical coordinates. You can also switch off the point.
4. Press to apply the new calibration.

Note – Each calibration calculation is independent of the previous one. When a new calibration is applied, it overwrites any previously calculated calibration.

Performing an Automatic Site Calibration (Field)

A calibration calculates the parameters needed to convert the GPS-measured coordinates into local grid coordinates. During an RTK survey, Trimble Survey Controller can automate this process. When you use the Auto calibrate function, the software automatically computes and stores a calibration every time a calibration point is measured.

To calibrate a survey automatically, follow this general procedure:

1. Key in, transfer, or use a conventional instrument to measure the grid coordinates of the local control points.
2. Select the *Auto calibrate* check box. (See below.)
3. Use GPS to measure the calibration points. When you observe GPS data, set the *Measure points* method to *Calibration point*.

Step 1 through Step 3 completes the automatic calibration.

The following steps are optional:

4. Inspect the calibration results.
5. Change the results if they are unsatisfactory.

Selecting Auto calibrate

To select Auto calibrate:

1. From the main menu, select *Configuration / Survey Styles*.
2. In the dialog that appears, highlight the required RTK survey style. Tap **Edit**. The menu that appears has the same name as the RTK survey style that you added.
3. Select *Site calibration*. The *Site calibration* screen appears.
4. Select the *Auto calibrate* check box. For more information on site calibration see Chapter 10, Coordinate Systems and GPS Site Calibration Theory. Tap **Accept** to return to the menu for the chosen Survey Style.
5. Tap **Store** to save the changes and return to the main menu.

Performing a Site Calibration (Office)

A GPS site calibration establishes the relationship between WGS-84 points collected by GPS receivers, and local grid positions on a local map grid. The local map grid includes elevations above sea level, and the GPS data includes WGS-84 heights.

Published coordinate systems and geoid models do not usually allow for local variations in the projection. You can perform a GPS site calibration to reduce these variations and obtain more accurate local grid coordinates.

If you use data collected from terrestrial instruments only, you do not need to perform a GPS site calibration.

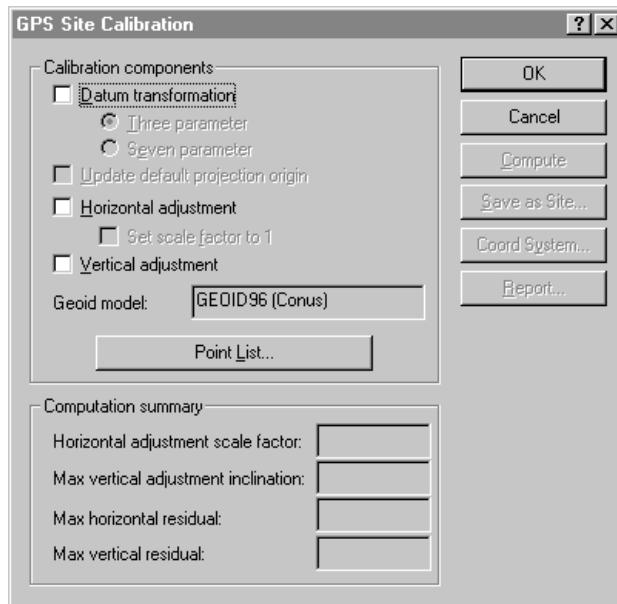
To carry out these procedures, first start Trimble Geomatics Office and open the relevant project.

Selecting the calibration components

To select which calibration parameters to include in the calibration calculations, use the *GPS Site Calibration* dialog.

To access it:

- From the main Trimble Geomatics Office menu, select *Survey / GPS Site Calibration*. The following dialog appears:



Note – If you perform an adjustment with the Network Adjustment module, and compute adjustment transformation parameters, when you access the dialog the following message appears:

Proceeding with this operation will remove the adjustment transformation parameters.

Note – You can only use one set of parameters derived from either a calibration or an adjustment. Network adjustment transformation parameters cannot be transferred to Trimble Survey Controller. If you want to transfer control points and a calibration to Trimble Survey

Controller and your project coordinate system has network adjustment transformation parameters, you must first perform a GPS site calibration. For more information, refer to the topic Calibration and Adjustment Transformation Parameters in the Help.

To select the calibration components to be calculated, use the *Calibration Components* group in the dialog. You can calculate:

- a datum transformation (seven-parameter or three-parameter)
- an update of the default Transverse Mercator projection origin (if applicable)
- a horizontal adjustment
- a vertical adjustment

Computing a datum transformation

If you are using a published coordinate system, a predefined datum transformation is usually specified, for example, a three- or seven-parameter transformation, a multiple regression definition, or a Datum Grid file (NADCON). In these cases, it is unlikely that you will require a different datum transformation, so make sure that the *Datum Transformation* check box is clear. However, if there is no datum transformation information available, or if you have reason to doubt the available parameters, then compute a datum transformation.

To compute a datum transformation:

1. In the *GPS Site Calibration* dialog, select the *Datum transformation* check box. The *Three parameter* and *Seven parameter* options become available.
2. Select the option for the transformation that you want to compute.

For more information, refer to the topics Three-Parameter Transformation and Seven-Parameter Transformation in the Trimble Geomatics Office Help.

Note – This option is not available with projects that have the default projection coordinate system, because the default projection is based directly on the WGS-84 ellipsoid. This means that no datum transformation is required.

Updating default projection origin

The *Update default projection origin* check box in the *GPS Site Calibration* dialog is only available if the current coordinate system is the default Transverse Mercator projection.

As the default projection has neither a latitude and longitude origin, nor a false northing and false easting defined, updating the origin ensures that the origin of the projection is local; that is, it is close to the survey data in your project.

To update the default projection origin using the first 2D point pair used:

- Select the *Update default projection origin* check box.

If you are carrying out a GPS calibration on a project that already has the default projection defined, clear this check box. The default projection definition does not change.

Computing a horizontal adjustment

A horizontal adjustment is a plane transformation consisting of:

- translations in the north/south and east/west directions
- a rotation around a defined origin
- a scale factor

The software computes transformation parameters using least-squares methods to find the transformation that gives the adjustment parameters that, when applied to GPS positions, best fit the control

grid coordinates. The horizontal adjustment minimizes any residual error between the control grid coordinates and the grid coordinates calculated from the GPS positions.

To include a horizontal adjustment:

1. In the *GPS Site Calibration* dialog, select the *Horizontal adjustment* check box. The *Set scale factor to 1* check box becomes available.
2. To force the scale in the computed calibration to *one*, select this check box.



Tip – Initially, compute a horizontal adjustment without the scale factor set to *one*. This determines if the computed scale factor is close to one. If the computed scale factor is **not** close to 1, check the selected calibration point pairs.

Computing a vertical adjustment

A vertical adjustment is an inclined plane adjustment that consists of:

- a vertical shift at a defined origin
- inclinations in the north and east directions.

This requires three 3-D calibration point pairs. The parameters for this adjustment are computed using least squares methods. The least squares calculation finds an adjustment plane that best fits the elevations derived from the GPS heights with the control point elevations. With one 3-D calibration point pair, only the vertical shift parameter can be computed. If there are two 3-D control point pairs available, the system defines a correction plane that exactly fits these pairs.

If the project uses a geoid model, then the vertical adjustment is computed and applied on top of the geoid model corrections.

To include a vertical adjustment, in the *GPS Site Calibration* dialog, select the *Vertical adjustment* check box.

Selecting the Calibration Point Pairs

Use the *Point List* dialog to select the calibration point pairs you want to use to calculate the GPS site calibration parameters. A calibration point pair consists of:

- a GPS point (a point with a GPS position or derived from GPS data)
- a grid point (not a GPS derived point), which is normally a control point (or an adjusted point)

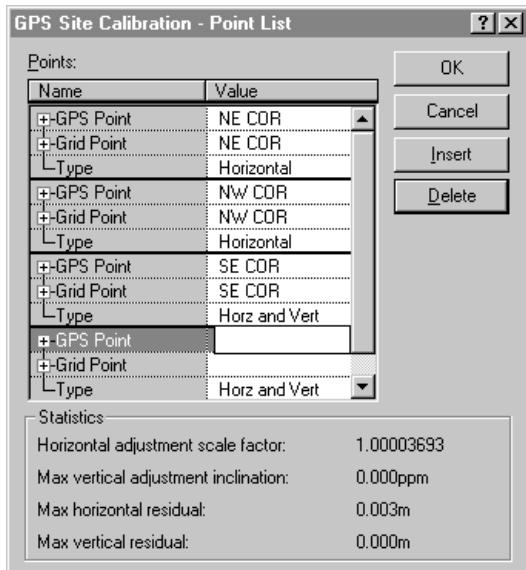
Note – If a point is derived from a grid position and a baseline, it cannot be selected as a GPS or grid point for calibration.

As you select or specify points for inclusion in the point list, Trimble Geomatics Office checks that each GPS point has a GPS derivation, and that each grid point does **not** have a GPS derivation. When a point does not conform to these requirements, an error message appears.

Trimble recommends that you use at least five 3D control point pairs. This provides redundancy in the results so that the points pairs used in the calibration can be changed if required.

To select calibration point pairs:

1. From the main Trimble Geomatics Office menu, select *Survey / GPS Site Calibration*. The *GPS Site Calibration* dialog appears.
2. Click **Point List**. The following dialog appears:



Use it to specify the calibration point pairs from which the calibration parameters are computed.

3. In the first *GPS Point* field, to select the first GPS point you want to use in the calibration, do one of the following:
 - Use field fill-in and click an existing GPS point.
 - Enter the name of the GPS point.
 - Expand the *GPS Point* field (click the plus sign next to the field) and enter the WGS-84 latitude, WGS-84 longitude, and WGS-84 height in the appropriate fields. The latitude and longitude position is used in the calibration computation, but a GPS point is not added to the database.

A box appears on the GPS point in the graphics window.

4. Complete the calibration point pair. To do this, use one of the following methods to select the grid point associated with the GPS point you selected in the previous step:
 - Use field fill-in and click an existing grid point.
 - Enter the name of the grid point.
 - Expand the *Grid Point* field and enter the northing, easting, and elevation in the appropriate fields. The northing and easting position is used in the calibration computation, but a grid point is not added to the database.

The following occurs:

- A cross appears on the grid point in the graphics window.
- A line appears between the GPS point and the grid point.
- The *Type* field is filled in.

If the calibration point pair is 3D, the *Type* field is set to *Horz and Vert*. If you do not want to use the calibration point pair in the vertical adjustment computation, change the type to *Horizontal*. If you do not want to use the calibration point pair in the horizontal adjustment computation, change the type to *Vertical*.

If the calibration point pair is 2D, the *Type* field is set to *Horizontal*. You cannot change this value because all other types are invalid.

If the calibration point pair is 1D, the *Type* field is set to *Vertical*. You cannot change the *Type* field as all other options are invalid.

Note – If you have a point defined with an underlying grid and a WGS-84 point, the point list is populated with the grid point when you include a GPS point.

5. Repeat Step 1 to Step 4 to select all of the calibration point pairs that you want to use in the calibration.



Tip – The *Statistics* group shows the scale factor, vertical adjustment inclination, and residuals for the calibration, based on the data entered in the point list. Use these statistics to ensure that the data you have entered is correct.

6. Once you have entered all of the calibration point pairs you want to use, click **Close**. The *GPS Site Calibration* dialog returns.



Tip – To select all of the calibration points in the graphics window that are defined in the point list, choose *Select / Calibration Points*.

Computing the Calibration Parameters

Once you select the calibration point pairs for the GPS site calibration, the **Compute** button in the *GPS Site Calibration* dialog becomes available. When you click this button, Trimble Geomatics Office uses the selected calibration point pairs to compute the GPS site calibration parameters.

You can perform any number of GPS site calibrations in a project. If you apply a new calibration to a project, the coordinate system is updated with the new calibration parameters, and all points in the database are updated with the new coordinate system values.

Analyzing the Calibration Parameters

When GPS site calibration parameters have been computed, a summary of the quality of the calibration parameters appears in the *Computation summary* group. Use the summary to confirm that the computed calibration is valid.

Table 13.1 shows the computation summary parameters.

