SURVEY PRO

for Recon & Nomad

User's Manual

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Welcome

Congratulations on your decision to purchase a Tripod Data Systems product. TDS is serious about providing the best possible products to our customers and know that you are serious about your tools. We are proud to welcome you to the TDS family.

Survey Pro can be run in three modes: Conventional, Leveling and one of two versions of GPS. The first portion of this User's Manual explains how to get started with Survey Pro no matter which mode you are running in. Conventional surveying examples start on Page 57, which are useful when performing traditional surveying methods with a total station. Leveling mode is discussed on Page 201. The last portion of the User's Manual explains how to perform GPS surveying and starts on Page 221.

The TDS Survey Pro team is continually improving and updating Survey Pro. Please take a few minutes to register your copy so that you will be eligible for upgrades. You can do this either by completing and returning the product registration card or by visiting our Web site: www.tdsway.com.

Getting Started

TDS Survey Pro is available with the following modules, each sold separately:

- **Standard**
- **Pro**
- **Basic GPS**
- **GPS**
- **Robotic**
- **Leveling**
- **Trimble System Extension**

Throughout the manual and software, it is simply called Survey Pro. For a listing of which features are included in each product, contact your local TDS dealer.

This manual covers the routines that are available in all of the different modules.

Manual Conventions

Throughout the Survey Pro Manual, certain text formatting is used that represents different parts of the software. The formatting used in the manual is explained below.

Fields

When referring to a particular field, the Field Label, or its Corresponding Value is shown with text that is similar to what you would see in the software.

Screens and Menus

When referring to a particular screen title, the text is <u>underlined</u>.

Buttons

When referring to a particular button, the text is shown in a Button Format, similar to that found in the software.

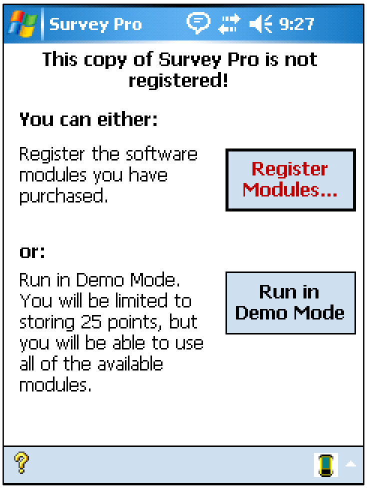
Survey Pro Installation

Survey Pro is installed from the Installation CD running on a PC. It will load Survey Pro and then install it on the data collector with the next ActiveSync connection.

1. Turn on the data collector and connect it to your PC. If you are using ActiveSync it will attempt to make a connection.
2. With an ActiveSync connection, you will be asked if you want to install TDS Survey Pro. Answering YES will install the application on the data collector. An installation routine will also run on the data collector to complete the process.

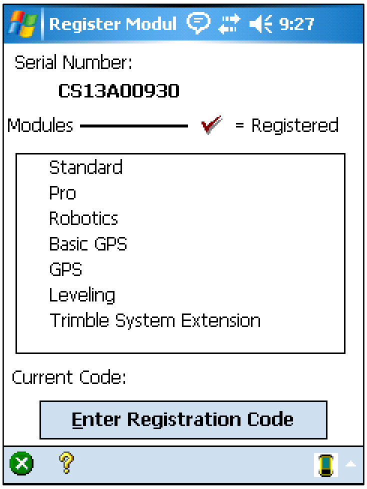
Registering

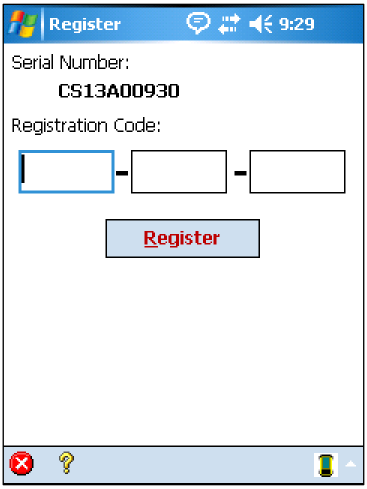
After Survey Pro is installed, the Standard Module must be registered for Survey Pro to be fully functional. If it is not registered, Survey Pro will only run in demo mode, which means all jobs will be limited to no more than 25 points, and if a job is stored on the data collector that exceeds this limit, it cannot be opened.



If you start Survey Pro and the standard module has not yet been registered, the screen shown here will open. Tap the Register Modules... button to access the Register Modules screen. To run in demo mode, simply tap Run In Demo Mode.

To register your Modules, tap the Enter Registration Code button.





Enter the registration code provided by your TDS dealer in the Registration Code field and tap Register. This will register all of the modules that you have purchased. If there are modules that you feel should be registered but are not, contact TDS tech support.

Add-on modules can also be purchased from your local TDS dealer to upgrade your TDS Survey Software. Upgrading involves simply registering the appropriate module using the same method as described above

If you want to register a particular module, access the Register screen by tapping File, Register Modules from the Main Menu.

Contact your TDS dealer and give him your unique serial number that is displayed on this screen. He will give you a registration code for the module that you purchased.

Tap the Enter Registration Code button for the appropriate module, enter the registration code in the dialog box that opens and tap Register…. All the features for the module that you purchased will now be available.

Note: You should keep a record of all registration codes purchased in case they need to be reentered at some point.

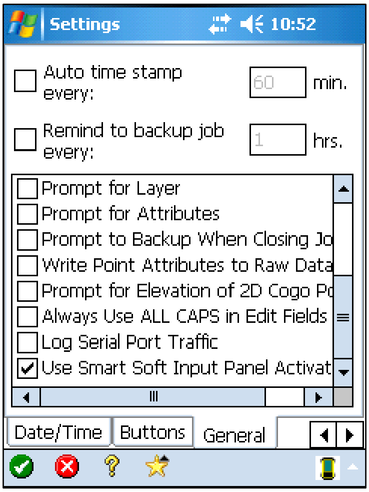
Data Entry

Using a handheld device without a keyboard requires some adaptation but one can get very proficient when using all the shortcuts available to navigate around quickly. Even if you are already familiar with the Survey Pro software, reading this section can help you get the most from your handheld device.

Survey Pro offers several alternatives to input characters without a physical keyboard. These methods take the form of an overlay window, called *Soft Input Panels* (SIPs). You interact with a SIP through the touch screen. While you can get by using the standard SIPs, The Recon also provides a custom SIP called Recon Keyboard, which is optimized for Survey Pro.

Smart SIP

The Smart SIP is available when running Survey Pro and will automatically provide the user with the appropriate SIP when it is needed. The SIP can also be configured to automatically open when the cursor is inside an input field.



Enabling the Smart SIP

The Smart SIP is enabled by default, but if it has been disabled, you can re-enable it using the following steps:

From the Main Menu, open the **Job** > **Settings** > **General** screen.

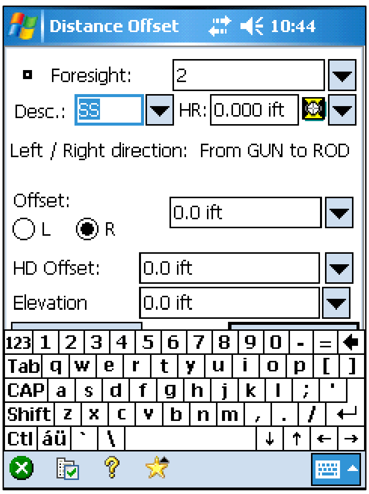
Check the **Use Smart Soft Input Panel Activation** checkbox.

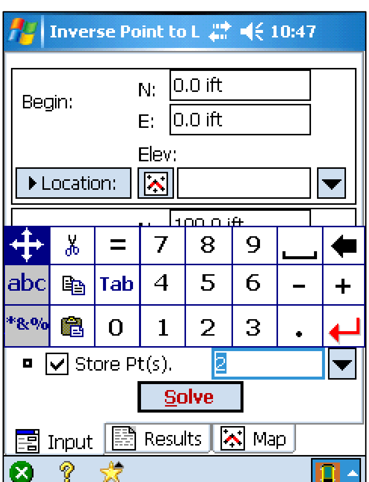
If the Smart SIP were *not* enabled, the user would need to click on the SIP icon on the taskbar to toggle the visibility of the SIP prior to entering data.

Using the Smart SIP

Whenever you tap in an edit field, the appropriate SIP will automatically open. The type of edit field where the cursor is placed determines the type of SIP that opens. The SIP will position itself so that it does not cover the edit field.

There are three types of edit fields:





- **Point name edit fields**: These default to the numeric SIP.
- **Alphanumeric edit fields**: such as Description, File Name, Layer Name, etc. These default to the alphanumeric SIP.
- **Numeric edit fields**: such as HI / HR, angles, distances, etc. These default to the numeric SIP.

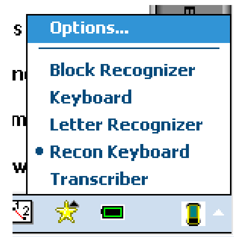
The SIP will close when:

- You tap in a blank area of the dialog.
- You tap on another control, like a button or a list box.
- You switch to another tab page.
- The current dialog is closed or another dialog appears.

Changing SIPs

While the cursor is in an input field, you can select a different SIP to use for entering text into that field and Survey Pro will remember your selection and open the new SIP whenever the cursor is placed into the same type of input field. The same behavior will occur if you switch between the alpha and numeric keyboards.

To select a different SIP, tap the up-arrow button next to the SIP icon. A list of all installed SIPs will open. Simply tap on the SIP you want to use.



Hardware Buttons

Survey Pro allows you to remap the function of the hardware buttons from a list of commonly used functions.

Some of the functions offered for button remapping include: Enter, Escape, Tab, Quick Pick, Take Shot, etc. You can also use Page Up/Down to move between tab pages where applicable. See the Buttons Settings screen in the Reference Manual for more information on customizing the hardware buttons.

Angle and Time Conventions

Throughout the software, the following conventions are followed when inputting or outputting angles and time:

Azimuths

Azimuths are entered in degree-minutes-seconds format and are represented as DD.MMSSsss, where:

- DD One or more digits representing the degrees.
- MM Two digits representing the minutes.
- SS Two digits representing the seconds.
- sss Zero or more digits representing the decimal fraction part of the seconds.

For example, 212.5800 would indicate 212 degrees, 58 minutes, 0 seconds.

Bearings

Bearings can be entered in either of the following formats:

- S32.5800W to indicate south 32 degrees, 58 minutes, 0 seconds west.
- 3 32.5800 to indicate 32 degrees, 58 minutes, 0 seconds in quadrant 3.

Time

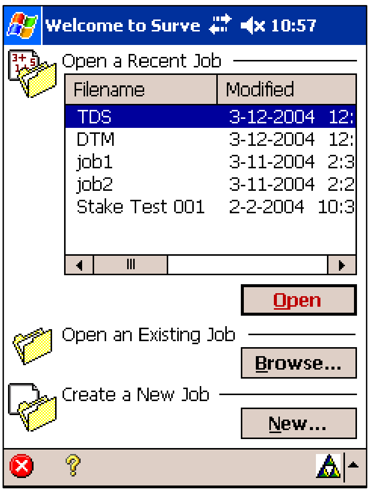
When a field accepts a time for its input, the time is entered in hours-minutes-seconds format, which is represented as HH.MMSSsss where:

- HH One or more digits representing the hours.
- MM Two digits representing the minutes.
- SS Two digits representing the seconds.

- sss   Zero or more digits representing the decimal fraction part of the seconds.

Using Survey Pro

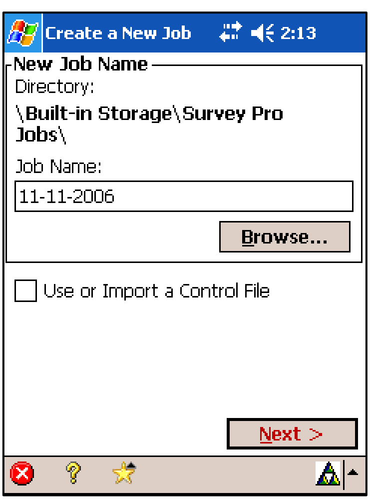
Tapping the screen with a stylus is the primary method for interaction with Survey Pro.



You can start Survey Pro by tapping the icon, selecting Programs, then selecting Survey Pro.

Note: The proper way to exit Survey Pro is by selecting File, Exit from the Main Menu. Exiting in this way guarantees that the settings will get saved properly to the registry.

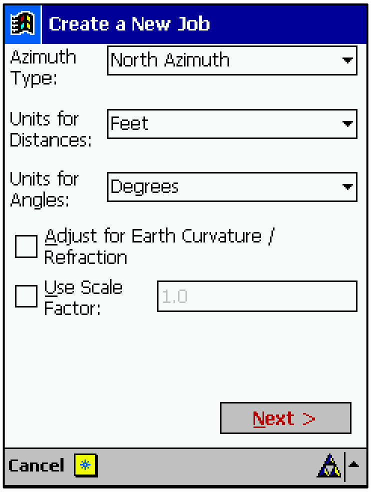
Once Survey Pro is started, the Survey Pro splash screen will open. Since Survey Pro requires a job to be opened when it starts, you will be prompted to open a recently opened job, an existing job, or to create a new job. The example below briefly explains how to create a new job so you can begin exploring the software.



1. Tap the New... button. The Create a New Job dialog box will open, which prompts you for a job name where the current date is the default name.

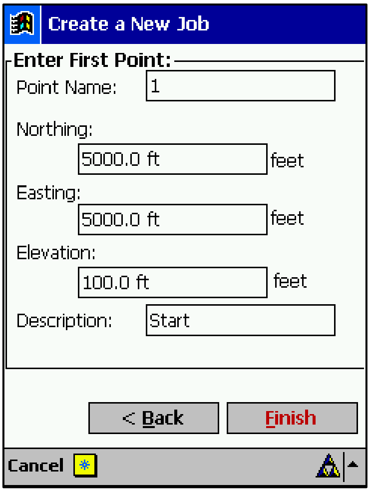
2. Either type in a new job name or accept the default name. Control points can optionally be used or imported from another existing job by checking the Use or Import a Control File checkbox. (See Page 36 for more information on control files.) For this example, leave this unchecked and tap Next > to continue.

3. Another screen will open where you select some of the job settings. Select the settings that you desire and tap Next > to continue.

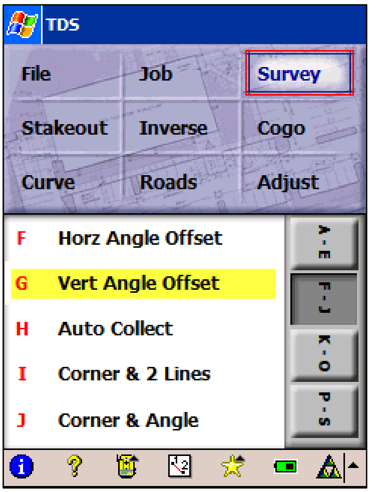


Note: When creating a new job, it is important that the Units for Distances field be set to the correct units. This allows you to seamlessly switch between different units in mid-job, but problems can arise if these units are inadvertently set to the incorrect units when new data is collected.

4. Since all jobs must have at least one point to start with, the final screen displays the default point name and coordinates for the first point. Accept the default values by tapping Finish. This will create and store the new job. You are now ready to explore the software.



Navigating Within the Program



The starting point in Survey Pro, which appears once a job is open, is called the Main Menu, which is shown here. All the screens that are available in Survey Pro can be accessed starting from the Main Menu. Likewise, closing any screens that are open in Survey Pro will eventually take you back to the Main Menu.

The Main Menu consists of two main areas. The upper half of the screen contains a set of large buttons called main menu items. The lower half of the screen contains the submenu items that are associated with the selected main menu item.

When a main menu item is tapped, the corresponding submenu items will become available in the lower area. When a submenu item is tapped in the lower area, the corresponding screen will open. It is from these screens where you do your work.

If a main menu item contains more submenu items than will fit on the screen, index card-style tabs are displayed on the right. Tapping these tabs will display additional submenu items.

The hardware keys can also be used to navigate within the Main Menu and any other Survey Pro screen. The highlighted rectangle displays the area of the screen that is currently active.

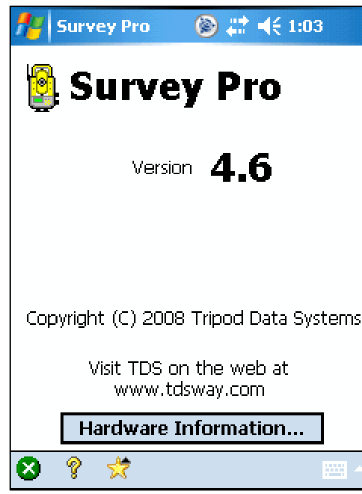
The bottom area of the Main Menu contains a set of icons that perform the tasks discussed below.

Command Bar

The command bar is the bottom portion of each Survey Pro screen and it contains buttons that are appropriate for the current screen. All of the possible buttons are described below.

About Survey Pro

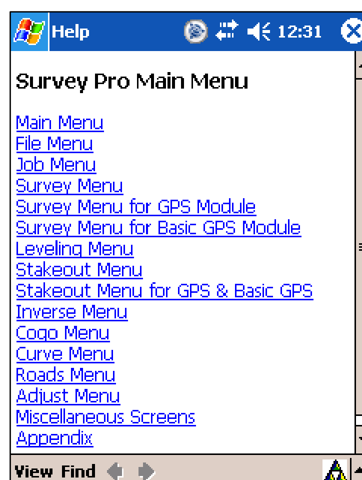
Tapping this button from the Main Menu or selecting File > About Survey Pro will open the About Survey Pro screen, which displays information on the version of Survey Pro that is installed.



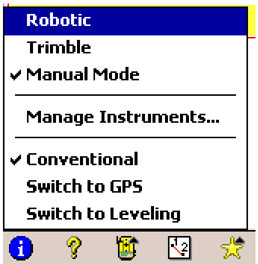
The Hardware Information button is a shortcut to the Windows System Information screen.

Online Help

This button opens the online help, which allows you to access information for each screen similar to the information you would find in the reference manual.



Surveying Mode



The instrument icon indicates which collection mode the software is running in. There are three possible surveying modes: Conventional, GPS, and Leveling. Tapping this icon will open a list of options to do any of the following:

- Switch to another instrument mode.
- Select a different instrument profile. (See the Instrument Settings screen in the Reference Manual for more information.)
- Quickly access the Instrument Settings screen. (See the Instrument Settings screen in the Reference Manual for more information.)

Map View

This button will access the map view of the current job when it is tapped. The map view is available from many screens and is discussed in detail on Page 28.

Quick Pick

The Quick Pick button will open a customizable list of routines. To quickly access a routine, just tap on it. See Page 24 for more information.

Battery Level

The battery icon at the bottom of the Main Menu displays the condition of the data collector's rechargeable battery. The icon has five variations depending on the level of charge remaining: 100%, 75%, 50%, 25%, 5% and charging.

Tapping the battery icon is a shortcut to the Microsoft Power Settings screen. You can get more information while viewing this screen by tapping then .

OK

This button performs the desired action then closes the current screen.

Cancel

This button is red in color and closes the current screen without performing the action intended by the screen.

Close

This button is green in color and closes the current screen.

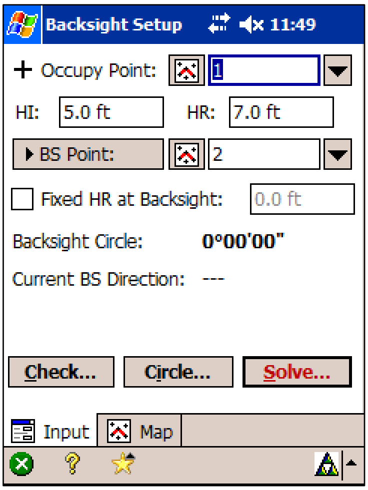
Settings

This button opens the Settings screen associated with the current screen.

GPS Status

This is used to view the current status and access the settings for a GPS receiver when using the GeoLock feature (Page 165). It is only available from the Remote Control and Remote Shot screens when using a supported robotic total station.

Parts of a Screen



Many screens share common features. To illustrate some of these features, we will examine parts of the Backsight Setup screen, shown here. You can access the Backsight Setup screen by selecting Survey, Backsight Setup from the Main Menu.

Input Fields

An input field is an area where a specific value is entered by the user. An input field consists of a label, which identifies the data that is to be entered in that field and a rectangular area with a white background, where the data is entered. A field must first be selected before data can be entered in it. You can select a field by tapping on its data area. When a field is selected, a dark border is drawn around it and a blinking cursor is inside the field.

Output Fields

Output fields only display information. These fields typically display values in **bold text**, do not have a special colored background, and the value cannot be changed from the current screen. For example, in the Backsight Setup screen, the Backsight Circle value is an output field.

Power Buttons

The Backsight Setup screen contains two power buttons. Power buttons are typically used to provide alternate methods of entering or modifying data in an associated field. To use a power button, simply tap it. Once tapped, a dropdown list will appear with several choices. The choices available vary depending on with which field the power button is associated. Simply tap the desired choice from the dropdown list.

Tapping the first power button in the Backsight Setup screen allows you to specify an occupy point using other methods or view the details of the currently selected point. You should experiment with the options available with various power buttons to become familiar with them.

Choose From Map Button

The Choose From Map button is always associated with a field where an existing point is required. When the button is tapped, a map view is displayed. To select a point for the required field, just tap it from the map.

Note: If you tap a point from the map view that is located next to other points, another screen will open that displays all of the points in the area that was tapped. Tap the desired point from the list to select it.

Scroll Buttons ▸ Button

When a button label is preceded with the ▸ symbol, it indicates that the button label can be changed. Each tap of the ▸ symbol will toggle through the various button label options and the corresponding field associated with it. For example, in the Backsight Setup screen, the backsight can be defined by a point or a direction by toggling the scroll button between ▸ BS Point and ▸ BS Direction.

Special Point Symbols

Some field labels are preceded with a special symbol. For example, the Occupy Point field in the Backsight Setup screen is displayed as "+ Occupy Point" The plus symbol indicates that the occupy point is represented as a plus symbol when viewing it in the Map View. Other symbols are also used to represent other types of points.

Index Cards

Many screens have access to other screens that are still part of the original screen. The different screens are selected by tapping on various tabs, which look like the tabs of on index cards. The tabs can appear along the top of the screen or the right edge.

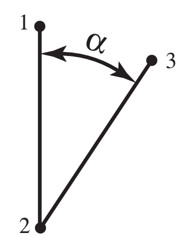
The Backsight Setup screen consists of two cards. One is titled Input, and the other is titled Map.

Input Shortcuts

Distances and angles are normally entered in the appropriate fields simply by typing the value from the keypad, but there is a shortcut that can simplify the entry of a distance or angle.

If you want to enter the distance between two points in a particular field, but you do not know offhand what that distance is, you can enter the two point names that define that distance separated by a hyphen. For example, entering 1-2 in a distance field would compute the horizontal distance from Point 1 to Point 2. As soon as the cursor is moved from that field, the horizontal distance between the points will be computed and entered in that field.

An alternate method to using this shortcut is to tap the ▼ power button, select Choose from map... and then tap the two points that define the distance that you want to enter. Once you tap ✔ from the Map View, the horizontal distance between the two tapped points will appear in the corresponding field.



Likewise, there is a similar shortcut to enter angles in fields that accept them. If you wanted to enter the angle, α, from the illustration shown here, you would simply enter 1-2-3 in the appropriate field. As soon as the cursor is moved from that field, the angle formed by the three points entered will be entered in that field. As with specifying a distance, you could also use the power button as described above and tap the points of the angle in the correct order.

Another shortcut can be used to enter distances with fractional inches (architectural units). Simply key in the feet, inches, and fractional inches where each value is separated by a space and the fraction is entered using a dash (-), or a forward slash (/). For example, to enter 3 feet, 6 and 3/32 inches, you would key in 3 6 3-32. Once the cursor leaves that field, the distance will automatically be converted to the appropriate decimal distance.

If working with distances under 1 foot, it is acceptable to exclude the feet value; for example "8 5-64" would be interpreted as 8 and 5/64 inches. Likewise, if entering a fractional distance under an inch, you would only enter the fractional inch.

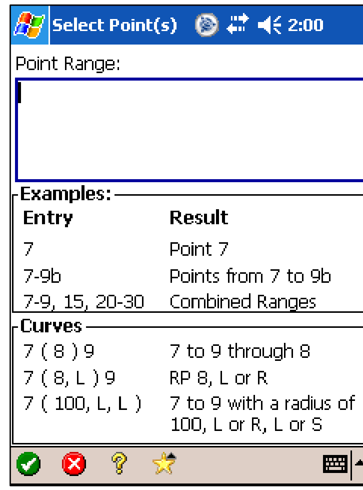
The following details should be considered when using the above method to enter fractional inches:

1. When the job is configured for International Feet or US Survey Feet, it is assumed that the distance entered is in the same units as the job is configured for.
2. If the job is configured for meters, it is assumed that the distances entered are in International Feet and will be converted to meters when the cursor leaves the current field. (You cannot use this method to enter a metric distance in fractional format.)
3. If a fractional inch is entered that cannot be evenly divided by 1/64 inch, it will automatically be converted to the nearest 64th inch. This conversion would be negligible for survey data and unlikely to occur.

An alternate method to using this shortcut is to tap the Quick Pick button while the cursor is in a distance field that you want to change and select AU Conversion. Enter the appropriate feet, inches and fractional inches and tap Use. See the Reference manual for more information on the AU Conversion screen.

Point List Editor

Many screens contain a To/From... button, which accesses the Select Point(s) screen that allows you to enter a simple list of points or a list of points that describe a line that can contain curves.



Examples of how to enter different lists of points are displayed in the lower portion of the screen. Once the list is entered, tap ✓ to return to the previous screen.

Note: Spaces in point lists are ignored. They are only used in the examples for clarity.

The examples for entering the three possible curve types are explained in detail as follows:

- 7 (8) 9
  The first example, defines a curve that passes through Points 7, 8 and 9, respectively.
- 7 (8, L) 9
  The second example defines a curve where Point 8 is the radius point and the curve begins to the Left (from the point of view of the radius point), turning from Point 7 to Point 9.

Note: When defining a curve with a radius point, the other two points must be the same distance from the radius point for a solution.

- 7 (100, L, L) 9
  The third example describes a curve with a radius of 100, using the same units as the job, that begins at Point 7, turning to the Left (from the point of view of the radius point), creating a Large arc (> 180°), and ending at Point 9.

Entering Distances in Other Units

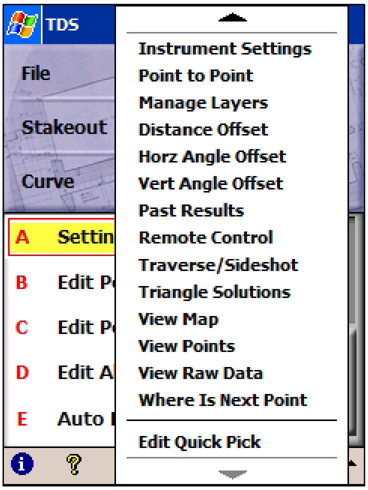
When a distance is entered in a particular field, it is normally entered using the same units that are configured for the current job, but distances can also be entered that are expressed in other distance units.

When entering a distance that is expressed in units that do not match those configured for the job, you simply append the entered distance with the abbreviation for the type of units entered. For example, if the distance units for your current job were set to International Feet and you wanted to enter a distance in meters, you would simply append the distance value with an m or M for meters. As soon as the cursor is moved to another field, the meters that you entered will be converted to International Feet.

The abbreviations can be entered in lower case or upper case characters. They can also be entered directly after the distance value, or separated with a space. The following abbreviations can be appended to an entered distance:

- International Feet: **f** or **ft** or **ift**
- US Survey Feet: **usf** or **usft**
- Inches: **i** or **in**
- Meters: **m**
- Centimeters: **cm**
- Millimeters: **mm**
- Chains: **c** or **ch**

Quick Pick



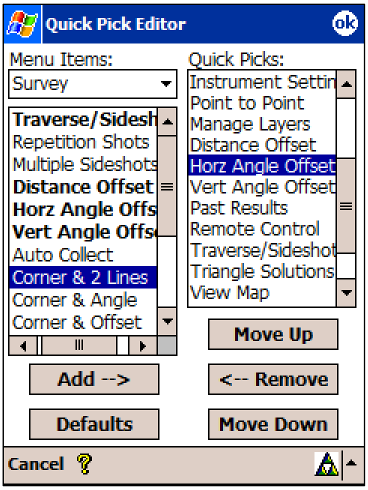
The button is called the *Quick Pick* button and is available at the bottom of most screens in Survey Pro. This button is used to quickly access any of several commonly-used routines. The list of routines available from the Quick Pick button can be customized and sorted in any order.

To access a screen with the Quick Pick button, first tap and then tap the desired routine.

Customizing the Quick Pick List

If you want to customize the Quick Pick list, tap the button then scroll to the bottom of the list and tap Edit Quick Pick. This opens the Quick Pick Editor.

Tip: You can quickly get to the bottom of the Quick Pick list by tapping then pressing the up-arrow hardware button once.



The current Quick Pick list is displayed in the right column and the routines that can be added to the list are displayed in the left column, where the routines that are already in the Quick Pick list are shown in bold.

To add a routine, first select the menu item from the Menu Item dropdown list where that routine is normally accessed from the Main Menu. (Not all routines can be added to the Quick Pick list. If a routine is not listed, it cannot be added.)

Select the routine from the left column then tap the Add --> button to add it to the Quick Pick list on the right.

The new routine will initially be placed at the bottom of the list. To move it elsewhere in the list, select it and tap the Move Up or Move Down buttons. (Any other routines in the Quick Pick list can also be repositioned in this way.)

To remove a routine from the Quick Pick list, select it and tap the <-- Remove button.

Tapping the Defaults button will revert the custom list back to the default list. Since any changes will be lost, a prompt will first ask if you are sure.

Smart Targets

Survey Pro has the ability to create and store custom configurations for any number of prisms or other target types. These are called Smart Targets.

Smart Targets are useful when working with multiple prisms on the same job, particularly when the prisms have different characteristics such as rod height and/or offset because the user can quickly switch between different Smart Targets before taking a shot.

Smart Targets also provide a way to quickly switch between taking a shot at a prism and taking a shot at a reflectorless target. The total station EDM configuration is switched for you automatically.

Selecting Smart Targets

You can quickly select any existing Smart Target from a screen that has an HR field. Tap the power button corresponding with the HR field that you want to shoot. A icon displayed next to the power button indicates a *prism* target type is currently selected. A icon indicates a *reflectorless* target type is currently selected

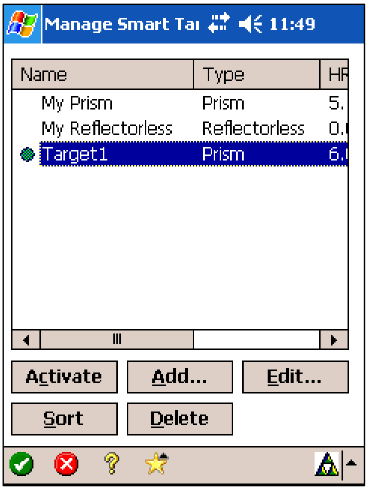
All the available Smart Targets will be displayed in the upper portion of the drop-down list. The Smart Targets listed will depend on if you are selecting a Smart Target for your foresight or your backsight.

Simply tap the Smart Target that you want to use from the drop-down list. The preset configuration for the selected Smart Target will be automatically set.

Manage Smart Targets

Select Manage Smart Targets from the same drop-down list described above to access the Manage Smart Targets screen. From here you can create a new custom Smart Target or edit any existing Smart Target.

Survey Pro includes two foresight Smart Targets called My Prism and My Reflectorless, respectively and one backsight Smart Target called My Backsight Prism. These can be edited or deleted, but at least one prism and one reflectorless foresight Smart Target and at least one prism backsight Smart Target must exist at all times. Because of this, for example, you would not be able to delete My Backsight Prism unless another Smart Target with a prism target type for your backsight was available. Similarly, you would not be able to change My Reflectorless to a prism target type unless you already had another foresight Smart Target configured with a reflectorless target type.



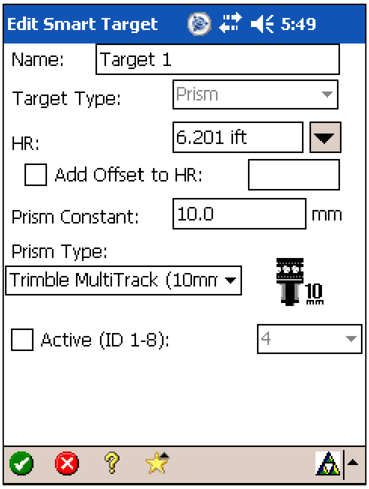
To delete an existing Smart Target, tap it to select it and then tap Delete.

Tapping Sort will sort the list of Smart Targets alphabetically.

You can also activate a Smart Target from this screen by tapping the desired Smart Target to select it and then tapping Activate, although it's faster to activate Smart Targets using the shortcut described above. The active Smart Target is shown with a ● symbol next to it.

To create a new Smart Target tap the Add... button. To edit an existing target, tap it from the list to select it and then tap Edit... . Either option will open the Edit Smart Target screen.

The Smart Target Name you provide will be shown in the drop-down list when you switch between Smart Targets.



The Target Type field determines how the EDM will be configured on the total station when taking shots to the Smart Target. It can be Prism when using a standard prism, Reflectorless to perform distance measurements without a prism, Long Range Prism, which increases the output power of the EDM for shooting prisms at long distances, or On Gun, which uses the EDM settings configured on the total station (Not all target types are supported by all total stations.)

Note: If using a Trimble S6/VX, there are special smart target settings available, which are described under Smart Targets in the Reference Manual.

The HR field will be the default rod height whenever this Smart Target is selected. Updating the HR from any screen that has an editable HR field while a Smart Target is selected will also save that new value here, making it the new default HR for the current Smart Target.

If the Add Offset to HR is checked, the offset entered in the corresponding field will then be added to the rod height you provide. (A negative value would subtract the offset from the HR.) This is useful for people who use a device that always elevates their rod by a fixed distance, but still want to use the rod height measurement displayed on the rod for simplicity.

For example, if you were in the Backsight Setup screen and selected a foresight Smart Target with a default HR of 5 feet and an HR offset value of 1 foot, you would see 5.00 ift displayed in the foresight HR field of the Backsight Setup screen, as well as every other editable foresight HR field, but you would see 5.0+1.0 ift in every output-only HR field showing the HR entered plus the offset. (The raw data file will also clearly note when a rod height offset is being applied.)

The Prism Constant field should contain the prism constant for the prism associated with this Smart Target as long as a prism constant is not also set in the total station. If a prism constant is set in Survey

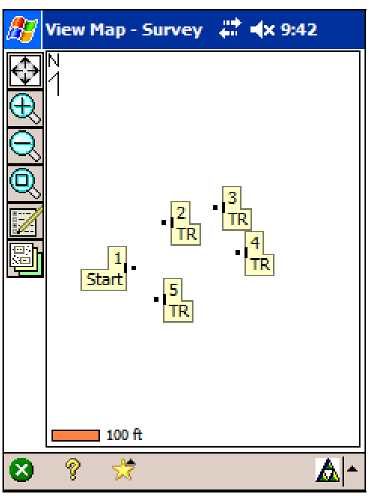
Pro and on the total station, it will be applied twice resulting in incorrect distance measurements for every shot.

If you are using a robotic total station that supports prisms that output a target ID, the Use Target ID field will be available where you can specify the target ID for the Smart Target.

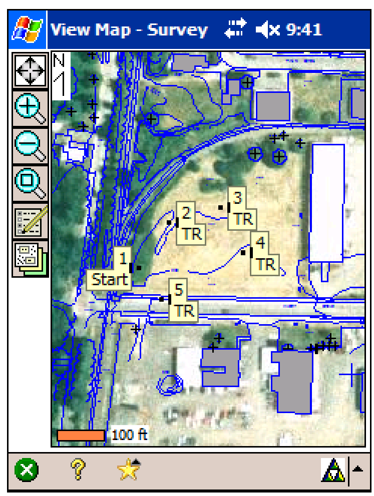
If Use For Search is available and selected, the total station will only look for the Target ID when it is searching for the target. Once the target is found, it will track the prism, but it is possible for the total station to start tracking a different reflector that comes into view. If Use Always is selected, the total station will continuously monitor the Target ID and only track the prism with the specified Target ID.

Tap ✅ to close the Edit Smart Targets screen and save any changes.

Map View



Main map view shown without basemaps



Main map view shown with basemaps

Many screens provide access to a map view. The map view is a graphical representation of the objects in the current job.

There are different map views depending on from where the map view is accessed and they can display slightly different information such as a vertical profile.

The main map view is accessed from the Main Menu by tapping the button at the bottom of the screen in the command bar. If you are using basemaps, it is from this map view where the basemaps are managed.

All other map views are accessed by tapping the button from a variety of screens.

A bar is shown at the bottom of every map view that indicates the scale.

The buttons along the left edge of the screen allow you to change what is displayed in the map view.

Tip: You can pan around your map by dragging your stylus across the screen.

Zoom Extents Button: will change the scale of the screen so that all the points in the current job will fit on the screen.

Zoom In Button: will zoom the current screen in by approximately 25%.

Zoom Out Button: will zoom the current screen out by approximately 25%.

Zoom Window Button: allows you to drag a box across the screen. When your finger or stylus leaves the screen, the map will zoom to the box that was drawn.

Zoom To Point Button: prompts you for a point name and then the map view will be centered to the specified point with the point label displayed in red.

Turn To Point Button: Tap this button and then tap a point in the map view to automatically turn the total station to the selected point. This is only available when a robotic total station is selected and Remote Control is active in the Instrument Settings.

 **Increase Vertical Scale**: is only available when viewing a vertical profile. Each time it is tapped, the vertical scale of the view is increased.

 **Decrease Vertical Scale**: is only available when viewing a vertical profile. Each time it is tapped, the vertical scale of the view is decreased.

 **Zoom Preview Button**: will display only the points that are currently in use (only available from certain map view screens).

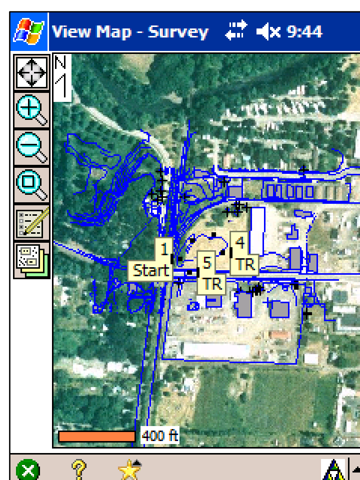
 **Map Display Options**: accesses the <u>Map Display Options</u> screen, described below.

 **Manage Basemaps**: accesses the <u>Manage Basemaps</u> screen, described below (only available from the main map view, accessed from the command bar button in Main Menu).

Basemaps

Basemaps can be used in jobs to more accurately display local objects and terrain in the map view to give the surveyor a better idea of where they are in relation to local land features.

There are two general types of basemaps – raster images and CAD drawings. Raster images are usually created from photographs and can accurately display the local terrain with great detail. CAD drawings are created from CAD software and will typically display points, roads, boundaries and any other objects that can be drawn with lines.



Basemap Files

Survey Pro supports basemap files from AutoCAD, GeoTiff, and TDS.

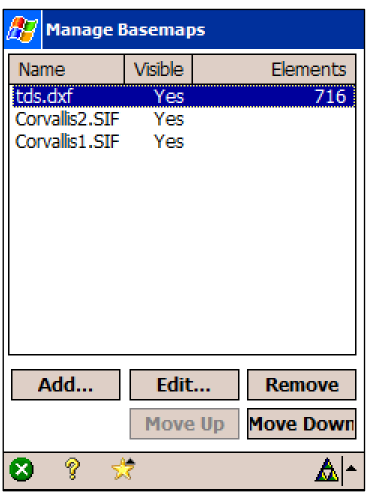
Since basemap files can be large in size, the following points should be considered when managing basemap files:

- Before you can use a basemap in Survey Pro, you need to copy the appropriate basemap files from a PC to the same directory where your current job is located. If the basemap files are stored in a different directory and then added to the current job, the files will be copied to the job's directory.
- If you use the Save As routine and save the current job to a new directory, any basemaps associated with that job will be copied to the new location.

Manage Basemaps

Once the basemap files are stored on the data collector, they must be added to the current job before they can be viewed in the map view.

1. To add basemaps, open the Main Map View by tapping the button in the command bar from the Main Menu.



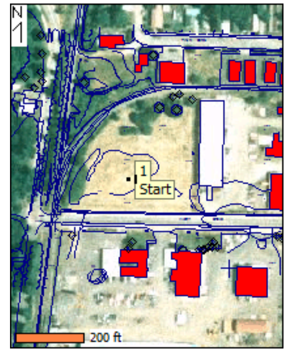
2. From the main Map View, tap the button to open the Manage Basemaps screen shown here.
3. Tap the Add... button. This will open a new screen where you can select the basemap that you want to add to the current job.
4. Once a basemap is added, it will appear in the list in the Manage Basemaps screen.
5. Repeat Steps 3 and 4 to add any additional basemaps.

Basemaps are drawn to the screen in the reverse order that they are listed in the Manage Basemaps screen, where the first basemap in the list is the last one drawn, and thus, will be drawn "on top" of any other basemaps. This is important to remember if any basemaps overlap since if a raster basemap were drawn on top of another basemap, it would cover any basemaps below it.

The list shown contains a vector basemap, tds.dxf that occupies the same area as the other two basemaps, which are raster basemaps. The vector basemap is at the top of the list so the points and lines it contains will be drawn last and appear on top of the two raster basemaps.

Raster basemap drawn first.

Vector basemap drawn last.

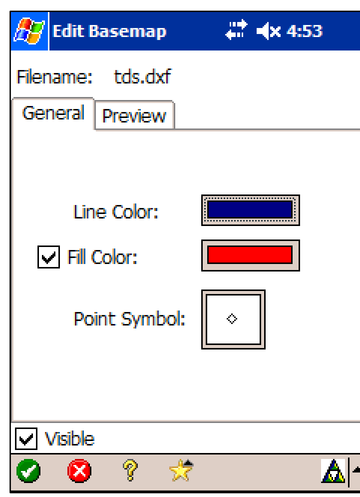


Resulting map view with both basemaps in view.

6. To change the order of the basemaps in the list, select a basemap and tap the Move Up or Move Down buttons to move it up or down in the list, respectively.

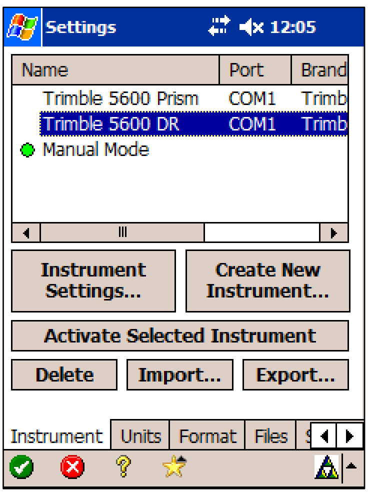
7. To remove any basemap from the list, select it and tap Remove. This will remove the basemap from the list and un-associate it from the current job. (This will *not* delete the corresponding basemap file.)

8. The colors of the objects in vector basemaps can be modified by selecting the basemap and then tapping Edit... to open the Edit Basemap screen.



The Settings Screen

The Settings screen is used to control all of the settings available for your surveying instrument, current job, and Survey Pro software. It contains several index card-style tabs. Each card contains different types of settings.

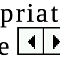


Most of the settings remain unchanged unless you deliberately change them, meaning the default settings are whatever they were set to last. For example, if you create a new job where you change the direction units from azimuths to bearings and then create another new job, the default direction units for the new job will be bearings.

Survey Pro behaves in this way since most people use the same settings for a majority of their jobs. This way, once the settings are set, they become the default settings for all new jobs and current jobs.

Some settings are considered critical and are therefore stored within the job. The following settings are stored within a job and will override the corresponding settings in the Settings screen when it is opened:

- Scale Factor – Surveying Settings Card
- Earth Curvature On or Off – Surveying Settings Card
- Units for Survey Data (distances) – Units Settings Card
- North or South Azimuth – Units Settings Card
- Angle Units – Units Settings Card

You can change to other Settings screens by tapping the appropriate tab at the bottom of the screen. If the tab is not in view, tap the  buttons to scroll through all the available tabs.

Consult the Reference Manual for an explanation of each field on every Settings screen.

If using a Bluetooth total station, refer to the Bluetooth section on Page 316.

File Management and ForeSight DXM

Survey Pro uses a variety of files to store data and information about your project. The files include the main data file, the .JOB file, and the raw data file, the .RAW file, and several other supplementary files that Survey Pro can use for additional information. To help manage this data and to supplement Survey Pro capabilities, TDS has an office product called ForeSight DXM.

ForeSight DXM is a complete data management tool that works directly with Survey Pro data files. ForeSight DXM can make any project easier to manage and makes doing every day tasks, such as downloading, quick and easy. ForeSight DXM has a variety of analysis tools, geodetic tools including projection setups, and the capability to convert TDS data files into many other formats, including LandXML, for use in CAD.

ForeSight DXM makes the field-to-office and the office-to-field process seamless and easy. If you don't already own a copy of ForeSight DXM, contact your TDS Dealer for more information. You can also download a full-featured demonstration copy of ForeSight DXM from the TDS Web site at www.tdsway.com.

Job Files

Every job that is used with TDS Survey Pro actually consists of at least two separate files; a job file and a raw data file. Each file performs a different role within the software.

A job file can be created in the Data collector, or on a PC using TDS ForeSight DXM (or other PC software) and then transferred to the Data collector. It is a binary file that has a file name that is the same as the job name, followed by a *.JOB extension. A job file is similar to the older TDS-format coordinate file, except in addition to storing point names and their associated coordinates, a job file also contains all of the line work as well.

When you specify points to use for any reason within Survey Pro, the software will read the coordinates for the specified points from the job file. Whenever you store a new point within Survey Pro, the point is added to this file.

A job file can be edited on the Survey Pro when using the Edit Points screen. Since a job file is binary, it requires special software for editing on a PC, such as TDS Survey Link. It can also be converted to or from an ASCII file using Survey Link. (Refer to the Survey Link documentation for this procedure.)