Table 13.1 Computation summary group parameters

Field	Description
Horizontal adjustment scale factor	Shows the computed scale factor for the Horizontal adjustment. If you select the <i>Set scale factor to 1</i> check box, the field displays 1. Use it to confirm that the computed scale factor is close to one. If it is not, there is a problem with one or more of the calibration point pairs.
Max vertical adjustment inclination	Shows the maximum inclination for the computed height adjustment based on the computed <i>Slope north</i> and <i>Slope east</i> values. Check that this value is consistent with accepted values for your area.
Max horizontal residual and Max vertical residual	Shows the maximum residuals for the last computation carried out. The software warns you if the maximum horizontal residual error is greater than the value specified in the registry settings. Check that these values are within expected ranges; normally in the order of centimeters.

Note – To change the maximum error and maximum iteration count, use the Windows Registry on your computer. For more information, refer to the topic *Changing Calibration Settings Using the Registry in the Trimble Geomatics Office Help*.

If any of the fields in the *Computation summary* group of the *GPS Site Calibration dialog* are not within expected ranges, use one of the following methods to find the problem calibration point pairs:

- Examine the calibration point pairs.

To find an error in a GPS site calibration:

- Repeat the GPS site calibration procedure but leave out a different point pair each time. When the computation summary values are what you expect, this means that you have found the problem pair.
- Check that the grid points have the correct coordinates.

- Check that you have the best known coordinates for the base point of your GPS survey. If the errors in the calibration are small, they may be caused by errors in the observations. An error in the observation of up to one part per million (1 ppm) can be introduced by each 10 m (33 ft) of error in the base coordinates. If you reobserve with a more accurate base position, you may improve the observations and hence the calibration results.

If you locate an error in one of the calibration point pairs, fix the error and recalibrate. If you cannot fix the error, delete the calibration point pair from the point list and recalibrate.

Viewing a Report

To view a report of the last computed GPS site calibration:

- In the *GPS Site Calibration* dialog, click **Report**.

A detailed report of the calibration computation, named Calibration.html, appears in the default HTML viewer on your computer.

Use the report to inspect the individual calibration parameters. The report is saved in the project's *Reports* folder. When you recalibrate, a new report overwrites the old one.

Calibration report

The Calibration report includes:

- Project details
- Datum transformation parameters
- Updated default projection definition
- Horizontal adjustment parameters
- Vertical adjustment parameters

- Geoid model definition
- Residual differences between GPS and known coordinates

The following sections describe each part of the Calibration report and include report samples where appropriate.

The Project Details section

Figure 13.1 shows the *Project Details* section. This section shows the project details, including the project name and the coordinate system used.

GPS Calibration Report			
Project : NA Test			
User name		Date & Time	2:20:22 PM 9/5/00
Coordinate System	Projection from data collector (WGS 84)	Zone	Zone from data collector
Project Datum	NAVD-88	Geoid Model	GEOID96 (Conus)
Vertical Datum	Meters		
Coordinate Units	Meters		
Distance Units	Meters		
Height Units	Meters		

Figure 13.1 Project Details section of a Calibration report

The Datum Transformation Parameters section

Figure 13.2 shows the *Datum Transformation Parameters* section. This section shows the datum transformation method used in the calibration and the computed parameters.

Datum Transformation Parameters	
Method	Three Parameter
Translation along x axis	-2.050m
Translation along y axis	-3.254m
Translation along z axis	2.952m

Figure 13.2 Datum Transformation section of a Calibration report

The Updated Default Projection (Transverse Mercator) Definition section

The *Updated Default Project (Transverse Mercator) Definition* section shows the updated projection origin values (when the *Update default projection origin* option has been selected).

The Horizontal Adjustment Parameters section

Figure 13.3 shows the *Horizontal Adjustment Parameters* section. This section shows the horizontal adjustment parameters computed from the calibration.

Horizontal Adjustment Parameters

Northing coordinate of rotation center	10208.059m
Easting coordinate of rotation center	10162.285m
Rotation about the center point	-0°00'07.889133"
Translation north	-0.003m
Translation east	-0.012m
Scale factor	1.00003693

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Figure 13.3 Horizontal Adjustment Parameters section of a Calibration report

The Vertical Adjustment Parameters section

Figure 13.4 shows the *Vertical Adjustment Parameters* section. This section shows the vertical adjustment parameters computed from the calibration.

Vertical Adjustment Parameters

Northing coordinate of origin point	10063.693m
Easting coordinate of origin point	10362.152m
Vertical separation at origin	-27.969m
Slope north	0.000ppm
Slope east	0.000ppm

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Figure 13.4 Vertical Adjustment Parameters section of a Calibration report

The Geoid Model Definition section

The *Geoid Model Definition* section shows the name of the geoid model used for the project.

The Residual Differences Between GPS and Known Coordinates section

The *Residual Differences Between GPS and Known Coordinates* section shows the residual differences between the point pairs used in the calibration. Use this section to identify suspect point pairs.

This section includes:

- Summary
- Point residuals

Figure 13.5 shows the *Summary* subsection. This subsection shows the maximum residuals and the associated GPS points.

Summary			
	Maximum error	Root Mean Square error	Point
Horizontal	0.003m	0.002	NE COR
Vertical	0.000m	0.000	SE COR
Three-dimensional	0.003m	0.002	NE COR

Figure 13.5 Residual Differences Between GPS and Known Coordinate – Summary section of a Calibration report

The *Point Residuals* subsection shows all of the point pairs used in the calibration, and the residual differences. Any point pairs that have residuals greater than the value specified in the registry setting on your computer are shown in red.

Applying the Calibration

To apply the last computed GPS site calibration:

- In the *GPS Site Calibration* dialog, click **OK**.

Trimble Geomatics Office updates the project coordinate system with the calibration parameters.

To view the coordinate system details:

1. Select *File / Project Properties*. The *Project Properties* dialog appears.
2. In the *Coordinate System* tab, click **Details**. The *Project Coordinate System Details* dialog appears.
3. Select the *Adjustment* tab to view the horizontal and vertical GPS site calibration parameters.

The software performs a recomputation and updates the database with the new calibration parameters.

Using a GPS Site Calibration in Future Projects

If you plan to do future fieldwork in the immediate area, save the coordinate system (which includes the calibration parameters) as a site. You can then use the site as the coordinate system for future projects.

To do this:

1. In the *GPS Site Calibration* dialog, click **Save as Site**. The *Save as Site* dialog appears.
2. Enter a name for the site and then click **OK**.

The site is saved to the coordinate system database.

To use a saved GPS site calibration (as a site) in another project, make sure that the project area is within the points used in the GPS site calibration.

If you select the site for a new project that is within the area covered by the points used in the original calibration, you do not need to carry out another GPS site calibration.

For example, in Figure 13.6, save the GPS site calibration as a site in project A, then use the site in project B. However, do not use the site in project C because the area is outside the points used in the GPS site calibration.

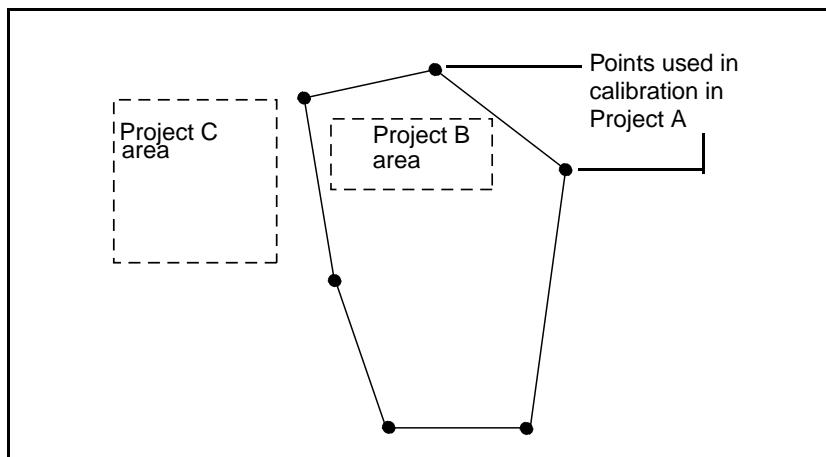


Figure 13.6 Site used for other projects

Field Procedures

In this chapter:

- Introduction
- Measuring points
- Cogo functions
- Stakeout
- Ending the survey

Introduction

This chapter describes how to carry out a variety of field procedures.

Measuring Points

In a conventional survey, the only type of points that you can measure are topo points or check points. In a GPS survey, you measure points by choosing one of several predefined point types.

In a GPS survey, the Survey Style (and so the survey type) you choose determines the type of point(s) that can be measured. A single Survey Style cannot measure every kind of point, so it is necessary to use different Survey Styles to measure different kinds of point. An RTK Survey Style, for example, can be used to measure observed control points, Rapid points, topo points, and calibration points.

This section shows how to measure points, using RTK or RTK & Infill methods.

Note – Dual-frequency receiver was used for the following examples.

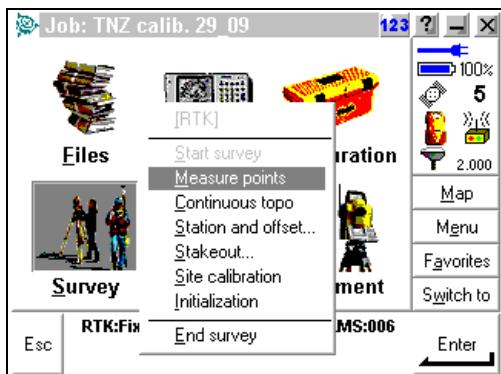
For RTK surveys, initialize the survey before measuring points.

Measuring a point in an RTK survey

Start a survey with the RTK survey style. For more information, see Starting the RTK Rover Survey, page 248.

To measure a point:

- From the main menu, select *Survey / RTK / Measure points*.



Note – You can also measure a point from the Map screen. To do this, open the job, tap **Map**, then tap **Measure**.

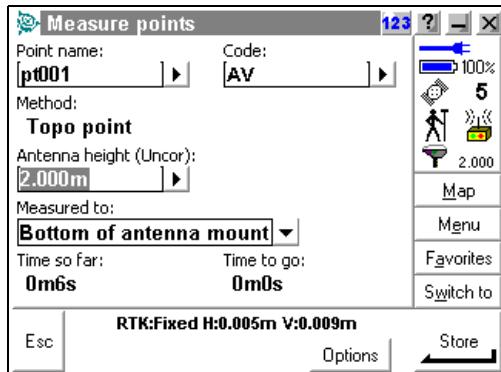
- Enter a name in the *Point name* field.
- Enter information about the point in the *Code* field. This is optional.
- In the *Type* field, select *Topo point*.

Note – *Topo point* is only one of the point types that can be measured. For more information, refer to *Measure points* in the Trimble Survey Controller Help.

- Enter a value in the *Antenna height* field. Make sure that the *Measured to* field is correct.
- When the antenna is vertical and stationary, tap **Measure** to start recording data.

The static icon () appears in the status line.

7. When the preset occupation time and precisions have been reached, the **Store** softkey appears. Tap it to store the point.



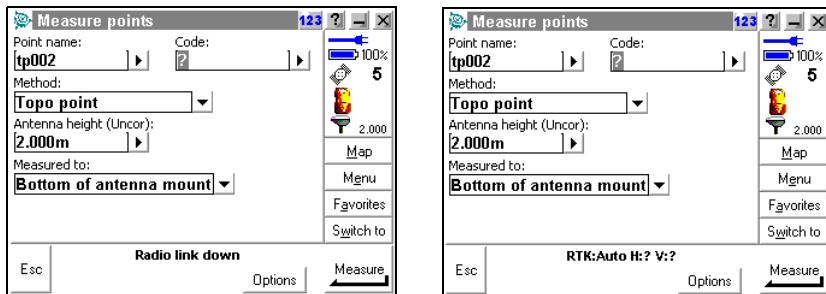
Tip – In the Survey Style, set the Auto store point field to Yes to automatically store the point when the preset occupation time and precisions have been met. To switch on *Auto store* for this survey, tap **Options**.

Measuring a point in an RTK & Infill survey

To do this:

1. Start a survey with the RTK & Infill survey style.
2. Follow the same procedure as outlined in Measuring a point in an RTK survey, page 285.

3. If the radio link becomes unavailable, the following screens appear:



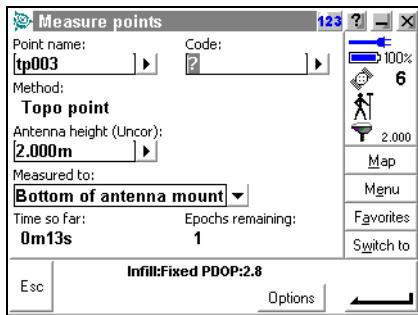
- a. Go back to the *Survey* menu and select *Start PP Infill*. The following screens appear:



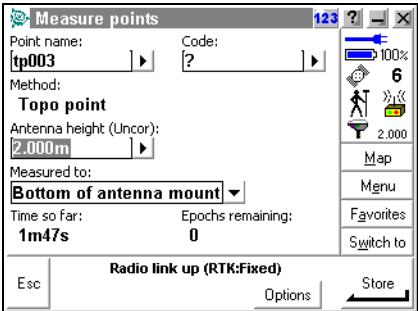
- b. You can start measuring points while the OTF initialization is in process or you can wait until PPK=FIXED and then start measuring.

If you have a previously observed WGS-84 coordinate, you can also perform a Known Point initialization.

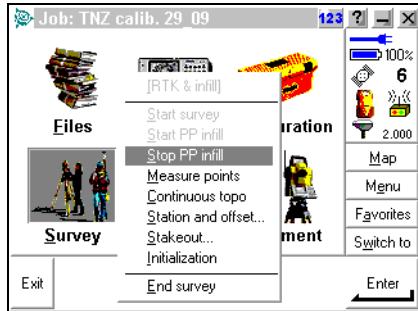
Note – If you decide to start measuring points before the OTF initialization is gained, make sure you are able to maintain the uninterrupted lock to SVs during the entire initialization time.



- c. Keep measuring points in infill mode until radio link becomes available again. Once the radio link is back on, the following message appears in the status line:



4. Go back to the *Survey* menu and select *Stop PP Infill*. The following screens appear:



5. Continue measuring points following the same procedure as outlined in Measuring a point in an RTK survey, page 285.

Measuring continuous topo points

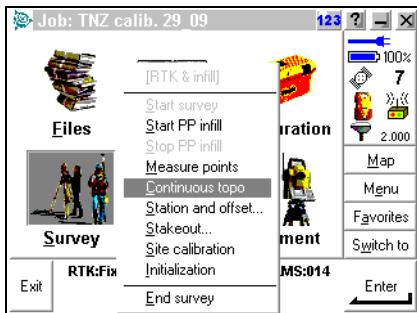
Continuous topo points are stored automatically and continuously after a preset time and/or distance once the required precisions are reached.

In a real-time survey, Trimble Survey Controller can measure a line of continuous *offset* points at the same time as a line of continuous topo points.

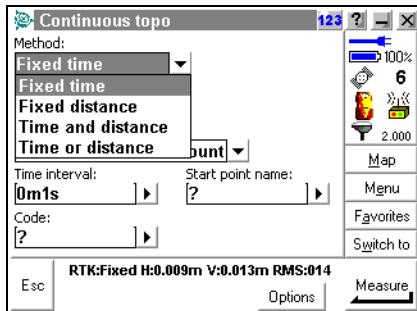
Measuring a line of continuous points

To measure a line of continuous topo points:

- From the main menu, select *Survey / RTK / Continuous topo*.

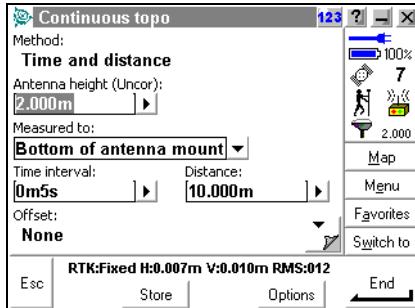


- Set the *Type* field to *Fixed time*, *Fixed distance*, *Time & distance*, or *Time or distance*.



- Enter a value in the *Antenna height* field. Make sure that the *Measured to* field is correct.
- Enter a value in the *Horizontal distance* field and/or the *Time interval* field, depending on the method you are using.
- You can also observe up to two offsets. Enter these as required. For more information, see the following section.

6. In the lower section of this dialog, enter a value in the *Start point name* field. This increments automatically. If required, enter a code.



7. Press **Measure** to start recording data, and then move along the feature to be surveyed.

There is an audible beep every time a point is recorded.

Note – To change the distance interval, time interval, or offset while measuring points, enter new values in the fields.

8. To stop measuring continuous points, press **End**.

Measuring a line of continuous offset points

To measure a line of continuous offset points:

1. From the main menu, select *Survey / RTK / Continuous topo*.
2. Set the *Type* field to the required method.
3. Enter a value in the *Antenna height* field. Make sure that the *Measured to* field is correct.
4. If the *Type* field includes Time, enter a value in the *Time interval* field.
5. Enter the interval in the *Distance* field, and change the setting in the *Offset* field to *None*, *One*, or *Two*.

6. Enter a value for the center line in the *Start point name* field. This increments automatically.
7. Enter the horizontal offset distance for Offset one (the first line of offset points).

Note – Enter a left or a right offset. For a left offset, enter a negative offset distance.
8. Enter the vertical offset distance for Offset one.
9. Enter a value in the *Start point name* field for Offset one. This increments automatically.
10. If measuring two offset lines, repeat Steps 5 through 9 for Offset two.
11. Tap **Measure** to start recording data, and then move along the feature to be surveyed.

There is an audible beep every time a point is recorded.
12. To stop measuring continuous offset points, tap **End**.

Calculating continuous offset points

Trimble Survey Controller calculates continuous offset points.

When three continuous points have been measured, the half-angle is calculated between the two lines described by the three points. The offset point is then placed at a distance computed from the offset value and the half-angle.

For the first continuous point, the offset point is placed at right angles to the line to the next continuous point. For the last continuous point, it is placed at right angles to the line to the previous continuous point.

These calculations ensure that the offset line stays parallel to the continuous line of points.

Figure 14.1 shows how continuous offset points are calculated.

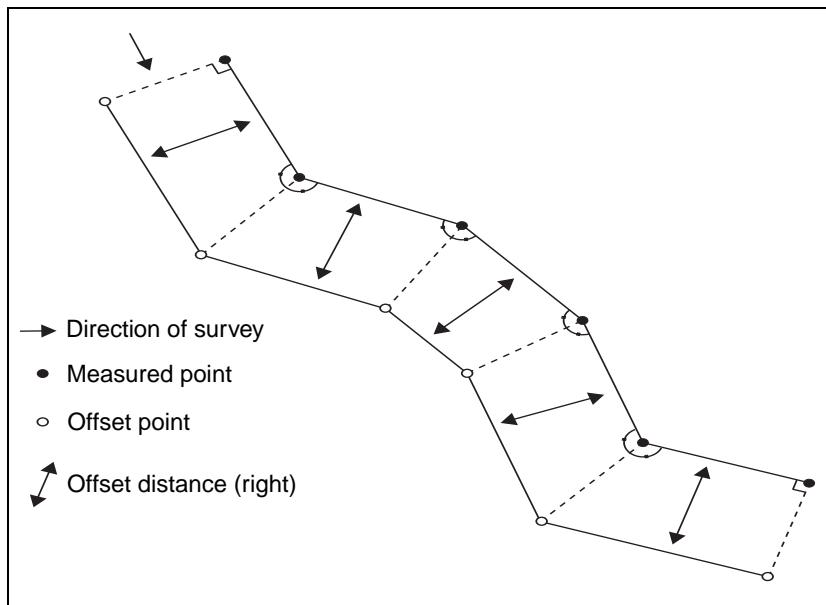


Figure 14.1 Calculation of continuous offset points

The line between offset points is parallel to the lines between the continuous points and is offset by the value specified.

Cogo Functions

Trimble Survey Controller provides coordinate geometry (Cogo) functions that perform various calculations using points stored in the database. The results can also be stored in the database. To access these functions, use the *Cogo* menu. This menu includes a calculator.



Warning – Do *not* change the coordinate system or perform a calculation after you have computed intersection points. If you do, the intersection points will not be in terms of the new coordinate system.

The Trimble Survey Controller Cogo function can perform the following calculations:

- Compute Inverse
- Traverse
- Subdivide a line
- Subdivide an arc
- Compute a point
- Compute area
- Compute azimuth
- Compute distance
- Compute average

Exercise 14: Using Cogo Functions – Subdivide a line

This exercise shows how to:

- Key in points and lines using the Key in menu
- Subdivide a line using Cogo functions.

For detailed instructions on how to perform other Cogo calculations, see the *Trimble Survey Controller Help*.

Keying in a point

To key in a point:

1. From the main menu, select *Key in / Points*. The *Key in/Point* screen appears.
2. You can key in grid, local, or WGS-84 coordinates. To change the coordinate fields, tap **Options** and change the coordinate view.
3. For this exercise, set the view to Grid. Then key in the following values, as described below:

Pt name	Northing	Easting	Elevation
100	100.00	3000.00	10
200	237.82	5619.03	55.02

4. In the *Point* screen, enter the first point name.
5. Enter a code if required (optional).
6. Key in the coordinates. Tap **Enter**.
7. Tap **Store** to store the point.
8. Repeat Step 4 through Step 7 for the second point.
9. Tap **Esc** to return to the main menu.

Keying in a line

To key in a line:

1. From the main menu, select *Key in Lines*. The *Key in / Line* screen appears.
2. You can key in grid, ellipsoid, or ground distances. To change the distances field, tap **Options** and change the Distances setting to Grid.
3. In the *Line* screen, enter the line name.
4. Enter a code if required (optional).
5. In the Method field, select Two points.
6. For Start point and End point, select from the list the two points entered in Keying in a point.
7. Tap **Calc**, then tap **Store**. The line is created.
8. Tap **Map** to view the points and the line.
9. Tap **Esc** to return to the main menu.

Subdividing a line

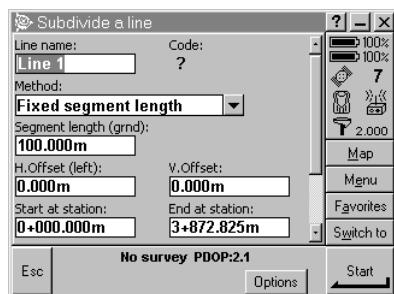
To subdivide a line using the Cogo function:

1. From the main menu, choose *Cogo / Subdivide a line*.
2. In the dialog that appears, enter values in each field as required.

In the list in the *Line name* field, select the line created in Keying in a line, above.

Select the required option from the *Method* field.

Specify a Start point name for the points which are created by subdividing the line.



3. Tap **Start** to calculate the results.
4. Tap **OK** to store the results in the Trimble Survey Controller database (this step is optional).
5. Tap **Map** (or select *File / Map of current job* from the main menu) to view the subdivided line.

Alternatively, select *File / Review current job* from the main menu to view the subdivided line as a list.

Stakeout

This section shows how to stake out a point.

Note – Before staking out grid coordinates, define a projection and datum transformation.

Trimble recommends that you carry out a complete calibration before staking out any points.

General procedure

To stake out a point:

1. Define the point and store it in the Trimble Survey Controller database.

To define the point, do one of the following:

- Transfer a job from the Trimble Geomatics Office software
- Key in data
- Calculate coordinates using one of the Cogo functions

2. Initialize the survey.
3. Navigate to a point.
4. Stake or mark the point.
5. Measure the as-staked point (this is optional).
6. Repeat Step 3 through Step 5 until all points are staked out.
7. End the survey.



Warning – Do not stake out points and **then** change the coordinate system or perform a calibration. If you do, any points staked out after the changes will not be in the same terms as the points already staked out.

Exercise 15: Staking out a point

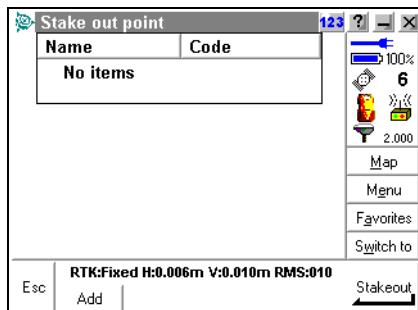
This exercise shows how to stake out points created in Using Cogo Functions – Subdivide a line, page 295.

To stake out a point:

1. From the main menu, select *Survey / <RTK survey> / Stakeout / Points*. You can also select points from the *Map* screen for immediate stakeout.

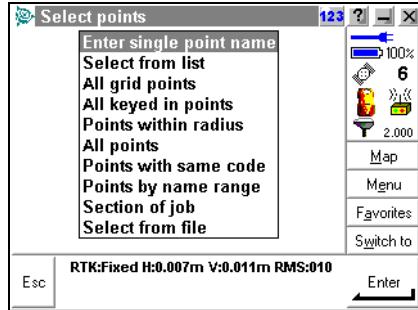
Note – If a survey is already running, the list of survey styles does not appear.