When a job file is converted to an ASCII file, the resulting file is simply a list of points and coordinates. Each line consists of a point name, northing or latitude, easting or longitude, elevation or elliptical height, and a note where each value is separated by a comma.

Raw Data Files

A raw data file is an ASCII text file that is automatically generated whenever a new job is created on Survey Pro and cannot be created using any other method. It has the same file name as the current job file (the job name), followed by the *.RAW extension.

A raw data file is essentially a log of everything that occurred in the field. All activity that can create or modify a point is written to a raw data file. Survey Pro never "reads" from the raw data file – it only writes to the file. Since a raw data file stores all of the activity that takes place in the field, it can be used to regenerate the original job file if the job file was somehow lost. This process requires the TDS Survey Link software.

Since a raw data file is considered a legal document, it cannot be edited using any TDS software other than appending a note to it using the View Raw Data screen. Editing a raw data file would invalidate all of its contents and is not supported in any way by TDS.

When viewing a raw data file on a PC using a simple text editor or on Survey Pro using the View Raw Data screen, the file is shown unaltered, which can appear somewhat cryptic. When viewing the file from within Survey Link, the codes are automatically translated on the screen to a format that is easier to understand.

Control Files

The current job can be configured to access the points from another job stored on the data collector. When the current job is using points from another job, that other job is called a *Control File* and the points in the control file are called *Control Points*. (Any non-point objects in a control file are always ignored.)

A control file can be selected from the New Job wizard when creating a new job, or the [File] [Import Control] screen can be used to select a control file for an existing job, or to manage the current control file. See the Reference Manual for more information on these screens.

There are two methods for accessing control points: imported control points and external control points. Each method has advantages and disadvantages, which are explained below.

Import Control File

When a control file is imported, the control points are copied into the current job and stored on a special layer called CONTROL.

Importing control points provides improved RAW data consistency since each control point is written to the raw data file as a store point. This can significantly help when regenerating points from RAW data and generating reports in the office.

Importing control points may not be the best method when using very large control files, while collecting relatively small sets of points since the imported control points can make the current job very large with too many points to easily manage.

Importing control points is also not recommended when you want to switch between different control files from the current job.

External Control File

When using an external control file, the points in the control file are simply linked to the current job and do not become a permanent part of the current job. Because of this, an external control file can later be unlinked, or *cleared* from the current job.

Some users prefer to keep a set of known points in a separate control file when repeatedly working on new jobs in the same general area. That way when they return to the job site, they can create a new job, but select the external control file to easily have access to the known control points.

Once an external control file is selected, the control points can be used in the same way as the job's points with the following exceptions:

- An external control file has *read only* attributes. This means that the points in the control file cannot be modified or deleted; they can only be read. For example, you can select a control point to use as an occupy point during data collection or as a design point during stake out, but you could not use a control point for a foresight where you intend to overwrite the existing coordinates with new coordinates. You would also be unable to modify a control point from the Edit Points screen.
- Since the points in an external control file are shared with the points in the current job, you cannot open an external control file if any of the point names used in it are also used in the current job. If you attempt to do so, a dialog will tell you that a duplicate point name was encountered and the control file will not be opened.

Description Files

A *Description File* is used to automate the task of entering descriptions for points that are stored in a job. They are especially useful when the same descriptions are frequently used in the same job.

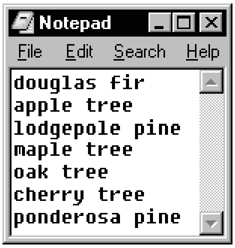
A description file is a text file containing a list of the descriptions that you will want to use with a particular job. The file itself is usually created on a PC, using any ASCII text editor such as Notepad, which is included with Microsoft Windows. It should then saved using any file name and the .txt extension and then transferred to the data collector.

It is important to realize that when you use a more sophisticated application, such as a word processor to create a description file, you must be careful how the file is saved. By default, a word processor will store additional non-ASCII data in a file making it incompatible as a description file. However this can be avoided if you use the Save As... option from your word processor and choose a Text Only file format.

Description files can be created in two different formats; one includes codes and the other does not. The chosen format determines how descriptions are entered. Each format is described below.

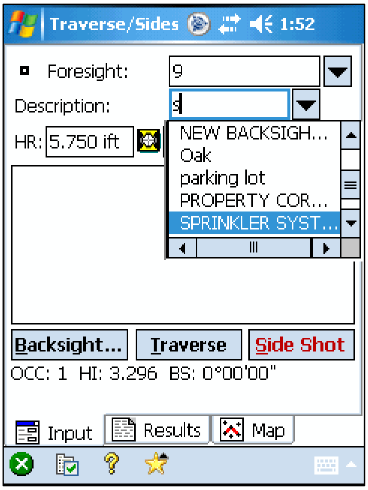
Description Files without Codes

A description file that does not contain codes is simply a list of the descriptions that you will want to use in a job. The content of a sample description file, without codes, is shown here.



The following rules apply to description files without codes:

- Each line in the file contains a single description.
- A single description can contain a maximum of 16 characters (including spaces).
- Descriptions do not need to be arranged in alphabetical order. (Survey Pro does that for you.)
- Descriptions are not case sensitive.



To use a description from a description file without codes, simply start typing in any Description field. Once you start typing a description, a dropdown list should appear displaying all of the descriptions that are in the description file in alphabetical order. If a list does not appear, confirm the Show Description List Automatically checkbox is marked in the Description Settings screen.

A quick way to access the Description Settings screen is by using the ▼ power button associated with every Description field and selecting Description Settings... You can also manually show the description list if it does not open automatically by selecting Show Description List from the power button options. The Edit Descrition List... option opens the Edit Description List screen where you can modify the list and optionally save it to a file as described in the Reference manual under the Miscellaneous Screens section.

If the first letter(s) that you typed match the first letters of a description in the description file, that description will automatically be selected in the dropdown list. Once the desired description is selected, press [**Enter**] or double-tap the description on the screen. You can also use the arrow keys to scroll through the dropdown list to make an alternate selection.

Normally the selected description replaces any text entered in the Description field, but you can optionally append the selected description to the text entered by adding a '+' symbol after the entered text. For example, if you entered NW+ in a description field and then selected Property Corner from the description list, the resulting description would be NW Property Corner.

Description Files with Codes

A description file that uses codes is similar to those without codes, except a code precedes each description in the file. A sample description file with codes is shown here.

The following rules apply to description files that use codes:

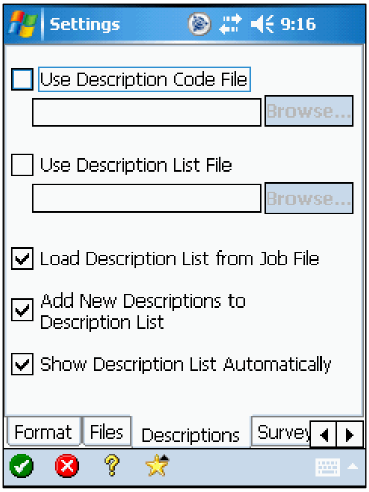
- Each line contains a code/description pair.
- The code must be followed by a single space or tab, and then the description.
- A description code can consist of up to seven characters with no spaces.
- Description codes are case sensitive.
- The description is limited to 16 characters.

To use a description from a description file with codes simply type the code associated with the desired description in any Description field. As soon as soon as the cursor moves out of the Description field, the code is replaced with the corresponding description. For example, if you were using the description file shown above and you typed lo in a description field, lo would be replaced with Lodgepole Pine once the cursor was moved to another field.

You can combine a description with any other text, or combine two descriptions by using an ampersand (&). For example, entering Tall&do would result in a description of Tall Douglas Fir. Entering b&oa would result in a description of Big Oak Tree. Keep in mind that if you combine text that results in a description being longer than 16 characters, it will be truncated.

If you want to enter a description followed by text that happens to be an existing code that you don't want to convert, you need to insert an asterisk (*) between the codes. For example, if code "1" was associated with "Stake" and "2" was associated with something else and you wanted a description of "Stake 2," simply enter "1*2" as the description.

Associating a Description File



Once a description file is loaded on the data collector, it must be associated with the current job. This takes place in the Job > Settings > Descriptions screen. Check the box of the type of description file you want to associate with the job and use the corresponding Browse button to navigate to and select the file. You can associate both a description file with codes and one without simultaneously if desired.

The Load Description List from Job File option will add any unique descriptions to the description list that were already used in the current job.

The Show Description List Automatically should be marked when using a description file without codes. This results in the description list being displayed automatically as soon as you begin entering text into a Description field.

Feature Codes

As explained above, a description or descriptor codes can be used to help describe a point prior to storing it, but this can be a limited solution for describing certain points.

Survey Pro also allows you to describe any object using *feature codes*. Feature codes can be used to describe objects quickly and in more detail than a standard text description, particularly when data is collected for several points that fit into the same category. For example, if the locations for all the utility poles in an area were being collected, a single feature code could be used to separately describe the condition of each utility pole.

When describing an object using feature codes, a selection is made from any number of main categories called *features*. Once a particular feature is selected, any number of descriptions can be made from sub-categories to the selected feature called *attributes*.

In general, a feature describes what an object is and attributes are used to describe the details of that object.

To take advantage of feature codes, a feature file must first be created using the TDS Survey Attribute Manager, which is included in Version 7.2, or later of the TDS Survey Link software.

The TDS Survey Attribute Manager can also be used to view or modify the selected features in a particular job and to export them to any of several different file formats for use in other popular software packages.

Note: You can switch between different feature code files in mid-job, but if a collected attribute does not match an attribute in the current feature code file, it can still be viewed, but not edited.

For more information on creating a feature file, refer to the Survey Attribute Manager section of the Survey Link manual.

Features

The primary part of a feature code is called a *feature*. Features generally describe what an object is. Two types of features are used in Survey Pro: *points* and *lines*, which are described below.

When assigning a feature to data that was collected in Survey Pro, only features of the same type are available for selection. For example, if selecting a feature to describe a point in a job, only the point features are displayed. Likewise, if selecting a feature to describe a polyline, only the line features in the feature file are displayed.

- **Point Features**
  A point feature consists of a single independent point. Examples of a point feature would be objects such as a tree, a utility pedestal, or a fire hydrant.
- **Line Features**
  A line feature consists of two or more points that define a linear object, such as a fence or a waterline. In Survey Pro, these are stored as polylines, but line features can also be used to describe alignments.

Attributes

A feature, by itself, would not be useful in describing a point or line with much detail since a feature only helps describe what the stored point is. *Attributes* are used to help describe the details of the object.

Attributes are either typed in from the keyboard or selected from a pull-down menu and fall into the following three categories.

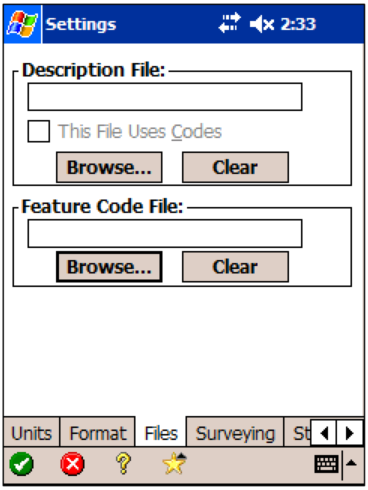
- **String Attributes**
  A string attribute consists of a title and a field where the user can enter any characters up to a specified maximum length. An example of a string attribute is an attribute titled Notes where the user would enter anything to describe a feature.

- **Value Attributes**
  A value attribute accepts only numbers from the keypad. These attributes are setup to accept numbers that fall in a specified range. Some examples of a numeric attribute would be the height of a tree or a utility pole's ID number.

- **Menu Attributes**
  A menu attribute is an attribute that is selected from a pull-down menu rather than typed in from the keypad. Menu items can also have sub-menu items. For example, you could have a feature labeled Utility with a pull-down menu labeled Type containing Pole and Pedestal. There could also be sub-menu items available that could be used to describe the pole or pedestal in more detail. Menus can only be two levels deep, but there is no limit to the number of items that can be listed in a pull-down menu.

Using Feature Codes in Survey Pro

Before you can use features and attributes to describe points in Survey Pro, you must select a valid feature file to use with the current job.



To select a feature file, open the Job | Settings screen from the Main Menu and then select the Files card. Tap the lower Browse... button, locate and select the appropriate *.FEA feature file.

Once a feature file is selected for the current job, you can configure Survey Pro to prompt for attributes whenever a point, line, or alignment is stored. There are three cards within the Job | Settings screen to configure this prompt.

There is a ☑ Prompt for Attributes checkbox in the Survey card, the Stakeout card and the General card. The first affects if you are prompted for attributes only when an object is stored from the routines within the Survey menu. Likewise, the second affects only objects stored from the routines in the Stakeout menu. The prompt in the General card affects if you are prompted for attributes when an object is stored from any other routines, such as the COGO routines.

The features and attributes for existing points, polylines, and alignments can also be edited using the Edit Points and Edit Polylines and Edit Alignments screens, respectively.

Layers

Survey Pro uses layers to help manage the data in a job. Any number of layers can exist in a job and any new objects can be assigned to any particular layer. For example, a common set of points can be stored on one layer and another set can be stored on a different layer.

The visibility of any layer can be toggled on and off, which gives full control over the data that is displayed in a map view. This is useful to reduce clutter in a job that contains several objects. The objects that are stored on a layer include points, polylines, and alignments.

TDS ForeSight can read a JOB file and output an AutoCAD DXF file containing all the original layer information. This conversion can also be performed using TDS Survey Link 7.2, or later via the Survey Attribute Manager, which is included as part of that program.

Layer 0

Layers can be added, deleted and renamed with the exception of Layer 0. Layer 0 is a special layer that must exist in every job. It cannot be deleted or renamed.

Layer 0 provides two main functions: compatibility with AutoCAD; and is used as a layer for the storage of objects that are not assigned to any other layer. Since all the objects in a job have to be assigned to a layer, Layer 0 is always there so a situation cannot occur where an object is stored, but does not exist on any layer.

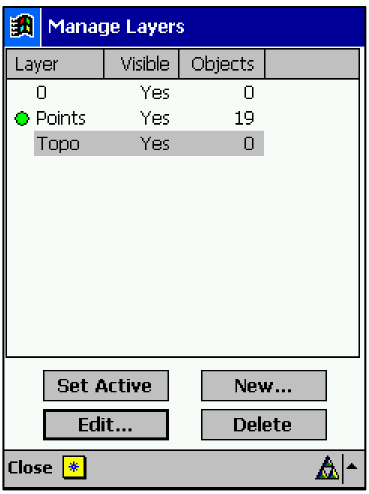
Other Special Layers

Some layers are automatically created, but unlike Layer 0, these layers behave exactly the same as any user-created layer; they can be renamed or deleted. For example, whenever control points are imported, a Control layer is automatically created and the points in the control file are stored to that layer. (Any non-point objects in a control file are always ignored.)

Similarly, whenever a new job is created, a Points layer is automatically created and selected as the active layer. The active layer is the default layer where any new objects will be stored.

Managing Layers

You can configure Survey Pro to prompt for a layer whenever an object is stored. If this prompt is turned off, any new objects that are stored will simply be stored to the active layer. There are three cards within the Job Settings screen to configure this prompt.



There is a ☑ Prompt for Layer checkbox in the Survey card, the Stakeout card and the General card. The first affects if you are prompted for a layer only when new data is stored from the routines within the Survey menu. Likewise, the second affects only data stored from the routines in the Stakeout menu. The prompt in the General card affects if you are prompted for a layer when data is stored from any other routines, such as the COGO routines.

Most layer management is performed from the Job, Manage Layers screen. This screen allows you to add, delete, rename and change the visibility of the various layers. You can also set the active layer from here. This screen is also available from several different locations, such as the new Map Display Options screen and any of the controls that allow you to select layers.

Changing the Active Layer

To change the active layer, tap the desired layer and then tap the Set Active button. There must always be an active layer and there can only be one active layer at a time. The active layer is marked with the ● symbol.

Creating a New Layer

A new layer can be created by tapping New..., which opens the New Layer dialog box where a name and if the new layer should be visible is entered.

Changing a Layer Name or Visibility

Selecting a layer and then tapping Edit... opens the Edit Layer dialog box where the name and visibility can be changed for the selected layer. You can also edit a layer by double-tapping on it. (Layer 0 cannot be renamed.)

Deleting a Layer

You can only delete an empty layer. If a layer contains any objects, they must first be moved to a different layer. To delete a layer, select the layer and tap Delete. (Layer 0 cannot be deleted.)

Moving Objects from One Layer to Another

The objects on a layer can be moved to a different layer using the object's appropriate edit screen. For example, to move several points from one layer to another, select the desired points in the Edit Points screen and tap Edit. Select the layer you want to move them to and tap ✔.

Working with 2D Points

Most people work with 3D points, but Survey Pro also allows you to work with 2D points (points without elevations). You can also work with a combination of both 3D and 2D points.

It is important to remember that data collected from a 2D point will also be 2D, so care should be taken when working without elevations. To assist the user, various warnings will appear when working with 2D points.

Some routines require elevations and are therefore inaccessible when working with 2D points. When attempting to perform a routine using a 2D point that requires 3D points, the following error will result:

> "This operation requires an occupy point with a valid elevation."

Examples of routines that require elevations and do not support 2D points include:

- Slope Staking
- Stake DTM
- Vertical Angle Offset
- All Road Layout Routines

You can quickly see if any 2D points exist in the current job by opening the [Job], [Edit Points] screen and scrolling down the Elevation field. Any point where the elevation is shown as '---' is a 2D point. You can convert a 3D point to a 2D point by simply editing the point and deleting the elevation.

The items below explain what to expect when working with 2D points in a variety of situations.

Traverse / Side shot

Setting up over a 2D occupy point will result in any traverse or side shot taken from that point to also have no elevations. When a 2D point is selected as the occupy point in the Backsight Setup screen, the following message will be displayed:

> "Note: Selected occupy point has no elevation. All points computed with this point will have no elevation computed for them."

An elevation adjustment on a traverse containing any 2D points is not possible. If an attempt is made to do so, the following message is displayed:

> "Traverse contains a 2D point. Cannot adjust elevations."

Point Stake

When performing point stake using a 2D point, no cut/fill information is provided. This is the case when either the occupy point or the stake point is 2D. Cut/fill information is only provided when both the occupy point and stake point have elevations.

Offset Stake

Offset stakeout functions similar to point stake, although cut/fill information can be generated when using a 2D alignment and 3D occupy point when a design elevation for the stake point is provided. The following message is displayed in this situation:

> "A 2D alignment has been selected; no cut/fill information will be computed unless a design elevation is entered."

Slope Stake

Slope staking is not possible when using 2D points since elevations are required.

Control Points

Control points can be all 2D, all 3D, or a mixture of both. The same limitations for working with 2D non-control points will apply when working with 2D control points.

Polylines

Lines can be added to your project that can represent anything such as a roadway, a building, or a lot boundary. These lines are referred to as *polylines*. Polylines can be compared to the point lists used in other TDS data collection software. They can consist of several individual curved and straight sections. A point must be stored in the project for all the locations on the polyline where a new section begins and ends.

Polylines can be used to compute information such as the perimeter and area for a lot boundary. They can also make it easier to compute and store offset points for the sides of a roadway when a polyline exists that defines a roadway centerline.

Refer to the Reference Manual for information on all the screens that are used to create and edit polylines.

Alignments

Alignments are similar to polylines in that they define specific lines in the current job and typically describe the centerline of a road. An alignment can then be used in the Offset Staking, Offset Points, Offset Lines, and Slope Staking screens. Unlike polylines, alignments do not need points for the locations where the alignment changes (called *nodes*).

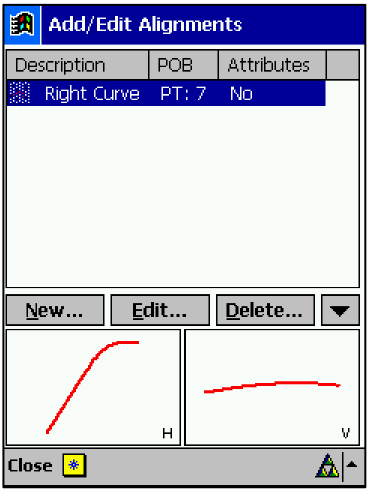
Alignments are created by separately defining the horizontal and vertical details of a line. Although no points are required to define an alignment, the starting position must be tied to a specific location in the current job, the POB, which can be defined by an existing point or known coordinates.

The horizontal and vertical details of an alignment are defined in sections. The first horizontal and vertical section always begins at the specified starting location and each new segment is appended to the previous horizontal or vertical segment.

Once all the horizontal and vertical alignment segments are defined, Survey Pro merges the information to create a single 3-dimensional line.

The vertical alignment (VAL) must be equal in length or longer than the horizontal alignment. The HAL must not be longer than the VAL.

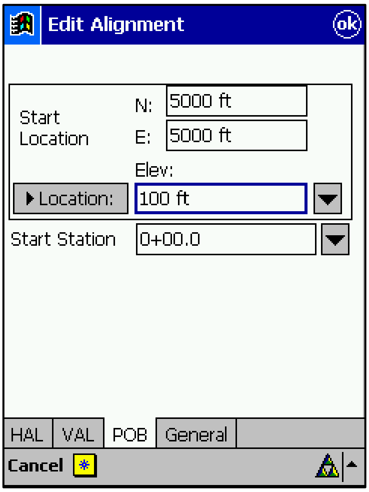
Creating an Alignment



In this step-by-step example, we will create an alignment that has all the possible horizontal and vertical segment types.

1. Select Job, Edit Alignments from the Main Menu. If any alignments exist in the current job, they will be listed in this screen. An existing alignment can then be edited or deleted, but for this example, we will create a new alignment.

2. Tap New... to create a new alignment. This will open the Edit Alignments screen where you can begin adding horizontal and vertical segments.

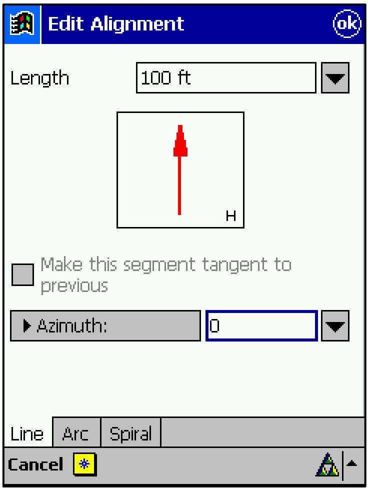


3. Tap the POB tab and enter North, East and Elev coordinates of 5000, 5000, 100. This will be the starting location of the horizontal and vertical definition. (Alternatively, you could define the starting location by tapping the Location / Point button where Point is displayed and then select an existing point.)

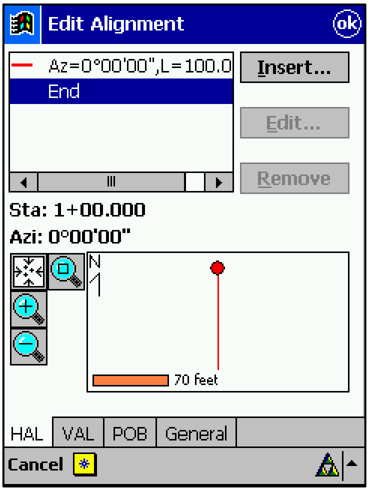
Horizontal Alignment

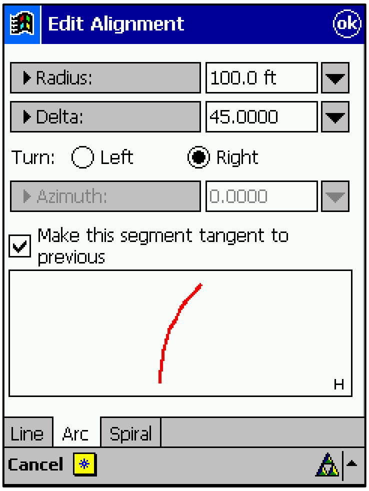
4. Tap the HAL (Horizontal Alignment) tab and then tap the Insert button. This will open the Edit Segment screen where the first horizontal alignment segment can be defined.

5. Tap the Line tab to insert a straight line segment. Enter a Length of 100 and an ▸ Azimuth of 0.



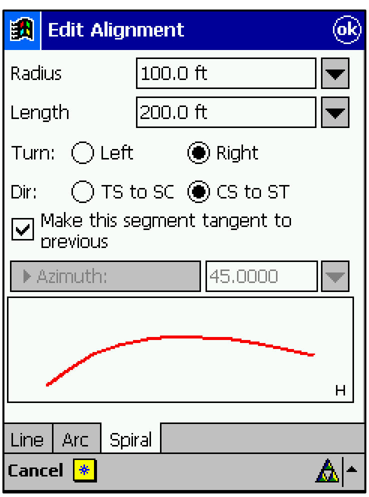
6. Tap to add the segment to the horizontal alignment. You will return to the Edit Alignment screen where the new segment is displayed. The graphic shows every horizontal segment entered so far with the selected segment in bold. The dot in the picture indicates the beginning of the selected segment (in this case it is the end). This is where the next segment will be placed when using the Insert button.





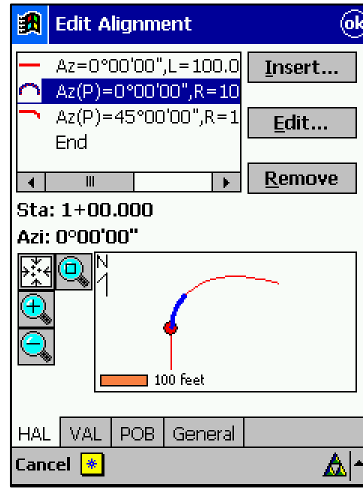
7. Tap the Insert button again and then tap the Arc tab to insert a horizontal curve.
8. Enter a Radius of 100, a Delta of 45 and select a Right turn. Check the Make this segment tangent to previous checkbox so that the curve will be positioned so the entrance to the curve is tangent to the end of the previous segment.
9. Tap to add the segment to the horizontal alignment.

Note: A new segment can be inserted between two existing segments by selecting the existing segment that is to occur after the new segment and then tapping the Insert button.



10. Tap the Insert button again and then tap the Spiral tab to insert a spiral curve.
11. Enter a Radius of 100, a Length of 200, select a Right of turn and a CS to ST direction, and check the Make this segment tangent to previous checkbox.
12. Tap to add the segment to the horizontal alignment. This completes the horizontal definition. You now need to define the vertical alignment.

Note: When creating a new horizontal segment and using the Make this segment tangent to previous option, the new segment will appear in the Edit Alignment screen tagged with a **(P)** (see picture). This means that if the previous horizontal segment is edited or deleted, thus changing the orientation, all subsequent horizontal segments that have the **(P)** tag will also be adjusted so they will remain tangent to the previous segments.

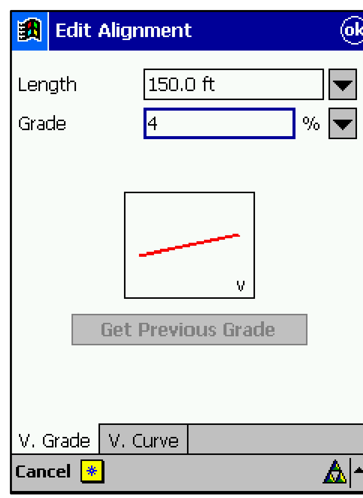


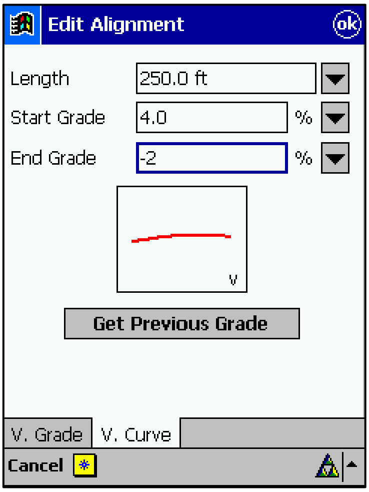
Vertical Alignment

We have now added all available horizontal segment types. Next, we will define the vertical alignment.

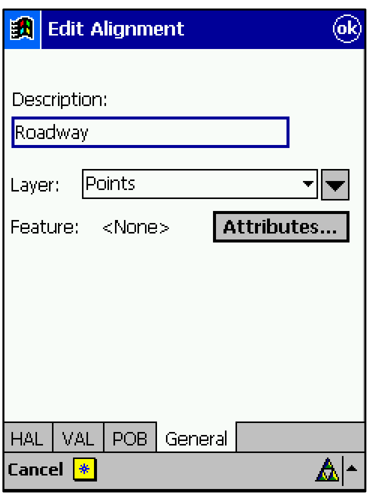
The horizontal and vertical alignments are defined independently of each other, but the first vertical segment that is defined will always start at the same POB defined for the horizontal alignment (Step 3).

13. Tap the VAL (Vertical Alignment) tab and then tap the Insert button.
14. Tap the V. Grade tab to insert a grade. Enter a Length of 150 and a Grade of 4%.
15. Tap ✔ to add the segment to the vertical alignment.



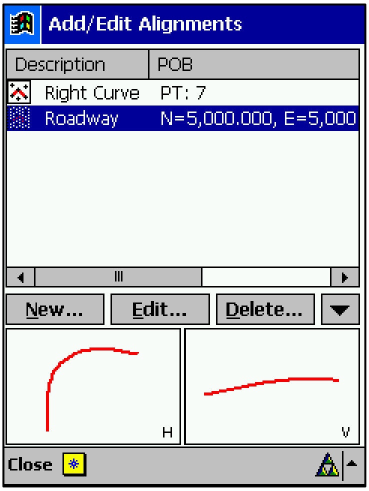


16. Tap the Insert button again and then tap the V. Curve tab to insert a parabolic vertical curve. Enter a Length of 250 and tap the Get Previous Grade button to automatically set the Start Grade to the ending grade of the previous segment. Enter an End Grade of -2%.
17. Tap ✅ to add the segment to the vertical alignment.



18. Tap the General tab and enter a Description of Roadway.

19. Tap ✓ from the Edit Alignment screen to return to the Add/Edit Alignments screen where the new alignment is stored and displayed.



You have now completed a new alignment using all the available types of segments. You can select the new alignment for use in the Offset Staking, Offset Points, Offset Lines and Road Layout routines.

Note: If the horizontal and vertical alignments end at different stations, they can only be processed in the staking routines as far as the end of the shortest alignment.

Conventional Fieldwork

This section will explain how to get started using Survey Pro to collect data from a total station and perform stake out. It is assumed that you are familiar with the operation of your total station.

The first section describes the backsight setup procedures for various scenarios. The next section walks you through the steps involved to setup and perform a simple side shot and traverse shot. The third section walks you through a simple point-staking example.

The remainder of the chapter illustrates the procedures to perform the more complex routines in the Survey Pro software in a step-by-step manner. They are intended to explain only how to use a particular routine without the need for you to enter any specific values to read through the example.

When beginning any job, the setup is the same; you need to establish an occupy point and a backsight.

The occupy point is the point where you will setup the total station. The coordinates for the occupy point must exist in the current job or active control file. They can be assumed coordinates; known coordinates; or computed with the resection routine. (The resection routine is discussed later.) Any point in the current job can be an occupy point.

Once an occupy point is established, the second reference you need is a backsight point or direction. This can be in the form of a point stored in the current job, or an azimuth or bearing.

The horizontal angles recorded during data collection are relative to the backsight. If a point is not available in the job to use as a backsight, you can assume a backsight direction or you can use the solar observation routine, described later, to establish a backsight.

The scenarios below will describe four different possibilities for defining a backsight.

Scenario One

You know the coordinates and locations for two points on your lot and want to occupy one and use the other as a backsight.

Solution

1. Create a job using the coordinates for one of the known points as the first point.
2. Use the Edit Points routine to add a second point using the coordinates for the remaining known point.
3. From the Backsight Setup screen, set the Occupy Point field to the point number of one known point and setup the total station over that point.
4. Toggle the BS Direction / BS Point button to BS Point and enter the point name for the second known point in that field.
5. Aim the total station toward the other point and tap Solve... to open the Backsight Solved screen.
6. Confirm the BS Circle value is zero and tap Send Circle to zero the horizontal angle on the instrument, then tap ✔. If the Always Prompt for Backsight Check option is checked in the Job > Settings > General screen, you will be prompted to check your backsight.

You are now ready to start your survey.

Scenario Two

You have found two points on your lot and know the azimuth between them, but you do not have coordinates for either.

Solution

1. Create a job using the default coordinates for the first point.
2. From the Backsight Setup screen, set the Occupy Point field to the point that was just created.
3. Setup the total station over the point where the known azimuth is referenced.
4. Toggle the [BS Direction] / [BS Point] button to [BS Direction] and enter the known azimuth to the second point here.
5. Aim the total station toward the second point and tap [Solve...] to open the Backsight Solved screen.
6. Confirm the BS Circle value is zero and tap [Send Circle] to zero the horizontal angle on the instrument, then tap ✔.

You can optionally take a shot at the backsight by pressing the [Store Backsight Point] button from the Backsight Solved screen so you have coordinates for it.

You are now ready to start your survey.

If you later find true state plane coordinates for any of the points in your job, you can use the Translate routine to adjust all the coordinates accordingly.

Scenario Three

You have one point established on your lot and you know the azimuth to an observable reference.

Solution

1. Create a job using the coordinates of the established point for the first point. If the coordinates are unknown, accept the default coordinates.
2. From the Backsight Setup screen, set the Occupy Point field to the point that was just created.
3. Setup the total station over the established point.
4. Toggle the BS Direction / BS Point button to BS Direction and enter the azimuth to the observable reference here.
5. Aim the total station toward the observable reference and tap Solve... to open the Backsight Solved screen.
6. Confirm the BS Circle value is zero and tap Send Circle to zero the horizontal angle on the instrument, then tap . If the Always Prompt for Backsight Check option is checked in the Job > Settings > General screen, you will be prompted to check your backsight.

If you later find true State Plane coordinates for any of the points in your job, you can use the Translate routine to adjust all the coordinates accordingly.

Scenario Four

You have only one known point on a job.

Solution

You have two options in this situation. One, you can assume an azimuth for an arbitrary backsight reference and rotate the job later using the Rotate routine once you have determined the actual orientation.

Secondly, you can use the Sun Shot routine to determine an azimuth to an arbitrary reference.

Summary

In general, you would follow these steps when you begin working on a job.

1. Create a new job or open an existing job.
2. Setup over the Occupy Point.
3. Aim the total station toward the backsight and zero the horizontal angle on the instrument.
4. Fill in the Backsight Setup screen and tap Solve... to open the Backsight Solved screen.
5. Confirm the BS Circle value is zero and tap Send Circle to zero the horizontal angle on the instrument, then tap ✓. If the Always Prompt for Backsight Check option is checked in the Job > Settings > General screen, you will be prompted to check your backsight.
6. Start your survey.

Note: The backsight circle angle is subtracted from all horizontal angles that are read during data collection and the resulting points are adjusted accordingly. This is usually only done when surveying in true azimuths. This value can be change from the Backsight Circle or Backsight Solved screens.

Most non-staking related data collection is performed from the Traverse / Sideshot screen. When you take a shot using the Traverse button, the routine expects that you will eventually be occupying the foresight that you are shooting and backsighting your current occupy point. When you are ready to setup on the next point, the occupy, foresight and backsight points will automatically be updated accordingly.

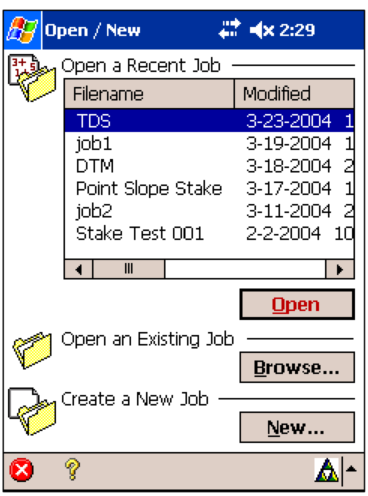
After taking a shot using the Side Shot button, the routine does not expect the total station to be moved before the next shot and will therefore only automatically advance the foresight point.

Data Collection Example

This section illustrates the necessary setup and usage of the Traverse / Side Shot screen, which is the primary screen used during data collection. We will create a new job and manually add another point to the job to use as a backsight. We will run in Manual Mode so the shot data must be entered manually. This example and the following stakeout example are the only examples that are designed where the user should follow along and enter the values in their data collector as they are provided in the example.

Setup

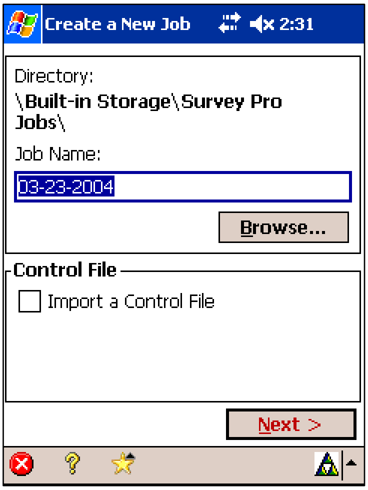
1. Create a new job.



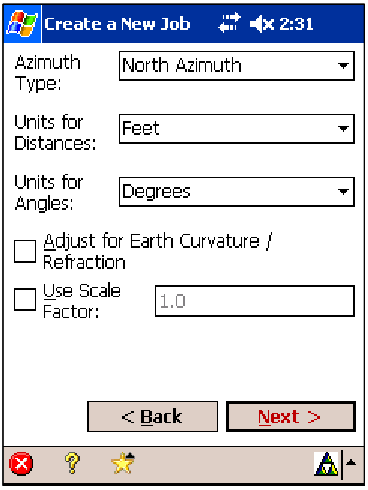
a. From the Main Menu, select File, Open / New.

b. Tap New... to open the Create a New Job screen.

c. Enter any job name that you wish in the Job Name field and tap Next >.

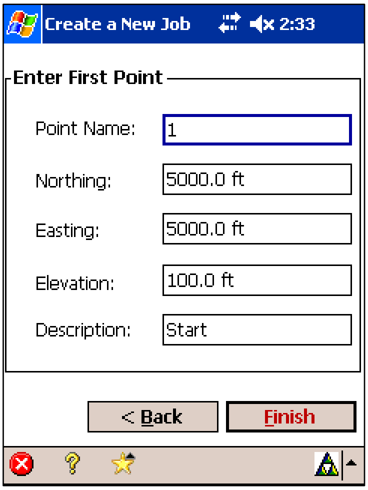


d. For this example, simply accept the default job settings and tap Next >.



Note: When creating a new job, it is important that the Units for Distances field be set to the correct units. This allows you to seamlessly switch between different units in mid-job.

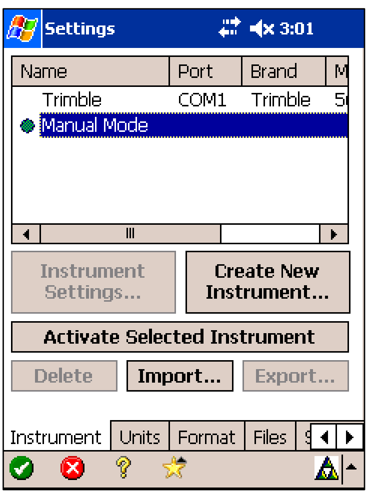
Problems can arise if these units are inadvertently set to the incorrect units when entering new data. For example, assume a new job was created by hand-entering a list of coordinates where the job was set to International Feet and the coordinates being entered were in US Survey Feet. Now assume you created another new job and correctly set it to US Survey Feet. If you then imported the hand-entered points from the other job, they would be converted to different units when no conversion should have taken place. Depending on the magnitude of the imported coordinates, the error after the conversion could be significant.



e. Accept the default coordinates for the first job point by tapping Finish. You will return to the Main Menu.

2. Check the job settings.

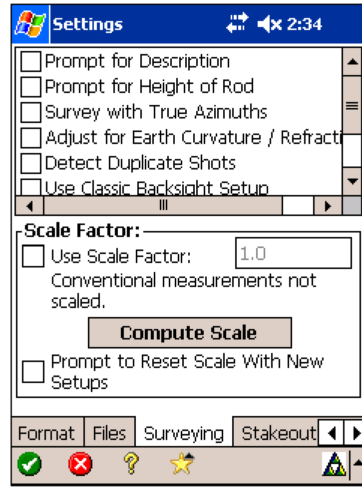
a. Tap Job, Settings from the Main Menu to open the Settings screen.



b. Tap the Instrument tab if it is not already selected and make sure the Manual Mode profile is activated. If the symbol is not shown next to it, select Manual Mode and tap Activate.

c. For this example, tap the Surveying card and uncheck all the checkboxes.

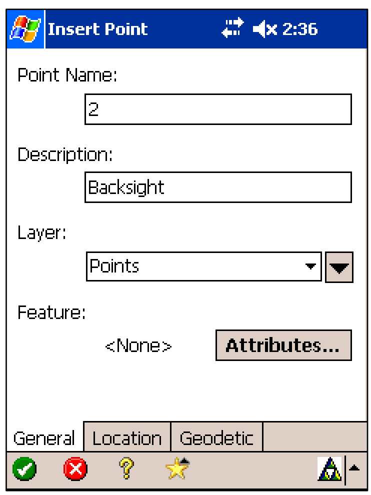
d. Tap (OK) to save the job settings.

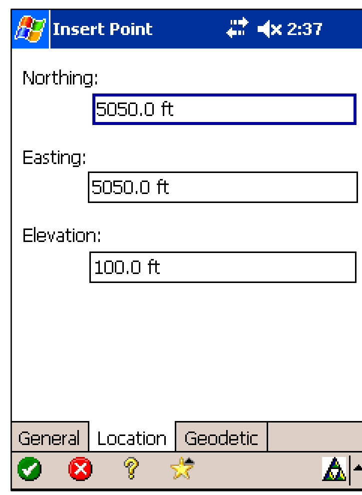


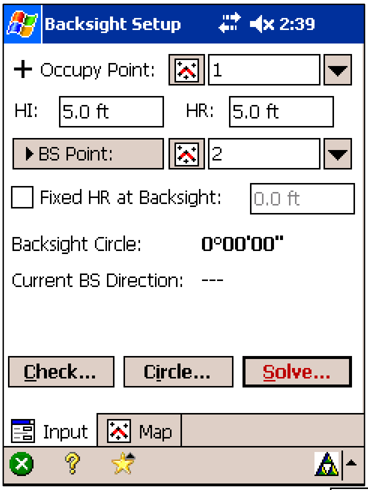
3. Add a backsight point to the job.

a. Select Job, Edit Points from the Main Menu.

b. Tap Insert... and enter a new point using the General and Location cards with the following values, as shown:
Point Name: 2
Northing: 5050
Easting: 5050
Elevation: 100
Description: Backsight
and then tap .







4. Set up your backsight. In this example, we will setup on Point 1 and backsight Point 2, which was just created.

   a. Access the Survey, Backsight Setup screen.

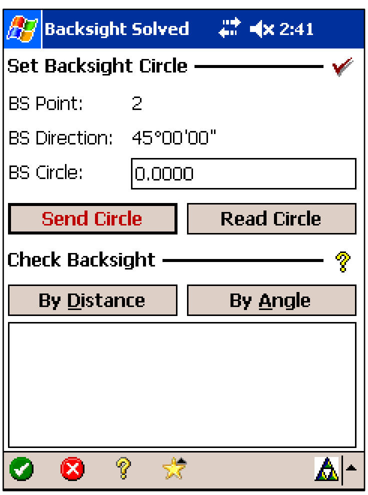
   b. In the Occupy Point field, enter 1 as the point name.

Tip: You can also select an existing point from a map view or from a list by using the ▼ power button.

   c. Enter an HI and HR of 5 feet each.

   d. Toggle the BS Direction / BS Point button to BS Point and enter 2 as the point name.

   e. Leave the Fixed HR at Backsight field unchecked.



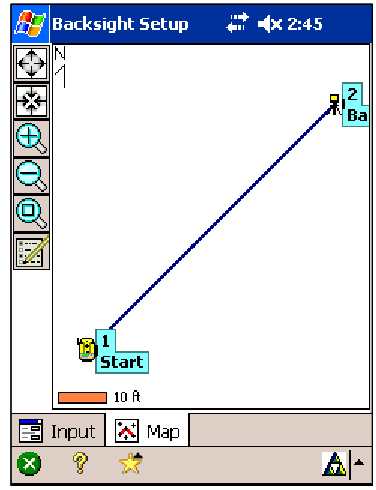
   f. Tap Solve... to open the Backsight Solved screen.

   g. Confirm that the BS Circle value is zero. If not, change it to zero.

   h. Tap the Send Circle button. This would normally zero the horizontal angle on the instrument and is a required step to properly exit from the screen.

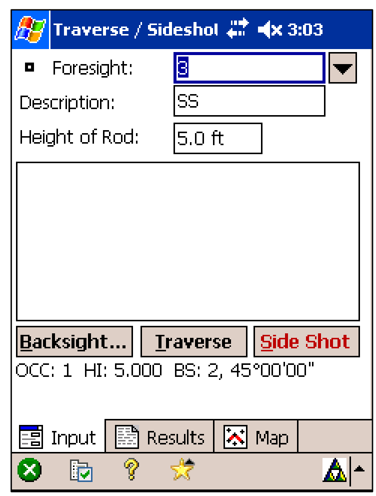
i. Tap to exit from the Backsight Solved screen. The map view will open showing your current setup.

j. Tap (Close) to continue.



Performing a Side Shot

5. Access the Survey, Traverse / Sideshot screen and fill in the appropriate fields. The backsight information is displayed in the lower portion of the screen. At this point, it is assumed that your total station is over the occupy point and its horizontal angle was zeroed while aiming toward the backsight.

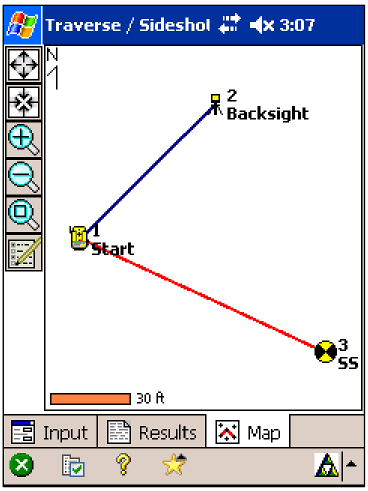


a. In the Traverse / Sideshot screen, enter the following data:
Foresight: 3
Description: SS
HR: 5
These values will define the point name, description, and rod height for the next point that is stored.

b. Assuming that the total station is aiming toward the prism, which is located over the foresight, tap Side Shot. When connected to an instrument, this would trigger the total station to take a shot, compute coordinates for the new point and store it. Since we are running in Manual Mode, we will enter the shot data from the keypad.

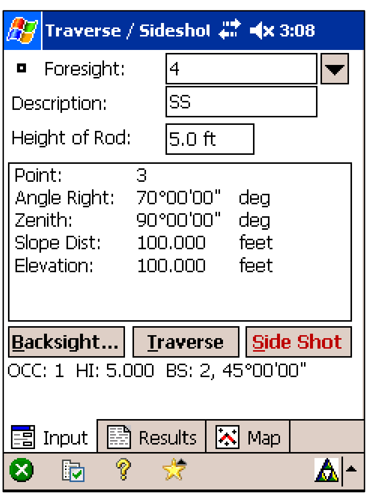
c. Enter the following data:
Angle Right: 70
Zenith: 90
Slope Dist: 100 and then tap (OK). The new point is

computed and stored. The Foresight point will automatically advance to the next available point name and the information from the last shot is displayed on the screen.



d. You can see a graphical representation of the previous shot by tapping the Map tab. See Page 24 for more information on the Map View.

Performing a Traverse Shot



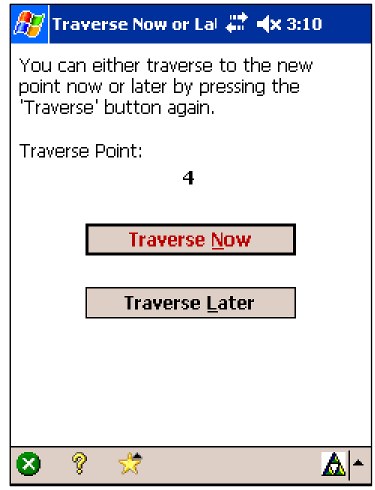
6. The steps involved in performing a side shot are nearly identical to performing a traverse shot. The difference is you must specify if you plan to move the total station to the current foresight point after the shot is taken.

a. Tap the Input tab of the Traverse / Sideshot screen. The Foresight point should now be updated to 4.

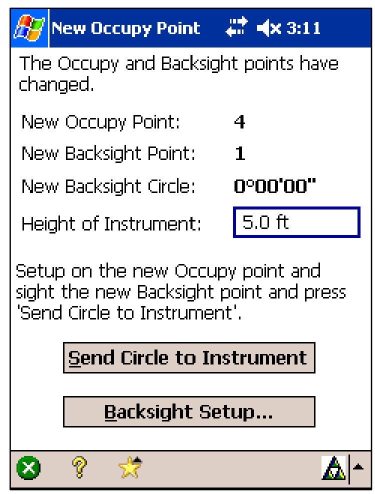
b. Assuming that you are now aiming the total station at a prism located over the foresight point, tap Traverse. This would trigger the total station to take a shot, compute coordinates for the new point and store it. Since we are running in Manual Mode, we will enter the shot data from the keypad.

c. Enter the following data:
Angle Right: 45
Zenith: 90
Slope Dist: 50 and then tap ✔.

The new point is computed and stored and the Traverse Now or Later prompt will open asking if you want to advance to the new point now or later. For this example, tap the Traverse Now button.



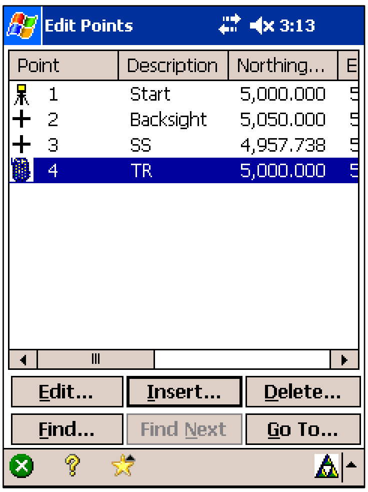
The New Occupy Point dialog box will open, shown here, which displays details of the new setup. You can see that the previous foresight point is now the current occupy point and the previous occupy point is now the current backsight point.



Note: If you selected to traverse later, the traverse point is still stored, but you would then have the opportunity to shoot additional side shots before you advanced to the next point. This is useful when you want to shoot the traverse shot first before any settling occurs to the tripod. In that situation, when you are ready to advance, you would tap Traverse again where you would then answer to a prompt that asks if you are ready to advance or re-shoot the traverse point. (If you select to re-shoot the traverse point, the previous traverse point is still stored, but as a side shot.)

d. Since we are running in Manual Mode and cannot send data to an instrument, tap (Close). You will notice at the top of the Traverse Sideshot screen that the occupy point has been updated to 4, the backsight is updated to 1, and the foresight is updated to 5, which is the next available point name.

When out in the field, you would now move your total station over the new occupy point, aim it toward the previous occupy point (the current backsight), enter the correct instrument height in the Height of Instrument field and tap Send Circle to Instrument. This would update the Traverse / Side Shot screen and set the total station's horizontal angle to zero where you are then ready to collect more data.



You have now created a job, checked the settings, setup a backsight and collected data in the form of a side shot and a traverse shot. If, at any time, you want to view the coordinates of your points, you can do so from the Job, Edit Points screen.

Data Collection Summary

1. Open or create a job.
2. Check the job settings.
3. Setup a backsight.
4. Collect data in the form of traverse shots or side shots.

Stakeout Example

When setting up to perform stakeout, the requirements are nearly the same as with data collection. You need an existing occupy point, backsight point or direction, and a foresight. The main difference is existing points are being located during stakeout rather than new points being collected.

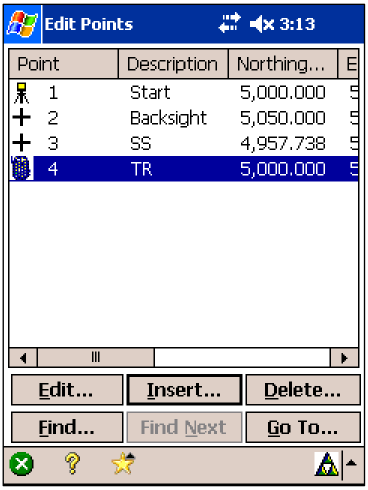
In the example below, all of the steps required to perform a simple point staking job are explained from the initial setup to the staking itself. For consistency, this example assumes you are running Survey Pro in Manual Mode so the shot data will need to be input from the keypad. The software behaves differently in Manual Mode compared to when using a total station. The differences are noted where applicable.

For this example we will use the job that was created with the Traverse / Side Shot Example, above. When staking the first point, we will take two shots to the prism to "home-in" on the design point. When staking the second point, we will only take one shot combined with the Store/Tape routine to store the stake point.

Set Up

1. Open the job that was created in the Traverse / Side Shot example.

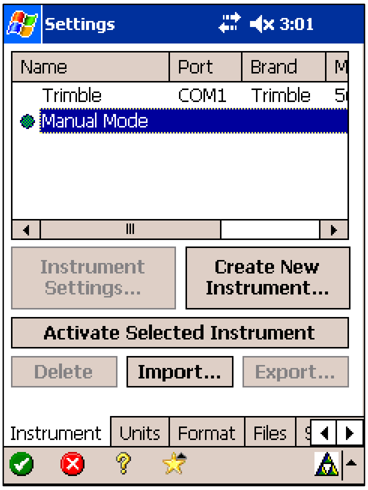
   a. From the Main Menu, select File, Open / New to open the Open / New screen.



b. Tap the file name that was created earlier listed in the Open Recent Job list and then tap Open. The coordinates for that job are shown here.

2. Set the job settings. (Only the settings that affect this example are covered here.)

   a. Select Job, Settings from the Main Menu.



   b. Tap the Instrument tab if it is not already selected and make sure the Manual Mode profile is activated. If the symbol is not shown next to it, select Manual Mode and tap Activate.

   c. Tap the Surveying tab and confirm that all of the checkboxes are unchecked.

   d. Tap the Stakeout tab and make sure the Cut Sheet Offset Stored field is set to Actual Offset.

Note: When performing stakeout, you have the option of storing cut sheet information. This information is stored in the raw data file, and when using software on a PC, such as Survey Link, it can be extracted to create a cut sheet report.

   e. Tap to save the job settings.

3. Setup your backsight. In this example, we will setup on Point 1 and backsight an object where it is assumed that the direction to that object is known. When connected to a total station, you would setup over your occupy point and aim toward the backsight before continuing.

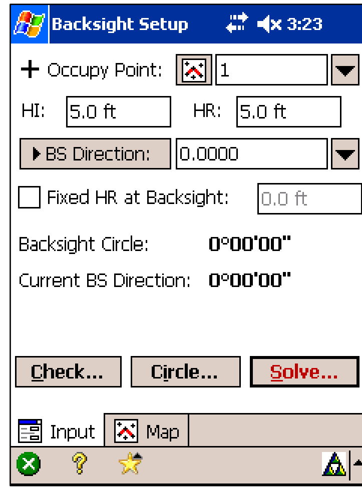
a. Access the Survey, Backsight Setup screen.

b. In the Occupy Point field, enter 1 as the point name.

c. Toggle the BS Direction / BS Point button to BS Direction and enter 0 as the backsight direction.

d. Enter an HI and HR of 5 feet.

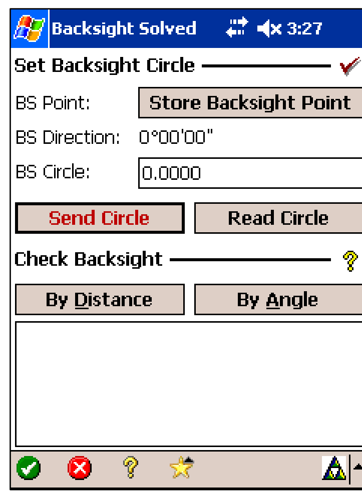
e. Leave the Fixed HR at Backsight field unchecked.

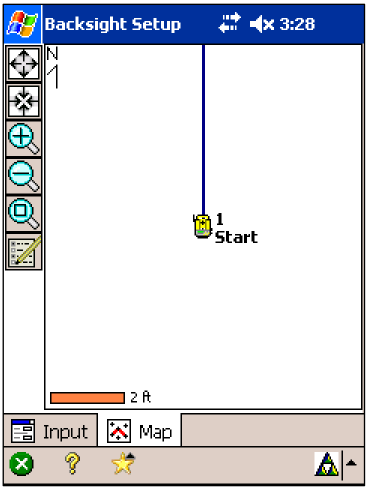


f. Tap Solve... to open the Backsight Solved screen.

g. Confirm that the BS Circle value is zero. If not, change it to zero.

h. Tap the Send Circle button. This would normally zero the horizontal angle on the instrument and is a required step to properly exit from the screen.

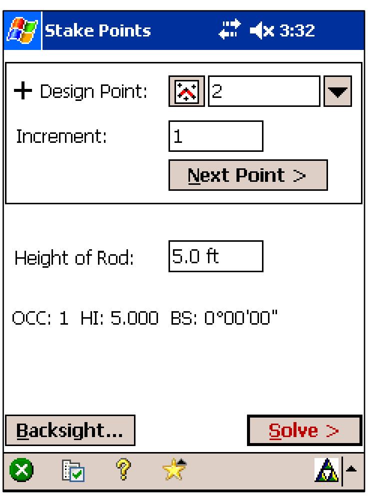




i. Tap (OK). The Map View will automatically open showing your current setup. Tap (Close) to continue.

Staking Points

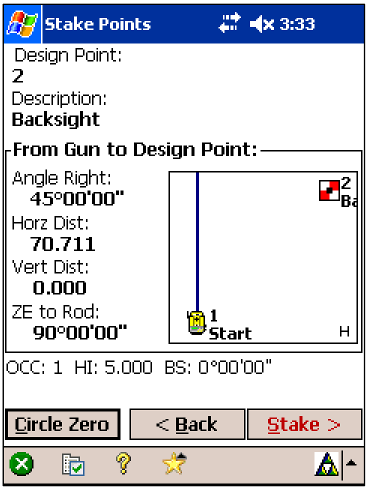
4. Stake the first design point (Point 2).



a. Access the Stakeout, Stake Points screen from the Main Menu. The backsight information is displayed near the bottom of the screen. At this point, it is assumed your total station is over the occupy point and its horizontal angle was zeroed while aiming toward the backsight.

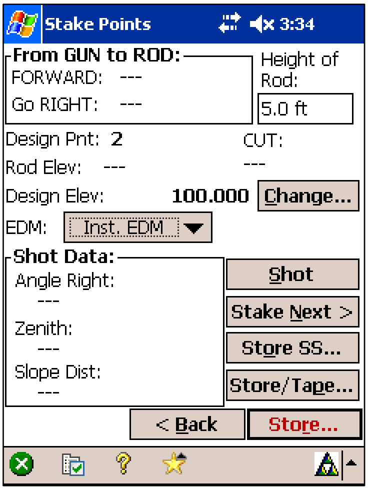
b. Enter the following data in the Stake Points screen:
Design point: 2
Increment: 1
Height of rod: 5 and tap Solve >.

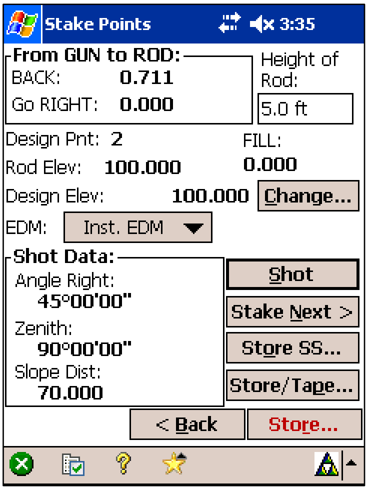
c. The second Stake Points screen will open that displays all of the information needed to locate the design point. When connected to a total station, you would turn the total station horizontally to 45°00'00", vertically to 90°00'00" and send the rod man out about 70 feet before continuing. Tap the Stake > button to continue to the third screen.



d. With a Height of rod of 5, tap the Shot button. (See the Reference Manual for an explanation of the other fields.)

e. Enter the following shot data:
Angle Right: 45
Zenith: 90
Slope Dist: 70 and then tap ✅ to continue.

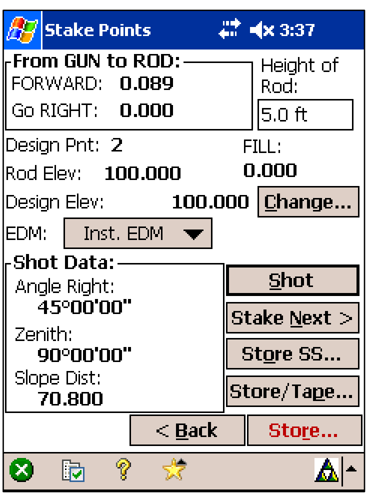




f. The Stake Points screen will show the necessary FORWARD / BACK and Go RIGHT / Go LEFT information that the rod man must move in order to be located over the design point. In this example, the Go RIGHT value indicates 0, which means the rod is precisely on the line between the total station and the design point. The BACK value indicates 0.711, which indicates that the rod must move back (away from the total station) 0.711 feet to be over the design point. The Fill value is zero so no dirt needs to be cut or filled at the rod location to match the design elevation.

g. Assuming the rod has been repositioned, take another shot by tapping the Shot button and enter the following new shot data:

Angle Right: **45**
Zenith Angle: **90**
Slope Dist: **70.8** and then tap ✓ to continue.

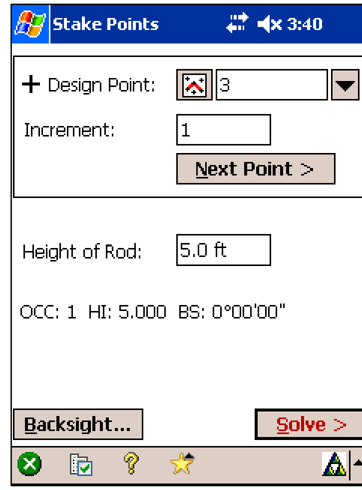


h. The rod must now move FORWARD by 0.089 feet to be over the design point. We will assume that this is close enough and will store the point from this shot by tapping the Store... button.

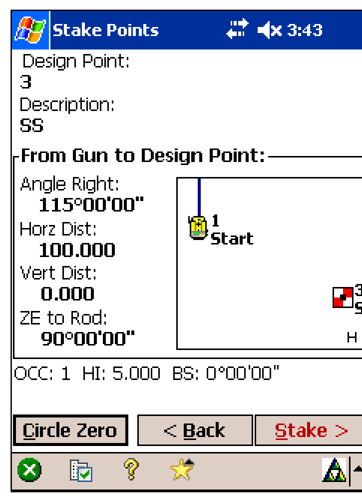
i. Enter the following point information:
Point: 5
Description: Staked and tap ✓. This will return you to the first Point Stake screen.

5. Stake the next design point.

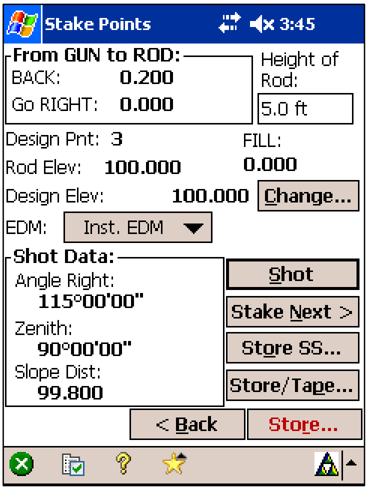
   a. We want to stake the next design point in the project. The Design Point should automatically advance by the Increment value. Make sure the Design Point is set to 3 and then tap **Solve >** to open the second Stake Points screen.



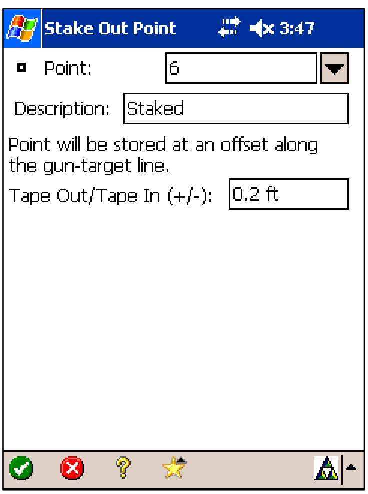
   b. The information needed to locate the next design point is displayed. When connected to a total station, you would turn the total station horizontally to 115°00'00", vertically to 90°00'00" and send the rod man out about 100 feet before continuing. Tap the **Stake >** button to continue to the third screen.



   c. Tap the **Shot** button and enter the following shot data:
      Angle Right: 115
      Zenith: 90
      Slope Dist: 99.8 and then tap (OK) to continue.



d. The rod man needs to move back by 0.2 feet to be over the design point. Rather than take another shot, we will instruct him to use a tape and place a stake at that location. Tap the Store/Tape... button to store the point.



e. Enter the following data in the Store Point (Tape Offset) screen:
Point Name: 6
Description: Staked
Tape Out/Tape In (+/-): 0.2 and then tap . This will result in coordinates for the stored point that are 0.2 feet further from the total station than the last shot to the prism.

Note: Negative Tape Out/Tape In values are toward the total station and positive values are away from the total station.

Point Staking Summary

1. Open a job that contains the design points that you want to stake.
2. Check the job settings.
3. Setup a backsight.
4. Stake the points from the Stake Points screen.

Surveying with True Azimuths

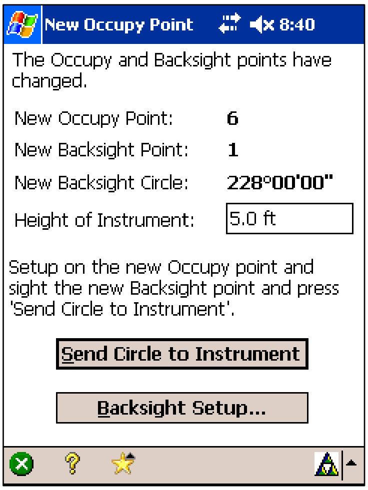
Some people need to collect all of their horizontal angles in the form of azimuths. Survey Pro can help automate this process by computing the backsight azimuth after each new setup in a traverse and updating the backsight circle and total station's horizontal angle accordingly.

1. You can setup on any existing point and use any other point in the job as a backsight if the coordinate system is properly aligned with true north. If not, you can occupy any point as long you have a known azimuth to any reference.
2. In the Surveying Settings screen (Job > Settings > Surveying), confirm that the Survey with True Azimuths checkbox is checked.
3. Set up the total station over the occupy point and aim it toward your backsight.
4. Access the Backsight Setup screen; enter the Occupy Point, and toggle the [BS Direction] / [BS Point] button to [BS Direction].

Note: When backsighting on a point, selecting [BS Direction] can still be used, as described next, making it easier to view the azimuth to the backsight.

5. If backsighting a known azimuth, enter it in the BS Direction field. If backsighting a point, use the shortcut method to enter the azimuth from the occupy point to the backsight point in the BS Direction field. For example, if you are occupying Point 1 and backsighting Point 2, enter 1-2 in the BS Direction field. Once the cursor leaves that field, the computed azimuth will replace what you typed.
6. Tap [Solve]. The Backsight Solved screen will open.
7. If the backsight azimuth is not already in the BS Circle field, enter it.

8. Tap Send Circle. This will set the backsight circle as the horizontal angle in the total station and set the same angle as the Backsight Circle value. This angle will then be subtracted from all horizontal angles received from the total station.



9. Begin your survey. When you traverse to a new point, the New Occupy Point dialog box will open showing you the azimuth computed to the new backsight point from the new occupy point. Once you are set up over the new occupy point, and aiming toward the new backsight point, press the Send Circle to Instrument button to update the Backsight Circle value and the horizontal angle on the total station. Repeat this step after setting up on each new traverse point.

Road Layout

Overview

The Road menu contains a powerful set of routines that allow you to enter and modify road layout information and then stake the road in the field. The road staking routines allow you to stake any part of the road or slope stake the road.

There are four basic components of a road: The Horizontal Alignment; the Vertical Alignment; Templates, and a POB. All of these components are described separately below and each is a required component to a complete road definition.

Horizontal Alignment (HAL)

The horizontal alignment, referred to as the HAL, defines the horizontal features of an alignment. It can contain information on straight, curved, and spiral sections of the alignment. Generally the HAL coincides with the centerline of a road, but it is not required to be the centerline. All stationing for an alignment will come from the HAL.

Vertical Alignment (VAL)

The vertical alignment, referred to as the VAL, defines the vertical components of the alignment including grades and parabolic vertical curves.

The VAL is generated in the same way as the HAL. The VAL can be the same length as the HAL, or longer, but it cannot be shorter.

Templates

Templates contain the cross section information for the road. Templates are stored in separate files with a TP5 extension so they can be used with multiple jobs. The templates are broken down into sections, called segments. Each segment contains a specified length, and slope or change in elevation. Templates can contain as many segments as needed, but must have at least one segment. Each segment describes one component of the cross section such as the roadbed, curb face, top of curb, ditch, etc. Each road alignment can contain as many templates as required to define the roadway, but all the templates used on one side of the road must have the same number of segments.

Templates can be further modified using widenings and super elevations:

Widenings are used to widen or to narrow the first segment of a template. The remaining segments of the template are not affected. This feature is intended to be a way of controlling the width of the first segment, typically the roadbed, without having to create and manage additional template files. Widening definitions basically act as two templates that modify the first segment.

Super elevations are used to bank curves in the direction of a turn. A super elevation accomplishes this by changing the slope of the first segment of a template – the slope of any remaining segments will remain unadjusted.

One super elevation defines a begin station and an end station where the slope change begins and where it finishes the transition for one side of a road. Therefore, to bank a two-lane road, four super elevations would be required – one at the beginning and one at the end of the curve for each side of the road.

A super elevation can either hinge at the outer edge of the first segment, or at the centerline. Hinging at the center results in the elevation of the outer segments to change. Hinging at the edge results in the elevation of the centerline changing. Because of this, Survey Pro will only allow you to hinge on edge for one side of a road. If the other side is also super elevated, you will be forced to hinge that side at the center so that an abrupt change in elevation does not occur at the centerline.

POB

The POB designates the location in the current job where the alignment starts. The POB can be defined by an existing point or specified coordinates and can be changed at any time. The VAL's start station elevation will be set from the POP.

Road Component Rules

The following section defines how the various components described above work together to form the road. This information is important because how each component reacts to the other component affects the shape of the resulting road.

Alignments

1. The alignment must have both HAL and VAL segments.
2. The VAL must be equal to, or longer than the HAL.

Templates

1. For each side of the road
    - All templates on a particular side of the road must have the same number of segments for. The fist template for each side of the road defines this number.
    - The station for the first template for each side must match the starting station of alignment.
    - All template stations must be within the station range for the alignment.
    - All templates must have at least one segment.
    - A template can contain one zero length segment making it effectively a blank template, but the first segment must be greater than 0.

- Template segments must have a name. The template editor provides fields to enter the segment name.

2. Any two templates without intervening Widening or Super Elevations will transition.

   - This means that each template segment will transition at a linear rate from its existing offset from the centerline to the new offset from the centerline as defined by the new template.

3. A template's first segment slope and/or width will be modified when:

   - A template is located within a Super Elevation or Widening definition including starting and ending stations and inside Widening or Super Elevation transition areas.
   - Templates will acquire first segment slope value from the Super Elevation definition, and/or acquire its first segment width value from the Widening definition.

4. Only one template may occupy any station.

   - As little as 0.001 units can be used to separate templates.

Widenings and Super Elevations

1. Super Elevation and Widening stations must be within the station range of the alignment.
2. Super Elevations and Widenings follow the same rules except that the start and end stations of a Super Elevation are defined by:

   - Super Elevations will start their transitions at a point equal to the user defined starting station minus ½ of the starting parabolic transition length if parabolic transitions are used.
   - Super Elevations will start their transitions at a point equal the user defined ending station plus ½ of the ending parabolic transition length if parabolic transitions are used.

3. Super Elevation start slope value and Widening start width value must match the first segment value defined by:

   - A previous Super Elevation or Widening. (Priority)

- A previous Template.

4. Super Elevation ending slope value and Widening ending width value must match the first segment value defined by:
    - A following Super Elevation or Widening. (Priority)
    - A following Template.
    - Exception: if the Widening or Super Elevation is the last element in the road, it’s end transition value does not have to match anything.
5. Super Elevation and Widening ending stations must be greater than their beginning stations.
6. Widenings cannot adjust the first segment horizontal distance to or from 0.
7. Super Elevations and a Widenings may overlap, are independent, and do not affect each other.
8. Super Elevations may not overlap other Super Elevations.
    - A Super Elevation’s ending station may be equal to a following Super Elevation’s beginning station.
    - A Super Elevation’s beginning station may be equal to a previous Super Elevation’s ending station.
9. Widenings may not overlap Widenings.
    - A Widenings ending station may be equal to a following Widening’s beginning station.
    - A Widening’s beginning station may be equal to a previous Widening’s ending station.
10. Super Elevations may hinge on edge.
    - Hinge on edge can only be used for one side of the road for any given Super Elevation station range.
    - If hinge on edge is used for one side of the road, Super Elevations must hinge from center on the opposite side of the road over the same station range.
    - Hinge on edge will modify the elevation of the Center Line.

Road Rules Examples

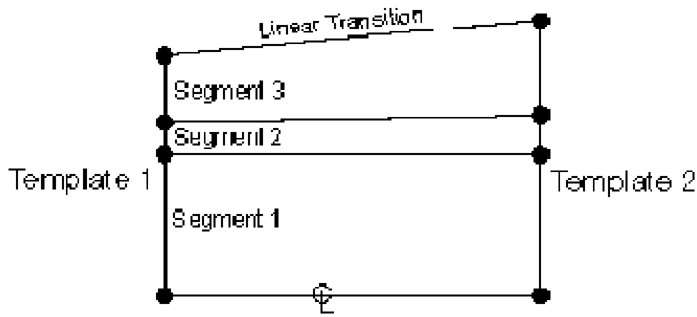


Figure 1 Overhead view of a template-to-template linear transition

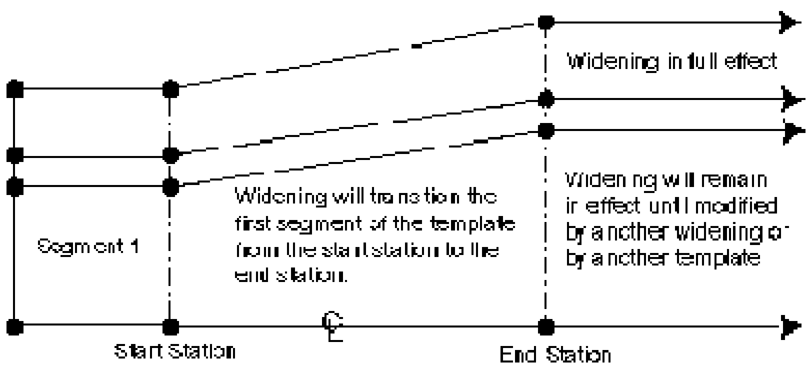


Figure 2 Template to Widening Transition

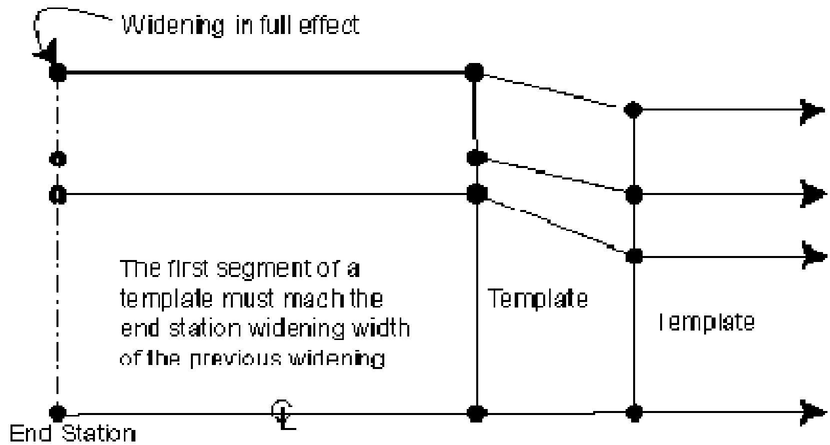


Figure 3 Widening to Template Transition

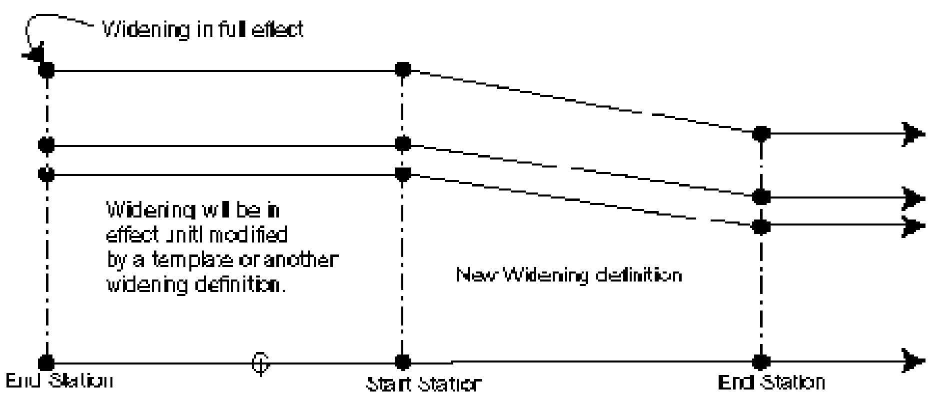


Figure 4 Widening to Widening Transition

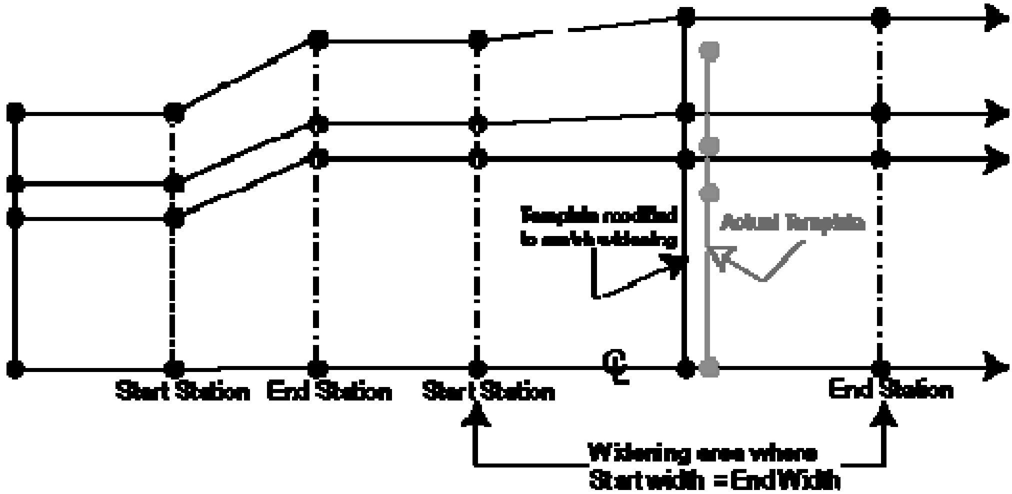


Figure 5 Template Inserted Into A Widening Area

Figure Descriptions

Figure 1 shows an overhead view of a simple transition from one template to another. Notice the linear transition of one template segment end node to the next.

Figure 2 shows an overhead view of a basic template to widening transition. The widening’s first segment width for the start station must match the first segment width of the previous template.

Figure 3 shows a transition from a widening to a template. This example shows that a widening basically defines a new template that has a modified first segment. The modified template (widening) will transition to the next template down the road.

Figure 4 shows the same concept as Figure 3 except another widening is used instead of a template.

Figure 5 depicts how a template can be inserted inside a widening definition. The widening will take precedence over the first segment so the first segment will maintain the length as defined in the widening definition. However, the segments outside of the first segment now take on the shape of the inserted template. The figure shows a widening where the start width is the same as the end width but having the widening use the same start and end width is not required. The first segment of the template will be adjusted to match whatever the widening says the width of the first segment should be at the station where the template is inserted.

Also notice in Figure 5 that we have defined a widening with the start width the same as the end width. This can be a handy tool to use if you need to widen the road for a relatively long distance but also need to change the template segments outside the first segment. Using a widening as shown enables you to use any template to modify the outside segments while retaining the same roadbed (first segment) width.

Super Elevations

The examples above show how widenings interact with templates. Super elevations work with templates in the same way, except instead of the width of the first segment being modified, the cross slope for the first segment is modified.

Creating Templates

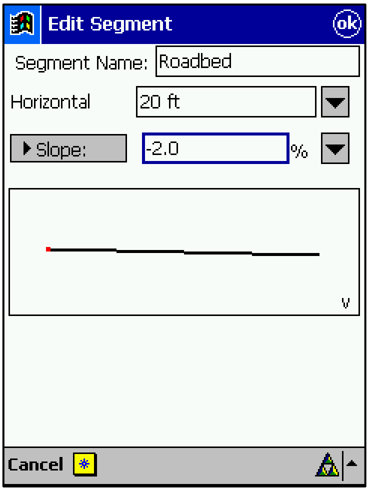
The information for a single template is stored in a separate file with a TP5 extension. Template names are limited to eight characters plus the extension so that they can be used in DOS-based data collectors. Each template stores information on the cross section for one side of the road.

A road can have as many templates as necessary, but each side of the road must only use templates with the same number of segments. Once the first template is selected, Survey Pro will only let you select from additional templates that have the same number of segments as the first template.

A template can be used on either side of the road. They are not right or left specific. A road could contain only one template, which would be used for both the right and left sides, but can also contain as many templates as necessary.

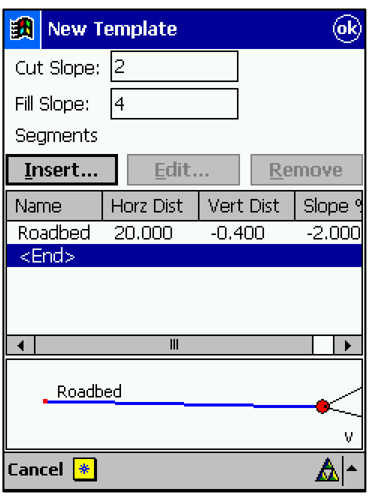
In this example, we will create a single template that contains a roadbed, a curb, and a ditch. Each segment will be defined in order, starting from the centerline and working toward the edge.

1. Tap [Roads], [Edit Templates] to open the Add/Edit Templates screen.
2. Tap [New...] to open the New Template screen. The Cut Slope and Fill Slope values are the slopes to compute the location of catch points with the Road Slope Staking routine. These values can also be easily changed from that routine. Enter a Cut Slope of **2** and a Fill Slope of **4**.



3. Tap Insert... . This will open the Edit Segment dialog box. Enter the following information to define the first segment, which will be a 20-foot wide roadbed with a –2% slope.

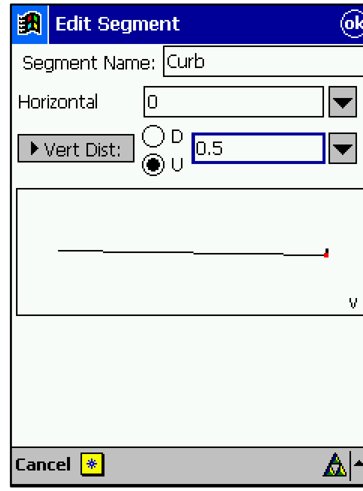
   Segment Name: **Roadbed**
   Horizontal Dist: **20**
   Slope: **-2**



4. Tap ✓ to return to the New Template screen where the new roadbed segment will appear in a list of segments. At this point, only the roadbed and <End> will be displayed in the list. Whenever a new template it inserted, it is inserted above the template that is selected in this list. Therefore, to add a new segment after the last segment, <End> should be selected prior to tapping Insert... .

5. With <End> selected, tap Insert... and enter the following data to add a new segment that will describe the face of a curb. Notice for the last field, you need to toggle the ▸ Slope button to ▸ V. Offset and select the ⦿U radio button to specify that the curb extends upward.

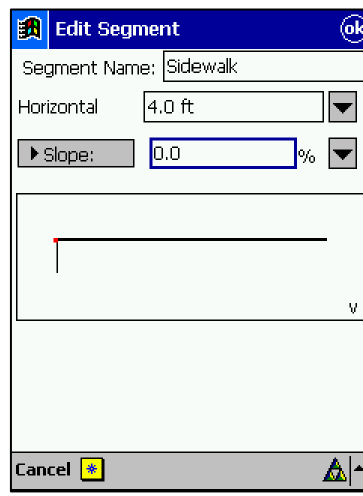
   Segment Name: **Curb**
   Horizontal Dist: **0**
   Vert Dist: ⦿**U 0.5**



6. Tap ✔ to return to the New Template screen where the new curb segment will appear.

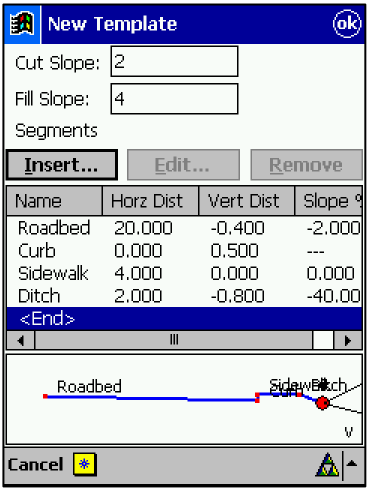
7. With <End> selected, tap Insert... and enter the following data to add a sidewalk and then tap ✔.

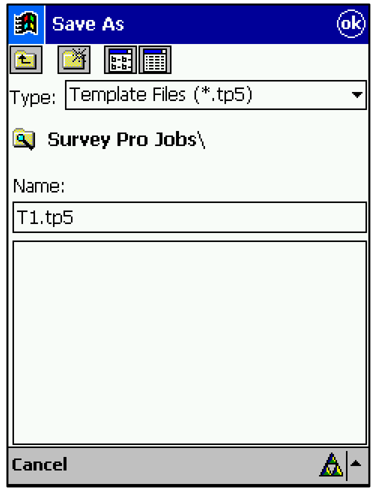
   Segment Name: **Sidewalk**
   Horizontal Dist: **4**
   Slope: **0**



8. With <End> selected, tap Insert... and enter the following data to add a ditch and then tap ✔.

   Segment Name: **Ditch**
   Horizontal Dist: **2**
   Slope: **-40**





9. Tap from the New Template screen and the Save As dialog box will open. Enter **T1** in the Name field and tap . This completes the creation of a template.

Building an Alignment

The Edit Alignments routine is used to create an alignment and is explained in detail starting on Page 50. If you do not currently have an alignment stored in Data Collector, either create a simple alignment now that is at least 300 feet long, or follow the instructions that start on Page 50 to create a new alignment that contains an example of each possible horizontal or vertical section.

Putting the Road Together

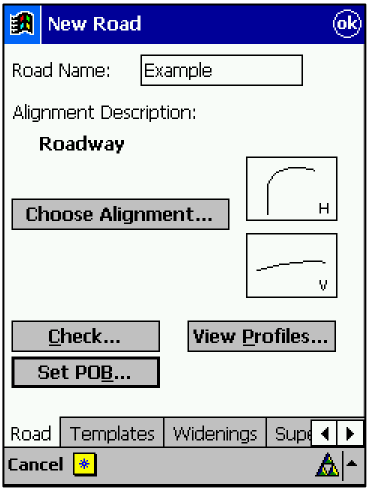
The final step in creating a road that can be point staked or slope staked is to use the Add/Edit Roads routine to combine the template(s) with the alignment and define any widenings and super elevations.

In this example, we will use only one template for the entire road. We will use a widening to add a second lane to the right side of the road and we will add four super elevation definitions to bank the left and right side of a curve.

Add Templates to the Alignment

1. Tap Roads, Edit Roads from the Main Menu to open the Add/Edit Roads screen.

2. Since we are creating a new road, tap New... to open the New Road screen.



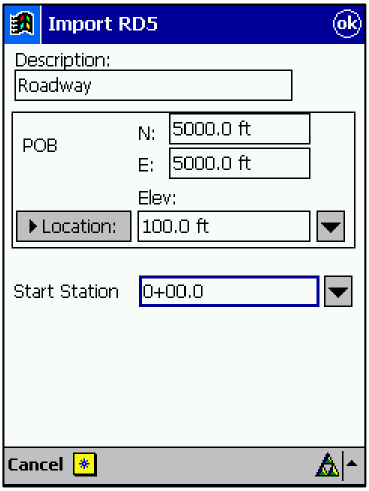
3. With the Road tab selected, enter a name for the road in the Road Name field. In this example, we used **Example**.

4. Tap the Choose Alignment... button and select an alignment. In this example, we selected the Roadway alignment created on Page 50. Tap to continue.

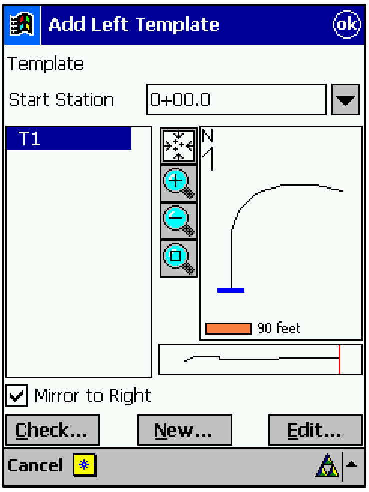
5. Tap the Set POB... to open the Road Alignment Properties screen to define where the road begins in the job.

6. Enter the following data then tap :

   North: **5000**
   East: **5000**
   Elev: **100**
   Start Station: **0+00**



7. The next step is to add the templates. We will use the template created earlier to define both sides of the road. Tap the Templates tab.

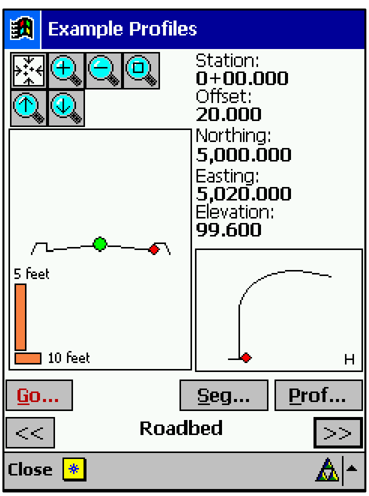


8. With <End> selected in the **L**eft column, tap the Add... button. This opens the Add Left Template screen, which allows you to add a template to the left side of the road.

9. All the available templates will be displayed in the Template column. Select the T1 template, created earlier.

10. Since we will use this template for both sides of the road, check the ☑ Mirror to Right checkbox and tap to return to the New Road screen. We now have the minimum number of components to completely define a road: an alignment, and a left and right template.

11. Tap Check... to confirm that the road is okay. You should get a message stating success.

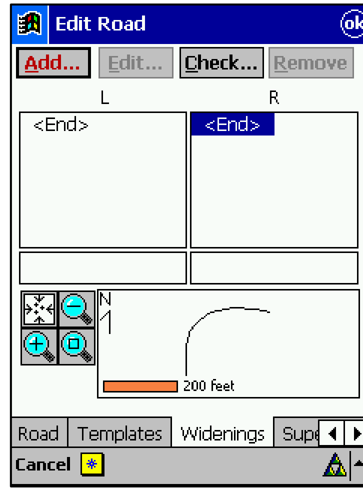


Note: Once templates have been added, you can return to the Road card and tap the View Profiles... button to view the cross-sectional profile of the road at any station.