A dialog similar to the following appears:

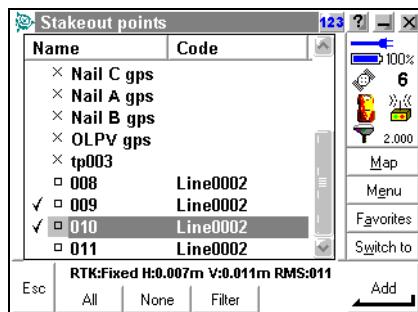


If this is the first time you have used the Stakeout function in this job, this list is empty.

2. Transfer points from the Trimble Survey Controller database to the *Stakeout/Points* list. To do this:
 - a. Press the **Add** softkey. The following dialog appears:

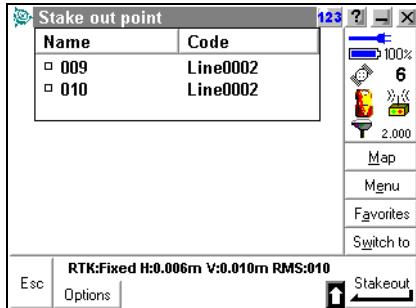


- b. From this list, choose how points are to be selected. Choose *Select from the list*. The following dialog appears. This time, it displays a list of points in the Trimble Survey Controller database:

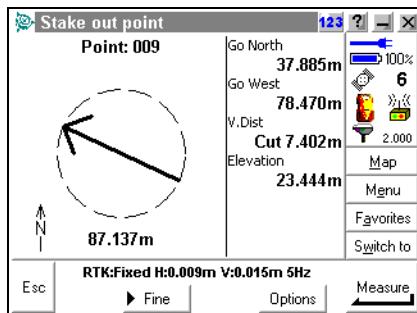


- c. Tap a point to select it. A check mark appears next to the selected point name. Do this for each point to be staked out.

- d. When you have selected all the points to be staked out, tap **Add** to return to the *Stakeout point* screen. The dialog displays the selected points:

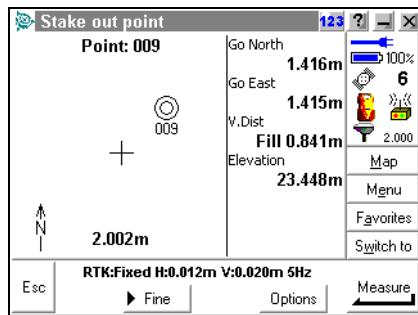


- e. Select the point to be staked out. To do this, tap the point.
3. Make sure that the survey is initialized. For more information, see page 251.
4. The dialog that appears shows:
- The azimuth and horizontal distance from the present position to the point to be staked out
 - a graphical representation of these values:



5. The azimuth and distance to the next point appear on the right of the screen.

To navigate using the arrow in the graphical display screen, move forwards with the controller held in front of you. The arrow points in the direction of the point to be staked out. Walk towards the point. When you are about three meters from the point, the display changes. Two concentric circles (resembling a bull's-eye) show the position of the point, and a cross shows your position, as shown below:



The **Fine** softkey appears when you are in Coarse navigation mode. The location values displayed are sensitive, and the precisions are large (the position update rate is 5 Hz). Use this mode to locate the design points when you are far away.

The **Coarse** softkey appears when you are in Fine navigation mode. The location sensitivity is slower, and the precisions are small (the precision update rate is 1 Hz). Use this mode to locate the exact position of the design point.

When you get closer to the point, press **Fine** to go into Fine mode. The graphical display screen zooms in and magnifies the display. Walk toward the point until the cross on the screen is over the two concentric circles. Remember to keep the pole vertical. Mark the point with a stake or nail as required. Tap **Esc** to return to the *Stakeout / Points* screen.

Note – You can configure the survey style to make Trimble Survey Controller go to Fine mode automatically.

6. Do one of the following:
 - To record the as-staked point, place the range pole over it. When the range pole is centered and vertical, tap **Measure** to measure the point. Tap **Store** to store the point. Tap **Esc** to return to the *Select / Points* screen.
 - If you do not want to measure the as-staked point, tap **Esc** to return to the list. Stake out more points.

Ending the Survey

When you have measured or staked out all the points you need, end the survey:

1. From the *Survey* menu, select <RTK survey> / *End survey*.
2. Tap **Yes** to confirm the instruction. Trimble Survey Controller asks if you want to power down (turn off) the receiver. Tap **Yes**.

Note – The software will prompt you to disconnect the cable from the receiver. Disconnect the cable, then tap OK.
3. Return to the base station and connect the controller to the receiver. Select *Survey* / <RTK survey> / *End survey*.
4. Tap **Yes** to confirm the instruction.
Trimble Survey Controller asks if you want to power down (turn off) the receiver.
5. Tap **Yes** again.

Office Procedures

In this chapter:

- Introduction
- Processing RTK & Infill data
- Processing results
- Accepting results
- Reporting on the project
- Additional reports
- Report links

Introduction

This chapter describes how to process data obtained from an RTK survey. It also describes how to prepare reports on the processed results and the survey project.

Processing RTK & Infill Data

This section describes how to process the infill data segments to produce GPS baselines to replace your infill autonomous positions. You can process infill-collected data only from the  Survey view in Trimble Geomatics Office.

A base station started with the RTK & Infill survey style sends RTK corrections. It also records raw observations in a .DAT file during the entire survey session.

A rover receiver started with RTK & Infill survey style records RTK observations in a .DC file. It also records raw observations in a .DAT file when the radio link is unavailable.

When the DC file with infill segments is imported into Trimble Geomatics Office, a *.DAT file is linked to the DC file.

This roving *.DAT file is used in association with a base receiver *.DAT file. It is processed with a baseline processor to analyze and redisplay the data to a better precision. The baseline processor in Trimble Geomatics Office evaluates the processed solutions of your data.

Note – For more information on transferring files from a GPS receiver and Trimble controller, see Exercise 16.

If the data you recorded pass all the user-defined settings, the processed results can then be merged with the original data. The autonomous positions associated with the baseline solutions will be removed.

If the results do not meet the required standards, you can try to improve them using proper postprocessed techniques.



Tip – Use Select / By Query / Autonomous GPS points to quickly determine which positions in your database represent base or infill autonomous data points.

Figure 15.1 outlines workflow for processing data collected with the RTK & infill survey style.

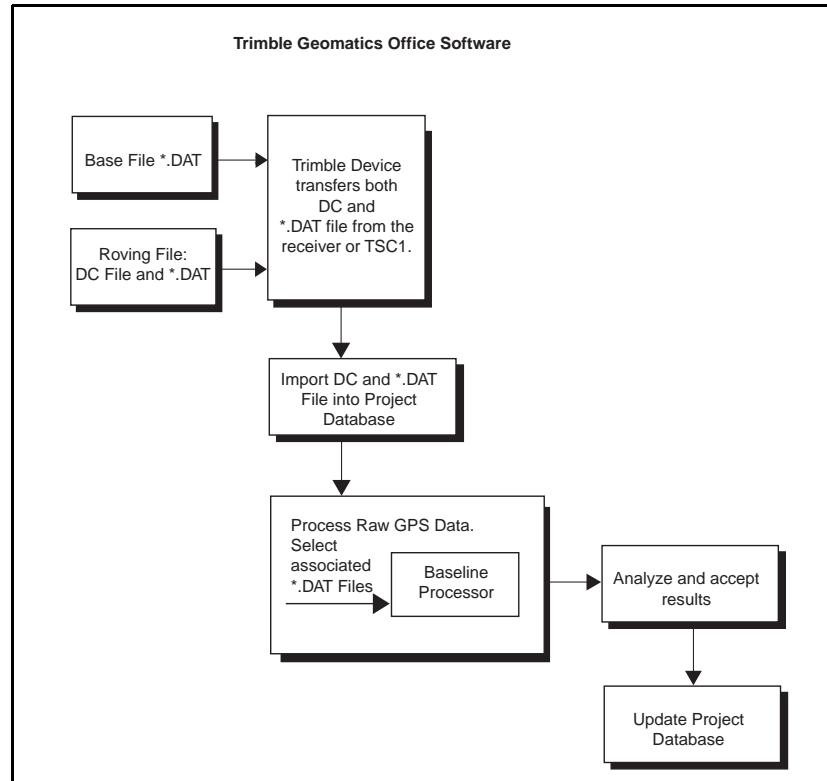


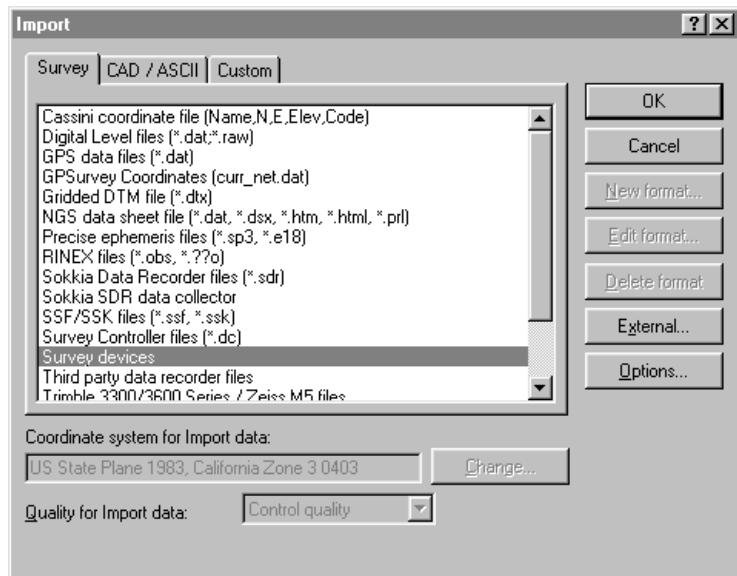
Figure 15.1 Flow of RTK & Infill data

Exercise 16: Transfer files from Trimble Survey Controller or a GPS receiver

To transfer files from Trimble Survey Controller to Trimble Geomatics Office:

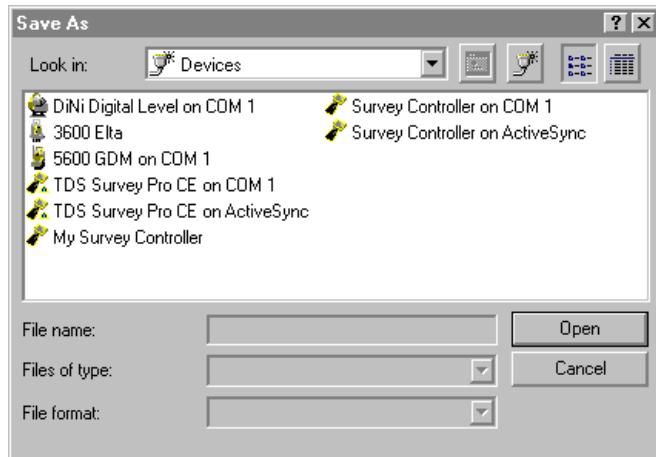
1. On the office PC, start Trimble Geomatics Office and open the project to receive the files.
2. Do one of the following:
 - Select the *Import*  tool.
 - Select *File / Import*.

The following dialog appears:



3. In the *Survey* tab, select *Survey Devices*.

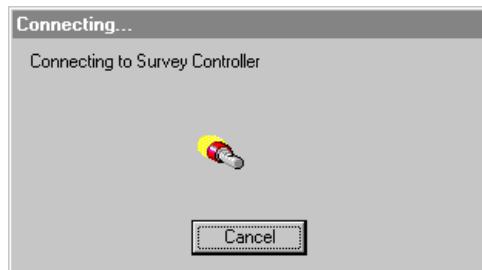
4. Click **OK**. The following dialog appears:



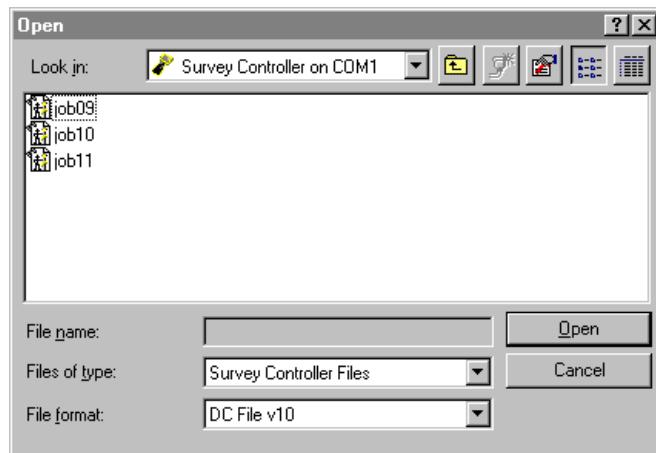
Once you have checked that Trimble Survey Controller is connected to the correct COM port and is in the appropriate data transfer mode, you can import the data.