Add Widenings

12. Tap the Widenings tab. We will define a widening where a new lane will begin in the right side of the road.

13. Tap <End> in the **R**ight column and then tap the Add... button. This opens the Add Right Widening screen, which allows you to add a widening to the right side of the road

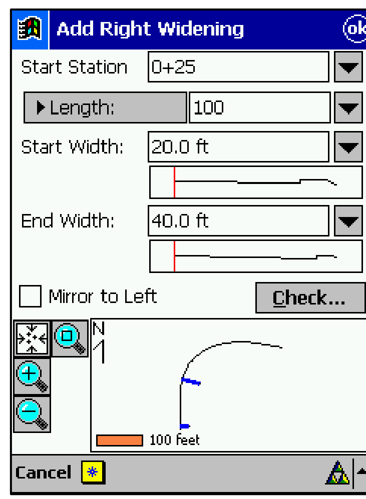


14. In the Start Station field, enter 0+25. This is where the widening will begin.

15. The length of the widening is 100 feet so toggle the ▸ End Station button to ▸ Length and enter **100**.

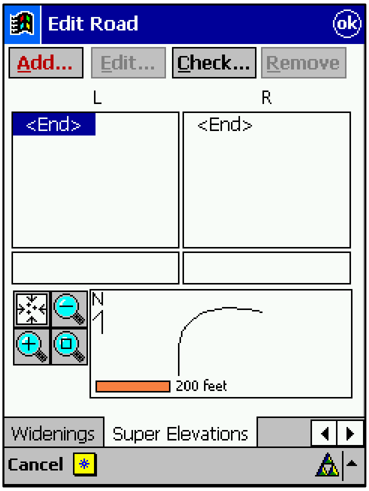
16. The starting width of a widening must equal the width of the first segment of the template that leads into the widening, or if a previous widening leads into it, it must equal the width of the previous widening. Leave the Starting Width field set to its default value of 20.

17. Since we are adding a lane with this widening, enter **40** in the Ending Width field. This widening will now begin at 0+25 and over a 100-foot span; the first segment of the template will increase in width from 20 feet to 40 feet. Bold lines in the map view illustrate the beginning and ending widths of the widening.



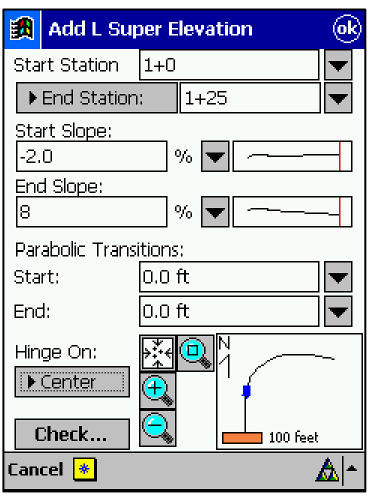
18. Tap ✔ to continue.

Add Super Elevations



19. Tap the Super Elevations tab where we will insert a super elevation at the beginning and end of a curve for the left and right sides of the road.

20. With <End> selected in the **L**eft column, tap the Add... button. This opens the Add Left Super Elevation screen, which allows you to add a super elevation to the left side of the road.



21. We will start the super elevation 100 feet from the beginning of the road so enter **1+00** in the Start Station field.

22. The super elevation will be at the final slope after 25 feet so enter **1+25** in the ▸ End Station field.

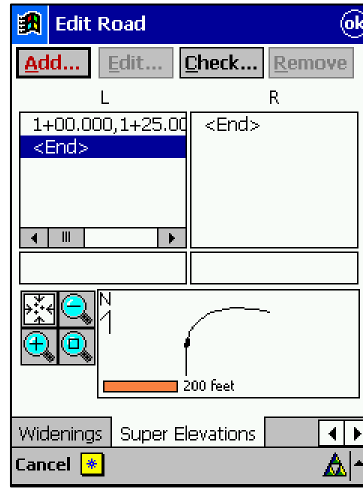
23. The start slope must be the same as the slope of the first segment of the template that leads into the super elevation, so leave the Start Slope field set to -2.

24. We want the ending slope to be 8% so in the End Slope field, enter **8** for simplicity, we will not use parabolic transitions so leave those fields set to 0.

25. Most super elevations hinge at center so be sure the Hinge on field is toggled to ▸ Center and then tap ✔ to continue. This will complete the super elevation for the beginning of the curve on the left side of the road.

26. We now need to add a super elevation at the end of the curve on the left side of the road to change the slope back to -2%.

27. With <End> selected in the **L**eft column, tap the Add... button again.

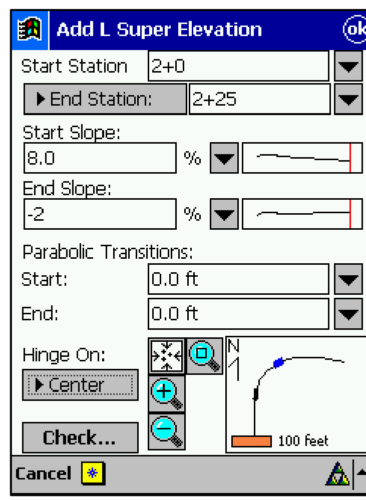


28. From the Add Left Super Elevation screen we will start the transition out of the super elevation, 200 feet from the beginning of the road so enter **2+00** in the Start Station field.

29. The super elevation will return to the original slope after 25 feet so enter **2+25** in the ▸ End Station field.

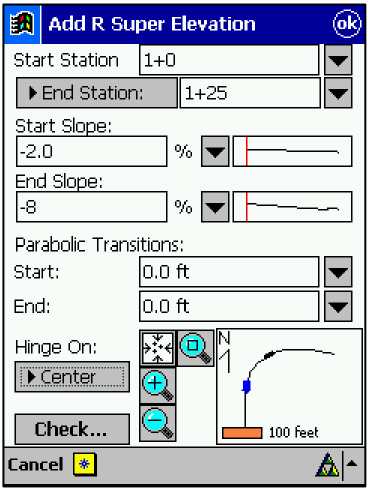
30. The start slope must be the same as the slope of the road where it leads into the super elevation, so leave the Slope 1 field set to 8.

31. We want the ending slope to be -2% so in the Slope 2 field, enter **-2**. Leave the parabolic transition fields set to 0.



32. Be sure the Hinge on field is toggled to ▸ Center and then tap to continue. This will complete the super elevation entries for the left side of the road.

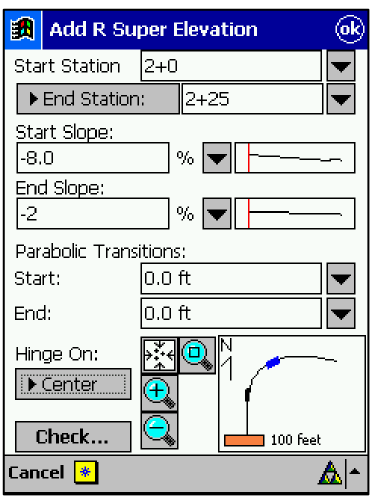
33. We now need to repeat the above steps for the right side of the road. Tap <End> in the **R**ight column to select that side of the road and then tap the Add... button to open the Add Right Super Elevation screen.



34. Enter the following data just as you did for the left side of the road and then tap .

Start Station: **1+0**
End Station: **1+25**
Start Slope: **-2**
End Slope: **-8** (notice this is a negative value)
Parabolic Transition Start: **0.0**
Parabolic Transition End: **0.0**
Hinge on: Center

35. With <End> selected in the **R**ight column, tap the Add... button again to add the final super elevation.



36. Enter the following data to describe the second super elevation on the right side of the road and then tap .

Start Station: **2+0**
End Station: **2+25**
Start Slope: **-8**
End Slope: **-2**
Parabolic Transition Start: **0.0**
Parabolic Transition End: **0.0**
Hinge on: Center

37. This completes the definition for an entire road including templates, widenings and super elevations. To make sure there are no errors, tap Check.... You should get a message stating success.

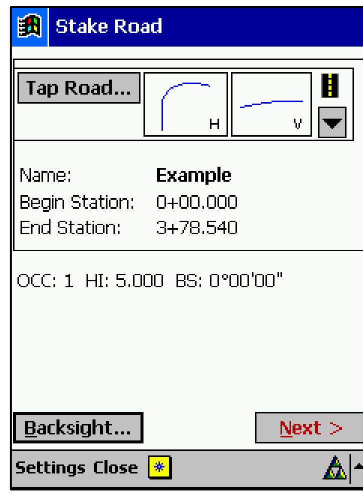
38. Tap to save the road.

You are now ready to stake the road in the field. Close any open windows to return to the Main Menu.

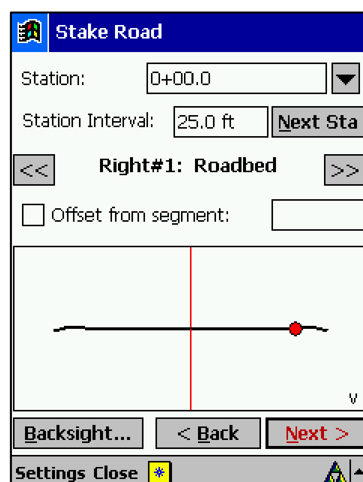
Staking the Road

With your road fully designed, you are now ready to stake the road. Staking a road is a simple and intuitive process. If you are familiar with point staking, you should be able to easily stake a road.

This section explains how to get started using the Stake Road routine and then refers you to the point staking example when the screens become identical.

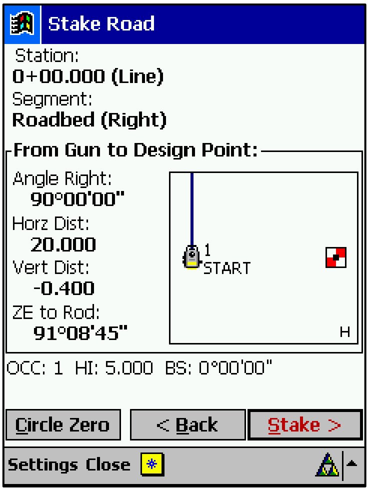


1. Tap Roads, Road Stakeout from the Main Menu to open the Stake Road screen.
2. Tap the Tap Road... button to open the Tap on a Road screen. All of the roads that exist in the current job will be displayed.
3. Tap on the road that you want to stake and then tap ✓. When the road is selected, it will be drawn with a bold line.
4. If the backsight is not yet defined, tap the Backsight... button to set up your backsight.
5. With the road selected and the backsight set up, tap Next > to continue. The next screen that opens shows the profile of the road at the starting station.
6. In the Station field, enter the station that you want to stake and in the Station Interval field, enter the distance that you want the Station to advance when you are ready to stake the next station.
7. Use the << and >> buttons to select the node (the segment end point) on the template shown in the graphic area of the screen that you want to stake. Each press of either of these buttons will advance the selection to the next node and display the name of the selected segment in the middle of the screen. The selected node is shown in the graphic portion of the screen as a red circle.
8. You can optionally stake an offset to the selected node by entering the offset distance in the Offset

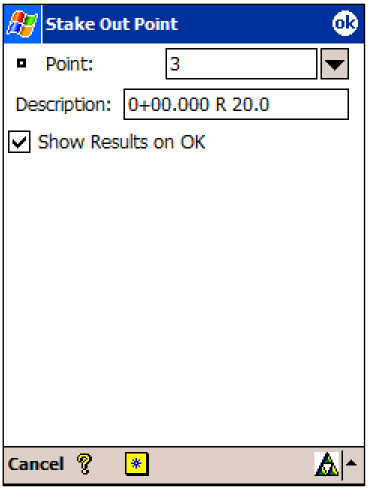


from segment field. (A positive offset value extends away from the centerline.)

9. Once the correct station to stake is entered and the desired node is selected, tap the Next > button to continue.



10. The next screen that opens is identical to the screens used in point staking, since that is essentially what is occurring at this point. If you are not familiar with Point Staking, refer to Page 75.



11. Once you are satisfied with the rod location, tap Store... and the prompt shown here will open where the new point number and description can be entered. Tap ✓ to store the stake point. If the Show Results on OK checkbox is checked, tapping ✓ will store the point and display detailed cut/fill results to other nodes, which can then be written on the stake.

Note: If the Write Cut Sheet Data Only (No Store Point) checkbox is checked in the Stakeout Settings screen, this prompt will not appear, although the Results screen will still appear if the Show Results on OK checkbox was never un-checked from this prompt. (It is checked by default.)

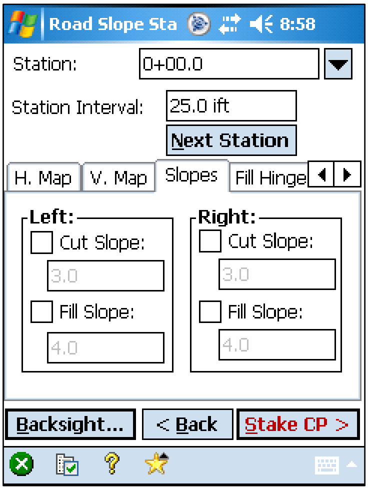
12. Once the point is staked and stored, you will return to the screen described above where a new node can be selected and staked or the station to stake can be advanced by the station interval by tapping the Next Sta button.

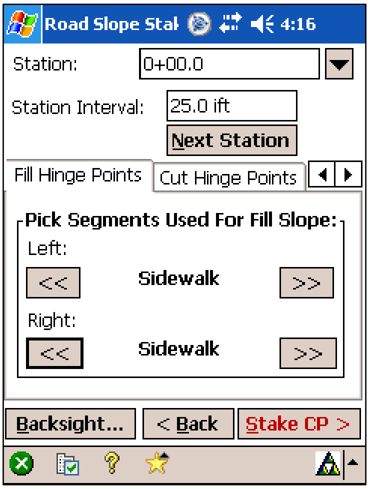
Slope Staking the Road

The road slope staking procedure is nearly identical to the non-road layout slope staking routine described on Page 164. The main difference is the road layout templates can contain more segments, which modifies the options of where the hinge point should be located depending on if a cut or a fill is required.

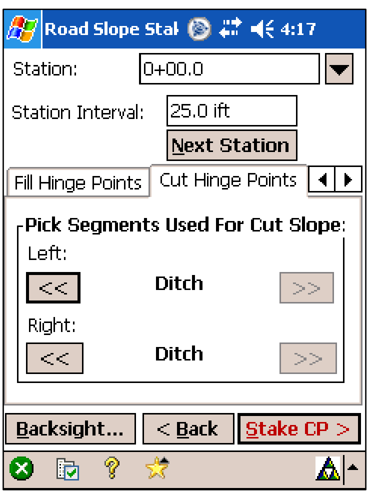
1. Tap Roads, Slope Staking to open the Road Slope Staking screen.
2. Tap the Tap Road... button to open the Tap on a Road screen. All of the roads that exist in the current job will be displayed.
3. Tap on the road that you want to stake and then tap ✓. When the road is selected, it will be drawn with a bold line.
4. If the backsight is not yet defined, tap the Backsight... button to set up your backsight.
5. With the road selected, tap Next > to continue.
6. In the Station field, enter the station that you want to slope stake and in the Station Interval field, enter the distance that you want the Station to advance when you are ready to slope stake the next station.
7. The H. Map and V. Map tabs are used to view information about the horizontal and vertical details of the road at the current station. Tap the Slopes tab to set up your slopes.
8. The Cut Slopes and Fill Slopes are automatically set to the values contained in the template being slope staked. You can override these values by checking the appropriate boxes and changing the values accordingly. When doing this, the new cut/fill slopes entered will always be used regardless of the values stored in the templates.

   Fill slopes do not need to be entered as negative values since Survey Pro knows that these are negative slopes.





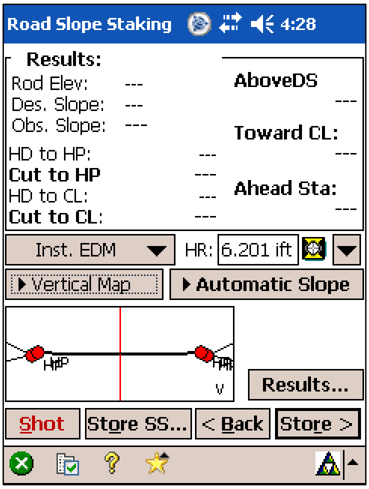
9. Tap the Fill Hinge Points tab to define where the hinge point will be computed in areas that require a fill. Use the << and >> buttons to select the desired segment. (The hinge point will be computed at the end of the selected segment.)



10. Now tap the Cut Hinge Points tab and define where the hinge point will be computed in areas that require a cut in the same way as you did in the previous step.

11. Tap the Stake CP > button to continue to the next screen where the catch points at the current station can be located. This screen is identical to the screens used in the non-road layout slope staking routine. If you are not familiar with these screens, refer to Page 171.

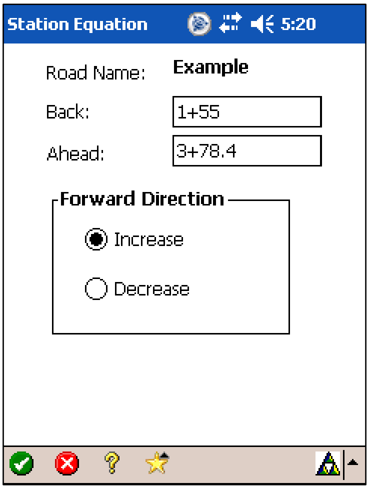
12. Once the catch point is staked and stored, you will return to the screen described above where the station to stake can be advanced by the station interval by tapping the Next Sta button and the process can be repeated to stake the next catch points.



Station Equation

Some alignments will have a specific location where the stationing changes. One example of when this might occur is where the alignment you want to stake merges with another alignment and at the location where they merge, you want to switch to the stationing used from the other alignment.

The Station Equation screen is used to define the location on the alignment where the original stationing, or the Back stationing changes as well as what the new stationing will be from that point forward, or the Ahead stationing.



In most situations, the ahead stationing will increase as you advance down the road, but you might also have a situation where the ahead stationing decreases as you advance forward. The Forward Direction section of the screen allows you to configure the station equation either way.

When staking a road that uses a station equation, all ahead stations are shown with a (2) after it to differentiate them from the back stations, such as 11+00 (2). Likewise, when keying in an ahead station, you must append it with a (2), otherwise it will be interpreted as a back station.

Two of the stakeout settings should be considered when using a station equation:

- When Stake "Corners", Not Just Even Intervals is checked, the location where the stationing changes will be considered a corner and will be included as you advance forward.
- When Use Perfect Stationing is checked, the perfect stationing will always be computed using whichever stationing that you are currently staking.

Station equations can only be used when staking a road, so the following three routines available from the Roads menu include the option to use a station equation. (Non-road layout stakeout routines cannot use a station equation.)

- Stakeout
- Slope Staking
- Show Station and Offset

DTM Stakeout

The Stake DTM routine allows you to stake an area and get cut/fill information between the point being staked and a reference DTM surface at the same horizontal coordinates. You can also obtain volume information between the surface being staked and a specified reference elevation or the reference DTM surface.

Reference DTM Surface

DTM Stakeout requires a DTM surface that defines the reference elevations for the area that you plan to stake. There are three ways to define the reference surface:

- A DXF file that contains a triangulated irregular network (TIN).
- A digital terrain model (DTM) file.
- A separate layer in the current job containing several points on the reference surface.

Survey Pro will use any of these three methods to compute the elevation information at any location within the boundaries of the reference DTM surface.

TDS ForeSight can be used to create a DXF file containing the correct information from a JOB file. ForeSight provides several options when exporting a DXF file and all the options will include the required 3D Face, or TIN information.

Both TDS ForeSight and Survey Link will export a DTM file from a DXF file.

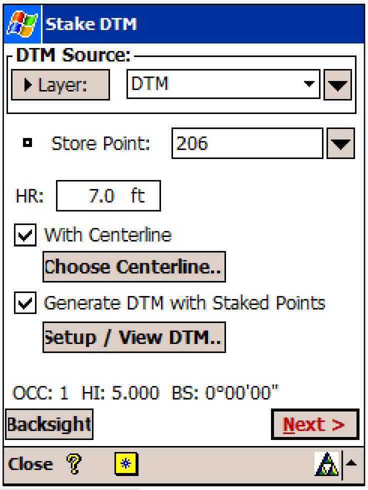
Note: The speed performance of the Stake DTM routine is enhanced when using a DTM file as opposed to a DXF file.

Set Up the Job

1. If your reference layer is defined by a DXF or DTM file, it must first be loaded into the data collector.

2. From the Main Menu, tap Stakeout, Stake DTM to open the Stake DTM screen.

3. In the DTM Source field, select if your DTM reference surface will be defined by a ▸ Layer or ▸ File and then select the layer or tap the ▾ power button, then Browse and select the appropriate DTM or DXF file.

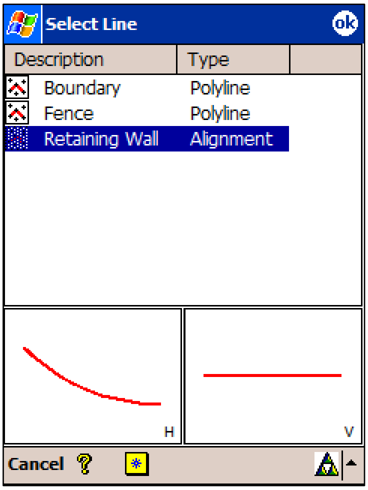


Warning: If importing a DXF or DTM file where the distance units in the source file are different than the distance units for the current job, the imported coordinates will be converted to the current job's distance units when they are imported. This is normally the desired result, but it can cause a problem if the distance units for the imported data or the current job were set incorrectly. This situation can most commonly occur when working with International Feet and US Survey Feet, where the conversion from one to the other is not always obvious.

Usually the difference between International Feet and US Survey Feet is negligible (2 parts per million), but when dealing with State Plane or UTM mapping plane coordinates, which are often very large in magnitude, the difference can be substantial if the coordinates are converted from one format to the other.

If importing coordinates from a source where you are not sure if the units are in International Feet or US Survey Feet into a job that is set to International Feet or US Survey Feet, you will usually just want to import them without any conversion being performed. To do this, be sure to select the same distance units for the source file as those set for the current job.

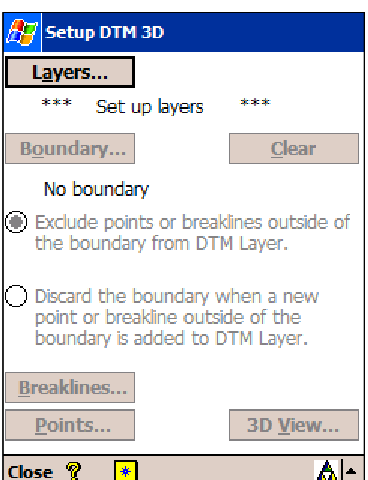
4. The name entered in the Store Point field will be used for the first point that is stored. Future points will be stored with the next available point names. Enter the rod height in the HR field.



5. You have the option of selecting a centerline to get offset and stationing information for the staked points. Checking the With C.L. checkbox and then tapping the Choose Centerline button will open the Select Line screen where you can select an existing polyline or alignment that defines a centerline. The selected line will also be displayed graphically in the DTM Shot screen, described later.

6. When the Generate DTM with Staked Points checkbox is checked, a DTM surface will be generated from the points stored on the selected DTM layer (not the reference DTM layer optionally chosen in the first screen). Any points staked and stored will also be added to this layer and the DTM will be updated accordingly.

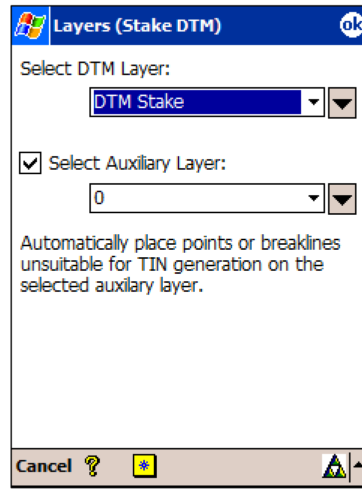
Selecting the Generate DTM with Staked Points option also allows you to view this surface from the 3D View screen while taking shots and it allows you to get live cut / fill and volume information between this surface and the reference DTM surface selected in the first screen. If unchecked, the 3D View is unavailable; no volumes will be computed; and cut / fill information is not displayed, but is still stored to the raw data file.



When you first check the Generate DTM with Staked Points box, you must also tap the Setup / View DTM... button. This will open the Setup DTM 3D screen, which is used to select your layers, and optionally select any break lines, and a boundary.

Select Your Layers

7. Tap Layers... from the Setup DTM 3D screen to open the Layers (Stake DTM) screen.



   a. Select the layer that you want to use for the stake points and other objects that exist on the surface you are staking. These points will be used to generate a DTM surface to compare to the reference DTM surface.

   b. Check the Select Auxiliary Layer checkbox to automatically store any points or break lines to the layer selected from the corresponding dropdown list that cannot be used for DTM generation. Examples of invalid objects would include a polyline that extends outside a boundary, or a point with identical coordinates to another point, but with a different elevation. Leaving this box unchecked will result in a prompt to select a layer prior to storing an invalid object.

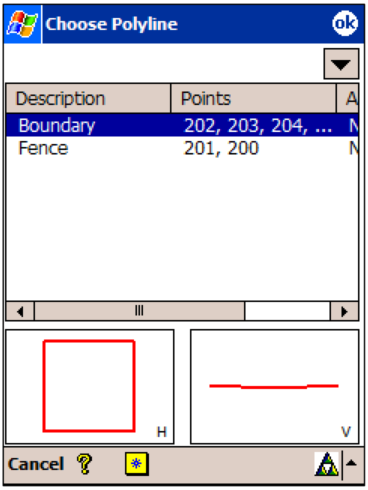
   c. Tap ✓ when finished to return to the Setup DTM 3D screen.

Select a Boundary (optional)

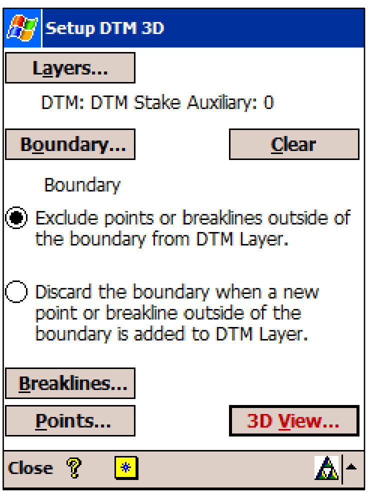
You can optionally define a boundary using a closed polyline for the points that are staked, which will limit the computation of the DTM surface within the selected boundary.

A valid polyline must be closed, and the line must not cross over itself, such as in a figure-eight.

8. To select a boundary, tap the Boundary... button, which will open the Choose Polyline screen.



a. All the polylines in the current job are displayed. Select the appropriate polyline and tap to return to the Setup DTM 3D screen.



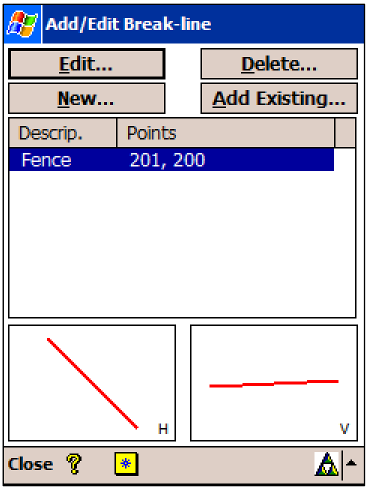
9. If a boundary is used, you must also select one of the two radio buttons in the Setup DTM 3D screen:

⦿ **Exclude points...**: will move any objects that occur outside the selected boundary to the Auxiliary layer.

⦿ **Discard the boundary...**: will initially move any points that exist outside the boundary to the Auxiliary layer. If a point is later stored outside the boundary, the selected boundary is automatically unselected.

Select any Break Lines (optional)

Break lines are polylines that define any linear object on the surface you are staking such as a trench, a fence, or the face of a cliff. No TIN will pass through a break line when generating the DTM surface. If a boundary is selected, the entire break line must fall inside the boundary. If any part of a break line touches the boundary, the break line is invalid.



10. To select a break line, tap the Breaklines... button to open the Add/Edit Break lines screen. If any break lines have already been selected, they will be listed here.

    a. To add an existing break line, tap the Add Existing... button. This will display all the polylines in the current job. Select the desired polyline and tap ✔. This will move the selected polyline to the (non-reference) DTM layer.

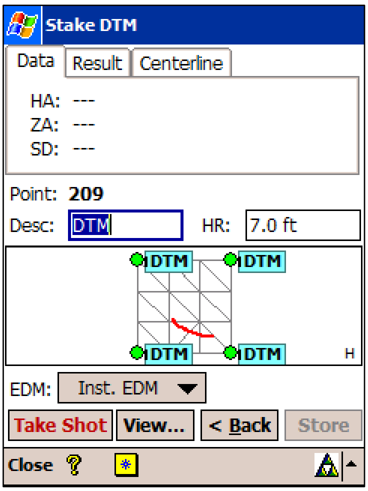
    b. When finished adding break lines, tap ✖ (Close) to return to the Setup DTM 3D screen.

11. When you return to the Setup DTM 3D screen, the Points... button will open the Points on DTM Layer screen where the points on the DTM layer can be viewed, new points can be imported, and existing points can be deleted (moved to the Auxiliary layer). The 3D View... button will open the 3D View screen where the DTM surface for the points on the DTM layer can be viewed from any angle.

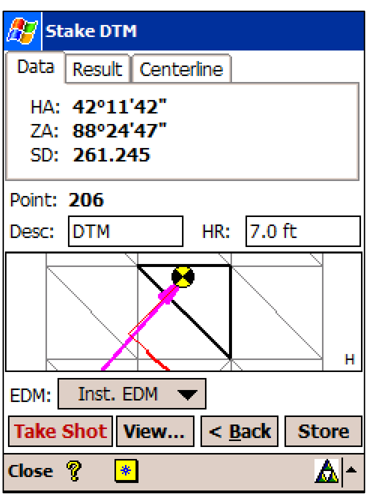
12. This completes the Stake DTM set up procedure and you are now ready to stake points. Tap ✖ (Close) from the Setup DTM 3D screen to return to the Stake DTM screen.

Stake the DTM

13. With the information correctly entered in the Stake DTM screen, tap Next > to continue.

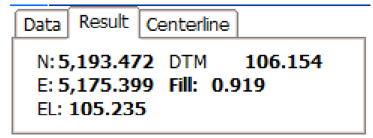


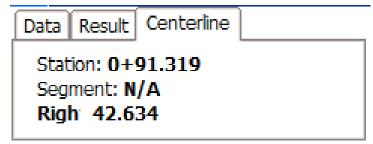
14. The second Stake DTM screen will open with a graphic that shows the reference DTM, the centerline, if used, and any break lines. Tap the Take Shot... button to take a shot.



15. If a shot is taken when the prism is located within the boundaries of the reference DTM and within the polyline boundary (if selected earlier), the graphic will change and the Data, Result , and Centerline (if one was selected) cards will be filled in. The graphic will show the current triangle in the reference DTM surface where the rod is located and a centerline and offset, if selected earlier.

16. At anytime, you can view the current (non-reference) DTM surface computed from the points staked so far by tapping the View... button.

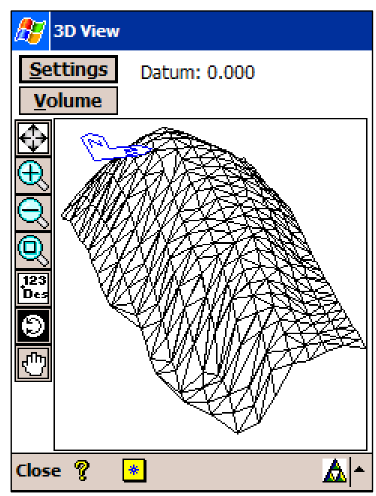




The Store button will store the last point shot. The Result card displays additional information about the last stake point and the Centerline card displays information related to the last stake point in relation to the centerline, if selected earlier.

View the DTM

17. Tap View... to access the 3D View screen. While staking points, you should periodically tap this button to view what the current DTM surface looks like. This is a useful quality assurance technique to determine where additional points are needed.



Note: The View... button is only available when Generate DTM with Staked Points is checked in the first Stake DTM screen and at least three points are stored on the non-reference DTM layer.

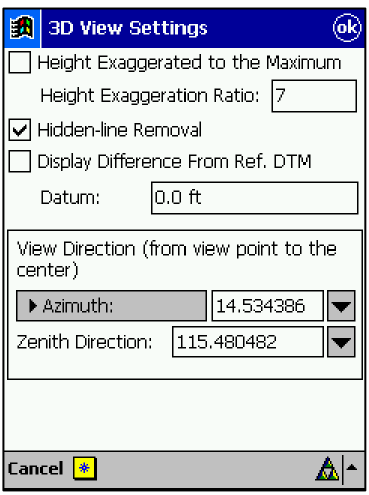
When the button is activated (darkened), dragging within the 3D View will result in the image being rotated to any angle. When the button is activated, dragging within the 3D View will pan the image.

The Volume button will display the total cut/fill volume difference between the DTM surface being staked and a reference elevation specified in the 3D View Settings screen, described next.

Note: The cut/fill values accessed from the Volume button are total volume differences between the DTM surface being staked and either the reference DTM surface, or a reference elevation (plane). The cut/fill values displayed in the Result card of the second Stake DTM screen are vertical distances between the current stake point and the reference DTM surface at the same horizontal coordinates.

The button toggles to display or hide the point names and descriptions in the 3D view.

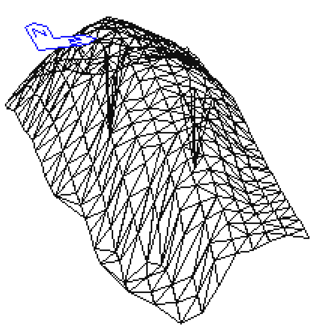
Datum: displays the datum elevation set in the 3D View Settings screen.



18. Tap the Settings button to access the 3D View Settings screen to configure the information displayed in the 3D View screen.

When **Height Exaggerated to the Maximum** is checked, the height exaggeration is automatically set to a high value to more clearly display elevation differences in the 3D view. When unchecked, the height exaggeration can be set manually in the next field.

Height Exaggeration Ratio: is the value that the height is multiplied by in the 3D view. Higher values mean more exaggeration; a value of 1.0 would result in no exaggeration.



When Hidden-line Removal is checked, all the lines that occur behind other surfaces in the 3D View screen will be hidden. The image shown here is identical to the image shown in the screen above except the hidden lines are not removed.

When Display Difference from Ref. DTM is checked, the vertical portion (z-axis) of the 3D View screen is computed by the elevation differences between the non-reference DTM surface and the reference DTM surface. This will result in any objects that occur above or below the reference DTM to clearly stand out as hills and valleys and the volume information provided in the 3D View screen will be between the staked points and the reference DTM.

When the Display Difference from Ref. DTM checkbox is unchecked, the Datum field can be set to a reference elevation. Cut and fill volumes in the 3D View screen will then be based on the difference of a horizontal plane at the elevation specified here and the non-reference DTM surface.

The View Direction (from view point to the center) settings allow you to specify the exact horizontal and vertical angle in which to view the DTM surface.

19. Tap ✔ from the 3D View Setting screen to return to the 3D View screen.
20. Tap ✖ (Close) from the 3D View screen to return to the DTM Shot screen. From there you can continue taking DTM stake shots.

Mapping Plane Scale Factor

When converting distances on a map to distances on the ground, you must correct for two different scale distortions. First, the effects of the map projection distortion must be corrected with the mapping plane scale factor. Second, the geometric effect of your height above the reference surface (ellipsoid height) must be corrected with the ellipsoid scale factor. Generally, these two scale factors are multiplied together into the combined scale factor. Although the scale factor is computed with differential equations of the map projection, one can visualize it in a geometric sense. Consider the following diagrams:

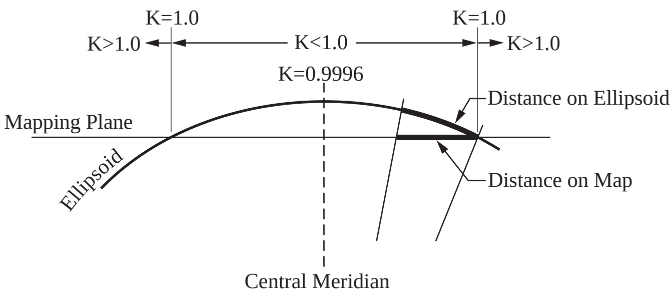


Fig. 3: Transverse Mercator Mapping Plane

A side view of the cylinder shows the effect of scale distortion.

Universal Transverse Mercator Projection

The scale factor at the central meridian (CM) is 0.9996. The scale factor is 1.0 approximately 170-km east and west of the CM. The scale factor is less than one between the CM and the point of tangency. The scale factor is greater than one beyond the point of tangency. Therefore, at the central meridian, a geodetic distance of 100m scales into a mapping plane distance of 99.96m.

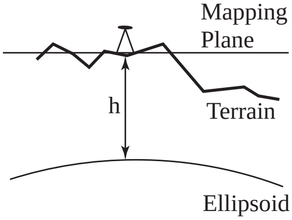


Fig. 4: Localization Stereographic Mapping Plane

A side view of the ellipsoid and stereographic mapping plane show the scale calculated for ground distances at the base height.

Ellipsoid Scale Factor

This scale factor accounts for the height of the ground above the reference surface (the ellipsoid). This scale factor is defined geometrically: Consider the following diagram:

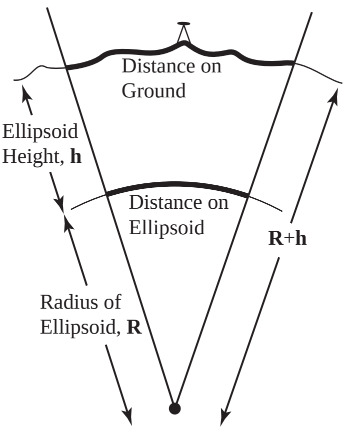


Fig. 5: Ellipsoid Scale Factor
The effect of height above the ellipsoid on scale.

$$dist_{ground}/(R+h) = dist_{elip}/R$$

$$dist_{elip}/dist_{ground} = R/(R+h)$$

$$k_{elip} = R/(R+h)$$

In most situations, the ellipsoid scale factor can be calculated at a single reference elevation and used for the entire survey, but on surveys where the elevation varies by more than 100 meters, you may also want to apply a sea level correction. A sea level correction works by computing a new ellipsoid height for each shot from the average elevation of the total station and the target.

Combined Scale Factor

Generally, the two scale factors are multiplied together into a combined scale factor. The combined scale factor is then applied to grid distances to get ground distances:

$$k_{cf} = k_{elip} * k_{map}$$

$$dist_{grid} = dist_{ground} * k_{cf}$$

Survey Pro allows you to scale the measurements you take on the ground so they properly align with the map grid you are using. This is set up using the Scale Factor wizard.

The mapping plane scale factor should not be confused with the Adjust for Earth Curvature/Refraction setting located on the Job > Settings > Surveying screen, which is independent of the mapping plane scale factor. If the earth curvature adjustment is enabled, it is applied to all total station measurements before any mapping plane scale factor is applied.

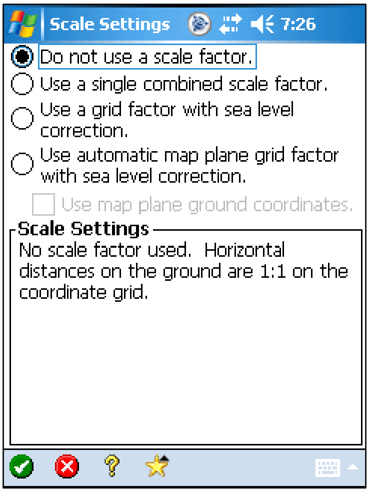
Scale Factor Settings

There are three modes of calculations with scale factor:

1. No scale factor.
2. Combined scale factor: Horizontal distance is scaled by the single scale factor entered by the user.
3. Grid Factor Plus Sea Level: Horizontal distance is scaled by the grid factor then scaled by sea level reduction.

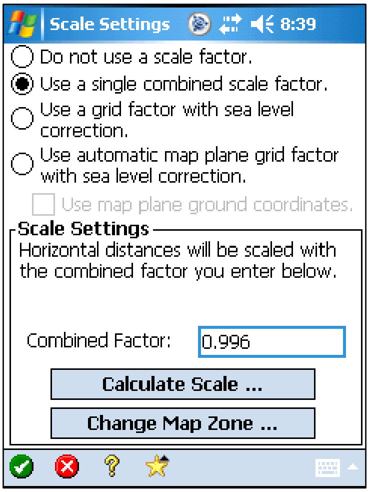
The first screen when setting up a scale factor is the Scale Settings screen. This is where you select how you want to compute and apply the scale factor. Each of the available choices is described below.

No Scale Factor



You should select Do not use scale factor option when you want to disable any ground to grid scaling or if your job is configured to use Ground – TDS Localization. You must tap from this screen and from the screen that follows (Job > Settings > Surveying) to save the changes.

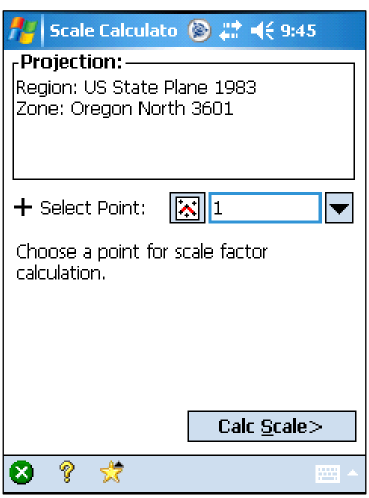
Combined Scale Factor



You should select Use a single combined scale factor option when using a single combined scale factor to reduce all your total station measurements. The scale factor might be provided for you, in which case you simply enter the value in the Combined Factor field and tap ✓ to return to the Job > Settings > Surveying screen, otherwise you can calculate the combined scale factor as described below.

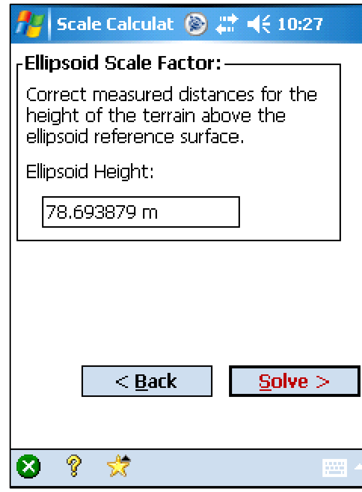
A map zone must be set up before a combined scale factor can be calculated. To configure a map zone, tap the bottom button to open the Select Coordinate System screen. This button is labeled Change Map Zone if a map zone is already configured or Set Map Zone if a map zone is not yet configured. Configuring a map zone is described in the *Mapping Plane Select Zone* section of this manual, starting on Page 251.

Tap Calculate Scale to open the Scale Calculator wizard, which is used to compute the combined scale factor based on the current map zone. If a map zone is not currently configured, the Select Coordinate System screen will open first where you can set one up.



Enter a reference point in the Select Point field and tap Calc. Scale>.

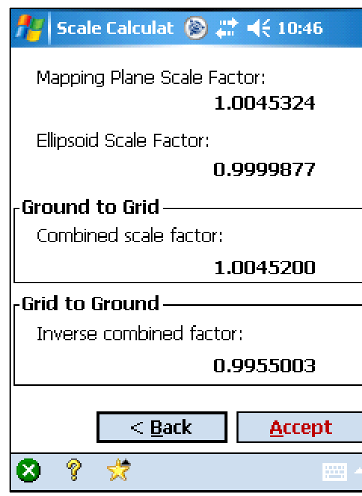
Enter the point's Ellipsoid Height to calculate the Ellipsoid Scale Factor, and tap Solve>.



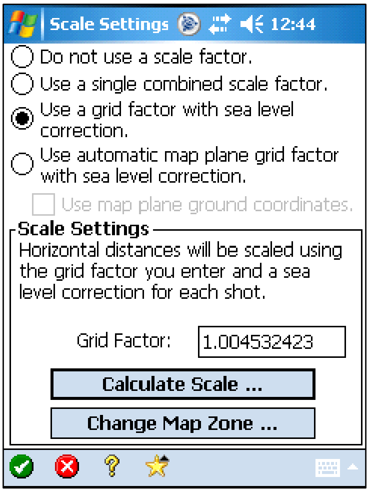
Review the calculated combined scale factor to be used for ground to grid reductions. The inverse combined factor is what you use for grid to ground calculations.

Tap Accept to return to the Scale Settings screen where the computed combined scale factor will be entered for you.

Tap from the Scale Settings screen and from the screen that follows (Job > Settings > Surveying) to save the changes.



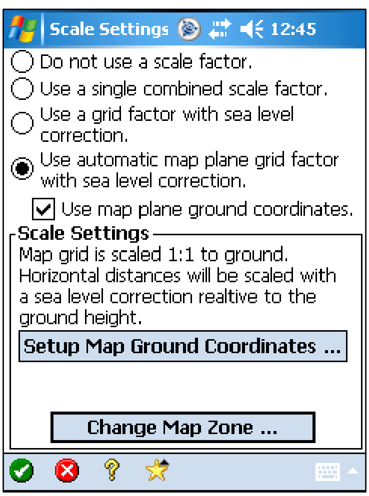
Grid Factor with Sea Level



You should select Use a grid factor with sea level correction option when you have a single grid factor and you want an elevation factor calculated for each total station shot. The grid factor you enter is combined with the elevation factor for each shot to yield the combined factor for that shot.

The grid factor may be provided or you can calculate it using the Calculate Scale wizard. This process is similar to the Use a single combined scale factor option (Page 123), except you are not prompted for an ellipsoid height since the elevation portion of the scale factor is done for each shot as sea level reduction.

Automatic Map Plane with Sea Level



You should select Use automatic map plane grid factor with sea level correction option when you want the grid factor computed for each occupy setup point and a sea level correction computed for each shot.

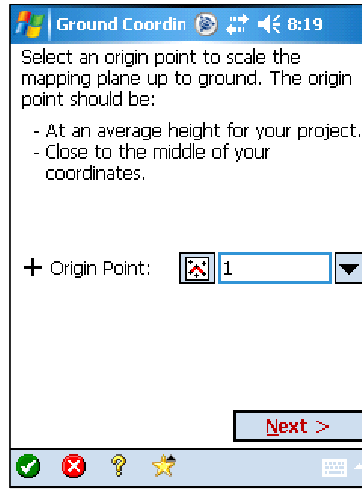
To configure a map zone, tap the bottom button to open the Select Coordinate System screen. This button is labeled Change Map Zone if a map zone is already configured or Set Map Zone if a map zone is not yet configured. Configuring a map zone is described in the *Mapping Plane Select Zone* section of this manual, starting on Page 251.

Map Plane Ground Coordinates

If you do want to use map plane ground coordinates, mark the Use map plane ground coordinates checkbox and tap the Setup Map Ground Coordinates button to set up your ground coordinates.

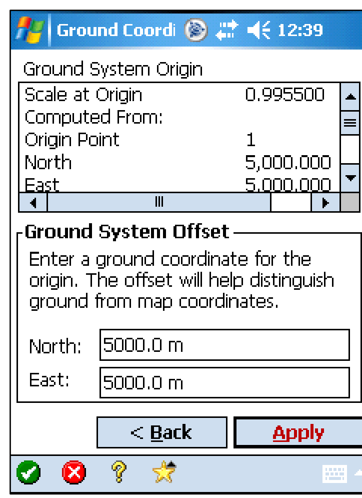
If a map projection zone is not already selected, you will first be required to select one. Once selected, the Mapping Plane Ground Setup wizard will open.

Enter the origin point and tap Next >. Ideally the origin point should be located near the center of your job and at an average elevation.



Enter the local ground coordinates for the origin. This will be the local plane coordinate of the Origin Point. It is recommended that you use a recognizably different coordinate range to distinguish the values from the grid coordinates. For example, a UTM coordinate of (4,997,000, 356,000) could become (5000,5000). The local coordinate you enter here is subtracted from the scaled grid coordinate of your origin point to get the ground offsets.

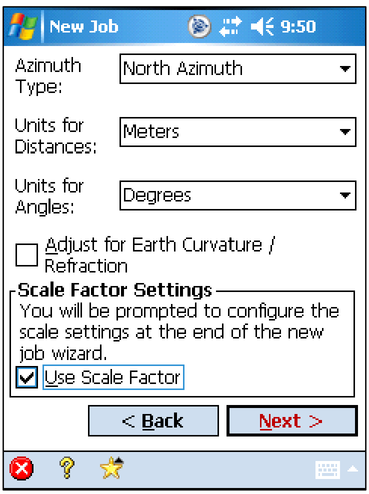
Tap Apply. This will update the entire job database northing and easting coordinates with the ground coordinate system transformation and return you to the Job > Settings > Surveying screen where you must tap ✓ to save your settings.



Accessing the Scale Factor Settings

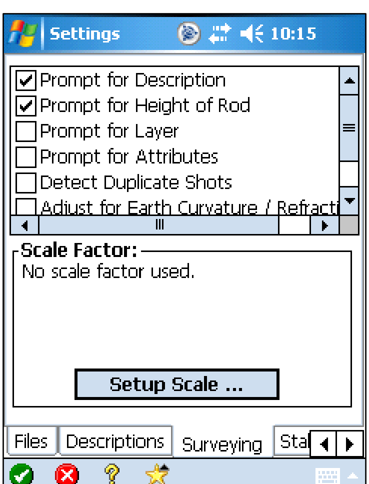
The Scale Factor settings are used to configure a mapping plane scale factor for the current job and are accessed in two different ways:

Scale Factor for New Jobs



When a job is being created, the second screen of the New Job wizard contains a Use Scale Factor checkbox. When checked, the Scale Factor settings will start as soon as the New Job wizard finishes. This setting is always unchecked by default.

Scale Factor for Existing Jobs

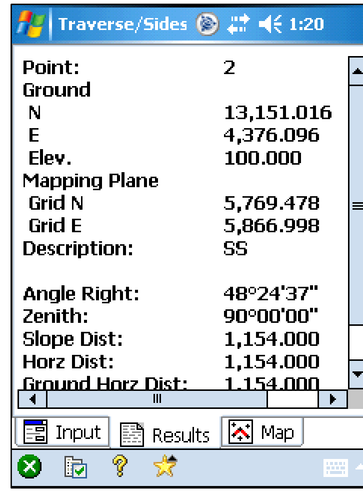


For existing jobs, the Scale Factor wizard can be accessed from the Job > Settings > Surveying screen by tapping the Setup Scale button. The area directly above this button provides details on the current scale factor configuration.

Whenever changes are made to the scale factor, you will return to this screen when the Scale Factor settings are configured. This screen will display the new settings and remind you to "Tap OK to update scale settings." You must then tap to save the changes. If you cancel out of this screen, any changes will be lost and the scale factor will revert to the previous configuration.

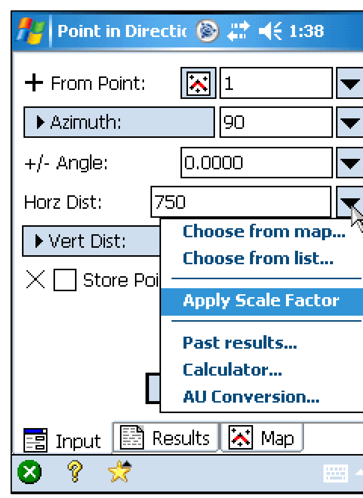
Working with a Scale Factor

Once a mapping plane scale factor is configured for a job, the scaling affects most of the other screens and routines. For example, when viewing the coordinates for a point, where you would normally only see the ground coordinates, you will now see both ground and grid northing and easting coordinates.

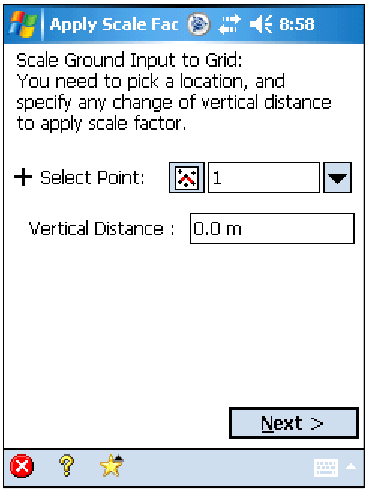


On screens that contain a field where a distance is measured from an instrument (manual input of shot data, GPS offset shot data, stakeout tape measurements), it is assumed these distances are on the ground and therefore the scale factor will be applied automatically before calculating horizontal distances in the job.

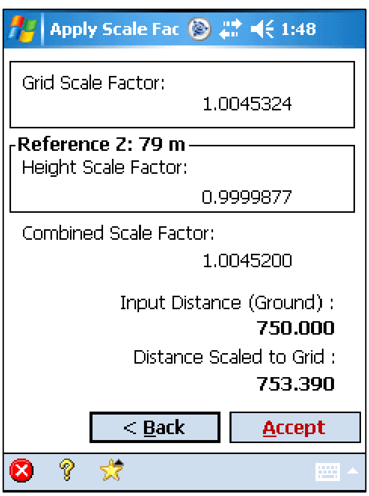
On screens that contain a field where a horizontal distance is always keyed-in manually, it is assumed that the distance you enter will be a grid distance and no scale factor is applied. If you need to enter a ground distance in one of these fields, you can scale the distance entered from ground to grid using the Apply Scale Factor option from the associated ▼ power button before solving.



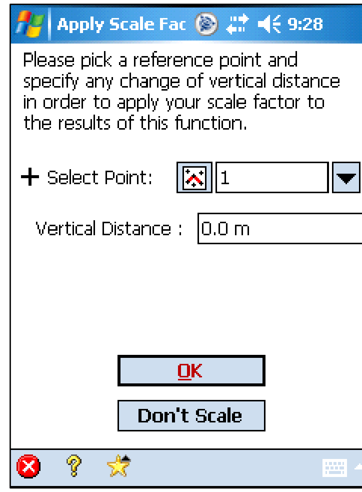
Once you choose Apply Scale Factor from the drop-down list, what happens next depends on how your scale factor is configured. If you are using a single combined scale factor, the number you input in the settings is applied and the new distance is inserted in the edit field without any additional steps.



If you are using a grid scale with sea level correction, including auto map plane mode, the Apply Scale Factor wizard will open where a reference point and vertical distance are needed to compute the scale factor. The Vertical Distance is the vertical difference from the reference point to your target. If working on a level surface, this value will be zero.



When you tap Next, or if your reference point is already known, you will be presented with the screen shown here where you can preview and accept the changes. When you tap Accept, you will return to the original screen and the Distance Scaled to Grid will replace the input distance entered in the edit field.



Some routines lack a point of reference for the Apply Scale power button, or for scaling output results. If you access one of these routines while using a sea level scale factor you will automatically be presented with the Scale Factor wizard before the routine opens.

For most routines, you will not see this screen since the reference point is already known.

Tapping Don't Scale closes the Apply Scale Factor wizard and the original routine will continue without scale parameters. All results will be shown in grid only.

Survey Pro uses the following rules to automatically identify a reference point:

- When there is a single point control, this is the reference point, such as with the COGO > Point in Direction screen.
- When there are multiple point controls, the first point is the reference point, such as with the COGO > Intersection screen.
- When a routine uses a polyline, the first point that defines the polyline is the reference point.
- When a routine uses an alignment, the POB is the reference point.

Other Special Cases

- Stationing and station intervals are always in grid.
- The Map Check routine handles scale factors in a unique way. There is no Apply Scale power button. Instead, the routine treats all input without scale and shows results without scale. However, if you tap the Add to Map button and a starting point (location), you will get a prompt asking if you want to scale all the inputs to grid.

Other Tutorials

This section describes how to use several of the routines in Survey Pro. Each example outlines the procedure to use a particular screen. The examples are written in a general way so the user can use their own data to become familiar with the routine.

Import / Export

The Import routine allows you to add the coordinates from any job to the current job, or import LandXML data.

The Export routine allows you to export any coordinates from the current job to a new job, or export the data in the current job to a LandXML file.

These routines provide full compatibility between older TDS file formats.

Warning: Importing coordinates from any source other than a JOB file requires that the distance units used in the source file be specified. It is not necessary to specify the distance units when importing coordinates from a JOB file since those units are written within the file.

If importing coordinates where the distance units in the source file are different than the distance units for the current job, the imported coordinates will be converted to the current job's distance units when they are imported. This is normally the desired result, but it can cause a problem if any distance units were set incorrectly. This situation can most commonly occur when working with International Feet and US Survey Feet where the conversion from one to the other is not always obvious.

Usually the difference between International Feet and US Survey Feet is negligible (2 parts per million), but when dealing with State Plane or UTM mapping plane coordinates, which are often very large in magnitude, the difference can be substantial if the coordinates are converted from one format to the other.

If importing coordinates from a source, such as an HP 48, where you are not sure if the units are in International Feet or US Survey Feet into a job that is set to International Feet or US Survey Feet, you will usually just want to import them without any conversion being performed. To do this, be sure to select the same distance units for the source file as those set for the current job.

*Importing *.JOB Coordinates*

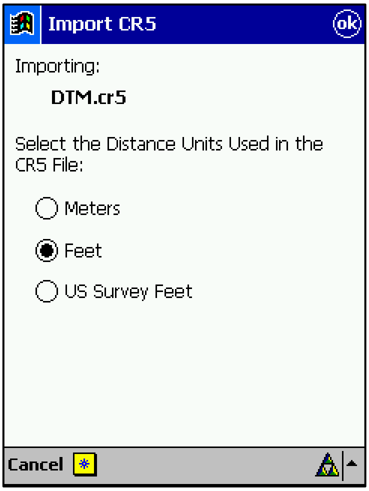
The steps below will add the coordinates from any existing TDS job file to the current job.

1. With the job open that you want to add points to, select File, Import.
2. In the Type field of the Import screen, select Job Files (*.job).
3. Tap the desired JOB file that you want to import and then tap ✓.
4. Select the layer where you want to place the imported coordinates from the Choose Layer screen.

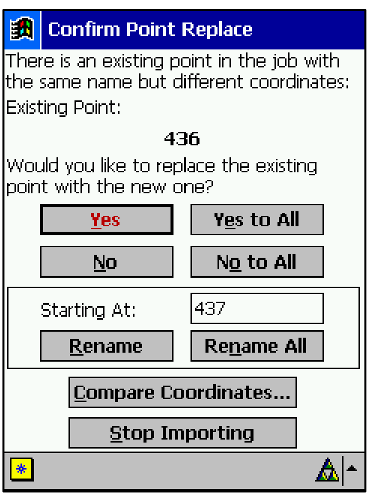
*Importing *.CR5 Coordinates*

The steps below will add the coordinates from any existing TDS coordinate file to the current job.

1. With the job open that you want to add points to, select File, Import from the Main Menu.
2. In the Type field of the Import screen, select Coordinate Files (*.cr5).
3. Tap the desired CR5 file that you want to import and then tap ✓.
4. Select the layer where you want to place the imported coordinates from the Choose Layer screen.



5. The Import CR5 dialog box will open where you must specify the distance used in the file being imported. Select the correct distance and then tap . (See warning above.)



If any of the point names in the source file match a point name already in the current job, the Confirm Point Replace dialog box, shown here, will open asking you what you want to do. Make the desired choice to continue.

If a duplicate point is encountered (duplicate name **and** coordinates), it will be ignored.

Importing LandXML Files

Survey Pro gives you the ability to import the following objects from a LandXML file:

Points

Both named and un-named (anonymous) LandXML points will be imported as Survey Pro points.

Like in other import coordinate functions, if an imported point name conflicts with an existing point name, a prompt will open asking if you want to rename the imported point or overwrite the existing point. If an imported point is identical to an existing point (same name and coordinates), the point is ignored.

If the imported point name is invalid (anonymous or invalid characters), a prompt will open requiring you to rename the point or stop the importing process. All the data that was imported prior to stopping will still be imported.

Alignments

A LandXML alignment will be imported as a Survey Pro alignment, only if all of the following conditions are met, otherwise it will be imported as a polyline.

- The nodes do not refer to valid points.
- The alignment contains spirals or irregular lines.
- The alignment is referred to by a road.

Parcels

LandXML parcels will be imported as polylines. If a node of the parcel does not refer to a valid point, a new point will be created at that node. If a parcel contains spiral curves, they will be converted to line segments.

Groups

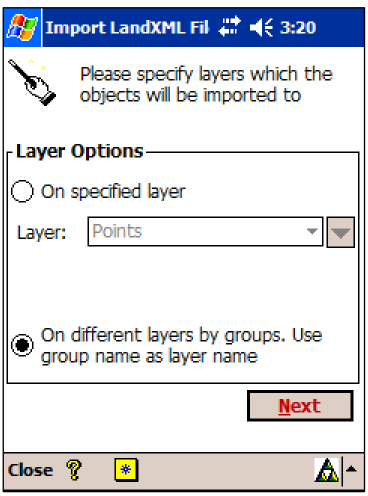
Group names of LandXML points, alignments, and parcels are treated like layers and the data in each group can be imported to a layer with the same name. If a group name is an invalid layer name, the objects in that group will be stored to the active layer.

Features

The only feature data that is imported from a LandXML file are TDS feature attributes.

Importing a LandXML File

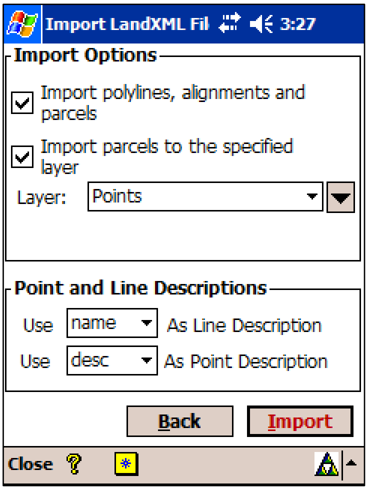
1. With the job open that you want to add LandXML objects to, select File, Import from the Main Menu.
2. In the Type field of the Import screen, select LandXML Files (*.xml).
3. Tap the desired LandXML file that you want to import and then tap ✓.



4. The first of two configuration screens will open.

   Selecting the On specified layer option will import all the data to the layer specified in the corresponding Layer field.

   Selecting On different layers by groups will create new layers in the current project named after the groups in the LandXML file. All the data in each group will be stored to their corresponding layer. If a group name is not a valid layer name, the data in that group will be stored to the active layer.



5. Tap Next to continue to the second screen.

   When the Import polylines, alignments and parcels checkbox is checked, everything in the LandXML file that can be imported will be imported. When this is unchecked, only the points will be imported.

   When Import parcels to the specified layer is checked, the parcels will be imported to the specified layer. All other imported objects will still be stored to the layer(s) defined in the previous screen.

   Imported lines can be given a description based on the name or description in the LandXML file by making a selection from the dropdown list.

   Similarly, the imported points can be given a description based on their description or code.

6. Tap Import to import the objects. A final Results screen will open listing the details of what was imported.

Import Control

The Import Control routine is a solution for people that are used to using control files with versions of Survey Pro prior to Version 4.0.

The Import Control routine is nearly identical to the Import routine with the primary exception that the imported points are always stored to a special layer called CONTROL.

The Import Control routine gives you some advantages over the older control file method of using control points in a job: You now have the ability to modify the control points, with some exceptions, and doing so will not modify the data in the source file from where the points originated.

Control points are typically important, well-established points that the user would not want to inadvertently modify. Because of this, if any routine attempts to modify a point on the CONTROL layer, a warning will first appear asking if you are sure before the changes are applied.

To use the Import Control routine, tap File, Import Control from the Main Menu and then follow along with the steps listed under the Import *.JOB Coordinates description on Page 132.

Control points can also be imported when a new job is created. Consult the File > New Job section of the Reference Manual for more information.

Exporting Coordinates

The steps below will copy selected points from the current job to a new job in a specified file format.

1. Select File, Export from the Main Menu to open the Export screen.
2. Select the type of file you are exporting coordinates to and tap Next>.
3. You can select the desired points to export using any of the following buttons:
   - Tap Points... allows you to select points by tapping them from a map view.
   - To/From... allows you to specify a range of points to export.
   - ▼ allows you to select all points; select all control points; or select points by their description.
4. If a JOB format file was selected, tap Export.

   If a CR5 format file was selected, tap Next>. You must then specify if you want to create a Sequential or Non-Sequential file.

Note: The HP 48 platform can only open sequential CR5 files.

   If a TXT format file was selected, tap Next>. This will lead to two additional screens where the desired format of the text file is configured. For an explanation of the available options, refer to the Reference Manual.

5. The Save As dialog box will open. Specify a file name for the new file in the Name field and tap Save. (The file extension is automatically added for you.)

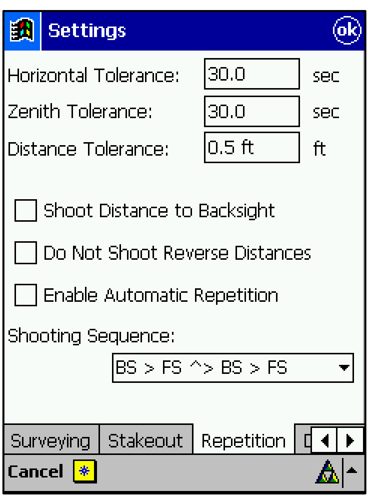
Repetition Shots

A repetition "shot" consists of one or more *sets*. A set consists of four individual shots; direct and reverse shots to a backsight and a foresight. The result of a repetition shot is to store the foresight point using average coordinate values that are computed from all the shots taken.

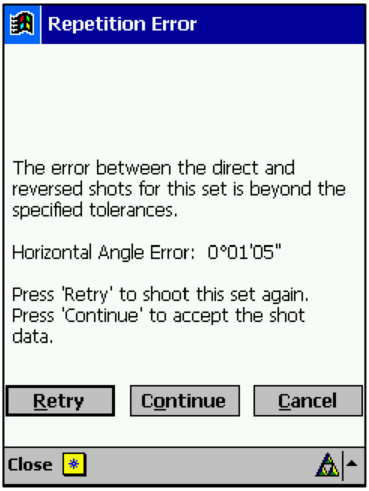
Repetition shots can be performed with a variety of options. This section explains how to perform a repetition shot and the different options available.

Repetition Settings Screen

The Repetition Settings screen is used to define the method that you will use when performing repetition shots. It includes acceptable tolerance values between the direct and reverse shots for each set and the desired shot sequence. The Repetition Settings must be set before you start taking shots.



1. Select Job, Settings from the Main Menu. (You can also tap the Settings button from the Repetition Shots screen.)
2. Tap the Repetition tab. (Use the ◄ ► buttons to expose hidden tabs.)

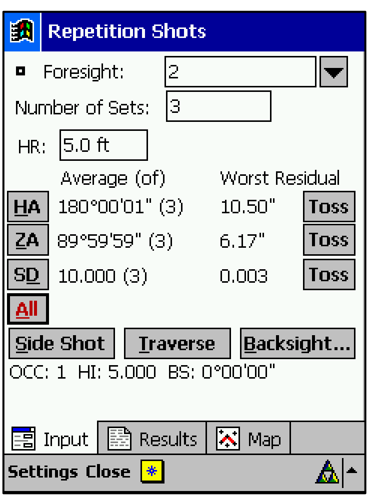


3. Set the Horizontal, Zenith, and Distance Tolerances in the appropriate fields. The direct shots for each set are compared to the corresponding reverse shots. If any of the angles or distances exceeds the specified tolerances, the Repetition Error dialog box, shown here, will open that asks what you want to do. You have the following choices:
   - Retry: Re-shoot only the last set.
   - Continue: Continue and use the shot anyway.
   - Cancel: Throw out all sets and start over.
4. If the Shoot Distance To Backsight checkbox is selected, distances will also be measured with each shot to the backsight and compared against the specified Distance Tolerance. This option, of course, would require a prism to be setup over the backsight point.
5. The Do Not Shoot Reverse Distances checkbox is available for people that use total stations that cannot measure distances when in the inverted, face two, position. Check this if you use this type of total station.
6. The Enable Automatic Repetition checkbox is for users with motorized total stations. When this is checked, the first shot to the backsight and foresight is performed normally, but when those shots are complete the total station will perform all the remaining shots for each set automatically unless the user interrupts the sequence.
7. The Shooting Sequence defines the order that the forward and reverse shots are performed for each set. The notation used should be read where the > symbol indicates to aim the telescope to the next point and the ^ symbol indicates that the total station should be flopped from face one to face two or vice versa. Each option is explained below.
   - BS > FS ^ FS > BS: Shoot backsight, shoot foresight, *reverse scope*, shoot foresight, shoot backsight
   - BS > FS ^> BS > FS: Shoot backsight, shoot foresight, *reverse scope*, shoot backsight, shoot foresight

- BS ^ BS > FS ^ FS: Shoot backsight, *reverse scope*, shoot backsight, shoot foresight, *reverse scope*, shoot foresight
- FS ^ FS > BS ^ BS: Shoot foresight, *reverse scope*, shoot foresight, shoot backsight, *reverse scope*, shoot backsight
- FS > BS ^ BS > FS: Shoot foresight, shoot backsight, *reverse scope*, shoot backsight, shoot foresight
- FS > BS ^ > FS > BS: Shoot foresight, shoot backsight, *reverse scope*, shoot foresight, shoot backsight
- BS ^ BS ^ > FS ^ FS ^: Shoot backsight, *reverse scope*, shoot backsight, *reverse scope*, shoot foresight, *reverse scope*, shoot foresight, *reverse scope*

Repetition Shots Screen

After the repetition settings are configured for your particular situation, the Repetition Shots screen is accessed where the actual shots are performed.



1. Select Survey, Repetition Shots from the Main Menu. If you have not already defined your backsight, you will need to do so before you can access the Repetition Shots screen.
2. Enter the Foresight point name, Number of Sets and HR (rod height) in the appropriate fields.
3. Tap the All button to start the process of shooting all of the sets using the sequence selected in the Repetition Settings screen.

4. Prompts will open after every shot that instruct you on which point to shoot next and when you when you need to flop the scope.

If at least three sets were performed, the Average (of) and Worst Residual fields will be filled in after the final shot is taken. The Average (of) values are simply average measurements for all of the shots taken. The Worst Residual is the angle or distance measurement that varied the most from the average from all the shots taken.

5. *Optional* – The particular measurement with the worst residual can be removed and consequently not used when computing the coordinates for the foresight point by tapping the corresponding Toss button. After tossing a measurement, the Average (of) and Worst Residual values are recomputed (assuming there is still data from at least three shots remaining).
6. *Optional* – You can re-shoot the specified number of sets, and only collect the horizontal angle, zenith angle, or slope distance from all the shots by tapping the HA, ZA, or SD button, respectively. This will replace all of the current shot data only for the selected data type with new data. You can even change the number of sets before shooting the new data.
7. Once you are satisfied with your shot data, tap Side Shot to store the new foresight point as a side shot, or tap Traverse to store it as a traverse shot.

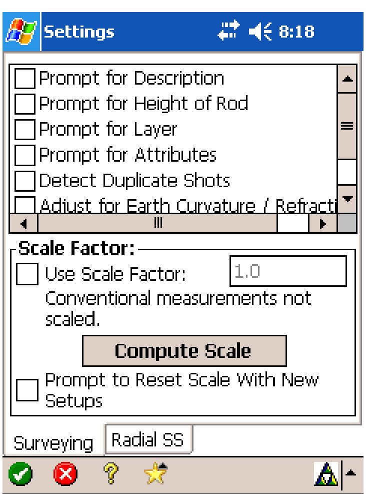
Radial Sideshots

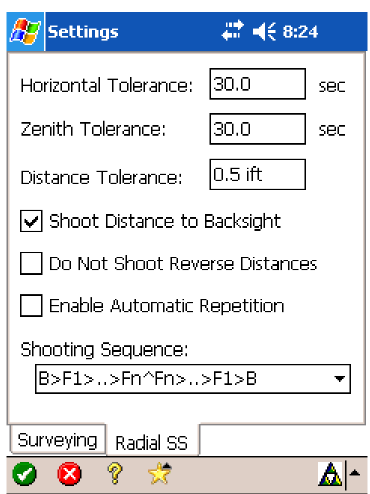
The Radial Sideshots screen is used to perform repetition shots to a backsight and any number of foresights (side shots) from the same occupy point. The behavior of the routine is a cross between the Repetition Shots routine (Page 139) and the Multiple Sideshots routine.

A single set in the Radial Sideshot routine starts with a direct shot to your backsight followed by a shot to each foresight. You then flip the scope and shoot reverse shots to each foresight and a reverse shot to the backsight. You can perform any number of sets and you have the option to shoot the reverse shots to each foresight in the same order that the direct shots were taken or in reverse order, but the backsight is always shot last for each set.

The following example illustrates how to use the Radial Sideshot routine.

1. From the Main Menu, select Survey, Radial Sideshots. If you have not already setup your backsight, you will need to do so first. You must use a backsight point since the routine does not support a backsight direction.





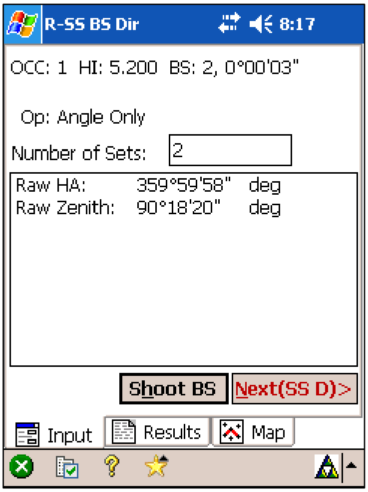
2. Before taking any side shots, you should tap the button to check the settings. The Radial SS Settings screen is only accessible from this location. It is identical to the Repetition Settings screen (Page 139) with the exception of the choices for the Shooting Sequence.

Note: When using a robotic total station and Enable Automatic Repetition is checked in the Radial SS Settings screen, only the direct (Face 1) shots for the first set will need to be shot manually. All remaining shots will be performed automatically.

The Shooting Sequence is where you choose to shoot all Face 2 side shots in the same order as the Face 1 shots (B>F1>..>Fn^F1>..>Fn>B), or in reverse order (B>F1>..>Fn^Fn>..>F1>B).

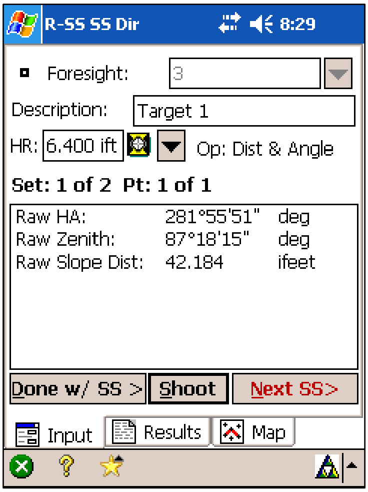
In the Surveying Settings screen, un-checking the first four options will keep the routine from prompting you for additional information before storing the computed side shots.

3. Enter the Number of Sets you want to perform and tap Shoot BS to take the Face 1 shot at the backsight point. When finished, the Results screen shown here will be displayed and the Next(SS D) > button will be enabled. Tap it to continue.



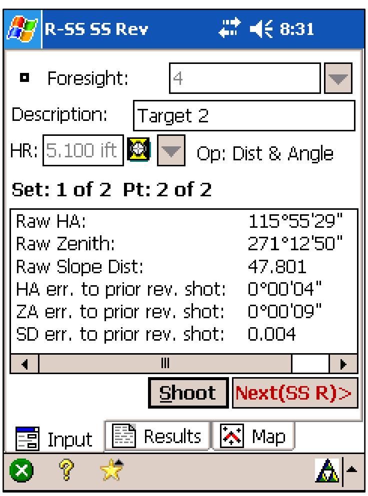
Note: For optimum accuracy when shooting repetition shots, fixed prisms should be set up over each point. Custom Smart Targets (Page 25) will also need to be created and selected for each prism.

4. You will now start shooting each side shot in Face 1. Be sure the description and current smart target is selected before shooting each Face 1 shot for the first set. (These are remembered and will automatically update for each subsequent shot.)



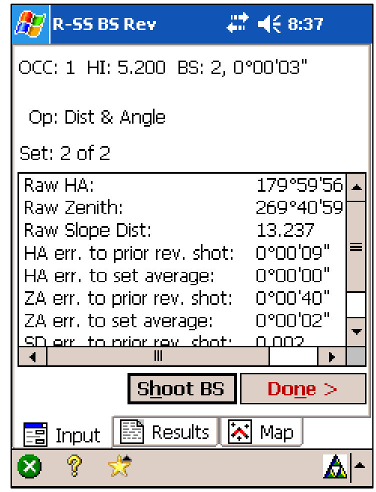
5. Tap Shoot to take a side shot. Once the shot is completed, the Results screen, shown here, will be displayed. You are now provided with three option:

   - Tap Done with SS > if you are finished taking all Face 1 side shots for this set and continue to Step 6.
   - Tap Shoot if you want to throw out the results for this shot and re-shoot it.
   - Tap Next SS> if you want to shoot another new side shot in Face 1. You will then repeat Step 4 for the new point. (The label for this button will change depending where you are in the routine and helps guide you through the process.)

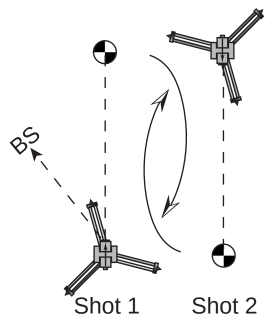


6. Once all Face 1 side shots are completed, reverse the scope to begin shooting the Face 2 side shots for the current set, taking a reverse shot to the backsight last. If additional sets are remaining, you will repeat the process from Step 4 until all the sets are complete.

7. When all shots for every set is complete, the lower right button will be labeled Done >. Tapping it will compute and store all the side shots.

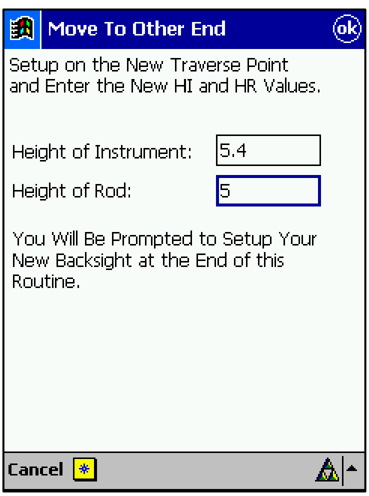


Shoot From Two Ends



The Shoot From Two Ends screen is used to provide more accurate vertical closure to a traverse. The routine requires that after the foresight is shot, its location is not computed until after the foresight point is occupied and a second shot is taken to the previous occupy point. Once the second shot is complete, the coordinates for the original foresight are computed from an average of both shots.

1. From the Main Menu, select Survey, Shoot From 2 Ends. If you have not already setup your backsight, you will need to do so before the Shoot From Two Ends screen will open.



2. Fill in the screen, including the number of sets that you want to shoot from each point in the Number of Sets field.
3. Tap Traverse, aim toward the backsight and tap Take Shot.
4. Shoot the specified number of sets to the backsight and foresight. When finished, the Move To Other End dialog box will open, shown here. At this point you need to move the total station over the current foresight point, place a prism over the current occupy point, fill in the dialog and tap ✓. A new screen will open.
5. Aim at the prism located over the previous occupy point and tap Take Shot. You will then need to shoot the specified number of sets to the previous occupy point.

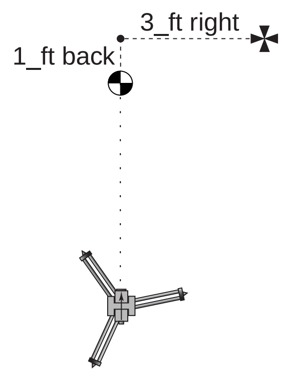
When the final set is complete, a screen will inform you of your new occupy and backsight point and the new point will be computed and stored.

Offset Shots

Three individual screens are used to perform offset shots. These include the Distance Offset screen, Horizontal Angle Offset screen, and Vertical Angle Offset screen.

Offset shots are generally performed to compute coordinates for points that cannot easily be occupied by the rod. The offset routine that you choose will depend on your situation. Each routine is explained below.

Distance Offset Screen

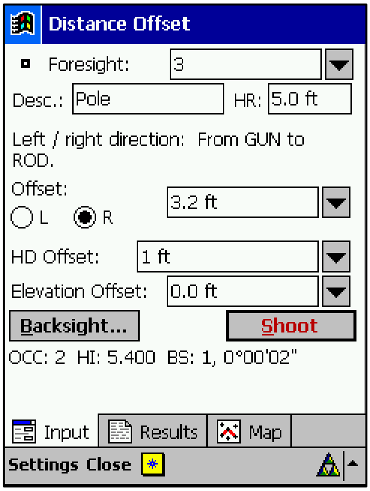


The Distance Offset screen will result in the storage of a point that is located at a specified horizontal and/or vertical distance away from the current rod location.

The routine requires independent horizontal and vertical distances (offsets) that are applied to a shot from the rod location.

In the example below, a point is stored that is 3 feet to the right of the prism and 1 foot behind the prism from the point of view of the total station.

1. From the Main Menu, tap Survey, Distance Offset. If you have not already setup your backsight, you will need to do so before the Distance Offset Shot screen will open.

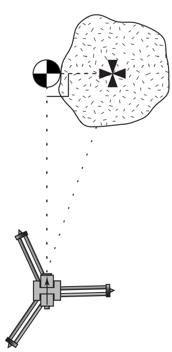


2. The rod person should measure the horizontal and / or vertical distance to the new point from the rod position. Horizontal measurements should be taken parallel and / or perpendicular to the line between the total station and the rod.

3. If the new point is to the left or right of the rod location, enter the perpendicular offset distance in the Offset field and select ⊙L if the new point is on the left side, or ⊙R to if the new point in on the right side (from the total station's point of view).

4. Enter a positive offset distance in the Horz Dist Offset field if the offset to the new point is behind the rod location (from the total station's point of view), or enter a negative offset distance if the new point is in front of the rod location.
5. If the new point is at a different elevation than the rod location, enter the a positive vertical offset in the Elevation Offset field, or a negative vertical offset if the new point is below the rod location.
6. After all the appropriate fields are filled in correctly, aim the total station at the prism and tap the Shoot button. The offset distance(s) entered will be applied when computing the coordinates for the new point and the new point will be stored as a side shot.

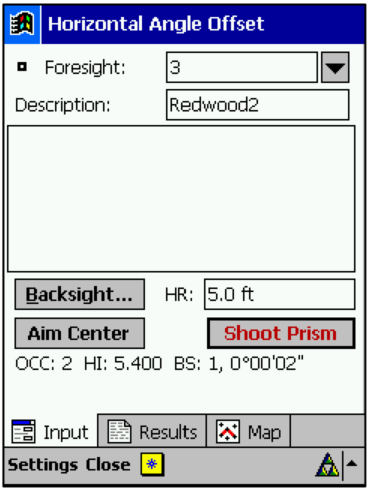
Horizontal Angle Offset Screen



The Horizontal Angle Offset screen is used to store a new point that lies on a line tangent to the rod and perpendicular to the line formed between the total station and the rod. (See illustration.) The routine requires two shots by the total station; one at the prism, located to the side of the new point; and one in the direction of the new point.

This example explains how to store a point at the center of an obstacle – such as a big tree.

1. From the Main Menu, tap [Survey], [Horz Angle Offset]. If you have not already setup your backsight, you will need to do so before the Horizontal Angle Offset Shot screen will open.

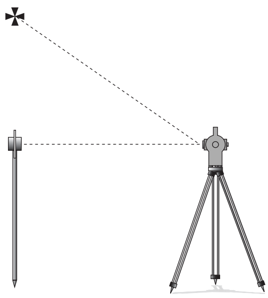


2. The rod person should position the prism to the side of the location of the new point so that the angle formed by the new point, the prism, and total station form 90°. (See illustration.)
3. With the total station aimed toward the new point, tap the [Aim Center] button. Only the horizontal angle is measure during this shot so a prism does not need to be used.
4. Aim the total station toward the prism located at the side of the new point and tap [Shoot Prism]. The new point will be stored as a side shot.

Note: The center shot and the prism shot can be taken in either order.

Vertical Angle Offset Screen

The Vertical Angle Offset screen is used to store a new point that is located directly above, or directly below the rod location. The routine requires two shots by the total station, one at the prism, and one in the direction of the new point.



This example explains how to store a point that is located above the rod – such as at the top of a utility pole.

1. From the Main Menu, tap [Survey], [Vert Angle Offset]. If you have not already setup your backsight, you will need to do so before the Horizontal Angle Offset Shot screen will open.

2. With the prism positioned directly below the location of the new point, aim the total station at the prism and tap Shoot Prism.

3. Aim the total station at the new point and tap Aim Zenith. (Only a zenith angle is measured during this shot so a prism is not necessary.) A new point will be stored with the same northing and easting as the rod location, but with a different elevation.

Resection

The Resection screen allows you to occupy an unknown point and compute its coordinates by shooting two to seven known points.

The accuracy of the computed occupy point depends on the following factors:

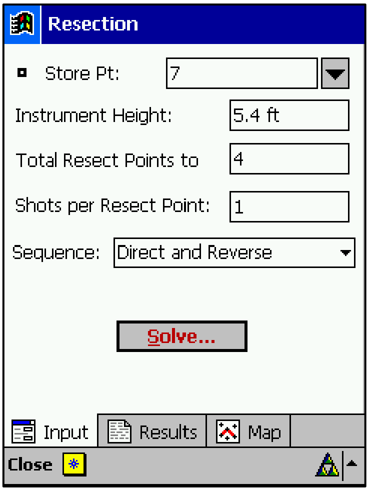
- The number of known points that are shot
- The accuracy of the known point's coordinates
- The position of the known points relative to the total station

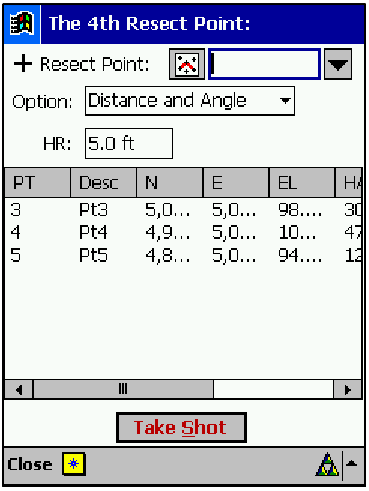
To better explain this last statement, when planning the location of the total station and the known points that you will shoot, try to avoid a situation where the horizontal angle turned between two known points is either near 0° or near 180°. Both of these scenarios create large errors in the computed point when a small error is made in measuring the horizontal angle. This is particularly true when performing a two-point resection.

Performing a Resection

Setup the total station over the location where you want to compute coordinates. Be sure that at least two known points are in view from this location. (The known points must already be stored in the current job.)

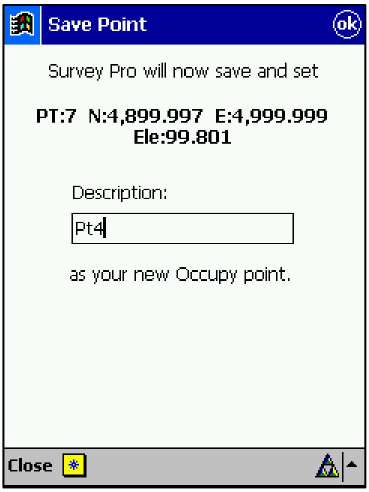
1. Tap Survey, Resection from the Main Menu.
2. Enter the occupy point name that you want to compute in the Store Pt field.
3. Enter the number of known points that are in view that you will shoot in the Total Resect Points to Shoot field. You must shoot at least two and no more than seven.
4. Enter the number of shots (forward and reverse) that you want to take to each known point in the Shots per Resect Point field.
5. In the Sequence field, specify if you want to perform Direct Only shots to each known point or Direct and Reverse shots.
6. Tap Solve... after each field is correctly filled in. A new screen will open where you can shoot a resection point.
7. Enter the name of the point that you plan to shoot in the Resect Point field.
8. If you are shooting more than two resection points, you have the option of taking Distance and Angle measurements with each shot or Angle Only measurements by making the appropriate selection from the Option pull-down menu.





Note: The Angle Only option allows you to perform all shots without the use of a prism, but the resulting occupy point that is computed will not have an elevation associated with it.

With this screen filled in correctly, aim toward the next resection point and tap the Take Shot... button to shoot the specified resection point.



9. Repeat Steps 7 through 9 until every resection point is shot. After the final shot is completed, the Save Point screen will open where you can specify a description for the new point.
10. Tap ✓ to return to the Resection screen. You can tap the Results tab to view information about the stored point or the Map tap to see a graphical representation of the resection.

Solar Observations

The Solar Observation screen is used to compute the azimuth to an arbitrary backsight based on the position of a celestial body, typically the sun.

You can either use the time set in the system clock on the data collector or an external timepiece. Whichever you choose, you should calibrate it against Coordinated Universal Time shortly before performing the solar observation. An accurate timepiece is critical when performing solar observations.

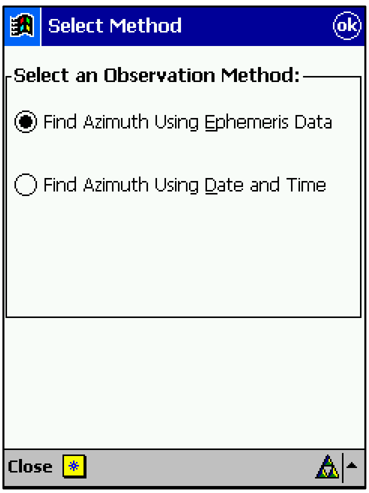
Two solar observation methods are available. One method requires data taken from an ephemeris and the other method does not. The example below illustrates performing a sun shot using ephemeris data since that method requires additional steps.

WARNING! Direct viewing of the sun without a proper filter will cause serious eye damage. Pointing a total station directly toward the sun without a solar filter can also damage the EDM components.

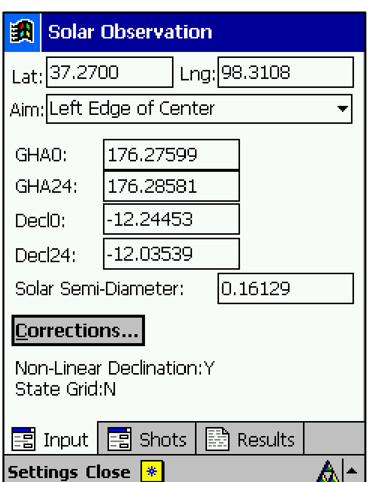
Performing a Sun Shot

1. Setup over a point with known or assumed coordinates and aim the total station at the backsight point to which you will determine the azimuth.

2. From the Main Menu, select Survey, Solar Observation.



3. A dialog will open asking you to select an observation method and tap ✓. For this example we will select the Find Azimuth Using Ephemeris Data option since it contains a couple additional steps.



4. Enter the latitude and longitude for your occupy point in the Lat. and Long. fields, respectively.

Note: Your latitude and longitude should have enough accuracy if it is scaled from a topographic map or measured using a handheld GPS unit.

5. In the Aim field, select the area of the celestial body where you plan to take your measurements. For sun shots, the trailing edge is usually used. (The left edge when in the northern hemisphere.)

6. Tap the Corrections... button if the correction settings displayed to the right of the button need to be changed.

- If performing a sun shot, check the Non-Linear Declination Correction checkbox. (Leave it unchecked for star shots.)

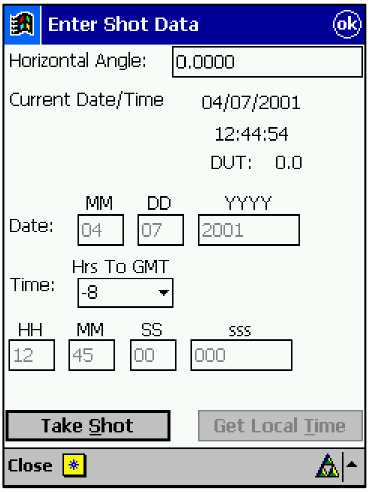
- Check the Correct to State Grid checkbox if you want the computed azimuth corrected to align with the local state plane coordinate system.

Note: The Central Meridian and Zone Constant values for the United States are provided in Appendix A of the Reference Manual.

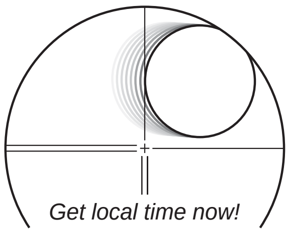
7. Refer to a current ephemeris and fill in the remaining five values. When the screen is correctly filled in, tap the Shots tab.

Note: The GHA0 and Decl0 values are read from the ephemeris for the current date. The GHA24 and Decl24 values are listed in the ephemeris for the following day. The semi-diameter is in minutes and seconds so your value will look something like 0.16084.

8. Tap the Shoot button to open the Enter Shot Data screen.
9. Enter the correct hours to GMT in the Hrs To GMT field, aim toward the backsight and tap Take Shot to record the horizontal angle to the backsight. (The true azimuth to this point will be computed at the end of the routine.)