To transfer the .dc file:

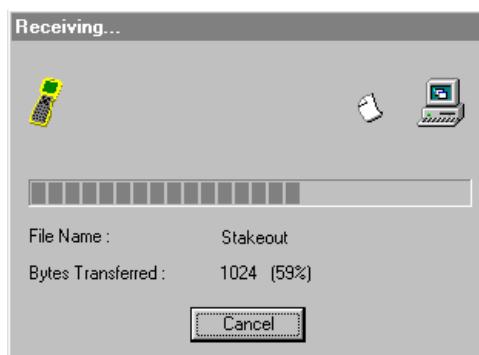
1. In the *Open* dialog, select a Trimble Survey Controller device.
Note – If transferring from the GPS receiver, select GPS receiver device
2. Click **Open**. The following dialog appears as the office PC connects to Trimble Survey Controller:



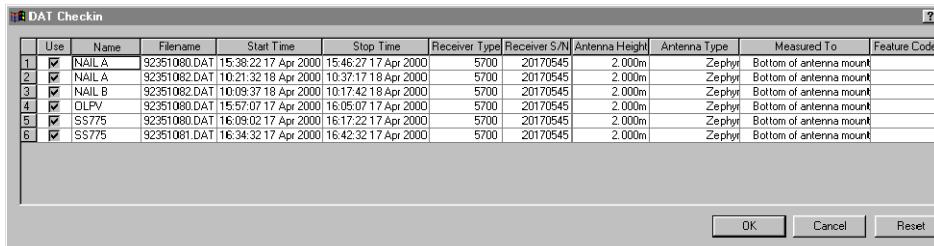
When the PC is connected, the *Open* dialog returns. The *Look in* field is set to the Trimble Survey Controller device that you are connected to and displays all of the Trimble Survey Controller jobs available, as shown below:



3. Select the file to import and click **Open**. The following screen appears:



4. When a .DAT file (or a .DC file with associated .DAT file) is transferred, a CHECKIN dialog appears:



This dialog gives you the opportunity to check the filename, start and stop times, and antenna height details before importing into the project database. Click OK to approve the *Checkin* information.

The data files are now in Trimble Geomatics Office database. Files imported into Trimble Geomatics Office (.DC and .DAT) are stored in C:\Trimble Geomatics Office\Projects\<Project Name>\Data Files folder.

Note – If you use the Data Transfer utility in standalone mode to transfer files, the recommended destination folder is C:\Trimble Geomatics Office\Projects\<Project Name>\Checkin folder. Use the Import tool to import those files into the Trimble Geomatics office database.

Exercise 17: Processing the infill (raw) data

To process the data file or files from the *Survey View*:

1. Download GPS data from the base and any rovers.
2. In Trimble Geomatics Office, select *Survey / Process GPS Baselines*.

This action will automatically begin processing the base raw satellite data with the observed rover positions also containing raw satellite data. The baseline processor uses styles to govern whether a baseline is completely solved.

Processor styles

From the *Survey / GPS Processing Styles*, you can review the settings which meet the conditions of your site. For example, select the Trimble **Default** style and the **Edit** button.

From the Trimble Default dialog that appears, you can set elementary processing settings. To gain more control over your solution types, use the **Advanced** button.

For more information on Advanced Settings, use the Help topics.

Elevation mask

You can use *Elevation mask (degrees)* to change the satellite elevation mask. By raising the elevation mask, the processor will reject low-elevation satellite data and you may improve the quality of your results.

Solution type

Additional information in the *Processor Settings* dialog includes the *Solution types* you require from the postprocessing.

- Fixed (recommended) – This is the recommended setting. The Baseline Processor will compute an iono-free fixed solution providing that the baseline length is greater than 5 km (3 mi) in length and the data are dual-frequency. An L1 fixed solution will be produced if the baseline length is less than 5 km and/or you are using a single-frequency receiver.
- Float only – The Float only setting restricts the processor to computing only float solutions for all baselines when processing. Use this setting when processing very long infill baselines [> 30 km (18 mi)] where a float solution may be the best achievable. Select the *Float only* option to save the baseline processor from performing an unnecessary integer search that will most likely fail.
- Code only (code differential) – The Code only setting uses an L1-only fixed computation to provide solutions. This result may occur due to a brief or unusually noisy observation. With this result, you should consider reprocessing the data with another base file, or reobserving.

For in-depth solution analysis, you should seek information regarding the processing raw GPS data can be found in the Trimble Geomatics Office *Help Topics*.

Processing Results

The baseline processor will:

- attempt to resolve the appropriate initialization parameters
- compute a baseline from the *base position* (determined by the base *.DAT file) to a *rover position*
- generate a summary solution table so you can analyze the quality of your observations

The results of the baseline processor computations display in a *GPS Processing* dialog. You now can review the computed vectors and make decisions as to which vectors meet the same level of quality (specifications) as your real-time survey data.

After viewing what data have passed the *Fixed*, *Float only*, or *Code only* solutions, focus your attention to the three columns named *Ratio*, *Refvar*, and *RMS*. Fully understanding these terms and their values requires a knowledge of Postprocessed surveying, which is beyond the scope of this manual. For more information, refer to the Trimble Geomatics Office Help. The default parameters in Trimble Geomatics Office will flag any Infill observations that require your attention.

Ratio – these values represent the ratio of the variance of the integer solution second-best candidate fixed solution to the variance of the best-candidate fixed solution.

Reference Variance – these values indicate how well the observed data fit the expected error in a particular baseline to the computed solution. The reference variance is unitless.

RMS – these values describe the statistical root mean square spread, or noise in the measurement of your solution. The RMS values should always be small.

To quickly review which points have met the specifications you set, use the check box column on the far left of the *GPS Processing* dialog.

Accepting Results

If you are satisfied with your results:

1. Click **Save** in the *GPS Processing* dialog to accept the results you have left checked on or off.
2. Trimble Geomatics Office software automatically recomputes the old, unprocessed data positions to the newly processed positions. You will see this change on project database screen.

Reporting on the Project

This section describes some of the reports that you can create using Trimble Geomatics Office. The reports provide summaries of projects and give you information that you can pass on to clients.

You can create a report for an entire project or for only a particular selection of entities in the project—before you create the report make your selection using one of the techniques described in Chapter 8 of the *Trimble Geomatics Office User Guide*.

Trimble Geomatics Office generates the reports in HyperText Markup Language (HTML) format and displays them on the default HTML viewer installed on your computer. The software supports the viewing of reports under [Microsoft Internet Explorer](#), and Netscape Navigator.

A typical project report includes a header containing the following project information:

- Project name
- User name
- Date and time
- Coordinate system and zone
- Datum
- Geoid model
- Units

To specify the information that appears in the report, create a custom report format.

Additional Reports

Trimble Geomatics Office also provides system database and custom reports.

System database reports are predefined report formats that you can use to obtain a summary of the current project. Normally, you do not need to edit these reports. However, you can modify them by editing the Asciirpt.dat file located in the Program Files\Trimble\Trimble Geomatics Office\System folder.

Custom reports are determined by primary record types or queries that you define, and which are in the database. You can create, or edit a custom report format. You can prevent these reports from being modified by editing the Asciirpt.dat file located in the Program Files\Trimble\Trimble Geomatics Office\System folder.

To create and view these additional reports:

1. Select *Reports / Additional Reports*. The *Additional Reports* dialog appears.
2. In the *Reports* list, select the report that you want to view.

Note – Where a report requires user entry, the name is followed by an ellipsis (...). If you choose such a report, Trimble Geomatics Office asks you to provide the parameters required to run the query.

The Points report and Stakeout report are two examples of custom reports.

Points report

The Points report summarizes the points in the project. To create and view this report, do one of the following:

- Select *Reports / Additional Reports*. In the *Additional Reports* dialog that appears, select the *Points* option and then click **OK**.
- In the project bar, select the *Trimble Survey* group, and then select the *Points Report* option.

Figure 15.2 shows an example of a Points report.

Points					
<i>Project : Example</i>					
User name		Date & Time			12:50:04 PM 8/29/00
Coordinate System	US State Plane 1983	Zone			California Zone 3 0403
Project Datum	NAD 1983 (Conus)				
Vertical Datum	NAVD-88	Geoid Model			GEOID99 (Conus)
Coordinate Units	Meters				
Distance Units	Meters				
Height Units	Meters				
 Coordinate units: Meters Elevation units: Meters					
Point listing					
	Name	Northing	Easting	Elevation	Feature Code
	N 245	606670.530	1829391.529	28.739	BM
	MOON 2	605992.373	1828075.584	22.270	
	WAVE	606827.615	1828553.591	24.955	
	KTOM	607734.163	1829226.803	32.769	
	COWBOY	607746.948	1827993.547	17.787	
	WAVE-NEE	?	?	?	OIT
	WAVE-GPS	606836.786	1828551.332	52.909	
	2000	606842.645	1828597.439	53.223	PP
	2001	606850.959	1828663.314	53.378	PP
	2002	606858.917	1828727.090	53.658	PP
	SE COR	606892.961	1828914.688	53.923	TRIG
	2005	606887.939	1828916.293	53.840	EOA ST
	2006	606887.644	1828914.803	53.820	EOA

Figure 15.2 Points report

Stakeout reports

You can generate reports based on stakeout records in the database. For example, the software can report the cuts and fills for all staked points in the database. To create and view a Stakeout report:

1. Select *Reports / Additional Reports*. The *Additional Reports* dialog appears.
2. Select one of the following:
 - All Staked Points – As Staked report
 - Design Points – As Staked report
 - Road – Story board report
 - Road – Catch point report

- Road – Point on Road report
- 3. Click **OK**.

Figure 15.3 shows an example of the Design Points – As Staked report.

Design points - As staked						
<i>Project : 7561</i>						
User name				Date & Time		
Coordinate System	Projection from data collector			Zone	12:58:01 1/11/00 Zone from data collector	
Project Datum	Datum from data collector			Geoid Model	Not selected	
Vertical Datum						
Coordinate Units	Meters					
Distance Units	Meters					
Height Units	Meters					
Name	Code	Design northing	Design easting	Delta north	Delta east	Cut/Fill
99	NAIL A	704817.973	288886.641	0.044	-0.004	0.050
101	NAIL C	704815.079	288916.473	0.018	-0.037	0.005
102	NAIL C	704815.062	288916.497	0.042	-0.031	0.004
103	NAIL C	704815.062	288916.497	0.034	-0.040	0.017
104	NAIL C	704815.062	288916.497	0.042	-0.027	0.012
101	NAIL C	704815.062	288916.497	0.001	-0.012	-0.061

[Back to top](#)

Figure 15.3 Design points – As Staked report

These reports can be customized for your particular project.

Level report

The Level report shows the level observations and data for your Level file. It is stored in the <Project name>\Reports\Level folder.

To access the report:

- Select *Reports / Level Reports* and then the Level file.

The report is displayed in the HTML viewer, as shown in Figure 15.4.

Level Report						
Contents						
Leveling Data						
Leveling Observations						
Station Points	BS	IS	FS	Elevation	Distance	Description
✓ 7	2.304m			50.000m	31.210m	
✓ 100		1.413m		50.891m	4.300m	
✓ 8			0.910m	51.394m	15.250m	
	2.062m				11.330m	
✓ 9			-3.580m	57.035m	8.980m	
	-2.374m				14.500m	
✓ 101		-3.505m		58.167m	4.730m	
✓ 10			0.793m	53.868m	10.560m	
	2.391m				15.400m	
✓ 102		1.344m		54.916m	2.330m	
✓ 102		1.344m		54.916m	2.320m	

Figure 15.4 Level report

The report shows the following information:

- Leveling data – This section summarizes the information displayed in the *Digital Level Import* dialog
- Leveling observations – the leveling observations table shows the following information:
 - ID – To point
 - From point – Quality
 - Delta elevation



Tip – To select the leveling observation in the graphics window, select the observation ID. This link lets you easily view the level observation in the *Properties* window.