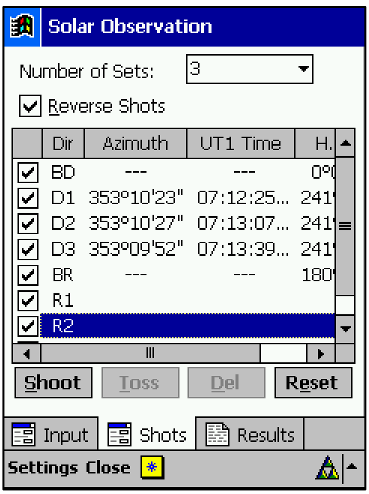


Note: The hours to GMT will be between +5 and +8 when in the continental United States.



10. **WITH A SOLAR FILTER INSTALLED**, aim ahead of the path of the sun so that the trailing edge has not yet contacted the vertical crosshair in the scope and tap Take Shot to record the current horizontal angle.

11. Watch the movement of the sun in the scope. As soon as the trailing edge of the sun contacts the vertical crosshair, either tap the Get Local Time button or use an external timepiece and note the precise time. (When using an external timepiece, manually key in the noted time in the HH, MM, SS, sss fields.)



12. Tap ✔ to continue. You will return to the Solar Observation screen and the computed azimuth for each shot taken is displayed with other shot information.

Note: You can delete and re-shoot the last shot taken by selecting it and tapping the Del button. This is useful if the last shot was in error.

13. If additional shots are remaining, the next required shot will be selected. Tap Shoot to access the Enter Shot Data screen to take the next shot.

14. Repeat Steps 10 through 12 until all forward and reverse shots have been performed.

15. After completing all shots, you can scan down the list and view the computed azimuth for each one. If any of the azimuths appear incorrect, you can have those shots excluded from the computed average azimuth from all shots. To exclude a particular shot, select the shot and then either tap the checkbox next to the shot or the Toss button. (You can include the shot again by selecting it and re-checking the checkbox or tapping the Incl button.

16. Tap the Results tab to view the average computed azimuth to the selected backsight.

What to Do Next

With the azimuth to the backsight known, you can now perform the following steps to begin your survey.

1. Without moving from the occupy point used while performing the solar observation, note the computed average azimuth from the Solar Observation Results screen.
2. From the Main Menu, access the Survey, Backsight Setup screen.
3. Toggle the BS Point / BS Direction button to BS Direction and enter the computed azimuth in that field.

Tip: You can use the ▼ power button and select the Past results... option to select, and automatically enter, the azimuth computed from the sun shot earlier.

4. Fill in the remaining fields with your current information and tap Solve.
5. Access the Survey, Traverse / Sideshot screen, aim toward the backsight used during the solar observation, zero your horizontal angle on the total station and tap either Side Shot or Traverse. The data collected should be aligned correctly with true north or your local state plane coordinate system.

Remote Control

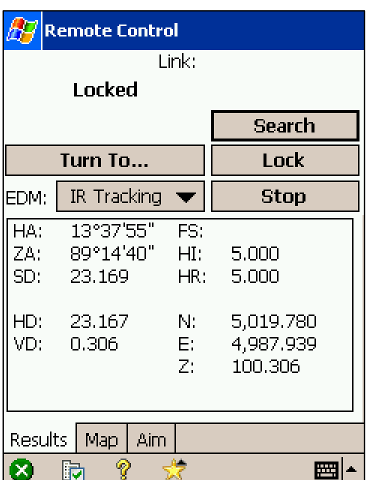
Remote control mode is a special mode that makes it possible for users to control a fully robotic total station from a remote data collector.

Remote control mode contains additional screens that are used exclusively with robotic instruments that perform tracking and aiming functions. The behavior of the software differs slightly in remote mode when a shot is taken and when performing stake out.

The remote control functions are available only after the robotic module is purchased, and a supported robotic total station is selected and enabled in the Settings screen.

The Remote Control Screen

The Remote Control screen is used to operate a fully robotic total station. It is used to control the total station to have a view of the prism and to activate search and tracking functions.



The Remote Control screen can be accessed in the following ways:

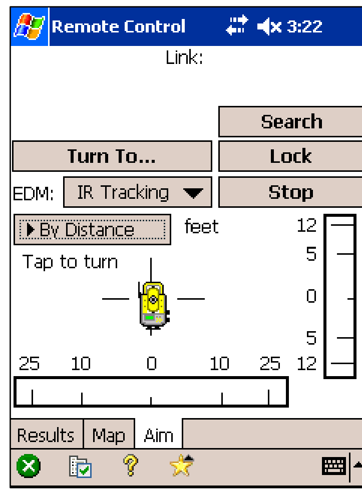
- Tap the Remote... button from any screen that includes it.
- Use the , Remote Quick Pick, if available.
- Select Survey, Remote Control from the Main Menu.

Once the Remote Control screen is open, you can perform the following functions:

You can turn the total station in any direction using the arrow keys on the keypad. As you face the total station, pressing an arrow key will start moving the total station in that direction. The total station will continue moving until the button is released. These keys are typically used to get the total station to aim in the general vicinity of the prism.

Once the total station is aiming near the prism, the Search button is used to start the total station in a search pattern. The search pattern continues until it finds the prism.

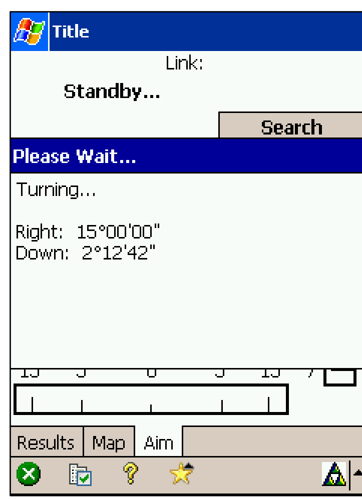
The Lock button puts the total station in track mode where it will track the movements of the prism and Stop will stop the total station from tracking the prism.



Tapping the Aim tab will open a screen used to precisely aim the instrument. (Course controls are still available using the arrow keys on the data collector and the Turn To... routine.)

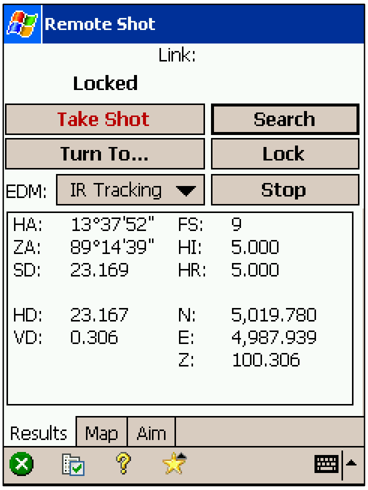
Tapping within this screen will turn the instrument in the amount that corresponds with the horizontal and vertical scale bars. Tapping within either scale bar will only turn the instrument horizontally or vertically depending on which bar is tapped.

The scale bars can either display angles or feet depending on the setting of the By Angle/By Distance button. The scale within the bars is determined from the last distance measured by the total station.



Once an area on the screen is tapped, a message will appear briefly that shows the amount the instrument is turning.

Taking a Shot in Remote Mode



When running in a non-remote mode, tapping the Traverse or Side Shot button will simply trigger the total station to take a shot. When running in remote mode, tapping these buttons will open the Remote Shot screen.

The Remote Shot screen is nearly identical to the Remote Control screen except it has an additional button that allows you to trigger the total station to take a shot. The screen is used to properly align the total station with the prism prior to taking a shot. Once the total station is aligned, a shot is taken by tapping the Take Shot button.

If the Remote Shot screen was accessed by performing a side shot, you will return to the Remote Shot screen after the shot is completed. If the Remote Shot screen was accessed by performing a traverse shot, you will return to the Traverse / Sideshot screen after the shot is completed.

Stake Out in Remote Mode

Performing stake out in remote mode is different from running in a non-remote mode because the feedback is continuous and provided in the rod's point of view instead of the total station's.

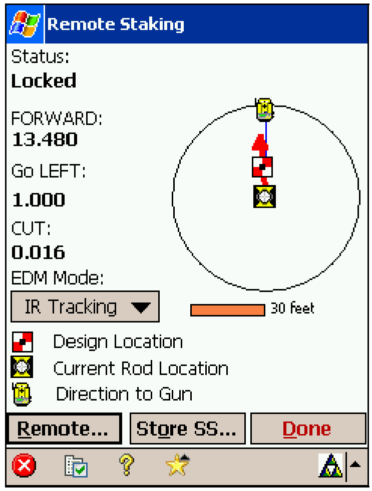
Stakeout data is presented in the Remote Staking screen. All of the information is displayed as if the rod person were facing the total station. The graphic portion of the screen will change depending on how close the rod is to the stake point.

When the prism is located more than 10 feet, or 3 meters from the stake point, the first screen shown below is displayed. In this situation, the prism is shown at the center of the screen and an arrow indicates the necessary direction of travel, as you face the total station.

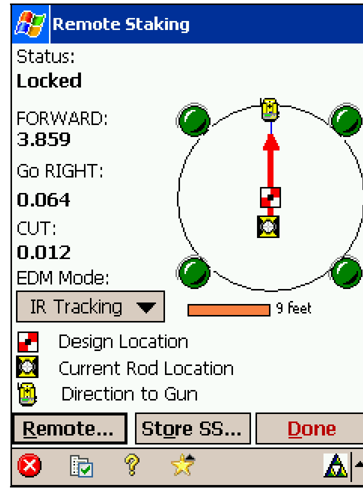
Once the prism moves to within 10 feet of the stake point, the second screen is displayed. The stake point is now at the center of the screen and the current prism location is displayed away from the center. Dark green "lights" are also displayed around the screen to indicate you are near the stake point.

When the prism is within 3 feet, or 0.3 meters of the stake point, the "lights" change to light green and locating the stake point is simply a matter of moving the round prism icon directly over the square stake point icon.

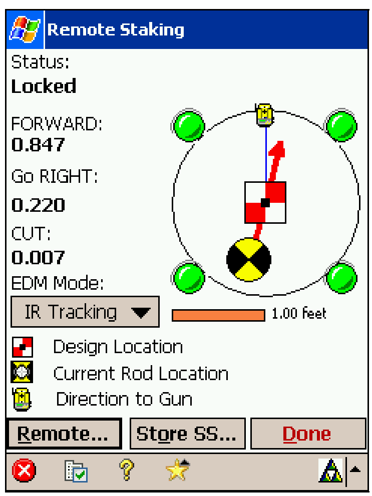
When you are satisfied with the location of the prism, tap the Done button. This will open the Stake Point screen (see Page 76) where the stake point can be stored.



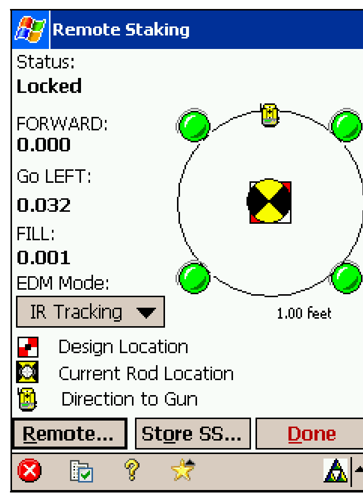
Remote staking beyond 10 feet from target



Remote staking between 1 and 10 feet



Remote staking within 1 foot from target



Remote staking over target

Slope Staking in Remote Mode

Slope staking in remote control mode functions in nearly the same way as with a non-remote total station (see Page 168). The one difference is when using the final Slope Staking screen, where the catch point is being located, the graphic portion of the Horizontal Map and Vertical Map is updated continuously. This allows the user at the rod position to watch the movement of the prism in relation to the slope and easily position the rod over the catch point.

Note: You can tap in the graphic portion of the screen to open the graphic in a larger window.

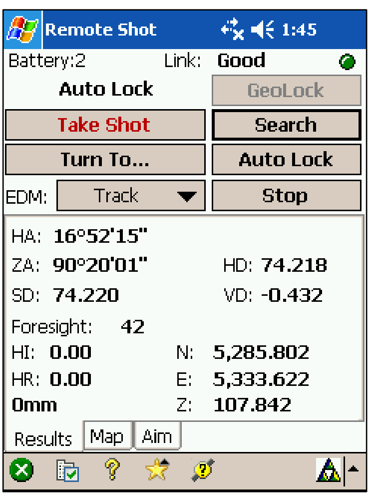
Although the graphic portion of the screen is continuously updated, the numeric values are not updated until the Shot button is tapped. This is because accurately locating the catch point depends on measuring an accurate elevation at the rod position. When the rod is moving, there is no way to estimate how far the rod is lifted off the ground. Therefore, the correct procedure for slope staking in remote mode is to use the graphic portion of the screen to locate the catch point as closely as possible, position the rod on the ground and press Shot. Once the values are updated, you can determine if the rod needs to be moved again.

GeoLock

GeoLock is a feature that uses a GPS receiver to calculate your position so while working robotically, if the total station loses lock of the prism, it can quickly turn to the location of the prism based on the GPS position and then automatically perform a search to lock back onto the prism.

GeoLock is available when using a Trimble or Geodimeter robotic total station, along with a GPS receiver that outputs a NMEA signal. Most inexpensive consumer handheld GPS receivers will output the required signal.

Communication between the data collector and GPS receiver can take place using a compatible data cable, Bluetooth, or a direct connection such as with a CompactFlash GPS receiver.



All of the GeoLock features and settings are accessed while in the Remote Control or Remote Shot screens. Specifically, you will use the GeoLock button and the satellite icon in the Command Bar, which changes color to indicate different situations related to GeoLock, as described below.

If you tap on the satellite icon, a list will open to access other GeoLock-related screens. At the bottom of this list is a message indicating the current GPS status, which coincides with the color of the satellite icon as follows:

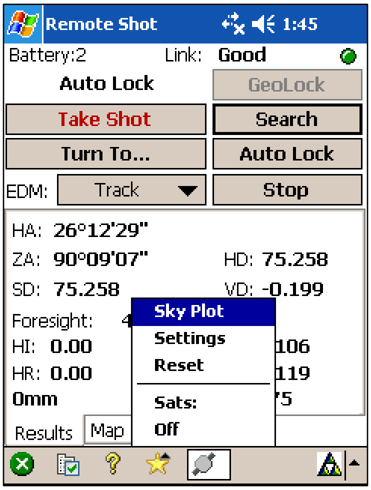
(gray icon) **Off**: GeoLock is not enabled.

(yellow icon) **On - Collecting Data**: GeoLock is active but a localization solution does not yet exist.

(red icon) **No GPS Data** or **GeoLock requires Backsight set**: No NMEA data is available or the backsight has not yet been set.

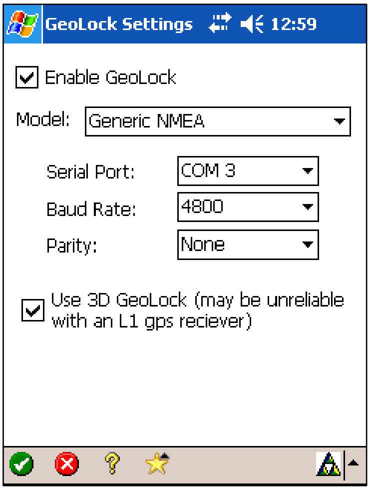
(green icon) **On - Ready**: GeoLock is active and a localization solution exists.

Configuring GeoLock



Once you have setup your job and total station, you need to power on your GPS receiver and establish communication.

1. Attach the communications cable, if applicable.
2. Open the Remote Control or Remote Shot screen.
3. Set your **EDM** mode to **Track**. This is important for the localization process, explained later.
4. Tap the satellite icon in the Command Bar to open a list of GeoLock options.
5. Tap Settings from the list to open the GeoLock Settings screen. (You can also access this screen by tapping Job > Settings > GeoLock...)



The options available in the GeoLock Settings screen will vary depending on if you are using a Holux, generic cable, or generic Bluetooth GPS receiver.

6. Make sure the Enable GeoLock checkbox is checked. If not, tap it to enable it.
7. From the Model field, select Holux if you are using a Holux CompactFlash GPS receiver or select Generic NMEA for any other receiver and configure the communication settings accordingly.

   If you are using a Bluetooth GPS receiver, select Bluetooth for the Serial Port and then tap Bluetooth to configure the receiver as described on Page 316.
8. If you check the Use 3D GeoLock item, the GPS elevation will also be used when calculating your GPS position, resulting in the vertical angle of the total station changing accordingly when using the GeoLock feature. Since uncorrected GPS elevations are less precise than the horizontal component, using this feature can result in less aiming accuracy unless surveying in mountainous terrain.

9. Tap ✅ to save the settings and close the screen. You are now ready to collect data and start the localizing process.

If the satellite icon is now red in color, tap the icon and read the bottom line of the list that opens to see what the problem is. If the message says No GPS Data, check your communication connection between the data collector and GPS receiver. If the message says GeoLock Requires Backsight set, you need to solve your backsight or no localization solution can be calculated.

Localizing

With your backsight set, the data collector now knows your position in the job's coordinate system and since it is receiving a GPS signal, the data collector also knows your position in the geodetic coordinate system, but the data collector has not yet aligned the job's coordinate system with the geodetic coordinate system. This is indicated by a yellow satellite icon with a question mark in it in the Command Bar.

The process of aligning the two coordinate systems is called *localizing* and until that happens; you will be unable to use the GeoLock feature, although you can still collect data.

Localizing takes place automatically in the background as you move around as long as the EDM is set to Track because the total station is routinely measuring your location while the GPS receiver is simultaneously measuring your location. Both of these measurements are compared and in theory, the more comparisons from different locations that are made, the better your localization solution will be and the more accurate GeoLock will be. Once a localization solution is available, the satellite icon will change to green.

Localization will still occur if the EDM is set to Standard, but a solution will take much longer to obtain because the total station will only measure your location when you take a shot.

There may be some situations where you will want to throw out your localization solution and start over. For example, if you moved the GPS receiver away from the prism, the GPS position would no longer match the position measured by the total station, resulting in an incorrect localization solution. To reset your localization, tap the satellite icon and select Reset from the list. The icon will change back to yellow and you will need to move around again to re-localize before you can use the GeoLock feature.

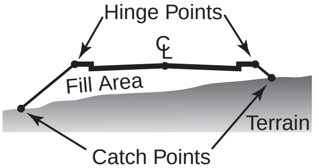
Using GeoLock

If, for example, you have a localization solution and you pass behind a group of trees where the total station loses lock on the prism, the GeoLock button will become enabled. Tapping GeoLock will instruct the total station to turn to the location of the prism based on the last GPS reading, followed by a search until the total station is locked back onto the prism.

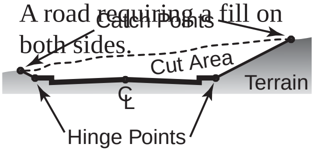
Slope Staking

The ultimate purpose of the slope staking routine is to locate where the design slopes that extend from the ends of a roadway intersect with the actual terrain at various stations. This intersecting point is called the *catch point*.

Before a road can be slope staked, it must first be designed. The first step to designing a road is to define the path of the road's centerline. This line can be in the form of a polyline or an alignment. Creating this line is explained in detail starting on Page 49.



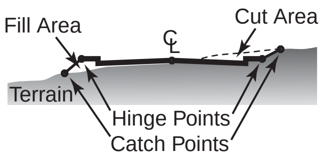
A road requiring a fill on both sides.



A road requiring a cut on both sides.

Once the centerline is defined, the cross-sectional profile of the road must be defined. This profile is then superimposed onto the centerline at a specified station interval. The final step is to go out in the field and stake the catch points at each of these stations.

A road's cross sectional profile always consists of left and right road surfaces, which are tangent at the centerline. An optional curb or ditch can also be included in the road profile. The final segment of a road's profile has either a specified positive slope or a specified negative slope, which ends at the catch point. This final segment attaches to the edge of the road at what is called the *hinge point* since this segment can hinge between a positive and negative slope around this point.



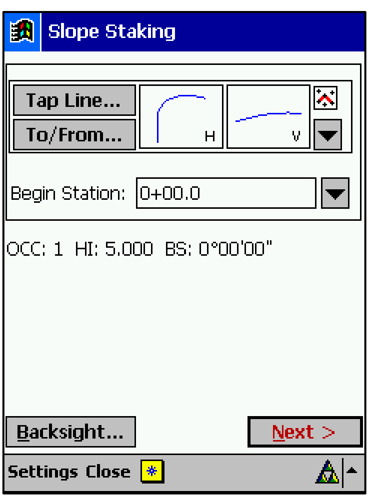
A road requiring a fill on one side and a cut on the other side.

The Slope Stake routine can automatically determine if the outer slope of the road profile should have a positive or a negative slope based on the location of the hinge point. If the hinge point is located below the surface of the terrain, a positive slope is selected and a cut will be required, starting at the catch point. If the hinge point is located above the surface of the terrain, a negative slope is selected where a fill will be required, starting at the catch point.

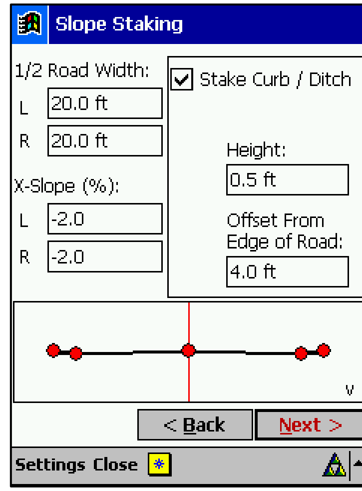
The illustrations here show examples of a road that requires a fill on both sides; a road that requires a cut on both sides; and a road that requires a fill on one side and cut on the other side.

It is important to remember that when slope staking a road, the road profile always remains the same and the slope of the final segment can only equal the specified positive (cut) slope, or the specified negative (fill) slope, but the length of this final segment can vary as much as necessary until it ends at the surface of the terrain (the catch point).

Defining the Road Cross-Section



1. From the Main Menu select Stakeout, Slope Staking. You will need to select a line that defines the centerline of your road. If one is not available, refer to Page 49 for details on creating polylines and alignments.
2. Tap the Tap Line button and then tap the polyline or alignment that describes the centerline of the road you want to slope stake and then tap ✓ to continue.
3. Enter the station that you want to assign to the starting point of your alignment or polyline in the Begin Station field.
4. If the backsight is not yet set up, tap the Backsight button and set up the backsight. Tap Next to continue.

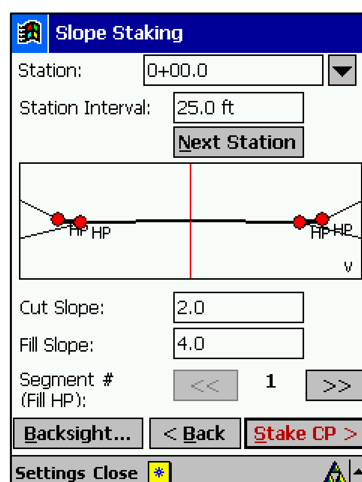


5. Enter the horizontal width of the left and right sides of the road in the 1/2 Road Width fields. These widths do not have to be the same.
6. Enter the cross-slopes of each side of the road in the X-Slope (%) fields.

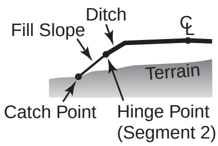
Note: A negative X-Slope value will result in a slope where water runs from the centerline of the road toward the edge.

7. If the road profile also includes a curb or a ditch, check the Stake Curb / Ditch checkbox and define the curb or ditch as follows.
8. If defining a ditch enter the depth of the ditch as a negative value in the Height field. If defining a curb, enter the height of the curb as a positive value in the Height field.
9. Enter the horizontal width of the curb or ditch in the Offset From Edge of Road field.

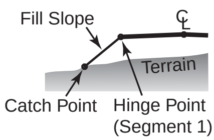
Note: You can tap in the graphic portion of the screen to open the graphic in a larger window.



10. Tap Next > to continue to the next screen.
11. Enter the first station that you want to stake in the Station field. This station will be referenced from the Begin Station, assigned to the starting point of the centerline earlier.
12. Enter the distance between each station that you want to stake in the Station Interval field.
13. Enter the Cut Slope and Fill Slope in the respective fields. These slopes will be used to compute the location of the catch point for either cut or fill situations.



A road with a ditch requiring a fill and the hinge point is at Segment #2.

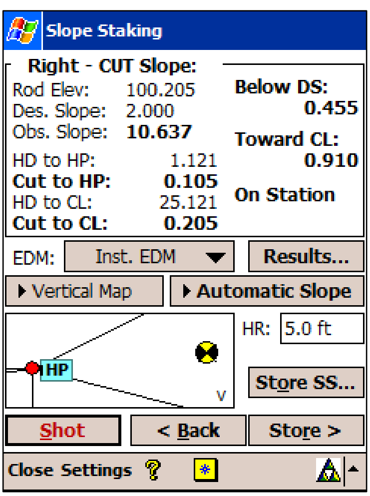


A road with a ditch requiring a fill and the hinge point is at Segment #1. (The ditch is ignored.)

14. The Segment # (Fill HP) field is used to select which segment to compute the slope from in a fill situation. This is useful when your road profile includes a ditch and you are staking an area that requires a fill. In this situation, the ditch would not be necessary so you have the option to compute the slope from Segment 1. (See illustration.)

15. Tap Stake CP > to begin locating the catch points.

Staking the Catch Point



16. If the Force Cut Slope / Force Fill Slope / Automatic Slope button is set to Automatic Slope (recommended), a cut slope will automatically be selected if the hinge point is located below the surface of the terrain and a fill slope will be selected if the hinge point is above the terrain. You can also force the computed values to be based on a cut slope or fill slope by tapping the button until it reads Force CUT Slope or Force FILL Slope respectively.

17. The Results button will display more detailed cut fill and location results, which is also accessible from the Store Catch Point screen.

Note: The Results button is only available from the Store Catch Point screen when using GPS or Remote mode, which is accessed after tapping Store >.

18. The Vertical Map / Horizontal Map / Shot Data button is used to toggle which information is displayed on the screen.

Note: You can tap in the graphic portion of the screen to open the graphic in a larger window.

19. With the rod in the general location of the first catch point that you want to stake, aim toward the prism and tap Shot. The distance and direction information will be computed and displayed along with other information pertaining to the shot. The routine automatically determines if you are staking the left or right catch point by the proximity of the rod.

Des. Slope is the design slope of the nearest cut or fill slope when Automatic Slope is selected, otherwise it is the design slope of the selected slope.

Obs. Slope is the observed slope of the terrain at the current rod location computed from the last shot and the corresponding hinge point.

Cut / Fill is the amount of cut or fill necessary for the rod to be on the design slope from the current rod location. If this value is zero, you have located the catch point, provided you are on the correct station.

Away (CL) indicates that the rod must move the specified horizontal distance away from the centerline (perpendicular to the centerline and parallel to the current station) to locate the catch point. Likewise, Toward CL indicates that the rod must move toward the centerline by the specified distance.

On Station indicates you are properly aligned on the current station. Back Sta indicates that the rod must move back toward the start of the alignment (parallel to the centerline) by the specified distance to be properly aligned over the current station. Likewise, Ahead Sta indicates that the rod must move away from the start of the alignment to be positioned over the current station.

The remaining information displays the horizontal and vertical distances to the hinge point and centerline from the current rod location.

Note: All previous shots taken while locating a specific catch point are shown in the map view as large X's. These can be useful in determining a situation where there is no catch point. (The slope never intersects with the surface of the terrain.)

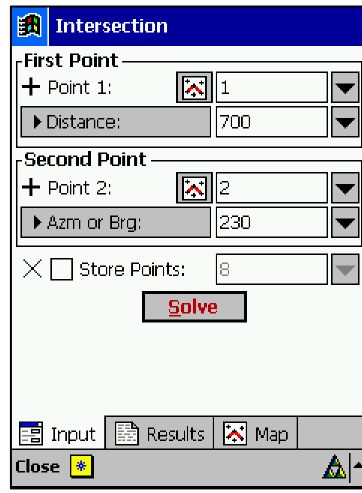
20. Once the catch point is satisfactorily located and staked, tap Store >.
21. Enter a Point Name and Description in the corresponding fields and tap Store CP.

    You can optionally stake a location at a specified horizontal offset from the catch point (away from the centerline) by entering the offset distance in the Offset from CP field and tapping Solve >. This will open a new screen where the offset point can be staked like any other stake point.
22. Tap Next CP >. You will be prompted if you are done staking points for the current station. If you tap Yes, you will return to the third slope staking screen where you can then tap the Next Station button and advance the Station by the Station Interval and begin locating your next catch point.

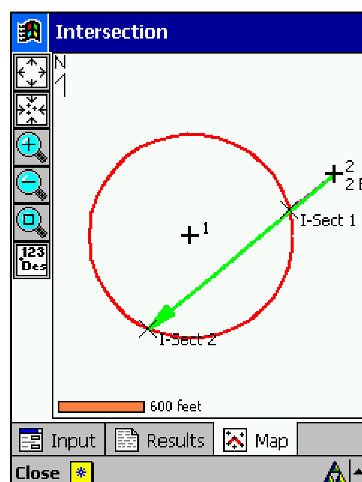
Intersection

The Intersection screen computes and optionally stores the coordinates for the intersection of two lines that are tangent to existing points.

Each line is independently defined by a known direction or a known length. In the situation where there is more than one possible solution, each solution is provided and optionally stored.



1. From the Main Menu, select Cogo, Intersection.
2. In the Point 1 field, enter the point name that is tangent to the first line that intersects with the other line.
3. Toggle the first button to Distance or Azm or Brg, depending on if the first line intersects at a known distance from Point 1, or at a known direction from Point 1, respectively.
4. In the same way that you defined the first line, define the second line tangent to Point 2 in the Second Point section of the screen.
5. If you want to store the intersecting point(s) that are computed from the routine, check the Store Points checkbox and specify a point name in the same field. If there is more than one solution, the additional points will be stored with the next sequential point name.
6. Tap Solve to compute the intersecting points. You can view the point's coordinates by tapping the Results tab and see a graphical representation of the intersections by tapping the Map tab.



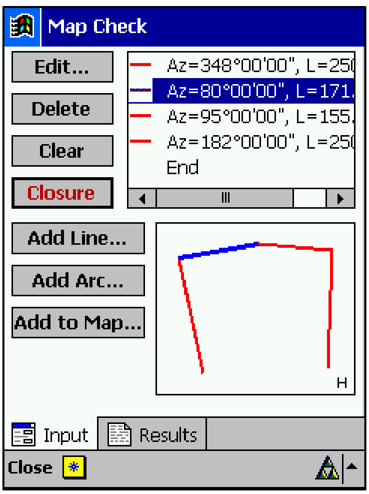
The map shown here illustrates a situation where two intersections were computed from a line with a known length tangent to Point 1 and a line with a known direction tangent to Point 2.

Map Check

The Map Check screen is used to enter distance and direction information from a map for straight and curved sections to compute closure, and other information from the entered boundary.

Entering Boundary Data

Each straight and curved section of the boundary is entered using the Add Line... and Add Arc... buttons in the order that the sections occur on the map.



1. From the Main Menu, tap Cogo, Map Check.
2. To add a straight section, tap the Add Line... button to open the Add/Edit Line screen.
3. Toggle the Azimuth / Bearing button to the desired setting and then enter the direction in that field.
4. Enter the length of the straight section in the Length field and tap ✔.

When you return to the Map Check screen, the straight section is displayed in a map view in the right-hand portion of the screen, along with any previously entered sections.

1. To add a horizontal curve to the boundary, tap the Add Arc... button
2. Describe the curve in the Add/Edit Curve screen.
3. Tap ✔ when finished.

Each section is added to the end of the previous section until all the sections are entered. When you are finished, you can view the details of the entered boundary by tapping the Results tab. You can also merge the entered data with the current project, described later.

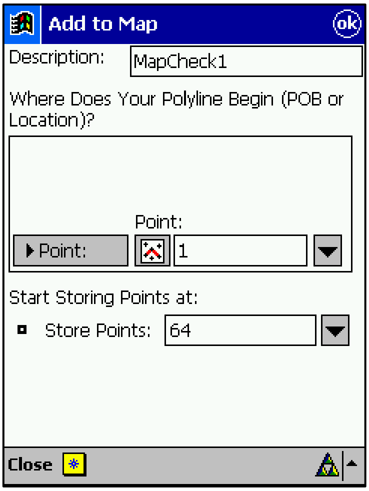
Editing Boundary Data

Any entered section can be modified if an error is discovered. To edit a particular section, select the section from the left-hand portion of the screen and tap the Edit... button. The details of the selected section will open in the same editor that was used to create it. Simply make the necessary changes and tap .

Adding Boundary Data to the Current Project

You can add the boundary data that was entered to your current project. Points will then be created for the ends of each section that was entered and the line for the boundary is stored as a polyline.

The polyline can be used in any routine that supports them such as Inverse Point to Polyline, Edit Lines, Computer Area, etc.



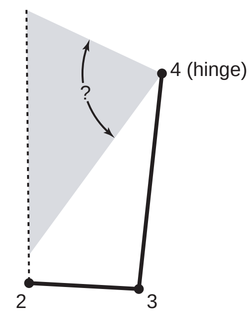
1. To add the boundary data to the current project, tap the Add to map... button.
2. In the Description field, enter the desired name for the polyline that will be stored.
3. Define the location of the beginning of the first section that defines your boundary.
    - To specify a new location, tap the Use Location> button and enter the appropriate northing, easting and elevation.
    - To specify an existing location, tap the Use Point> button, and enter the point name in the same field. (Alternatively, you can tap the button and then tap on a point from the map view.)
4. Enter a name for the initial stored point in the Store points field. Each new point that follows will automatically be stored with the next available consecutive point name.

Predetermined Area

The Predetermined Area routine will take a boundary with one open side and compute the location of a line that will enclose a boundary with a specified area.

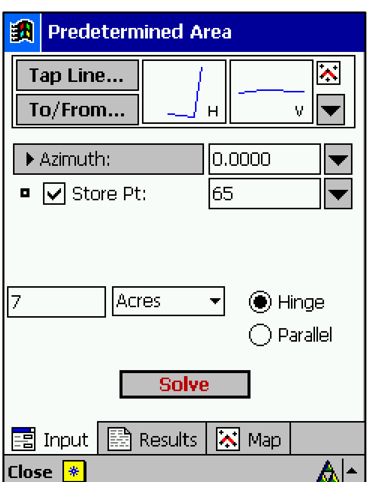
Two methods are available for computing a predetermined area, the Hinge Method and the Parallel Method. Each method is explained below.

Hinge Method



The Hinge Method computes the location of a side of a boundary that has one fixed point and a known direction. The fixed point acts as a hinge where the computed side can pivot.

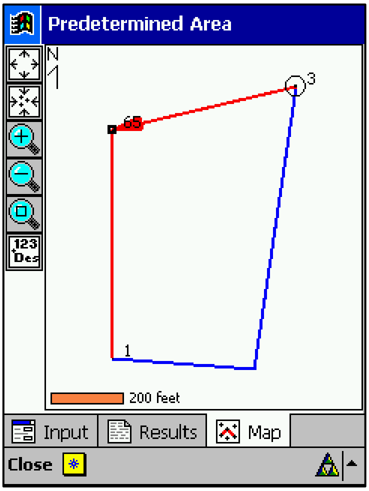
For example, assume you have three points that define an open boundary and a known direction for one side. You can use the Hinge Method to compute the location of the final side of the boundary so that the entire boundary encloses a 7-acre lot. The hinge point in this example is in the upper right corner of the boundary. The computed boundary line will fall somewhere in the gray area shown when the lot is equal to 7 acres.



1. Select Cogo, Predetermined Area from the Main Menu.
2. Tap the first power button and then select the Tap Points... option. Tap the points in the map view in the order that they occur in the boundary where the hinge point is tapped last.
3. Enter the direction of the left side of the boundary in the last field. In this example, the azimuth is 0.
4. Check the Store Pt 1 checkbox and specify a point number in the same field if you want the endpoint of the computed line to be stored.
5. Enter the desired area (7 acres in this example) and select the Hinge radio button.

Note: The boundary can have as many points as you desire, but the selected points must begin with the starting point of the fixed line that the hinge line intersect with and end with the hinge point.

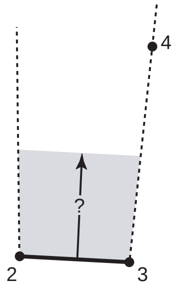
6. Tap Solve. The final boundary side will be computed and the data can be viewed by using the Results and Map tabs. If you selected to store a point in Step 3, the computed point will also be stored.

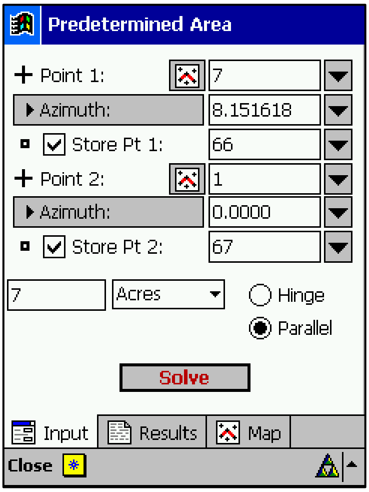


Parallel Method

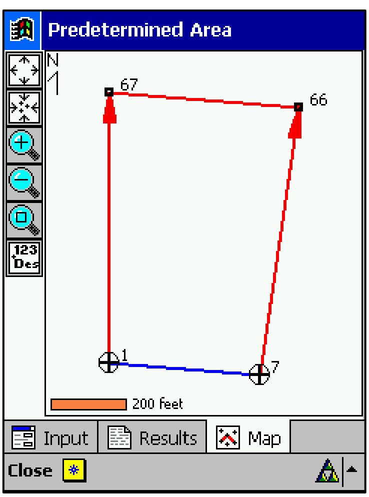
The Parallel Method computes the location of one side of a four-sided boundary where the computed side is parallel to a stationary side of the boundary.

Using the same lot as we used above, we will compute the location of a line in a 1/3-acre boundary that is parallel to line 2-3 and intersects with a line that runs north from Point 2 and Line 3-4 as shown here.





1. Tap Cogo, Predetermined Area from the Main Menu.
2. Enter the first point that defines one of the sides of your three-sided boundary in the Point 1 field.
3. Define the direction of this side of the boundary that will intersect with the endpoints of the computed line. For this example, you would tap the second power button and select Choose From Map… and then tap Points 7 and 1.
4. Enter the second point that intersects with the other side of the boundary in the Point 2 field and assign it an azimuth of 0 in the field below.
5. If you want to store points where the computed line intersects with the two sides, check each Store Pt box and specify point names in the corresponding fields.
6. Define the area of the boundary in the next field (7 acres in this example) and select the Parallel radio button.



7. Tap Solve. The final boundary side will be computed and the data can be viewed by using the Results and Map tabs. If you selected to store points, the computed points will also be stored.

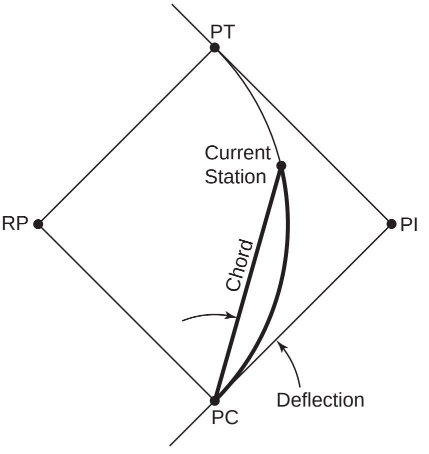
Horizontal Curve Layout

The Horizontal Curve Layout screen is useful to compute the locations of any station along a horizontal curve using one of four different methods. The values computed can be written down and used to later stake those stations in the field.

1. Tap Curve, Curve Layout from the Main Menu.
2. Select the method that you want to use to compute your curve layout data in the Method field. Each method is described below.

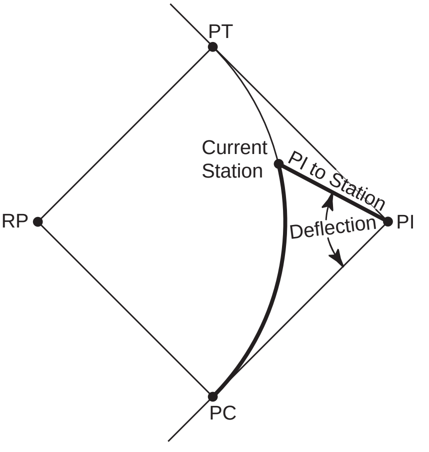
PC Deflection

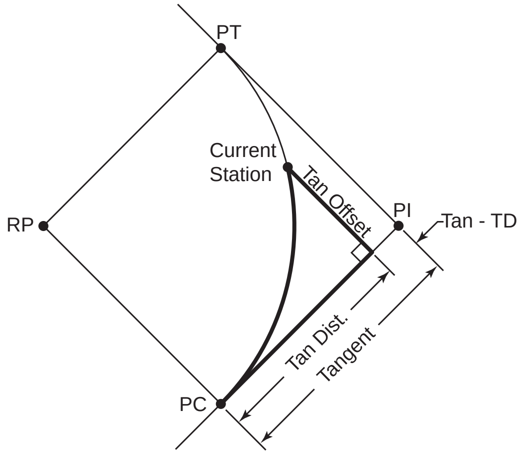
The PC Deflection method computes a chord length from the PC to the current station and a deflection angle between the PC-PI line and the chord.



PI Deflection

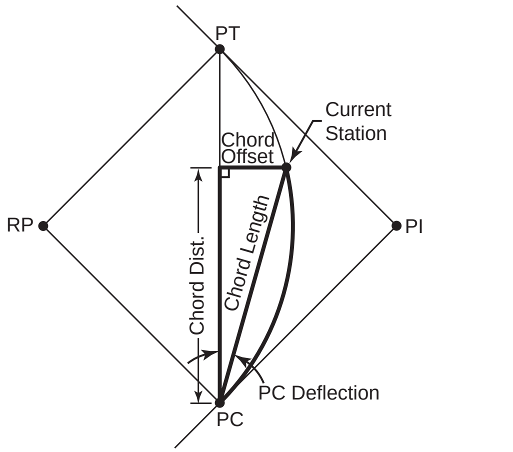
The PI Deflection method computes the distance from the PI to the current station and the deflection angle between the PI-PC line and the PI to Station.





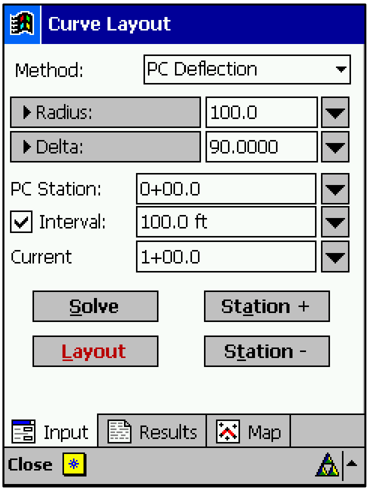
Tangent Offset

The Tangent Offset method computes a perpendicular offset length (Tangent Offset) from the PC-PI line to the current station and the distance on the PC-PI line from the PC to the Tangent Offset (Tangent Distance).



Chord Offset

The Chord Offset method computes a perpendicular offset length from the PC-PT line to the current station (Chord Offset), the distance on the PC-PT line from the PC to the chord offset (Chord Distance), the distance from the PC to the current station (Chord Length) and the deflection angle from the PC-PT line to the PC-Station line.



3. Define your horizontal curve by making the appropriate selections from the first two buttons and filling in the corresponding values.

4. Enter the station to be assigned to the PC in the PC Station field.

5. Check the Interval box if you want to compute data for stations at fixed intervals on the curve and enter the distance between them in the same field.

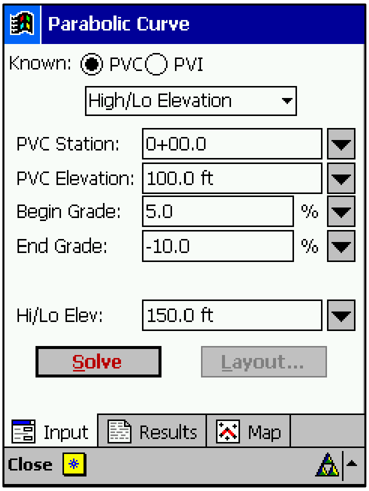
6. Enter the station that you want to compute in the Current Station field and tap Solve.

7. Tap the Results tab to view the numerical information for the location of the current station. Tap the Map tab to view a graphic of the current station on the curve.

8. Tap Station + to advance the current station by the specified station interval or tap Station - to subtract the station interval from the current station.

Parabolic Curve Layout

The Parabolic Curve Layout screen is useful to compute the locations of any station along a vertical curve when two parts of the curve are already known. The values computed can be written down and used to later stake those stations in the field.



1. Tap Curve, Parabolic Curve from the Main Menu.
2. In the Known field, select if the station and elevation for the PVC or the PVI are known by selecting the appropriate radio button. Also specify if the Curve Length, Point on Curve, or High/Lo Elevation is known from the dropdown list. (The remaining information that must be entered will vary depending on the choice made here.)
3. Fill in each field with the remaining information that pertains to your parabolic curve and tap Solve.

Note: The length of a parabolic curve is the horizontal distance from the PVC to the PVT.

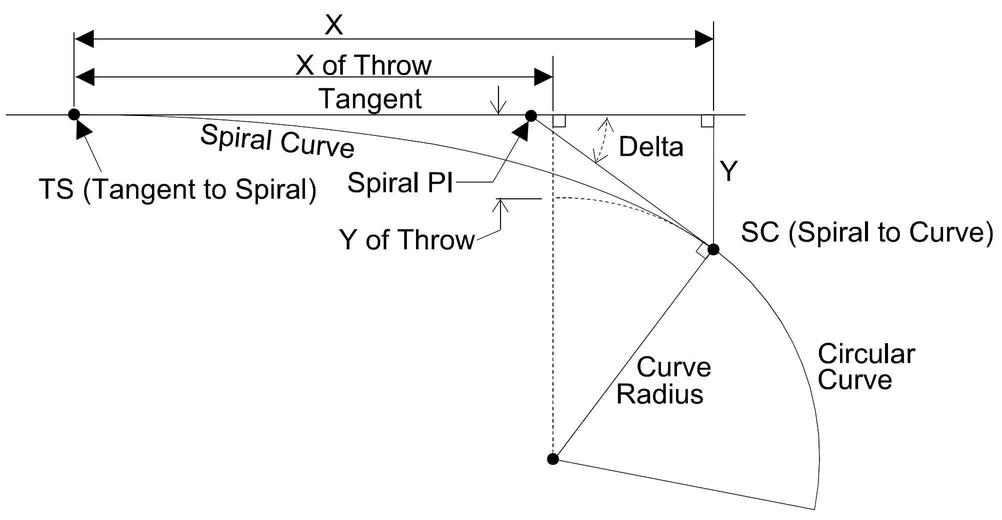
Note: The horizontal distance from the PVI to the PVC always equals the horizontal distance from the PVI to the PVT

Spiral Layout

A spiral curve is a special curve that has a specified radius at one end, which gradually changes to an infinite radius at the other end. It is commonly used as a transition between a straight section and a circular curve.

The Spiral Layout screen is used to calculate the pertinent parts of a circular curve after specifying the spiral curve's radius and length.

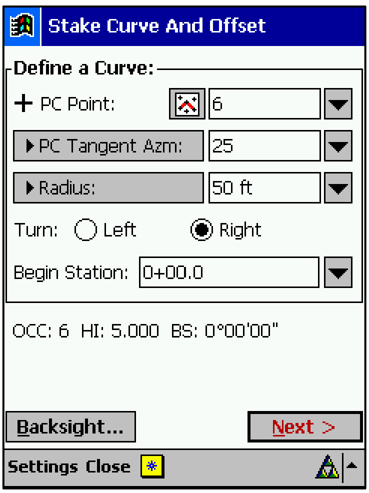
1. Tap Curve, Spiral from the Main Menu.
2. Enter the radius of the spiral curve in the Curve field.
3. Enter the length of the spiral curve in the Length field.
4. Tap Solve. The details of the specified spiral curve can be viewed by tapping the Results and Map tabs.



Curve and Offset

The Curve and Offset screen allows you to design a curve and stake it in the field. You can stake the curve's centerline or an offset to the curve at any specified station interval.

Define Your Curve



1. Tap Stakeout, Curve and Offset from the Main Menu.
2. If you have not yet setup your backsight, tap the Backsight... button and set it up.
3. Specify the point that you will use for the PC of your curve in the PC Point field.

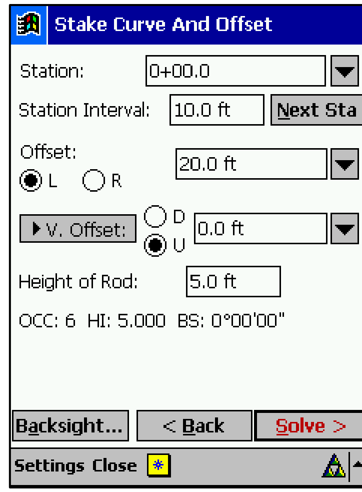
Tip: You can use the power button, ▼ to select a point from your map.

4. Define the direction of the tangent azimuth at the PC of your curve by selecting ▸ PC Tangent Azm or ▸ PC Tangent Brg and enter the appropriate value in this field.
5. Define the size of the curve by selecting ▸ Radius, ▸ Degree Arc, or ▸ Degree Chord and enter the appropriate value in this field.

Note: Since the length of the curve is not required, you can potentially stake a 360° curve.

6. Select the radio button that defines if the curve turns toward the Left or Right as you view the curve from the PC.
7. Enter the station that you want to assign to the PC in the Begin Station field. (This value is typically zero.)
8. Tap Next> to continue.

Set Up Your Staking Options



9. Enter the first station that you want to stake in the Station field.

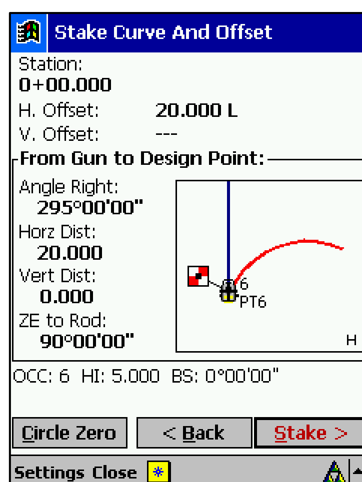
10. Enter the desired spacing between the staked stations in the Station Interval field.

11. In the Offset field, select L if you wish to stake an offset on the left side of the curve, or select R if you wish to stake an offset on the right side and enter the desired offset here. (If you are not staking an offset, enter an offset of zero.)

12. Tap the ▸V.Offset / ▸Grade button if you want to account for a vertical offset or percent grade for the staked points and enter the appropriate valued in the same field. When specifying a vertical offset, you must also select the D or U radio button to indicate if the specified offset is downward or upward from the design point, respectively.

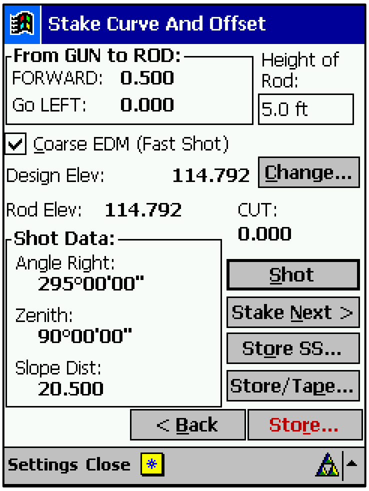
13. Enter the current rod height in the Height of Rod field and tap Solve>.

Aim the Total Station



14. Using the information displayed on the screen, aim the total station toward the design point and tap Stake >. The graphic portion of the screen shows the curve, backsight direction and design point location relative to the total station.

Stake the Point

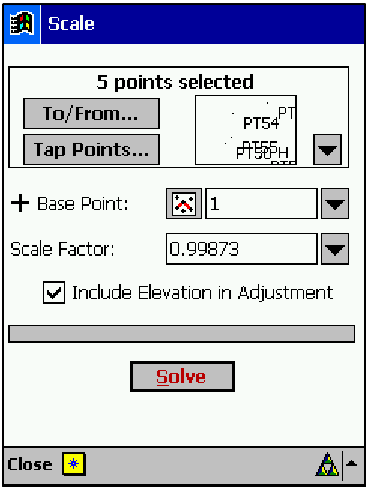


15. The final screen allows you to stake the current station. With the rod positioned where you want it, tap the Shot button to take a shot. If necessary, move the rod and take another shot until it is over the design point.

16. Tap the Store button to save the stake point. You will automatically be returned to the second screen (Step 9) where you can then tap the Next Sta button to advance the current station by the station interval and stake the next point.

Scale Adjustment

The Scale routine will adjust the coordinates of selected points by a specified scale factor relative to a base point. This is useful to repair data that was collected where an incorrect scale factor was applied.



1. Tap Adjust, Scale from the Main Menu.
2. Use the Tap Points... or To/From... button to specify the points that you want to adjust.
3. Enter the name of the base point in the Base Point field.
4. Specify the scale factor to apply in the Scale Factor field.
5. If you also want to adjust the elevations of the selected points, check the Include Elevation in Adjustment checkbox.
6. Tap Solve. The coordinates for the selected points will be adjusted.

Note: If you choose to also scale elevations, the scale factor will be applied to the difference in elevation between the base point and each selected point. For example, if the base point elevation was 100 and the elevation for a selected point was 150, applying a scale factor of 0.5 would result in an elevation of 125 for the selected point.

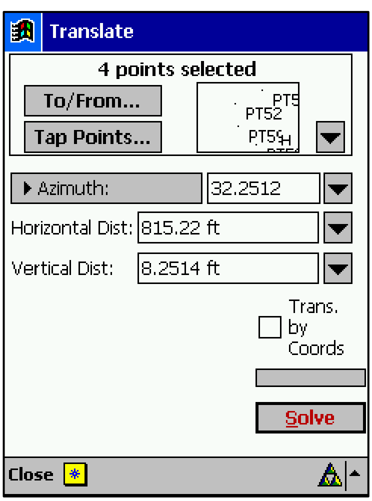
Translate Adjustment

The Translate routine will move points horizontally and/or vertically a specified distance and direction. This routine is often used after a survey was performed in an assumed coordinate system. If the actual coordinates for at least one of the points is found later, the Translate routine can be used to shift all of the affected points to the correct coordinate system and/or elevation.

1. Tap Adjust, Translate from the Main Menu.
2. Use the Tap Points... or To/From... button to select the points that need to be adjusted.
3. Define the direction and distance for the adjustment using either of the following two methods:

Translate by Distance and Direction

The Translate by Distance and Direction method simply requires that you enter the distance and direction to adjust the selected points.

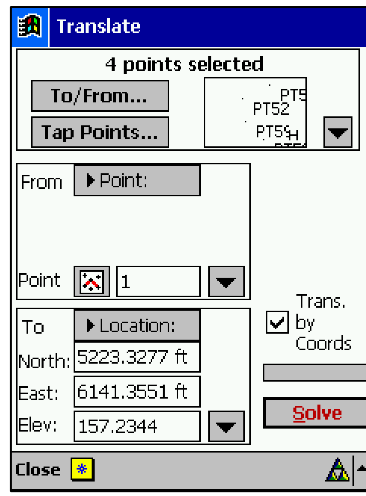


- Leave the Translate by Coordinates checkbox **un**checked.
- Toggle the Azimuth / Bearing button to the desired format and enter the direction to adjust the selected points.
- Enter the horizontal distance to adjust the selected points in the Distance field.
- Enter the elevation to adjust the selected points in the Elevation field.
- Tap Solve. The selected points will be adjusted by the direction and distance entered.

Translate by Coordinates

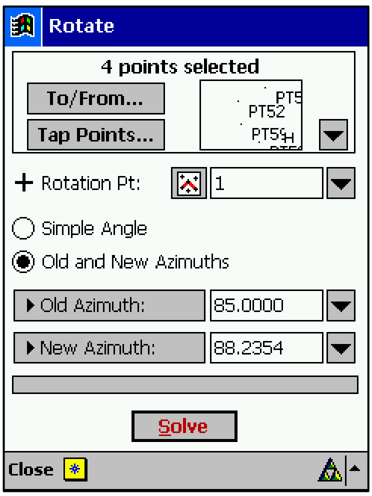
The Translate by Coordinates method requires that you define a starting location and an ending location. The adjustment will then move all of the selected points in the direction and distance as defined between the starting and ending locations.

- Check the Translate by Coordinates checkbox.
- In the From area, enter the starting location by tapping the ▸ Point / ▸ Location button and either specify an existing point name or enter coordinates.
- In the To area, define the ending location in the same way as you did for the starting location.
- Tap Solve. The selected points will be adjusted in the same direction and distance as between the starting and ending location.



Rotate Adjustment

The Rotate Adjustment routine will rotate selected points around a specified rotation point.

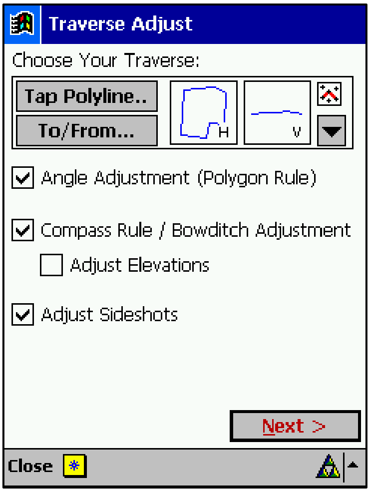


1. Tap Adjust, Rotate from the Main Menu.
2. Use the Tap Points... or To/From... button to select the points that need to be rotated.
3. Enter the point that the selected points will rotate around in the Pivot field.
4. Select a radio button for one of the following rotation methods:
   - If you select Simple Angle, simply enter the rotation angle in the appropriate field.
   - If you select Old and New Azimuths, enter an Old Azimuth and New Azimuth in the appropriate fields. (The rotation angle used is the computed angle from the old azimuth to the new azimuth.)
5. Tap Solve. The selected points will be rotated around the rotation point by the specified angle.

Traverse Adjust

The Traverse Adjust wizard will perform an angle adjustment, a compass rule adjustment, or both.

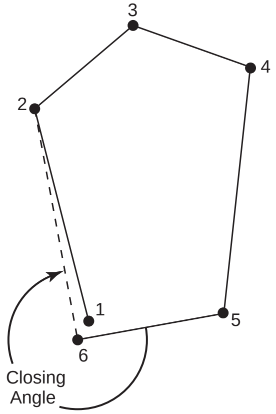
Angle Adjust



The Angle Adjust routine will compute the angular error in a closed traverse from a known closing angle. It will then distribute that error equally among all of the internal angles so that the resulting sum of the angles will equal (N–2)·180° because the sum of the internal angles of any closed polygon can be computed using this formula, where N is the number of sides of the polygon.

After performing an angle adjustment, all of the points except for the first two points will be adjusted. (The azimuth of the first leg will remain constant.)

The closing angle provided is used to compute the angular error. It is the angle as you occupy the closing point, aim toward the second point and turn an angle-right to the second-to-the-last traverse point (see illustration).



Note: An angle adjustment does not always adjust the closing point to a location that is closer to the starting point.

Compass Rule

The Compass Rule Adjustment will adjust either a closed or an open traverse. When adjusting a closed traverse, the error between the closing point and the initial point is computed and distributed among each traverse point, except the initial point resulting in a perfect closure. When adjusting an open traverse, the error between the final point's actual location and specified theoretical location is computed and distributed among the traverse points in the same way as with a closed traverse.

Typically the Angle Adjust option should also be selected to remove the angular when performing a compass rule adjustment.

Adjust Elevations

The Adjust Elevations option only applies when performing a Compass Rule adjustment. If this option is selected, the elevations for the adjusted points will also be adjusted along with the horizontal coordinates resulting in perfect closure vertically as well as horizontally. If this is unchecked, the traverse will only be adjusted horizontally.

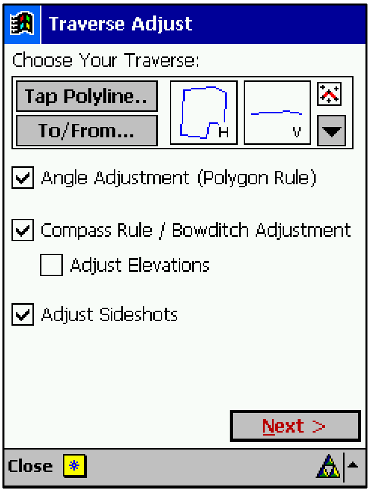
Adjust Sideshots

The Adjust Sideshots option allows you to also adjust any side shots that were stored while occupying any of the traverse points in the selected traverse.

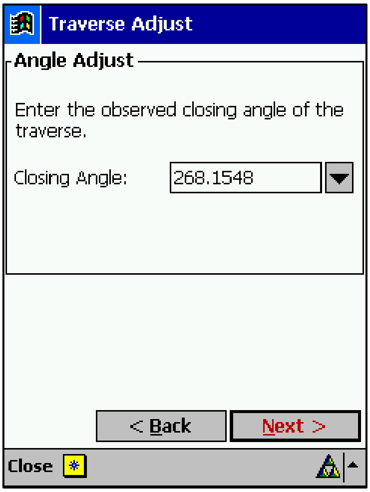
The side shots that will be adjusted are determined by the information stored in the raw data. Because of this, the end user cannot explicitly define which side shots to include or exclude from the adjustment.

The side shots are adjusted by first computing the new locations of the traverse points, which are the occupy and backsight points for the side shots. The routine will then read the original angles and distances recorded for each side shot and apply those measurements to the adjusted locations of the appropriate traverse points.

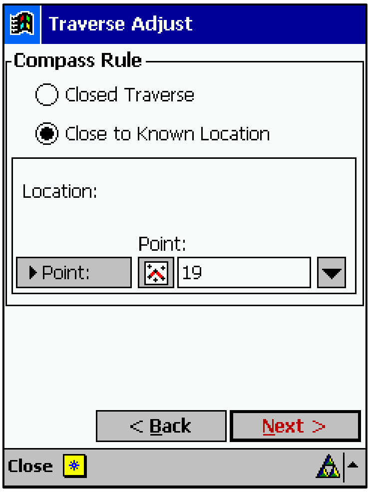
Performing a Traverse Adjustment



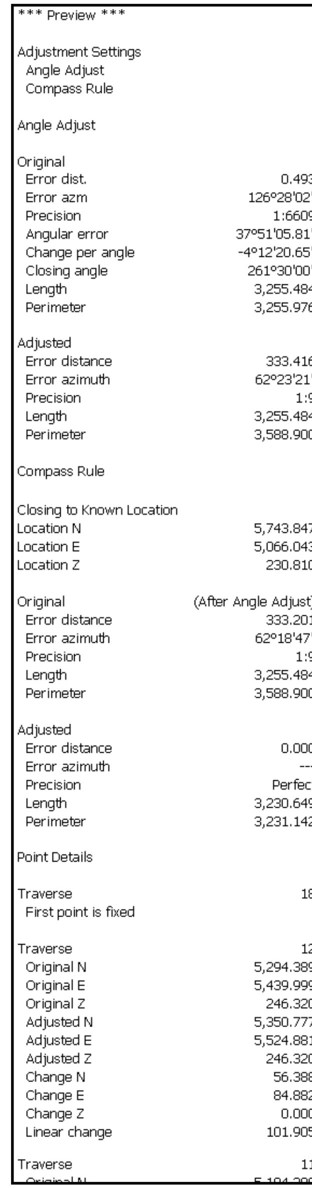
1. Tap Adjust, Traverse Adjust from the Main Menu.
2. Use the Tap Polylines... or To/From... button to select the polyline or points that define your traverse, which should be in the same order that the traverse points were collected.
3. Select the appropriate checkboxes to define the type of adjustment(s) to perform and what will be adjusted.
4. Tap Next > to continue to the next screen. The screen that opens will depend on the selections made from the main screen.



5. If an angle adjustment is being performed, the screen shown here will open. Enter the closing angle for the traverse in the form of an angle-right.
6. Tap Next > to open the next screen of the adjustment wizard.



7. If a Compass Rule adjustment is being performed, the screen shown here will open. Select Closed Traverse if you are adjusting a closed traverse or select Close to Known Location if you are adjusting an open traverse and closing to a known point or location. A closing location can be defined by an existing point or known coordinates by toggling the ▸ Point / ▸ Location button accordingly.



Note: if closing to a known location and a closing location is not specified, it is automatically assumed that the first point of the traverse will be the closing location.

8. Tap Next > to open the final screen of the adjustment wizard, which displays the changes that will be made by the adjustment where they can be previewed before the actual adjustment is applied.

   The screen lists the adjustment details in three main sections: the angle adjustment details; the compass rule adjustment details, and the point details where the before-and-after coordinates for each point are listed. An example of the information provided in this screen is shown here.

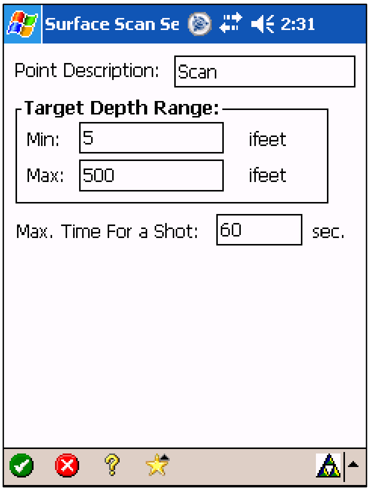
9. If you are satisfied with the changes that will be made by the adjustment routine, tap Adjust to perform the adjustment.

Surface Scan

The Surface Scan routine will automatically take a sequence of shots within a predefined area when used with a robotic total station running in reflectorless mode. The data collected can then be used with PC software to create a 3-D raster image of the surface or to generate a DTM surface, which can be used to compute volumes.

Before starting a scan, you should check the Surface Scan settings.

1. Select Survey > Surface Scan to open the Surface Scan routine.
2. Tap the button to check your settings.



   a. The Point Description will be used for each scanned point that is stored.

   b. The Target Depth Range is used to specify a minimum and maximum distance range for points located on the surface to be scanned. If any shot taken has a distance that falls outside the range specified here, that point will be rejected. (This is useful to automatically reject any points that do not fall on the surface you want to scan.)

Note: You can select > Remote Control to quickly measure some distances to determine your Target Depth Range. (EDM Mode must be set to Track.)

   c. If any shot in the surface scan takes longer than the time specified in the Maximum Time For a Shot field, that shot will be rejected and the routine will move on to the next shot.

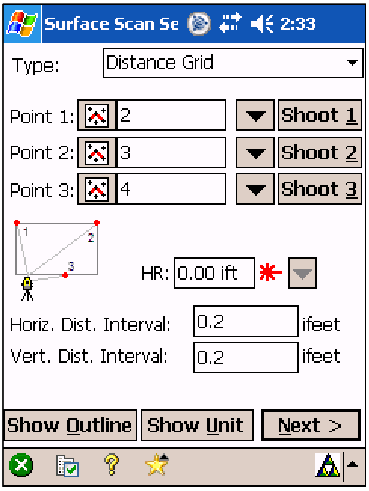
   d. Tap to return to the Surface Scan screen.

The Surface Scan routine requires that you first define the perimeter of the surface you want to scan along with the interval that determines how many shots will be taken within the perimeter. The more shots that are taken, the more detailed the surface scan will be, but the longer it will take to complete.

3. In the Select Type of Surface Scan field, select if you want to use either the Distance Grid method or Angle Grid method to set up the surface to shoot. Each method is described below.

Distance Grid

The Distance Grid method requires three shots to be taken to define the perimeter of the surface that you want to scan. The first and second shots must be in the upper left and right corners of the surface and the third shot can be anywhere along the lower edge of the surface.



a. Enter a point name for the first (top-left) point of your surface in the Point 1 field.

b. Aim the total station at the point and tap Shoot 1. The New Point screen will open where you can provide a new description for the point before storing it.

c. Shoot Point 2 and Point 3 to define the upper-right corner and bottom edge, respectively, of the surface in the same way Point 1 was shot.

Note: If any of the three points were stored during a previous scan, the point numbers can be entered manually without re-shooting them.

The Horizontal Distance Interval and Vertical Distance Interval fields are used to configure the spacing between each shot taken within the boundaries of the surface. The smaller the distances entered here, the more shots will be taken, resulting in a more detailed surface, but while taking more time to complete.

d. Enter the desired horizontal distance between each shot of the surface being scanned in the Horizontal Distance Interval field.

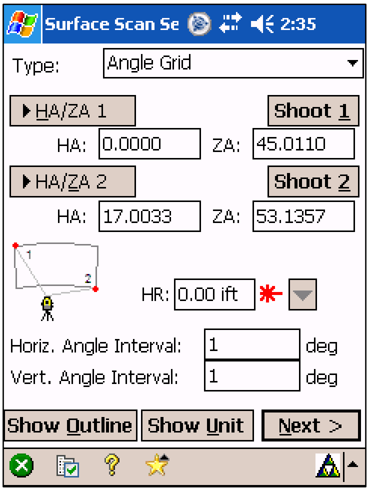
e. Enter the desired vertical distance between each shot of the surface being scanned in the Vertical Distance Interval field.

Distance Grid Advantage and Disadvantages

The advantage of using the Distance Grid method is it is more intuitive to set up the spacing between shots (distance interval) since the distance interval can be measured on the surface being scanned and irrelevant of how far the total station is from the surface.

The disadvantage of the Distance Grid method is it must be possible for the total station to measure distances to the three required shots that define the surface perimeter. The curvature or shape of some surfaces would make measuring distances to all these points impossible.

Angle Grid



The Angle Grid method requires angle measurements to be taken at two opposing corners of the surface to be scanned. (It is not required to shoot distances to these points.)

There are three ways to define the two corner points, but most users will choose to shoot the points with a total station as described below. The first of the other two method is to enter the horizontal and zenith angles by hand in their respective HA and ZA fields. The third method is to toggle the ▸ HA/ZA button for the respective corner to ▸ Point where an existing point can be selected.

a. Aim the total station in the upper-left corner of the surface to be scanned and tap Shoot 1.

b. Aim the total station in the lower-right corner of the surface to be scanned and tap Shoot 2.

Note: The two corner points in the Angle Grid method must encompass the area to be scanned – they do not have to be on the surface itself since no distances are measure to these points.

The Horizontal Angle Interval and Vertical Angle Interval fields are used to configure the spacing between each shot taken within the boundaries of the predefined surface. The smaller the angles entered here, the more shots will be taken, resulting in a more detailed surface, but while taking more time to complete.

c. Enter the desired horizontal angle to turn between each shot of the surface being scanned in the Horizontal Angle Interval field.

d. Enter the desired vertical angle to turn between each shot of the surface being scanned in the Vertical Angle Interval field.

Angle Grid Advantage and Disadvantages

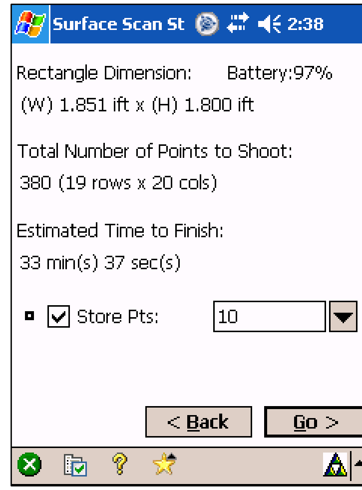
The advantage of using the Angle Grid method is the corner points that define the perimeter of the surface must only encompass the surface and do not have to be on the surface itself.

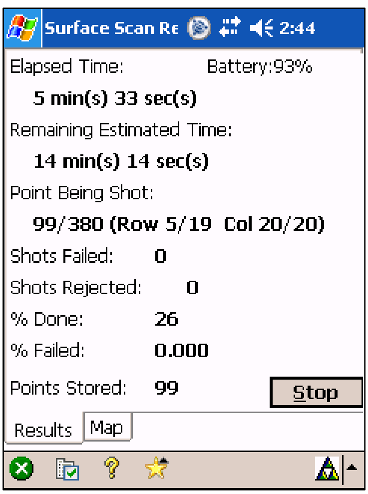
The disadvantage of the Angle Grid method is the spacing between each shot is based on the angles provided. The spacing is therefore affected by the distance between the total station and the surface being scanned. Finding a suitable angle interval may require some trial and error.

4. The HR should almost always be left at the default value of zero since all shots taken are reflectorless (no rod).
5. The Show Outline button is useful when the laser pointer is activated on the total station. Tapping this button will instruct the total station to “draw” a box around the perimeter.
6. The Show Unit button is similar to the Show Outline button, except it will draw a box around a single horizontal/vertical interval. This is useful to verify your interval results in satisfactory spacing.
7. Tap Next > to continue to the Surface Scan Statistic screen.

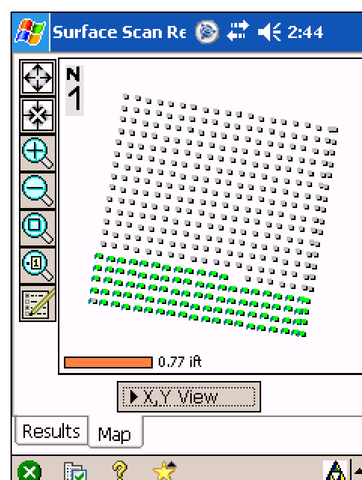
The Surface Scan Statistics screen displays useful information about the computed surface to be scanned, including an estimate on how long it will take to complete the surface scan.

8. Be sure to check the Store Pts box to store all the points that are scanned and specify the starting point number in the corresponding field.
9. Tap Go > to start the surface scan and open the Surface Scan Results screen.





The Surface Scan Results screen displays information related to how far along the routine is with the scan. It can be stopped early with the Stop button.



You can tap Map to view the Map card, which shows all the points that have been scanned in green, any points that were rejected in red and the points that have yet to be scanned in gray. (Existing points are displayed as smaller black squares.) You can toggle between an ▸ X,Y View or an ▸ X,Z View.

Leveling Fieldwork

Leveling is one of three possible surveying modes that can be used with Survey Pro.

Leveling mode in Survey Pro can only be used after purchasing and registering the Leveling Module. (See Page 4 for more information on registering modules.) Once registered, level loops and the 2 peg test can be performed.

Leveling data collection is organized into loops. A level loop is a series of level measurements that start with a backsight on a known point with a valid elevation. This point is referred to as the *Starting Benchmark*. The level loop is closed with a foresight to another known point, called the *Closing Benchmark*. A level loop can close on the starting benchmark or a different point with a valid elevation.

A level loop can have two states: open and closed. Once a new loop is created, it is automatically opened. It will remain open until you decide to close the loop. A level loop is closed after the shot is taken to the closing benchmark.

Level loops are stored within the current raw data and job files, which can contain any number of level loops.

Any open loop can be selected from the current job as the active loop for data collection. Once a loop is closed, it cannot be reopened for data collection and can only be viewed or adjusted.

Key Terms

Level Loop: A level loop is a series of data collection observations where a known elevation is initially recorded and used to precisely determine the elevation at other locations. A level loop is usually closed to the same benchmark where the loop was started, but can also be closed to any other benchmark with a known elevation.

Turning Point: An intermediate point used in a level loop that the rod occupies that is not a benchmark. Turning points are not stored in the job, they are not permanent marks on the ground, and only exist while the rod occupies them during the foresight/backsight measurements.

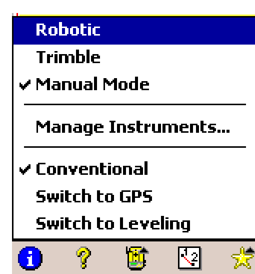
Benchmark: A point in a level loop that is stored in the current job. Benchmark points are usually permanent marks on the ground that can be reoccupied at a later date. Benchmarks are part of the level loop since they are used as the backsight for the next setup, with the exception of the closing benchmark.

Leveling Side Shots: An intermediate shot from any setup in the level loop. Side shot points are stored in the job file, but are not part of the loop (they are not used as the backsight for any setup).

Leveling Stake Points: An intermediate shot from any setup in the level loop where the elevation is compared to a design point to provide cut/fill values.

Turning Points vs. Sideshot/Stakeout Points: A level turn is the BS – FS observation that calculates the elevation of the next point in the loop. A level turn always advances the level to the next setup in the loop. A side shot or stake out is a FS observation to calculate an elevation of a point not in the loop. A side shot or stake out observation does not advance the level to the next setup in the loop.

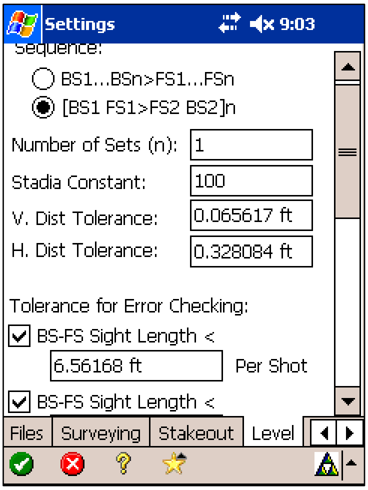
Leveling Set Up



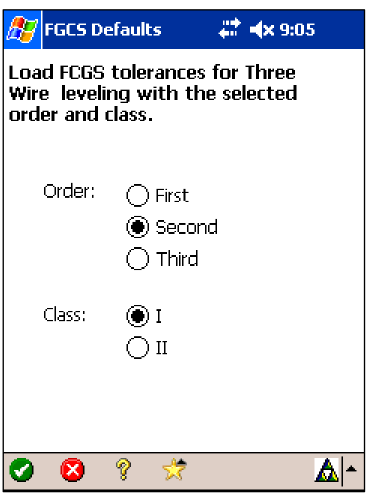
To switch to Leveling Mode, tap the instrument icon in the Command Bar of the Main Menu and then select Switch to Leveling. The leveling instrument icon in the Command Bar indicates Survey Pro is in Leveling Mode.

When Leveling Mode is active, the Surveying menu item is replaced with the Leveling menu item and the Stakeout menu items are disabled.

Level Settings



The Level Settings screen is where the shooting sequence and leveling tolerances are configured. Fill in the screen as necessary. If any shots exceed the tolerance specified and the corresponding checkbox is checked, a prompt will appear to warn you. Consult the Reference Manual for more information on the individual fields in this screen.



The Load FGCS Defaults button will open the FGCS Defaults screen where you can specify a particular order and class for the level loop. This will then automatically fill in all the tolerances on the previous screen with the default FGCS values.

Note: It is important to recognize that Survey Pro can only display a warning if tolerances are not met. It is up to the surveyor to determine if the level loop meets the criteria for a particular standard.

Leveling Methods

Survey Pro supports the following leveling methods:

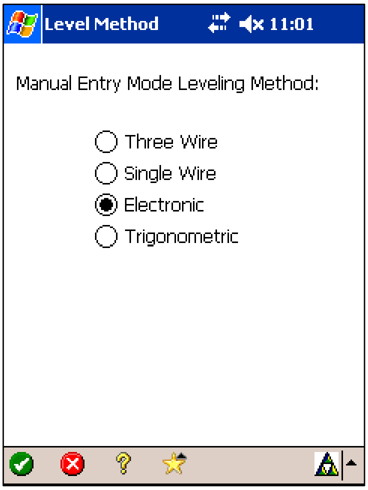
- Three Wire
- Single Wire
- Electronic
- Trigonometric

All of the leveling methods can be performed in Manual Mode, where the readings are read from an instrument and then manually keyed into the data collector. Electronic and trigonometric methods can be performed automatically, where the data collector communicates directly with the instrument and the readings are automatically transferred to the data collector.

Auto Leveling

If using an instrument where the data will be entered electronically, activate the existing instrument profile.

1. With Survey Pro in Leveling Mode, open the Job > Settings > Instrument screen.
2. If an instrument profile does not yet exist, tap the Create New Instrument button and create a new instrument profile. (See the Instrument Settings screen in the Reference Manual for more information on instrument profiles.)



Manual Leveling

If you will be entering data manually, select and activate the Manual Mode and tap Activate to activate it and then tap Instrument Settings to open the Level Method screen. Select the manual leveling method you want to use and tap ✓.

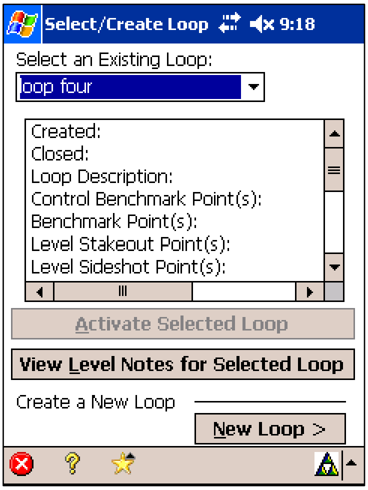
Level Loop Procedure

The procedure for leveling with Survey Pro is nearly identical no matter which method you are using. The main difference for each method is the type of information that is entered with each shot taken.

The steps that follow explain the procedure for taking all four various types of shots: Turning points, side shots, stakeout, and benchmarks. The various prompts for data entry while collecting in Manual Mode are also covered for each leveling method.

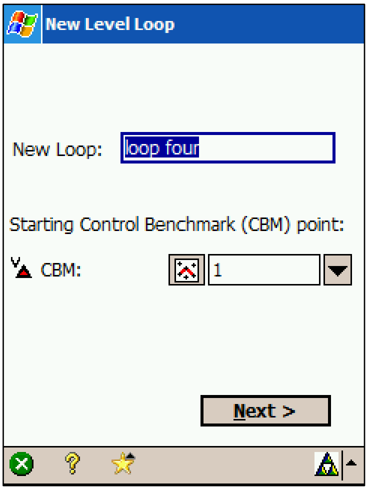
For the examples below, it is assumed you have already activated Leveling Mode and have configured your instrument and level settings. You should also already have a point stored in the current job with an accurate elevation to use as your starting benchmark.

Creating a New Loop

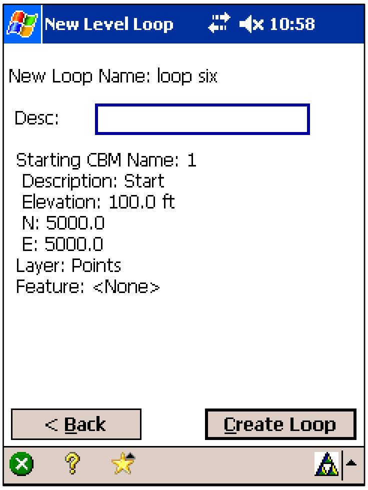


1. From the Main Menu, select Leveling > Select/Create Loop. This will open the Select/Create Loop screen.

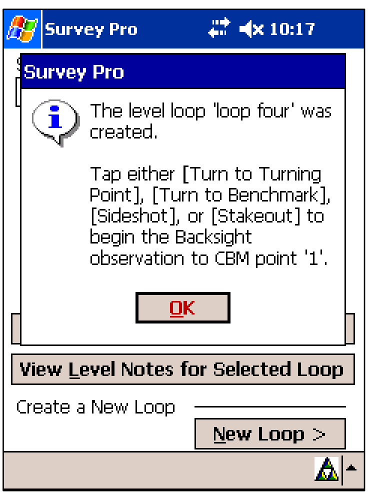
   You can select an existing loop that has not yet been closed, or create a new loop. Selecting a closed loop will display detailed information about that loop.



2. Tap the New Loop > button. The New Level Loop screen will open.
3. Enter a name for the new loop in the New Loop field and enter your starting benchmark in the CBM field. Tap Next > to continue.

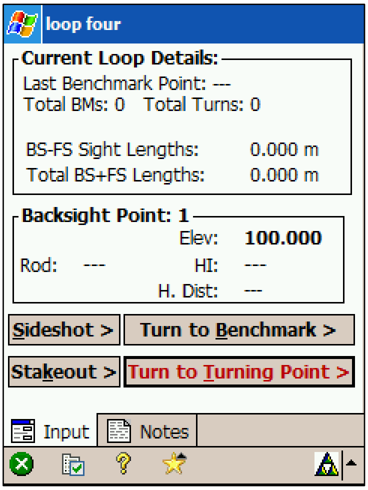


4. The details of the new loop are displayed on this screen. You can optionally enter a description for the new loop and then tap Create Loop to create and open the new loop.



5. A prompt will tell you that the new loop has been created. Tap OK and you will automatically be taken to the Level screen where you can begin collecting data.

Level Screen



6. This is called the Level screen, although the title bar displays the name of the current level loop. The Level screen will automatically open after a new loop is created, or if an existing loop (that has not yet been closed) is selected. It can also be accessed manually from the Main Menu by selecting Leveling > Level.

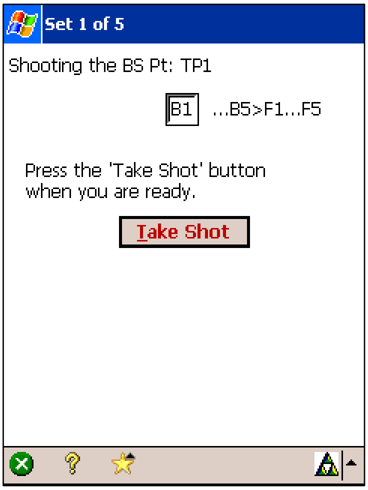
   The Level screen is used to indicate which type of shot you want to take next. Most of the time you will be shooting a turning point, as described in Step 7, and immediately begin taking shots.

   The other three options will open an intermediate screen where you must first provide additional information before taking shots.

   Once the necessary shots are taken for the selection made from this screen, you will return to this screen to make another selection. This process is repeated until the level loop is completed.

   When you access this screen for the first time after creating a new level loop, or after completing a set of shots, your next shot will always be at your current backsight no matter which type of shot you select from this screen. The backsight on the first shot of a new loop will always be at the starting benchmark.

Turn to Turning Point (Leveling Shots)



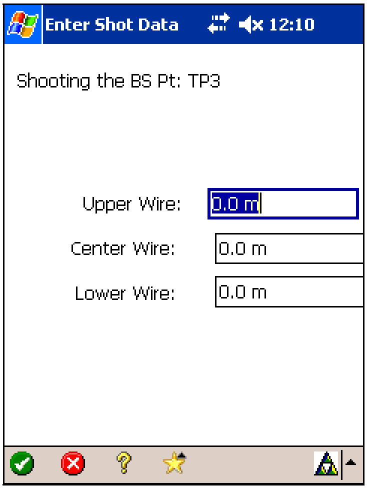
7. When shooting a turning point, you will immediately be prompted for the necessary shots for all sets in the sequence selected in the Level Settings screen (Page 203). This screen is also used when performing the actual shots for all the other types of shots that can be selected from the Level screen.

   The top line of this screen is saying that your backsight point for this setup is the first turning point that you shot for this loop (TP1), which indicates this is your second setup. If your backsight were a known point that was stored in the current job, the point name would be displayed here.

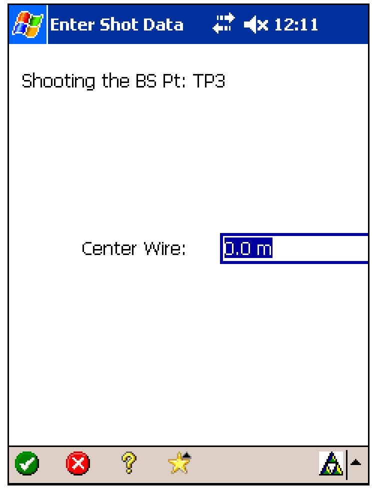
   The box on the second line tells you which shot to take next. The term B1 means to shoot the backsight for Set 1. If the box showed F3, it would mean to shoot the foresight for Set 3, and so on.

8. Tap the Take Shot button to take the shot.

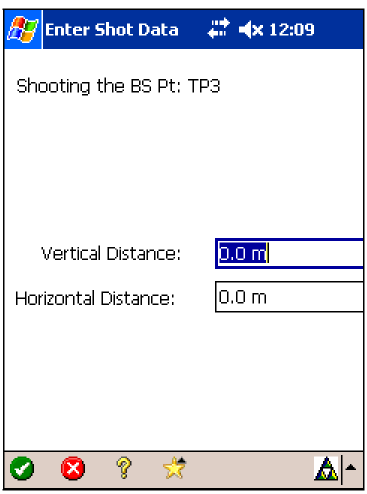
   When shooting in Manual Mode, you will be prompted to enter the shot data manually. The type of information required depends on which leveling method was chosen in the Level Method screen as described on Page 205. Each prompt is shown below.



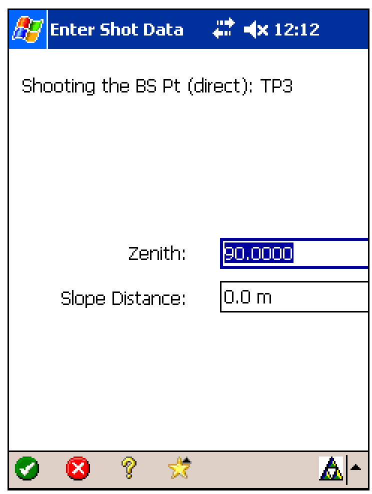
Three Wire Shot



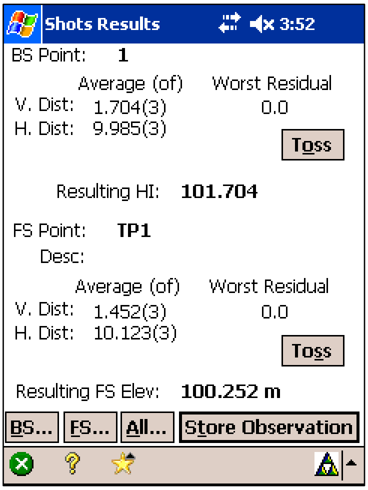
Single Wire Shot



Electronic Shot



Trigonometric Shot



9. Once all the shots in the sequence are completed, the Shot Results screen will open listing the details for each point.

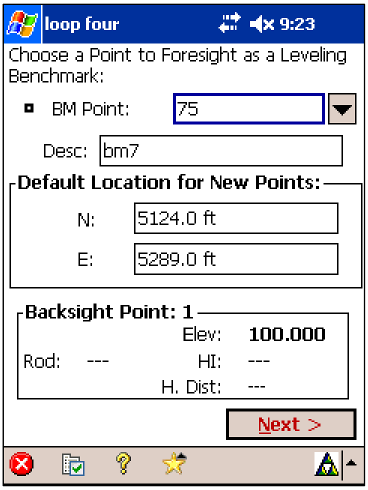
   You can remove the backsight and/or foresight shot with the worst residual by tapping the corresponding Toss button. The shots with the worst residuals are always removed first. Continuing to tap the button will eventually remove all the shots taken to that point.

   You can also add additional sets for the backsight, foresight, or both by tapping the BS... FS... or All... button, respectively.

10. If everything on the screen is acceptable, tap Store Observation to continue. You will return to the Level screen shown in Step 6.

If the completed shots were for a turning point or benchmark, you are expected to advance to the next setup where your previous foresight will become your new backsight. If you completed a side shot or stakeout shot, you will remain at the current set up to shoot additional points.

Turn to Benchmark



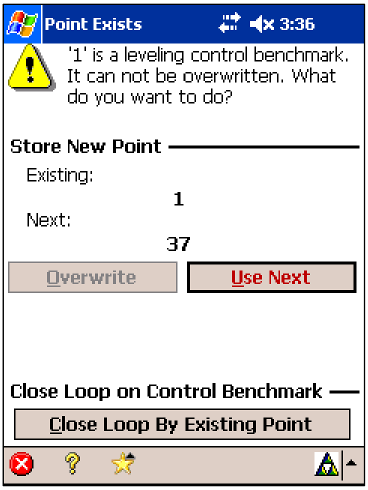
11. This option should be used whenever you will be shooting any benchmark other than the starting benchmark. (The starting benchmark is always the backsight for the first shot in a level loop.)

    Enter the benchmark point in the BM Point field. If this is a closing benchmark, this point must already exist in the current job.

    Shooting a benchmark other than the closing benchmark is similar to shooting a turning point, except the benchmark will either be stored as a new point, or if the point already exists, the elevation, or the elevation and coordinates can be overwritten with the values from this routine.

12. Tap Next > to continue.

Note: If you are intend to shoot your closing benchmark and accidentally tap Turn to Turning Point instead of Turn to Benchmark, you can simply cancel out of that screen to return to the Level screen and then make the correct selection.



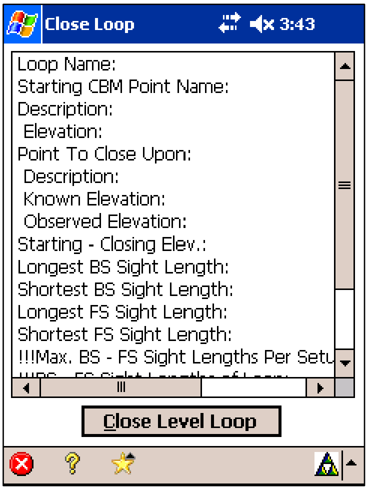
13. If shooting a point that already exists, the Point Exists screen will open.