Report Links

Many of the reports in Trimble Geomatics Office contain links to:

- other parts of the report
- other reports
- the graphics window
- the *Properties* window

These links let you find points and investigate erroneous data more easily. For example, if you find a misclosure reported in the Recompute report, you can select the relevant point, locate it in the graphics window, and then investigate it further in the *Properties* window.

For information on report links in specific reports, refer to the Help.

Section 2 — Field and Office Procedures Review

Questions

1. When are you required to leave a controller connected to the base receiver?
2. What is the meaning of the status line message: RTK=Auto?
3. When would you use the Trimble Geomatics Office postprocessing option?
4. What are the requirements for using the Trimble RTK & infill survey style?
5. What happens if you lose radio link during a real-time survey?
6. What happens if you lose radio link during an RTK & infill type of survey?
7. Is your RTK initialization sufficient for use with your postprocessed infill survey?
8. Name the three types of initialization used for postprocessed surveys.
9. What are the three differences between the RTK & infill and RTK configurations?

10. What must you do before starting an RTK & infill roversurvey?
11. When starting the postprocess (infill) portion of a survey, what must you do first?
12. How many seconds of continuous observation are required to perform an OTF initialization?
13. What type of measurements can you perform while in the Infill mode?
14. What methods are available to define a point prior to staking it?
15. Prior to performing stakeout operations, what type of survey style must you first start?
16. How does the stakeout/navigation screen change when you get within 3 m (10 ft) of your stakeout point?
17. What is the difference between the coarse mode and the fine mode as defined in the stakeout screen?

Answers

1. Maintain the connection to the controller when performing a RTK & Infill survey and having data logged to controller memory.
2. The radio link is down. You are now in Autonomous mode.
3. You would use the Trimble Geomatics Office postprocessing option when you have data collected in the Trimble RTK & infill survey style.
4. You must have two survey grade receivers (1 base, 1 rover) that can both either store raw GPS data on board, or have a controller linked to store the raw survey data.
5. The rover GPS receiver will work in an autonomous mode, meaning that the positional accuracy of any points measured will not be of a centimeter-level accuracy.
6. You can go to the Survey menu on the controller and select Start PP Infill.
7. No, you need to collect a second independent initialization for your Infill segments of data. A Known Point initialization on an observed RTK position can be used for this Infill initialization.
8. Four types of initialization used for postprocessed surveys are:
 - Known Point (Fixed Baseline)
 - New Point (Static Baseline)
 - OTF (On-the-Fly)
9. Logging device at the rover, logging device at the base, postprocess initialization times.
10. You must start your base in a mode that allows for raw data collection.

11. You must initialize the survey.
12. 480 seconds.
13. Topo, kinematic, and continuous topo—time only.
14. The point can be keyed in, observed in the field, imported from Trimble Geomatics Office, or be the result of a cogo operation.
15. You must have started an RTK or a RTK/Infill style survey, and you must currently be in RTK mode.
16. As you approach within 3 m (10 ft) of the point, the screen changes from the arrow display to a bull's-eye display.
17. When the **►Fine** softkey is displayed, you are currently in *Coarse* navigation mode. You will notice that the location values displayed are sensitive, and your precisions are large (the position update rate is 5 Hz). Use this option to locate your design points when far away. When the **►Coarse** softkey is displayed, you are currently in *Fine* navigation mode. You will notice that the location sensitivity is slower, and your precisions are small (the position update rate is 1 Hz). Use this option when locating the exact position of your design point.

Start to Finish

In this chapter:

- Introduction
- Task Review

Introduction

You now have the skills to perform a real-time survey.

This chapter provides a test of the real-time surveying techniques offered in this course, using Trimble equipment. Your instructor will provide you with a set of instructions to test your ability and confidence with your new skills.

Task Review

You will put into practice the information from the previous chapters, including:

- Creating a project in Trimble Geomatics Office
- Importing and exporting data
- Setting up and configuring field equipment
- Starting the survey
- Calibrating the site in the field
- Measuring points actively using feature codes and attributes
- Performing various calculations using Cogo function
- Staking out design points and storing the staked position.
- Staking out Cogo calculated points and storing the staked positions.
- Ending the survey
- Producing a plan in Trimble Geomatics Office using feature code processing
- Producing a point report in Trimble Geomatics Office

Notes



Station Index and Multibase

In this appendix:

- Introduction
- Station index
- Operating several base stations on one radio frequency

Introduction

This Appendix describes the station index and how to use it when operating with multiple base stations on one radio frequency.

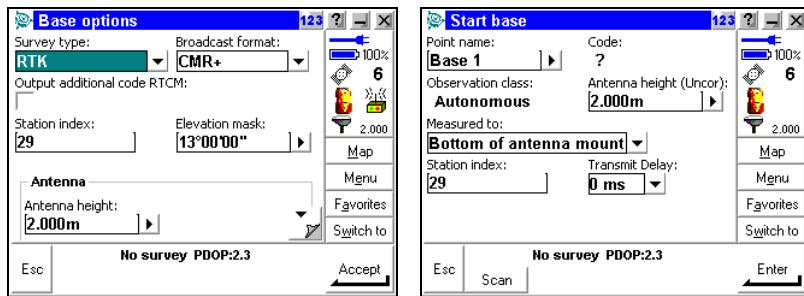
It also describes multibase operations and transmission delays.

Station Index

The station index is a unique identifying number allocated to each base station. In real-time surveys, the base receiver broadcasts the station index number as part of the broadcast message.

As shown in the following dialogs:

1. Set the station index number in the *Start base* screen.
2. Set the default station index number for the *Start base* screen in the *Station index* field in the *Base options* of the Survey Style.



Use station index

If you want to use multiple base stations on one radio frequency, in the *Use station index* field, enter the station index number that you want to use first.

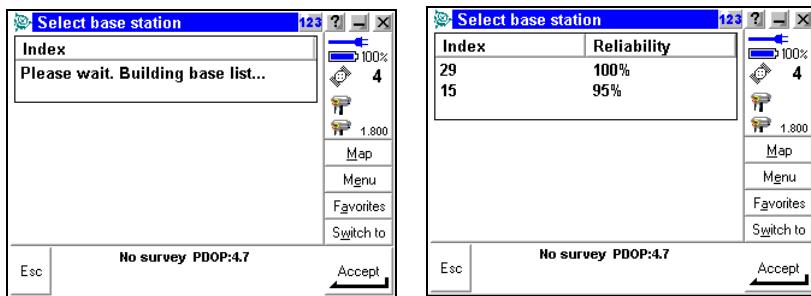
If you do not want to use multiple base stations on one frequency, enter the same station index number that you enter in the *Base options* screen.

To use any base station operating on the frequency set in the rover radio, press **Any**.

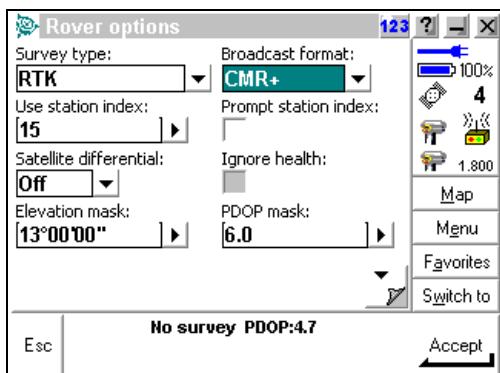
Note – If you press Any and there are other base stations operating on the frequency, you could use corrections from the wrong base in the rover survey.

Prompt for station index

When you use a receiver that supports multiple base stations on one radio frequency, you must indicate which base to use when you start the rover survey, as shown in the following dialogs:



To stop this question from appearing, set the *Prompt for station index* field to *No*, as shown in the following dialog. The station index number in the *Use station index* field is used:



Operating Several Base Stations on One Radio Frequency

In an RTK survey you can reduce the effects of radio interference from other base stations on the same frequency by operating your base station with a different transmission delay. This allows you to operate several base stations on one frequency, as follows:

1. Check that you have the correct hardware and firmware.
2. Set up the equipment and start a survey at each base station, specifying a transmission delay and a station index number.
3. Start a rover survey and specify which base to use.

Hardware and firmware requirements

To operate several base stations on one frequency, you must use receivers that support the CMR Plus correction record format. You **cannot** use Series 4000 or 4600LS receivers.

Only one Site Surveyor™ 4400 or MS750™ receiver can be used—it can only be used as the base with the 0 ms transmission delay. You do not need to set this. If you use a 4400 or MS750 receiver, it automatically broadcasts with a 0 ms transmission delay.

All other base and rover receivers must be GPS Total Station R7, R8, 5700, or 5800 or 4700 / 4800 receivers with firmware version 1.20 or later.

Note – Do not use transmission delays if you intend to use radio repeaters.

Starting the base with a transmission delay

When you use multiple base stations, you set the transmission delay for each base when you start the base survey. Each base must broadcast with a different transmission delay and station index number. The delays allow the rover receiver to receive corrections

from multiple base stations operating at the same frequency. The station index numbers let you select which base station to use at the rover.

Note – . When you carry out surveys using different base stations in one job, make sure that the coordinates of the base stations are in the same coordinate system and are in terms of each other.

The following example shows how to set up two base stations operating on the same frequency.

Two 5700 GPS receivers and TrimTalk 450 S radio modems are available for base station setup. Rover unit is 5700 GPS receiver with internal radio.

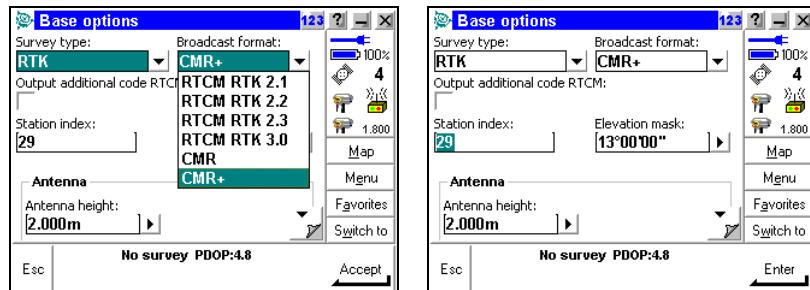
Approved radio frequency is 466.8375 MHz.

Base Station 1 will operate with station index No.15, and 0ms transmission delay.

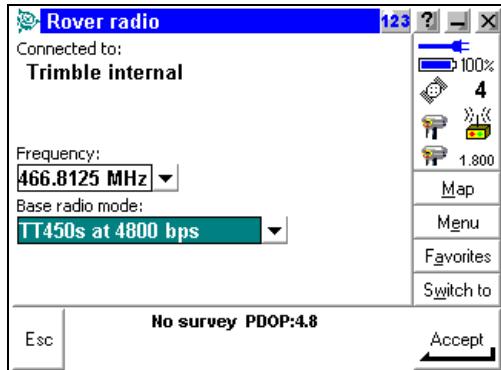
Base Station 2 will operate with station index No.29, and 500ms transmission delay.

To configure both base and rover survey style, do the following:

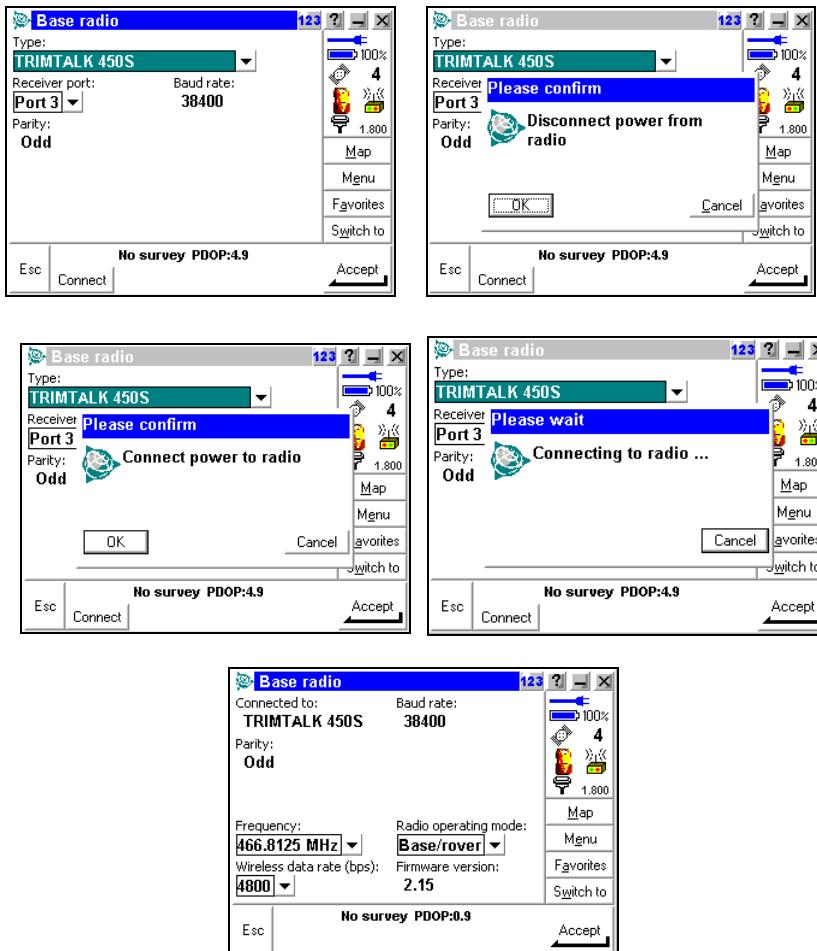
1. Create or edit an existing RTK Survey Style.
2. In the Survey Style (for both the base and the rover) select the CMR Plus correction message format, and specify a station index number, as shown in the following dialog:



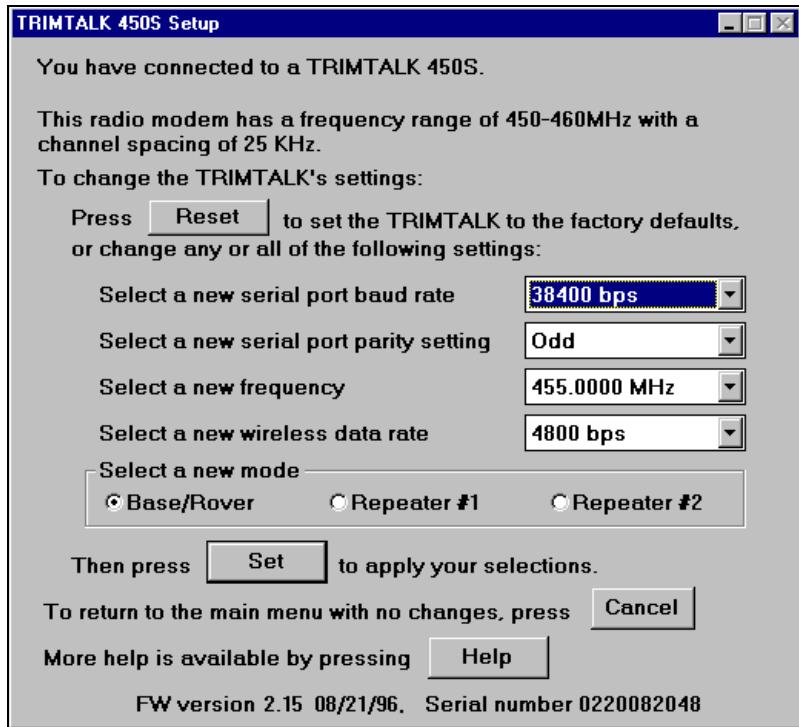
3. Make sure that both rover and all base radios are operating on the same frequency and with the same over-the-air baud rate. Use the controller to set the rover internal radio over-the-air baud rate to at least 4800 baud.



4. As shown below, use Trimble Survey Controller to connect to the base station's external radio. Check that the radio is set for the correct over-air baud rate, and change it if necessary.



Alternatively, to set the over-air baud rate on an external radio, use the TRIMTALK setup, as shown in the following dialog, or another appropriate utility:



Note – If you use a 4800 bps over-air baud rate, you can only use two base stations on one frequency. Increase the over-air baud rate if you want to increase the number of base stations on the same frequency.

5. Go to Start base survey. If the receiver you are using supports transmission delays, the *Transmission delay* field appears, as shown in the following dialog. Choose a value, depending on how many base stations you want to use, as shown in the following dialog, and Table A.1:

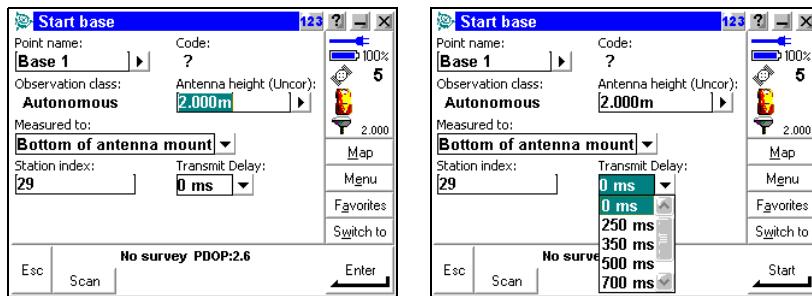


Table A.1 Number of bases / transmission delays

Number of base stations	Delays to use (ms)...			
	Base 1	Base 2	Base 3	Base 4
One	0			
Two	0	500		
Three	0	350	700	
Four	0	250	500	750

6. Repeat the same procedure to start the second base station. Change Station index number to No.25 and transmission delay to 500 ms.

Changing between base stations

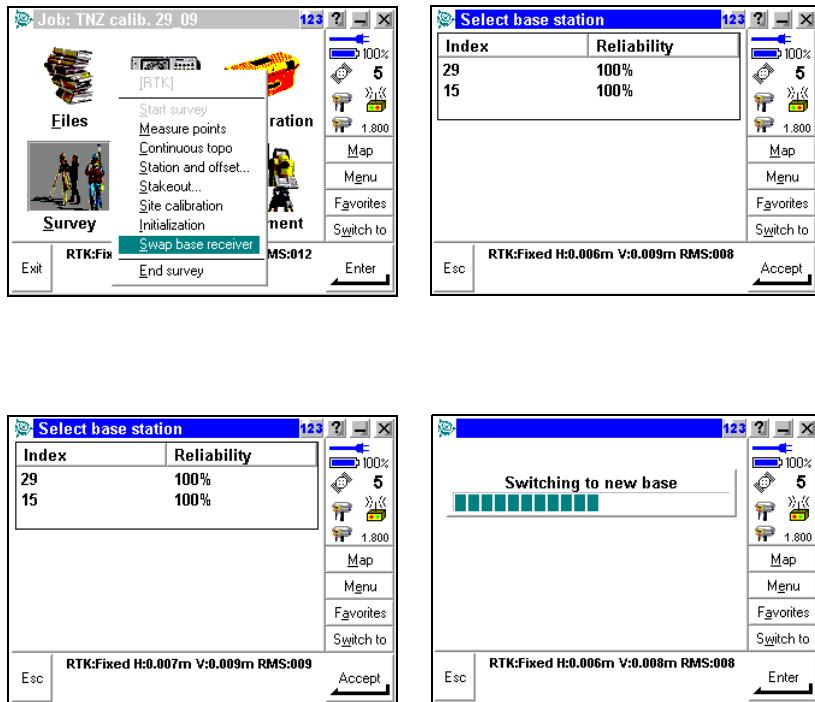
Now there are two base stations in the area, transmitting on the same frequency (466.8375 MHz):

- BASE No.1 – Station Index 15, Transmit Delay 0ms

- BASE No.2 – Station Index 29, Transmit Delay 500ms

Our system has been set up to use Base No.1, Station Index 15.

To change to the second available base station, use *Swap base receiver* from the *Survey* menu, as shown in the following dialogs:



Survey Controller will automatically lose initialization, end the current survey, and start a new one using base information from the newly selected base station.

B

Maximizing the Performance of the RTK Radio Link

In this appendix:

- Introduction
- Radio Waves
- Radio Modems
- Antenna
- Loss of Radio Link

Introduction

Wireless data communication link between base and rover receiver is crucial for successful RTK surveys. The radio data link passes the information from the base receiver to the rover receiver, enabling centimeter-level position computations in real-time.

This appendix provides useful information about radio communication that will help you maximize the performance of your RTK system.

Effectiveness of your radio data communication system depends on laws of physics. Understanding a few basic principles affecting radio signals will help you establish a reliable data communication system.

Radio Waves

Radio waves are part of an electromagnetic spectrum. Their wavelength depends on the frequency of the wave, and they travel at the speed of light. Table B.1 shows the portions of the electromagnetic spectrum frequencies that are considered radio waves:

Table B.1 Radio waves of the electromagnetic spectrum frequencies

Frequency Band	Frequency	Wavelength
Very Low Frequency (VLF)	10–30 kHz	30 km – 10 km
Low Frequency (LF)	30–300 kHz	10 km – 1 km
Medium Frequency (MF)	300–3000 kHz	1 km – 100 km
High Frequency (HF)	3–30 MHz	100 m – 10 m
Very High Frequency (VHF)	30–300 MHz	10 m – 1 m
Ultra-High Frequency (UHF)	300–3000 MHz	1 m – 10 cm
Super-High Frequency (SHF)	3–30 GHz	10 cm – 1 cm
Extremely-High Frequencies (EHF)	30–300 GHz	1 cm – 0.1 cm

For example, FM radio stations operate at a portion of the VHF band, AM radio stations at a portion of the MF band, TV stations at various frequencies in UHF and VHF band, etc.

Most radio frequency bands are divided into channels, each of which may be used to transmit voice or data.

Your RTK radio data link uses one dedicated radio channel in UHF or VHF band for communication. Data from a GPS receiver is modulated onto a radio carrier wave.

The manner in which radio waves travel from the transmitter antenna to the receiver antenna (propagation) is crucial in determining the distance at which radio communication is effective. Most reliable data communication depends on the line of sight between the transmitter and receiver radio.

Propagation, together with obstructions by natural or man-made structures and the ability of the radio signal to penetrate those obstacles, will ultimately determine the coverage area of radio signal.

This directly translates into limiting the area in which RTK surveys can be conducted.

Radio Modems

A radio modem modulates information to the radio carrier wave using one of the modulation methods.

In the case of voice communication, audio signals are picked up by the microphone and converted to varying voltage levels. This voltage is used by a radio transmitter to modulate carrier frequency. A radio receiver takes the modulated signal and applies it to the speakers, resulting in audio output.

For data communication, digital signal comprising of groups of binary data (1 and 0) is passed through a modulator which produces an analog waveform representing the data. The analog waveform is then transmitted by the radio hardware. The receiver takes the modulated signal and converts it back to binary digital signal.

Most data modems in commercial UHF / VHF bands rely on frequency modulation.

Some radio modems can transmit or receiver only, while some can act as a transmitter, receiver, or repeater (depending on the setting).

Some radio modems transmit on one predefined frequency and with one output power level, while others are frequency-programmable and have variable power output.

For example, TRIMMARK 3 can have 20 predefined frequencies and allows three power output levels (2, 10, and 25 W), while TRIMTALK 450S can have 20 predefined frequencies but only one power level output (0.5 W). Both units can operate in either Transmitter, Receiver, or Repeater mode.

Antenna

An antenna is the radiating element that takes the signal from a radio and sends it through the air. Antennas come in a variety of shapes and sizes, each designed for a specific use.

The type of the antenna is determined by the nature of the communications. For example, directional antennas are used to send data over long distances in a certain direction, while omni-directional antennas are used when the receiver antenna is constantly changing its position relative to the transmitter.

To maximize your radio data link coverage:

1. Use the right type of antenna.

In general, use a directional antenna for fixed point-to-point communication and an omni-directional one for communications mobile applications.

2. Choose the right location for the antenna.

Place the antenna on the highest point available. Where possible, select a base station location that takes advantage of terrain.

Separate the radio antenna from the GPS antenna by 2–3 m, to avoid possible interference with the GPS signal.



Tip – Use a tripod or telescopic range pole for mounting the radio antenna and improving range.

Note – Follow local regulations when installing antennas on buildings. Use a lightning arrestor.

Loss of Radio Link

The robustness, reliability, and coverage of your RTK system depends on several factors:

- power output of the transmitter
- frequency of the transmission
- topography of the land where the transmitter is located
- obstructions on the land such as buildings, forests, and other natural or man-made objects
- placement of the transmitter antenna and the location of the rover receiver antenna
- interference by other radio transmission sources such as other DGPS/RTK radios, public radio transmissions, and transmissions from airports, cellular sites, harbors, and emergency services.

The solution to issues caused by the above may or may not be remedied. Here are some solutions that you can deal with directly.



Warning – Make sure that your solutions comply with the legal requirements for radio transmission.

Raise radio antenna

Raising the radio antenna can help prevent the loss of radio link:

- The radio antenna can be raised at the base or at the rover.
- Doubling your antenna height can increase your radio range by up to 40%.

Set up a repeater

A repeater can help prevent the loss of radio link:

Some radio systems require changes to the internal settings to designate a radio as a repeater.

TRIMTALK 450S and TRIMMARK 3 radio systems allow two repeaters in a chain.

Change radio frequency

Use the Trimble controller to access the Trimble radio modems. Use a radio scanner prior to setting up the base station to determine if your will experience any radio interference on your selected frequency.

- Select a different (clear) radio frequency, if one is available.
- Make sure to change to the same frequency at both the base and rover.
- While in the field, use the survey styles to change the radio frequency from the controller.

Glossary

This section explains some of the terms used in this manual.

almanac	Data, transmitted by a GPS satellite, that includes orbit information on all the satellites, clock correction, and atmospheric delay parameters. The almanac facilitates rapid SV acquisition. The orbit information is a subset of the ephemeris data with reduced precision.
Anti-Spoofing (AS)	A feature that allows the U.S. Department of Defense to transmit an encrypted Y-code in place of P-code. Y-code is intended to be useful only to authorized (primarily military) users. Anti-Spoofing is used with Selective Availability to deny the full precision of GPS to civilian users.
autonomous positioning	The least precise form of positioning that a GPS receiver can produce. The position fix is calculated by one receiver from satellite data alone.
base station	In a GPS survey, you observe and compute baselines (the position of one receiver relative to another). The base station acts as the position from which all unknown positions are derived. A base station is an antenna and receiver set up on a known location specifically to collect data to be used in differentially correcting rover files. Trimble Reference Station (TRS) and a receiver in base station mode are examples of base stations.
baud	A unit of data transfer speed (from one binary digital device to another) used in describing serial communications; generally one bit per second.
C/A code	See Coarse Acquisition code .

CMR	Compact Measurement Record. A satellite measurement message that is broadcast by the base receiver and used by RTK surveys to calculate an accurate baseline from the base to the rover.
Coarse Acquisition (C/A) code	A pseudorandom noise (PRN) code modulated onto an L1 signal. This code helps the receiver compute the distance from the satellite.
constellation	A specific set of satellites used in calculating positions: three satellites for 2D fixes, four satellites for 3D fixes.
	All satellites visible to a GPS receiver at one time. The optimum constellation is the constellation with the lowest PDOP. See also PDOP .
data logging	The process of recording satellite data in a file stored in the receiver, the controller memory, or on a PC card.
data message	A message, included in the GPS signal, that reports on the location and health of the satellites as well as any clock correction. It includes information about the health of other satellites as well as their approximate position.
datum	See geodetic datum .
Differential Positioning	Precise measurement of the relative position of two receivers tracking the same satellites simultaneously.

DOP	Dilution of Precision, an indicator of the quality of a GPS position. DOP takes into account the location of each satellite relative to other satellites in the constellation, as well as their geometry relative to the GPS receiver. A low DOP value indicates a higher probability of accuracy. Standard DOPs for GPS applications are: <ul style="list-style-type: none">• PDOP – Position (three coordinates)• RDOP – Relative (Position, averaged over time)• HDOP – Horizontal (two horizontal coordinates)• VDOP – Vertical (height only)• TDOP – Time (clock offset only)
Doppler shift	The apparent change in frequency of a signal caused by the relative motion of satellites and the receiver.
DTM	Digital Terrain Model. An electronic representation of terrain in 3D.
dual-frequency	A type of receiver that uses both L1 and L2 signals from GPS satellites. A dual-frequency receiver can compute more precise position fixes over longer distances and under more adverse conditions because it compensates for ionospheric delays.
Earth Centered Earth Fixed (ECEF)	A cartesian coordinate system used by the WGS-84 reference frame. In this coordinate system, the center of the system is at the earth's center of mass. The z axis is coincident with the mean rotational axis of the earth and the x axis passes through 0° N and 0° E. The y axis is perpendicular to the plane of the x and z axes.
elevation	Height above mean sea level. Vertical distance above the geoid.
elevation mask	The angle below which Trimble recommends that you do not track satellites. Normally set to 13 degrees to avoid interference from buildings and trees as well as ground multipath errors.

ellipsoid	A mathematical model of the earth formed by rotating an ellipse around its minor axis. For ellipsoids that model the earth, the minor axis is the polar axis and the major axis is the equatorial axis. An ellipsoid is completely defined by specifying the lengths of both axes, or by specifying the length of the major axis and the flattening.
ephemeris	A set of data that describes the position of a celestial object as a function of time. Each GPS satellite periodically transmits a broadcast ephemeris describing its predicted position through the near future, uploaded by the Control Segment. Postprocessing programs can also use a precise ephemeris that describes the exact position of a satellite in the past.
epoch	The measurement interval of a GPS receiver. The epoch varies according to the survey type: <ul style="list-style-type: none">• for real-time surveys it is set at one second• for postprocessed surveys it can be set to a rate of between one second and one minute
feature codes	Simple descriptive words or abbreviations that describe the features of a point.
fixed solution	Indicates that the integer ambiguities have been resolved and a survey is initialized. This is the most precise type of solution.
float solution	Indicates that the integer ambiguities have not been resolved, and that the survey is not initialized.
GDOP	Geometric Dilution of Precision. The relationship between errors in user position and time, and errors in satellite range. See also DOP .

geodetic datum	A mathematical model designed to fit part or all of the geoid (the physical earth's surface). A geodetic datum is defined by the relationship between an ellipsoid and the center of the earth. It takes into account the size and shape of the ellipsoid, and the location of the center of the ellipsoid with respect to the center of the earth (a point on the topographic surface established as the origin of the datum).
	Various datums have been established to suit particular regions. For example, European maps are often based upon the European datum of 1950 (ED-50). Maps of the United States are often based upon the North American Datum of 1927 or 1983 (NAD-27, NAD-83). All GPS coordinates are based upon the WGS-84 datum surface.
geoid	The surface of gravitational equipotential that closely approximates mean sea level.
GPS	Global Positioning System. Based on a constellation of 24 operational satellites orbiting the earth at a high altitude.
GPS time	A measure of time used by the NAVSTAR GPS system. GPS time is based on UTC but does not add periodic 'leap seconds' to correct for changes in the Earth's period of rotation.
HDOP	Horizontal Dilution of Precision. See also DOP .
integer ambiguity	The whole number of cycles in a carrier phase pseudorange between the GPS satellite and the GPS receiver.
ionosphere	The band of charged particles 85 km-1000 km (53 miles-620 miles) above the earth's surface. The ionosphere affects the accuracy of GPS measurements.
L1	The primary L-band carrier used by GPS satellites to transmit satellite data. The frequency is 1575.42 MHz. It is modulated by C/A code, P-code, or Y-code, and a 50 bit/second navigation message.

L2	The secondary L-band carrier used by GPS satellites to transmit satellite data. The frequency is 1227.6 MHz. It is modulated by P-code or Y-code, and a 50 bit/second navigation message.
local ellipsoid	The ellipsoid specified by a coordinate system. The WGS-84 coordinates are first transformed onto this ellipsoid, then converted to grid coordinates.
multipath	Interference, similar to ghosting on a television screen. Multipath occurs when GPS signals traverse different paths before arriving at the antenna. A signal that traverses a longer path yields a larger pseudorange estimate and increases the error. Reflections from structures near the antenna can cause the incidence of multiple paths to increase.
NAVDATA	The 1500-bit navigation message broadcast by each satellite. This message contains system time, clock correction parameters, ionospheric delay model parameters, and details of the satellite's ephemeris and health. The information is used to process GPS signals to obtain user position and velocity.
NMEA	A standard, established by the National Marine Electronics Association (NMEA), that defines electrical signals, data transmission protocol, timing, and sentence formats for communicating navigation data between marine navigation instruments.
parity	A form of error checking used in binary digital data storage and transfer. Options for parity checking include Even, Odd, or None.
P-code	The 'precise' code transmitted by the GPS satellites. Each satellite has a unique code that is modulated onto both the L1 and L2 carrier waves. The P-code is replaced by a Y-code when Anti-Spoofing is active.

PDOP	Position Dilution of Precision, a unitless figure of merit expressing the relationship between the error in user position and the error in satellite position. Geometrically, PDOP is proportional to 1 divided by the volume of the pyramid formed by lines running from the receiver to four satellites observed. Values considered good for positioning are small (for example, 3). Values greater than 7 are considered poor. Small PDOP is associated with widely separated satellites. PDOP is related to horizontal and vertical DOP by $\text{PDOP}^2 = \text{HDOP}^2 + \text{VDOP}^2$. See also DOP .
PDOP mask	The highest PDOP value at which a receiver will compute positions.
postprocess	To process satellite data on a computer after it has been collected.
PRN	Pseudorandom number, a sequence of digital 1's and 0's that appear to be randomly distributed like noise, but that can be exactly reproduced. PRN codes have a low autocorrelation value for all delays or lags except when they are exactly coincident. Each NAVSTAR satellite can be identified by its unique C/A and P pseudorandom noise codes, so the term 'PRN' is sometimes used as another name for GPS satellite or SV.
projection	Projections are used to create flat maps that represent the surface of the earth or parts of that surface.
QC records	Quality Control records. With precise positioning applications, this receiver option lets you process RTCM-104 corrections and satellite data in real time to provide position precision statistics.
ratio	During initialization, the receiver determines the integer number of wavelengths between each satellite and the GPS antenna phase center. For a particular set of integers, it works out the probability that this is the correct set. The receiver then calculates the ratio of the probability of correctness of the currently-best set of integers to the probability of correctness of the next-best set. A high ratio indicates that the best set of integers is much better than any other set. (This gives us confidence that it is correct.) The ratio must be above 5 for New Point and OTF initializations.

RDOP	Relative Dilution of Precision. See also DOP .
reference station	See base station .
RMS	Root Mean Square. This is used to express the accuracy of point measurement. It is the radius of the error circle within which approximately 70% of position fixes are to be found. It can be expressed in distance units or in wavelength cycles.
reference variance	A measure of how well the baseline processor estimates the expected error. Ideally, the reference variance should approximate 1. The test for acceptance based on reference variance only looks for cases where the reference variance is greater than 1, indicating that more error was encountered than expected.
rover	Any mobile GPS receiver and field computer collecting data in the field. The position of a roving receiver can be differentially corrected relative to a stationary base GPS receiver.
RTCM	Radio Technical Commission for Maritime Services, a commission established to define a differential data link for the real-time differential correction of roving GPS receivers. There are two types of RTCM differential correction messages, but all Trimble GPS receivers use the newer Type 2 RTCM protocol.
RTK	Real-time kinematic, a type of GPS survey.
S/A	See Selective Availability .
Selective Availability (S/A)	Artificial degradation of the GPS satellite signal by the U.S. Department of Defense. The error in position caused by S/A can be up to 100 meters.
single-frequency	A type of receiver that only uses the L1 GPS signal. There is no compensation for ionospheric effects.
SNR	Signal-to-Noise Ratio, a measure of the strength of a satellite signal. SNR ranges from 0 (no signal) to around 35.
Super-trak	A Trimble proprietary method of processing the L2 signal when the P-code is encrypted.

SV	Satellite Vehicle (or Space Vehicle).
TDOP	Time Dilution of Precision. See also DOP .
TOW	Time of Week in seconds, from midnight Saturday night/Sunday morning GPS time.
tracking	The process of receiving and recognizing signals from a satellite.
UTC	Universal Time Coordinated. A time standard based on local solar mean time at the Greenwich meridian. See also GPS time .
VDOP	Vertical Dilution of Precision. See also DOP .
WAAS	Wide Area Augmentation System. A satellite-based system, available only in North America, that broadcasts GPS correction information. WAAS capable GPS receivers can track WAAS satellites. WAAS is synonymous with the European Geostationary Navigation Overlay Service (EGNOS) and Japan's Multifunctional Transport Satellite Space-based Augmentation System (MSAS).
WGS-84	World Geodetic System (1984), the mathematical ellipsoid used by GPS since January 1987. See also ellipsoid .
Y-code	An encrypted form of the information contained in the P-code. Satellites transmit Y-code in place of P-code when Anti-Spoofing is in effect.

Glossary