    If you are not shooting your closing benchmark, tap Overwrite to overwrite the existing point with the new computed elevation, or tap Use Next to store the benchmark as a new point. You will then return to the Level screen and will not continue with the following steps.

    If you are closing your level loop to this benchmark, tap Close Loop By Existing Point to continue.

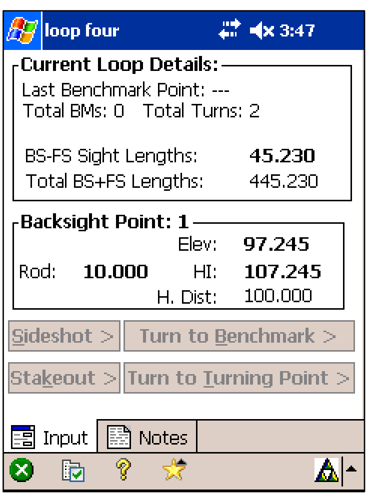
14. The next screen will prompt you to take the necessary shots as described in Step 7. Take the shots and store the observation to continue.

If you are not closing your level loop, you will return to the Level screen in Step 6. If you are closing your level loop, continue to the next step.



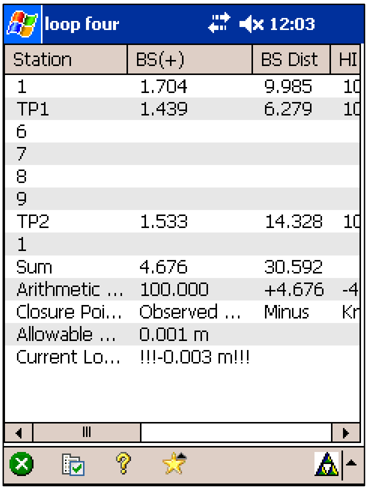
15. The Close Loop screen will open and display all the information about the loop. If you tap Close Level Loop, the loop will be closed and no more shots for that loop can be taken. You will then return to the Level screen and all the shot buttons will be grayed out.

Note: Once a level loop is closed, no additional shot data can be added to it.

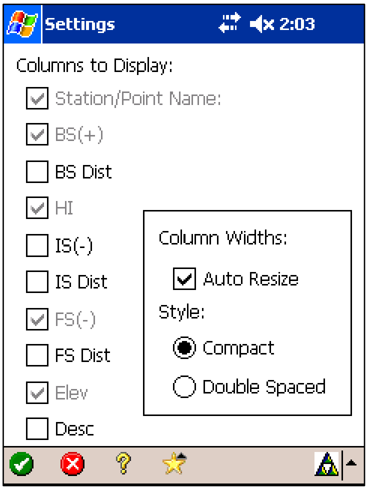


16. Tap the Notes tab to view all the information about the level loop.

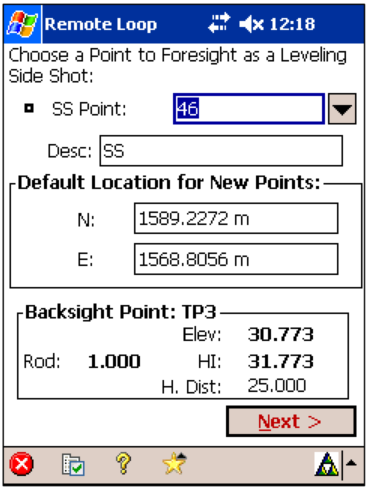
17. While viewing the notes for any level loop, you can tap the (Settings) button to customize the settings for this screen. (This is the only location where you can access this Settings screen.)



For more information on each field of this screen, consult the reference manual.



Side Shots



18. Prior to shooting a benchmark or turning point, you can shoot any number of leveling side shots to compute the elevation for any arbitrary points.

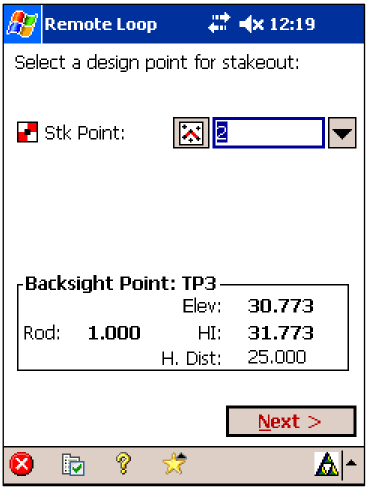
    Enter the point name in the SS Point field, and an optional description in the Desc field. Since the horizontal coordinates for the new point cannot be computed from the leveling routine, you must provide them manually in the N and E fields. Once you tap Next >, you can begin taking the necessary shots for the side shot in your shooting sequence, as described in Step 7.

    When you are finished, the new point will be stored, and you will return to the previous screen where you can select the next shot type. You will not advance to a new setup until after a turning point or benchmark is shot.

Note: Once a stakeout or side shot sequence is performed, the backsight for the current setup will be computed so any future shots from the same setup will only prompt you for foresight shots.

Stakeout

19. Shooting a leveling stakeout point is similar to a leveling side shot in that it must be done before shooting a benchmark or turning point from any particular setup, and once complete, you will return to the Level screen where the next shot type is selected, without advancing to the next setup.



Enter the point from the current job that you want to stake in the Stk Point field and tap Next > to take the necessary shots in your shooting sequence, as described in Step 7.

Since the horizontal coordinates cannot be computed from the leveling routine, it is assumed you already know the location of the stake point and only want to measure the elevation for that location to compute a cut/fill value.

Adjustment

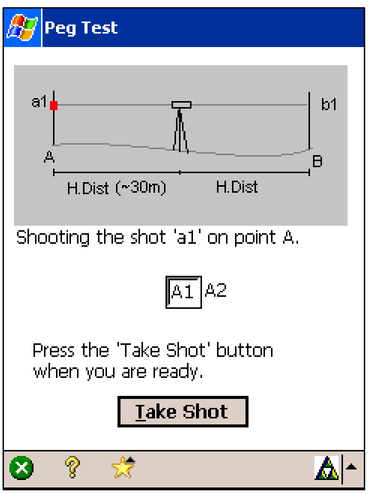
The Leveling > Adjustment screen can be used to remove the error computed from any existing closed loop. This is a simple arithmetic adjustment where the computed error can be either distributed equally among each setup in the loop, or a weighted adjustment can be distributed where setups that are farther apart will carry more of the error adjustment than those that are closer together.

See the Reference manual for more information on performing a level loop error adjustment.

2 Peg Test

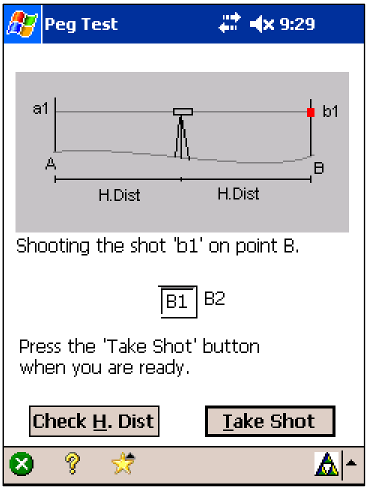
The 2 Peg Test is used to check the collimation error of the instrument. The test will compute the error, which can then be used to adjust the horizontal crosshair of the instrument.

1. Position two rods 50 to 90 meters apart (165 to 300 feet).
2. Pace off the distance between the rods and set up the level midway between them. (The placement of the rod over Point B can be adjusted after shooting Point A.)
3. Carefully level the instrument. You should be able to rotate the instrument 180° around its vertical axis without the bubble moving away from the center.



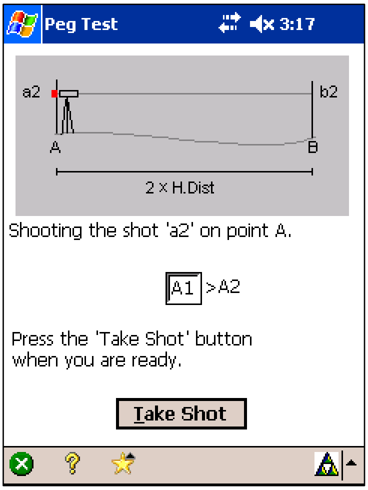
4. From the Main Menu, select Leveling > 2 Peg Test.
5. Tap Take Shot. The Leveling Shots screen will open where you will be prompted to take each set of shots to the rod over Point A. Once each shot is completed for the number of sets entered in the Level Settings screen, you will return to the Peg Test screen.
6. Turn the instrument to the rod over Point B.

7. You can optionally tap Check H. Dist to verify the instrument is centered between the two rods. The distance to Point B will be measured and compared to the horizontal distances previously measured to Point A and a come/go distance will be provided so the rod at Point B can be moved to equal the horizontal distance to Point A prior to taking the shots that will be used to compute the error.



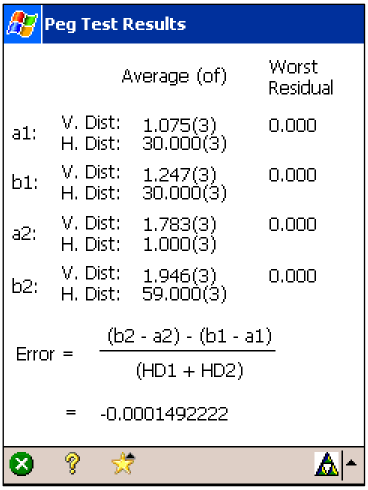
8. Tap Take Shot. The Leveling Shots screen will open again and prompt you to take the required shots to the rod over Point B. Once completed, the Peg Test screen will open with a new graphic showing the next setup.

9. Move the instrument as close as possible to the rod over Point A where a shot can still be taken to it. This is typically about 3 meters (10 feet) from the rod.



10. Tap Take Shot. The Leveling Shots screen will open again where you can take the required shots to Point A from the new setup.

11. Once complete, turn to Pont B and take the required shots to that point.



12. After the final shot is taken, the Peg Test Results screen will open showing the details of the shots taken and the computed error.

GPS Overview

This portion of the User's Manual includes basic fundamentals of GPS coordinate systems and measurements. The following section discusses how GPS coordinates are used in Survey Pro. Both of these sections contain general information that applies to both the GPS module and Basic GPS module.

Following these general sections are two sections that are specific for the GPS module and the Basic GPS module. Each of these sections provide instructions that guide you through how to set up GPS equipment and use Survey Pro for GPS data collection and stake out.

There are two methods to collect GPS measurements with Survey Pro: Real Time Kinematic (RTK), and data logging for post processing. Both methods calculate geodetic positions with a differential GPS solution using carrier phase pseudo range positioning. When doing RTK GPS, you will need to solve a coordinate system in the data collector to transform the real time geodetic coordinates into local coordinates for your survey. When doing post processing, you may solve a coordinate system in the PC software.

This section describes some basic concepts and terminology associated with RTK and post processing data collection. In this section, you will learn:

- Some basic terminology and theory required to understand GPS measurements.
- A description of the different GPS solution types, and the expected precision of each one.
- A description of the WGS84 datum and how to use different horizontal datum transformations in Survey Pro.
- A description of different vertical datums in North America.
- A description of geodetic and mapping plane coordinate systems.
- A description of scale corrections for the mapping plane, scale correction for height, and how to apply the combined scale factor to convert ground to grid distances.
- A description of using Ground Coordinates on a reference mapping plane.

- A description of geoid modeling and how to use geoid models for vertical transformations.

RTK and Post Processing

Using GPS for precise survey measurements requires data from two receivers to be collected simultaneously. There are two common methods for calculating positions with this data: Real Time Kinematic (RTK) and post processing.

In an RTK survey, at least one receiver acts as a base station, collecting GPS measurements and broadcasting the raw data over a modem link such as a radio, cell phone, or an Internet IP connection. The other receiver acts as a rover, receiving the base data and combining it with its own measurements for a real time solution of position at the rover.

The rover receiver can get the base data from a single base station setup in the field, or from a computer server delivering the base data over the Internet. Base data delivered over the Internet can use one of two methods: Single base, or Virtual Reference Station (VRS). Using data from a single base over the Internet is essentially the same as using a base station setup in the field. In this case the rover receives data from a single base station and calculates its RTK position where the expected precision is a function of the distance between the rover and the base. Using data from a VRS involves the network software calculating corrections from multiple base stations in the network. In this case, the rover receives data corrected for systematic errors and can calculate its RTK position with a precision similar to short baselines, even though the real distance to the base stations may be quite long.

In a post processing survey, two or more receivers log raw GPS measurements simultaneously to a file in the field. Then, the data is downloaded onto a computer where the differential solution is calculated (post processed) after the field data collection is completed.

Survey Pro can control GPS receivers for RTK, RTK simultaneous with post processing, and post processing only data collection.

GPS Measurements

GPS coordinates are computed using pseudo-range positioning. Pseudo-range positioning involves intersecting the ranges from the known SV position in a manner similar to a distance – distance intersection problem. Four SVs are required to determine three position dimensions and time. Position dimensions are computed by the receiver in Earth-Centered, Earth-Fixed X, Y, Z (ECEF XYZ) coordinates.

A pseudo-range solution will be one of two types: autonomous, or differential. A single GPS receiver can compute an autonomous position from ranges to four or more SV. This single receiver position is extremely coarse. One can expect errors in the order of 100-m on a bad day. For this reason, precise GPS measurements must be performed using differential positioning.

Differential GPS

Differential GPS (DGPS) positioning involves subtracting a combination of ranges measured to various satellites from two or more receivers measuring the same satellites simultaneously. When the signals are subtracted, the major error sources cancel each other out. However, because you are computing a difference in ranges, the DGPS measurement solves for a coordinate difference and not a coordinate. To compute a coordinate using a coordinate difference, you must first specify a starting point. In RTK survey, this starting point is the reference position the base receiver broadcasts over the data link. In a post processing survey, this starting point is specified by the user in the processing software.

Differential Solutions: Types and Quality

A differential GPS solution can be calculated using either the GPS code data, or the GPS carrier phase wave. A carrier phase solution can be calculated from either float ambiguities or fixed ambiguities. An explanation of these terms, and the expected precision from the different solution types is explained below.

Code Differential

Code differential solutions use the Coarse Acquisition (C/A) navigation code transmitted on the GPS carrier wave. Because the wavelength of the code segment is long (300m), code differential is the least precise differential solution. Accuracies of 1-10 meters are possible with DGPS using C/A code differential positioning.

Carrier Phase Differential

Highly precise coordinate differences can be measured using pseudo-range positioning with the carrier signal wave. Because the wavelength of the carrier wave is only 19 cm, mm-level positioning is possible. When the signal arrives at the antenna, you can measure the fractional part of the carrier wave. If you can then calculate the whole number of wavelengths between the SV and the antenna (the ambiguity), you can add it to the fractional part and multiply by the length of one cycle to measure a precise range.

Calculating the exact number of wavelengths uses a complicated least squares process, which is often called *ambiguity resolution*. The ambiguity resolution will yield either a float or a fixed solution.

- **Fixed Solution**

You know the number of wavelengths will be a whole number. Techniques are used to constrain the least squares solution to yield a whole number. If you get an acceptable solution, you say that this solution is fixed. A fixed solution will generate coordinate differences precise to about 15-ppm (single frequency) or 5-ppm (dual frequency), which translates into 15-mm or 5-mm over a 1-km base line.

Several things may prevent you from achieving a fixed solution: bad multi-path, low number of satellites and bad constellation geometry, poor radio link for corrections (RTK).

- **Float Solution**

If the constraint algorithm does not produce an acceptable fixed solution, then the ambiguity is allowed to be a decimal (float) number. A float solution will generate coordinate differences precise to about 100 to 500-ppm, which translates into 0.1-m to 0.5-m over a 1-km base line.

GPS Network Servers, NTRIP, and VRS

Traditionally, RTK GPS was done with a base and rover receiver setup on the survey site and using a radio data modem to get the observations from the base to the rover for the real time solution. Another way to do RTK GPS is to use one or more permanently operating base stations connected to an Internet network. You then use only a rover at the survey site, and an Internet capable modem to connect to the IP address of the network server and get corrections from the base.

The following section explains some of the concepts and terminology associated with getting GPS observations to the rover from one or more base receivers connected to the Internet.

GPS Network Servers

There are several different GPS network server software packages available. Each one offers different types of services using different technologies. However, the different services can be classified into one of three general categories:

- **Single Base**: This type of service is most like traditional RTK. With this type of service, GPS observations from a single base station connected to the server software are sent to the rover. The base station observations used are determined by what base the user selects to connect to.
- **Nearest Base**: Similar to single base, with this type of service you get GPS observations from a single base station connected to the server software. However, the server software automatically selects the base station observations to use to supply the rover with data from the nearest base.
- **Networked RTK**: This type of service uses the information from more than one continuously operating receiver connected to the network to model errors in the GPS solution. Then, the base observations sent to the rover are modified to apply the calculated corrections. The benefit to a networked RTK service is that you can get measurement precisions similar to short baselines even though the distance to the nearest real base station may be quite far. There are different proven technologies used to calculate

these corrections, such as Trimble VRS. A detailed description of these technologies is beyond the scope of this manual. Please see the end of this manual for references to more information.

Network Transfer of RTCM via Internet Protocol (NTRIP)

The Network Transfer of RTCM via Internet Protocol (NTRIP) is a standard established by the Radio Technical Commission for Maritime Services (RTCM). The NTRIP specification describes a standard for transferring satellite observation data over the Internet in different correction formats (RTCM, CMR…) The NTRIP specification also describes a standardized way for logging on to a server and selecting a specific service to use, plus establishing a method to use passwords and user names to access the service.

In Survey Pro, the term NTRIP is used to refer only to the method of logging onto a GPS server to select a service and possibly enter a user name and password. It is important to note that not all network GPS systems have an NTRIP log on procedure, even if they use NTRIP as a means of sending data over the Internet.

Virtual Reference Station (VRS)

Virtual Reference Station (VRS) GPS is a type of Networked RTK solution. In VRS GPS, the server software calculates corrections to the GPS observations based on the data from multiple continuously operating base stations in the network. Then, when the user connects to the network, the server software calculates observations for a single base point that is close to the rover's location. Although this virtual base point does not actually exist on the ground, it is still considered close to the rover's location, so the rover RTK engine will calculate base lines with precisions similar to base lines to a physical base that is located close to the rover. For more information on VRS and other networked RTK technologies, please see the references section.

GPS Coordinates

To represent positions in space you need two things. First, you need a datum to define an origin, an orientation, and a scale. Second, you need a coordinate system to specify the locations in the datum. GPS positions are in a global geocentric datum, using latitude and longitude angles to specify location. Most engineering and surveying jobs require positions in a 2D Cartesian coordinate system. In order to use GPS with most coordinate systems, you must transform the GPS measurements into local coordinates.

This section offers a more detailed description of some theory and terminology used to describe geodetic coordinate systems and datums in Survey Pro.

Datums

A datum consists of three components: an origin, an orientation, and a scale. The origin defines the start point, the orientation defines the direction of the bearings, and the scale defines the relative magnitude of the distance units. For example, a surveyor shows up at a new job site, places a monument in the ground and calls it (5000, 5000, 100). This establishes the origin of the datum. The surveyor does a sun shot and calculates the azimuth to a reference object. Astronomic north at this meridian establishes the orientation of the datum. Finally, the surveyor begins measuring distances with a total station. The EDM establishes the scale of the datum.

GPS measurements are taken in a global geocentric datum, the World Geodetic System of 1984 (WGS84). The WGS84 datum has its origin at the earth's center of mass, its orientation defined by the earth's spin axis and the intersection of the mean meridian of Greenwich with the mean equatorial plane, and its scale defined by metric standard measurement.

Geocentric datums such as WGS84 use a rotational ellipsoid to model the shape of the earth. The WGS84 ellipsoid was based on and is virtually identical to the Geodetic Reference System of 1980 (GRS80) ellipsoid. The ellipsoid origin is at the earth's center of mass. Its minor axis corresponds with the earth's rotation axis and its major axis corresponds to the mean equatorial plane.

WGS84 Geodetic v. Local Geodetic

When the coordinate system is a mapping plane in a datum other than WGS84, positions measured in WGS84 latitude, longitude and height, must be transformed into local latitude, longitude, and height before they can be used to calculate northing and easting with the specified map projection.

There are three methods of datum transformation supported by Survey Pro.

- Molodensky Transformation: Is the most commonly used transformation. Three parameters specify an X,Y,Z shift between WGS84 and the local datum origin. Survey Pro uses the Molodensky datum transformation algorithms specified in the National Imagery and Mapping Agency Technical Report 8350.2.[1].
- Similarity Transformation: The most precise method of datum transformation. The seven-parameter similarity transformation, also called the Helmert transformation, uses a shift of XYZ origin, a rotation about XYZ axes, and a scale to transform from WGS84 and the local datum.
- Grid File Datum Transformation: Is used when the datum differences are not consistent over large areas. A grid file datum transform uses a data set of shift values. For any location, an approximate shift can be calculated by interpolating from the data set.

For many surveying applications, the horizontal and vertical datums are separate. This is because GPS heights are measured on the ellipsoid with its origin at the earth's center of mass, while elevation is a function of local gravity field, which is influenced by the unequal distribution of mass in the earth.

Below is a description of some common horizontal and vertical datums used by Survey Pro.

[1] http://164.214.2.59/GandG/tr8350_2.html

Horizontal Datums

- **NAD27**

The North American Datum of 1927 (NAD27) horizontal datum was established in the early part of the twentieth century to define a horizontal coordinate system in North America. The datum originated at a central point, Meades Ranch in Kansas. From there, conventional triangulation and trilateration networks radiated outward to establish new monuments in the system. The datum was based on the Clarke 1866 ellipsoid, which was the best fitting ellipsoid for the North American continent at the time.

Survey Pro performs a grid transformation for NAD27 in the United States using the NADCON datum sets in *.DGF (datum grid file) format. Several specific Molodensky datum transformations are also available for other areas in North America.

Note: To use a grid datum, you must have the pair of *.dgf files for latitude and longitude shift in the `Geodata` folder on the data collector.

- **NAD83 = WGS84**

Later in the twentieth century, satellite and Very Long Baseline Interferometry (VLBI) measurements were added to the numerous conventional measurement networks and re-adjusted to define the North American Datum of 1983 (NAD83). NAD83 was created to conform to the new global datum, WGS84, and uses the same reference ellipsoid.

Survey Pro uses no datum transformation for NAD83. Therefore, NAD83 = WGS84 in Survey Pro projection calculations.

- **NAD83 ≠ ITRF WGS84(1996.0 , 1997.0 , …)**

Continuing improvements in GPS and VLBI technology, as well as increased cooperation among world wide agencies, like the International Earth Rotation Society (IERS), led to a much better solution for the Earth's center of mass and spin axis. The IERS's solution is adopted as the International Terrestrial Reference Frame (ITRF). Because the earth's center of mass and spin axis drift over time, you will often see the WGS84 datum followed by brackets

(1996.0). The date in the brackets indicates the epoch defining the datum.

This is all quite confusing. Fortunately, for most RTK GPS applications, you do not need to worry about these WGS84 differences. The significant part of the datum difference is a shift, and you correct this when you specify the GPS base position. The other part of the datum difference is the small rotation of the axes. These rotations are small enough to ignore except for the most precise first-order applications.

If your Survey Pro job requires a local datum in one epoch of WGS84 and the WGS84 datum in a different epoch, you can setup a seven-parameter similarity transformation. For the transformation parameters of any epoch of WGS84 and for a more detailed description of the similarity transformation and WGS84, see NGS Web site[2].

- **NAD83(1986) = NAD83(1996.0, 1999.0, …)**

In the same way that the control for the WGS84 datum is adjusted over time, the control for the NAD83 datum is also periodically updated. One motivation for the periodic readjustments of NAD83 is to account for the relative velocities of points on the stable North American tectonic plate and points on the moving Pacific tectonic plate. Chris Pearson of the US NGS has written a good paper on the history of NAD83 and the new US National Readjustment, completed in February 2007 and identified as NAD83(NSRS 2007). This paper can be found on the NGS web site.[3]

It is therefore important to pay attention to the epoch associated with a NAD83 control coordinate. If you are looking at an NGS data sheet for a number of different control monuments, make sure they are all in the same epoch of NAD83. Similarly, if you are using an OPUS solution and an NGS control monument on the ground, pay attention to the epoch of the datum of each position.

The good news again is that for RTK surveys, you usually do not need to worry about these differences. The important thing is to not mix

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[2] Snay, R. *How CORS Positions and Velocities Were Derived.* http://www.ngs.noaa.gov/CORS/Derivation.html Appendix B.

[3] http://www.ngs.noaa.gov/NationalReadjustment/Items/The%20national%20readjustment.html

apples and oranges. For example, if you set your base on a point with a known coordinate in the NAD83(1996.0) datum, then all the rover positions will be in the NAD83(1996.0) datum. Similarly, if you set the base on an autonomous position, and occupy one or more NGS control monuments all in the NAD83(1999.0) datum, then the localization corrects your entire survey to the NAD83(1999.0) datum.

If you need to mix control coordinates from different epochs of the NAD83 datum, such as using an OPUS solution in the NAD83(2002.0) datum and an NGS control sheet location in the NAD83(1999.0) datum, you must transform both coordinates into the same epoch of the datum. This can be accomplished with the NGS software for Horizontal Time Dependant Positioning (HTDP). Richard Snay of the NGS has written a good paper with a description of the theory behind how plate tectonics affects survey control, and how the HTDP software can be used to transform locations in North America into the same epoch of time. This paper can be found on the NGS web site.[4]

- **High Accuracy Reference Network (HARN)**

In the United States, the bulk of the measurements used to establish NAD83 were conventional. These measurements contain slight systematic errors that conflict with GPS measurements, which are more precise over long distances. To address this problem in the U.S.A., in 1988 the National Geodetic Survey (NGS) began to update NAD83 coordinate datums with HARN GPS surveys on a state-by-state basis. These HARN surveys determined small (< 5_cm) corrections to the location of A and B order control monuments across the states.

Survey Pro performs a grid transformation for HARN networks in the United States using the NADCON datum files in *.DGF format.

Note: To use a grid datum, you must have the pair of *.dgf files for latitude and longitude shift in the `Geodata` folder on the data collector.

- **Custom Datum Transformations**

Most North American and international datums are pre-programmed into the Survey Pro coordinate system database. If you require a

[4] http://www.ngs.noaa.gov/TOOLS/Htdp/Using_HTDP.pdf

datum not programmed into the database, you can use the Projection Key-In Wizard to create a custom Molodensky or similarity datum transformation.

Vertical Datums

GPS satellites orbit the Earth's center of mass, while objects on the surface of the planet are affected by the force of the local gravity field. Although it is possible to accurately model the orbits of satellites about the Earth's center of mass, modeling the local gravity field is much more difficult because of the unequal distribution of masses within the earth.

Everyone knows that water flows downhill from a higher elevation to a lower one. However, water will not always flow from a higher ellipsoid height to a lower one. Ellipsoid height is simply the altitude above the reference surface, and may not match the slope of the local gravity field. When surveying with GPS, you need to correct for the local gravity field to convert measured ellipsoid heights (h) into orthometric elevations (H). This is usually done with a geoid model.

Survey Pro can use several different geoid models to convert local ellipsoid heights into elevations in a particular vertical datum. Most geoid models are initially based on the global equipotential surface used in the definition of the initial WGS84 datum. Below is a description of some vertical geoid models and datums.

- **EGM96**

The National Imagery and Mapping Agency publishes the global geopotential model EGM96[5]. This geopotential model was used to generate the worldwide 15-minute geoid height grid data file, WW15mGH.grd. This file contains geoid separation values at 15-minute intervals for the entire globe and provides a good estimate of geoid slope corrections.

- **NGVD29**

The first continental height datum in the United States was the National Geodetic Vertical Datum of 1929 (NGVD29). According to the technology of the day, this datum was based on normal gravity, that is, the gravity field at the instrument when it was leveled. Points along the coast were chosen and their elevation above sea level was determined from a network of tide gauges. Spirit level networks were

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[5] http://164.214.2.59/GandG/wgs-84/egm96.html

then run across the country and closed on the opposite coast. This datum contained a number of systematic errors including un-modeled local gravity effects and refraction errors. Also, it was later discovered that the "mean sea level" from the Atlantic to the Pacific Oceans was not the same.

- **NAVD88**

In an effort to address these errors, the North American Vertical Datum of 1988 (NAVD88) was realized from a single datum point in Rimouski, Quebec. This datum is based on actual gravity, which provides a better representation of true orthometric elevations. The primary consideration in the choice of this datum point was to minimize the recompilation of national mapping products. A side effect of this choice is that the NAVD88 datum and the theoretical level surface used to define GRS80 do not agree. The offset between the NAVD88 vertical datum and the ITRF global geopotential model is in the neighborhood of 0.27m[6].

Survey Pro does not require choosing a specific vertical datum. For RTK applications, elevations are solved relative to the base using the vertical localization adjustment. Therefore, the vertical datum is established by the datum of the base elevation.

Coordinate Systems

A coordinate system is a way to describe positions in a datum. Coordinate systems range from simple Cartesian (y,x) or (N,E) positions on a flat plane to complex geodetic latitudes and longitudes on a reference ellipsoid.

Below is a description of some coordinate systems common in surveying:

- **Northing, Easting, Elevation**

Survey projects usually use simple plane coordinates. You assume your local datum models a flat earth, and you calculate coordinates in a Cartesian system where the simple laws of plane trigonometry

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[6] Milbert D.G. *Converting GPS Height into NAVD88 Elevation with the GEOID96 Geoid Height Model* http://www.ngs.noaa.gov/PUBS_LIB/gislis96.html p. 4

apply. When a vertical coordinate is required, most survey projects require orthometric elevations.

- **Lat, Lng, Ht**

Geodetic horizontal coordinates are usually expressed as two angles called latitude and longitude (ϕ, λ). Geodetic vertical coordinates are usually expressed as the distance above the ellipsoid called height. The angles describe a point's position on the surface of the reference ellipsoid. The height describes the altitude normal to the surface of the reference ellipsoid.

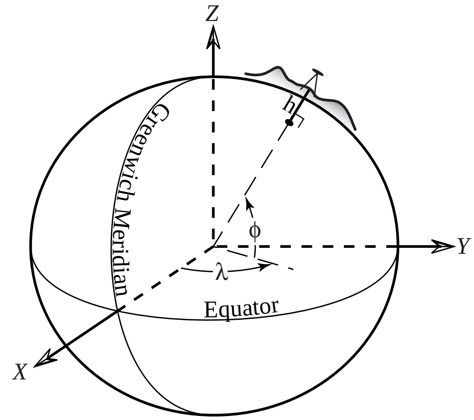


Fig. 1: Ellipsoidal Geodetic Coordinates

- **ECEF XYZ**

Geodetic coordinates are sometimes given in the Earth Centered Earth Fixed (ECEF) Cartesian coordinate system. This coordinate system has its origin at the Earth's center of mass, the primary (Z) axis is the earth's spin axis; the secondary (X) axis is the intersection of the equatorial plane and the mean meridian of Greenwich; the tertiary (Y) axis is orthogonal in a right handed system. An ECEF XYZ coordinate can be converted into the corresponding lat, lng, ht using standard formulas.

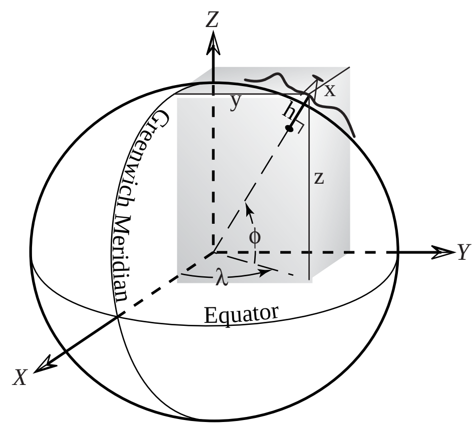


Fig. 2: Earth Centered Earth Fixed Geodetic Coordinates

For many surveying applications, the horizontal and vertical coordinate systems are separate. Below are descriptions of common horizontal and vertical coordinate systems used in surveying and mapping.

Horizontal Coordinate Systems

Survey projects use horizontal coordinates on either a local plane or a map projection. For small projects, you can assume a simple flat earth plane and calculate coordinates directly with measured distances. Use Ground - TDS Localization mode for this procedure. For large projects, a mapping plane is used to accurately represent the curved surface of the earth on a flat plane and conventionally measured distances need to be scaled to the mapping plane grid.

Map Projections

A map projection uses equations to transform local latitude and longitude into (y,x) Cartesian coordinates on a flat plane. Map projections attempt to minimize distortions to the following properties[7]:

- **Conformality**

A map projection is conformal when local angles are preserved. Conformal maps are important for surveying because, for second order surveys, angles measured on the ground are angles on the map. Meridians (lines of longitude) and parallels (lines of latitude) intersect at right angles and shape is preserved locally. The physical characteristic of conformality is that the scale factor at any point on the map is the same in all directions.

- **Distance**

A map projection is equidistant when it correctly plots distances from the center of the projection to any other place on the map. Most map projections involve some distortion of scale. Consequently, when converting distances measured on the ground to distances on the grid, a scale factor must be applied.

- **Direction**

A map projection is azimuthal when azimuths (angles from a point on a line to another point) are correctly plotted in all directions.

[7] http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html

- **Area**

A map projection is equi-areal when it correctly plots areas over the entire map. That is, all mapped areas have the same proportional relationship to the areas on the Earth that they represent.

Common Conformal Map Projections in Surveying

- **Transverse Mercator**

The Transverse Mercator (TM) projection results from projecting the ellipsoid onto a cylinder tangent to a central meridian. Scale distortion is maximum from east to west and minimum from north to south, so the TM projection is often used to portray areas with large north-south extent. Distortion of scale, distance, direction and area increase away from the central meridian.

Many national grid systems are based on the TM projection. The Universal Transverse Mercator grid system divides the world into 60 6-degree zones. About half of the states in the U.S. use a TM projection for their State Plane Coordinate Systems. The British National Grid (BNG) is a TM projection with origin at 49 degrees north latitude and 2 degrees west longitude.

- **Oblique Mercator**

The Oblique Mercator projection is similar to the Transverse Mercator projection; the ellipsoid is projected onto a cylinder. However, instead of the cylinder tangent to the ellipsoid along a meridian, it is tangent to the ellipsoid along any great circle other than the Equator or a meridian. This makes the Oblique Mercator projection appropriate for regions centered along lines, which are neither meridians nor parallels.

The Oblique Mercator projection is used for Alaska State Plane zone 1, which covers the panhandle.

- **Lambert Conformal Conic**

The Lambert Conformal Conic projection results from projecting a sphere onto a cone tangent at two (or one) parallels of longitude. Scale distortion is maximum from north to south and minimum from east to west, so the Lambert projection is used to map areas of large east-west extent. Distortion of scale, distance, direction and area increase as you move away from the standard parallels.

Lambert projections are used for about half of the State Plane Coordinate System zones in the USA.

- **Stereographic**

The Stereographic projection results from projecting an ellipsoid onto a plane. Directions are true from the center point and distortions in scale, area and shape increase uniformly away from the central point. The stereographic projection is azimuthal.

Because the scale is distorted somewhat uniformly in all directions, stereographic map projections are a good representation of a surveyor's typical flat earth ground coordinate system. For this reason, the stereographic map projection is used by the Ground - TDS Localization mode algorithm to convert (lat,lng) into local ground level coordinates. For more information on localization, see Page 283.

Scale Factors

When converting distances on a map to distances on the ground, you must correct for two different scale distortions. First, the effects of the map projection distortion must be corrected with the mapping plane scale factor. Second, the geometric effect of your height above the reference surface (ellipsoid height) must be corrected with the ellipsoid scale factor. Generally, these two scale factors are multiplied together into the combined scale factor.

Mapping Plane Scale Factor

This scale factor accounts for the distortions caused by the mapping plane equations as they fit a curved surface onto a flat plane. It is a function of the mapping plane equations and its exact value depends on your location on the map. Although the scale factor is computed with differential equations of the map projection, one can visualize it in a geometric sense. Consider the following diagrams:

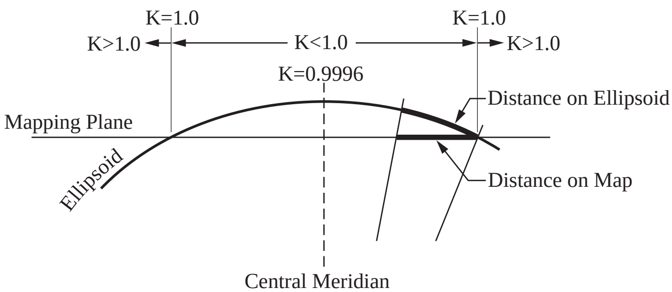


Fig. 3: Transverse Mercator Mapping Plane

A side view of the cylinder shows the effect of scale distortion.

- **Universal Transverse Mercator Projection**

The scale factor at the central meridian (CM) is 0.9996. The scale factor is 1.0 approximately 170-km east and west of the CM. The scale factor is less than one between the CM and the point of tangency. The scale factor is greater than one beyond the point of tangency. Therefore, at the central meridian, a geodetic distance of 100m scales into a mapping plane distance of 99.96m.

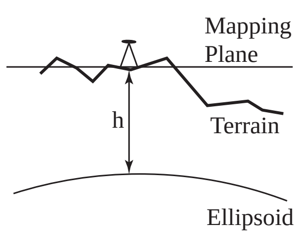


Fig. 4: Localization Stereographic Mapping Plane

A side view of the ellipsoid and stereographic mapping plane show the scale calculated for ground distances at the base height.

- **TDS Localization Stereographic Projection**

The scale factor at the start location (usually the first GPS base station in a project) is calculated for ground distances at the base height. The scale factor increases more or less uniformly in all directions as you move away from the base. The scale factor does not change appreciable within the range of RTK GPS, so this map projection is an excellent way to model simple flat earth ground level coordinate systems.

Ellipsoid Scale Factor

This scale factor accounts for the height of the ground above the reference surface (the ellipsoid). This scale factor is defined geometrically: Consider the following diagram:

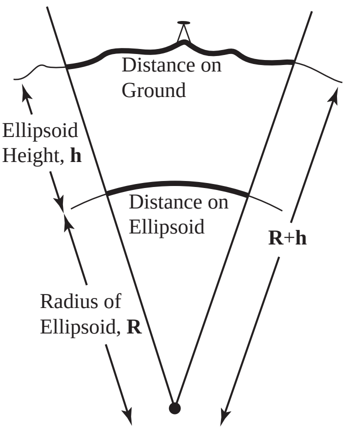


Fig. 5: Ellipsoid Scale Factor
The effect of height above the ellipsoid on scale.

$$dist_{ground}/(R+h) = dist_{elip}/R$$

$$dist_{elip}/dist_{ground} = R/(R+h)$$

$$k_{elip} = R/(R+h)$$

Combined Scale Factor

Generally, the two scale factors are multiplied together into a combined scale factor. The combined scale factor is then applied to grid distances to get ground distances:

$$k_{cf} = k_{elip} * k_{map}$$

$$dist_{grid} = dist_{ground} * k_{cf}$$

Vertical Coordinate Systems

GPS measurements provide ellipsoid heights. Most survey projects require orthometric elevations. To convert heights into elevations, you need to correct for the difference between the surface of the reference ellipsoid and the level surface representing the gravity field.

The procedure to convert heights (h) to elevations (H) involves the use of a geoid model. The geoid is a theoretical surface that approximates mean sea level. If one knows the separation between the reference ellipsoid and the geoid, called the geoid undulation (N), then one can determine orthometric elevations from ellipsoidal heights.

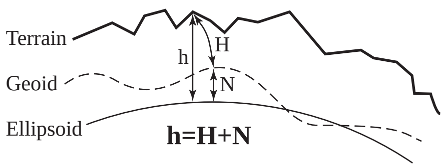


Fig. 6: The Height Equation

Geoid Models in TDS Software

Survey Pro has several geoid models in the coordinate system database. All of the geoid models use data files in geoid grid file (*.GGF) format.

> **Note**: To use a geoid model, geoid data files (*.GGF) must be in the `Geodata` folder on the data collector.

- In the U.S.A., Mexico, and the Caribbean you can use the NGS Geoid96 or the NGS Geoid99 models. This coverage includes the continental United States, Alaska, Hawaii, Mexico, and the Caribbean.
- In the continental USA you can use the new NGS Geoid03 model.

- In Canada you can use the Geodetic Survey Division HT 2.0 model, or the older GSD95, HT1_01, and HT97 models.
- For any location world wide, you can use the NIMA 15-minute geoid height grid data file, WW15mGH.*. This file covers the entire globe on a 15' x 15' grid.

In Australia you can use the AUSGEOID98 geoid model.

Note: To use any of these geoids with Survey Pro, you need files in Trimble .ggf format. For the US, Canadian, and EGM geoid models, you can convert the files from their original format into .ggf format using the Geoid File Convert and Sub Grid function in ForeSight DXM. The Australian AUSGEOID98 model is not supported in this function, so this data is available in six overlapping sub grid files already in .ggf format. All of the source files are included on the TDS Works CD in the `\Geodata` directory. Also, you can download data from the TDS Web site on the GPS page.

GPS Coordinates in Survey Pro

GPS positions are measured in a 3D coordinate system, which models the earth using an ellipsoidal shape. The horizontal position is usually given as two angles, relative to the ellipsoid axes, called latitude and longitude. The vertical position is usually given as a linear distance, perpendicular to the ellipsoid, called height. Most survey projects use horizontal coordinates on a plane which approximates a small piece of the ground assuming a 'flat earth'. The horizontal position is usually given as two linear distances, called northing and easting. The vertical position is usually given as a linear distance, describing the direction water will flow down hill, called elevation. The usual method to convert latitude, longitude and height to northing and easting is to use a map projection. The usual method to convert height to elevation is to use a geoid model. This section describes different ways to manipulate geodetic coordinates with both Survey Pro and ForeSight DXM and the methods Survey Pro uses to calculate local coordinates from GPS measurements. In this section, you will learn:

- A description of the horizontal and vertical projection modes used by Survey Pro to transform geodetic position into local coordinates.
- A description of the coordinate system database used by Survey Pro.
- How to use the Survey Pro Edit Points screen to edit plane and geodetic locations, and geodetic flags.
- How to use the Survey Pro Import menu to import coordinates and coordinate systems, and how to merge GPS coordinates from a *.GPS file.
- How to use ForeSight DXM (DXM) and Trimble Geomatics Office (TGO) to manage job files with geodetic coordinates from GPS measurements and coordinate system definitions.

Projection Mode

Survey Pro has two different modes for calculating local northing and easting from GPS measurements: Ground – TDS Localization, and Mapping Plane.

In Ground - TDS Localization mode, there is no map projection and no datum to transform geodetic to local coordinates. In this case, a default map projection is created with the first RTK base setup. Then, a localization adjustment is solved (Page 282). The localization adjustment is a 2D similarity transformation that shifts, scales, and rotates the default map projection's locations (y,x) into your local coordinates (N,E). In Ground - TDS Localization mode, when you measure a distance with an EDM, the distance measured on the ground is 1:1 with the distance on the local coordinate grid.

In Mapping Plane mode, there is a specified conformal map projection and geodetic datum to transform geodetic to local coordinates. In this case, you select the coordinate system from the database file (Page 250). This mapping plane and datum is used to calculate northing and easting from latitude, longitude and height. If you set your RTK base on a point with known coordinates, then no additional steps are required to solve the coordinate system. If you set your RTK base on an unknown point, then you can solve a localization adjustment to correct the positions to the proper local coordinates (Page 282). In Mapping Plane mode, when you measure a distance with an EDM, the distance measured on the ground is not usually 1:1 with the distance on the mapping plane grid. In this case, you must usually use a combined scale factor (Page 237).

In either horizontal projection mode, you can use one of three methods to calculate vertical coordinates: You can use a geoid model, with or without a vertical localization, to transform ellipsoid heights into local elevations. You can use a vertical localization to transform ellipsoid heights into local elevations. You can use no vertical adjustment and use the ellipsoid height differences directly for your local vertical coordinates.

Projection Mode Summary

Horizontal Projection Modes

Ground - TDS Localization

Local coordinates are at ground level, based on the project height.

Distances shot with EDM are at ground scale, so are 1:1 with coordinates solved by the projection.

Default map projection and datum are automatically initialized with RTK base setup.

Mapping Plane

Local coordinates are on a conformal map projection grid.

Distances shot with EDM are usually scaled by the combined scale factor to distances on the map projection grid.

User selects map projection zone.

Vertical Projection Modes

Localization (+Geoid)

- Vertical coordinate is orthometric elevation.

User must solve transformation from ellipsoid heights to elevations. This is done with localization on control points, or using a geoid model, or a combination of both.

Ellipsoid Heights

- Vertical coordinate is ellipsoid height.

Ellipsoid Heights mode requires no transformation setup. Use this mode when vertical coordinates do not need to be elevations.

Coordinate System Set or Solved

There can be multiple steps required before your coordinate system is ready to transform geodetic positions into local coordinates. The status of your coordinate system may be in one of three states: un-initialized, set, or solved.

A coordinate system is un-initialized when you have no zone record set. In Ground – TDS Localization mode, this means that you have not yet configured the first RTK base position in Survey Pro. In Mapping Plane mode, this means you have not yet selected a zone record from the coordinate system database.

A coordinate system is set when there is a zone record set. In Ground - TDS Localization mode, a default mapping plane zone is set when you configure your first base reference position for the job. In Mapping Plane mode, you select a zone from the coordinate system database.

A coordinate system is solved when it is ready to correctly transform GPS positions measured at the rover into your local coordinates. In Ground – TDS Localization mode, this is the case after you have solved the horizontal localization adjustment. In Mapping Plane mode, there are two cases. When you start a survey from a known base position, then the rover is already calculating accurate positions, and the coordinate system is set and solved. When you start a survey from a new autonomous base position, you must solve a horizontal adjustment from control points before you are ready to collect data.

Coordinate Systems of Network RTK Servers

Setting and solving the coordinate system in Survey Pro when using a network GPS server is not much different than using traditional base and rover RTK. You should keep the following guidelines in mind:

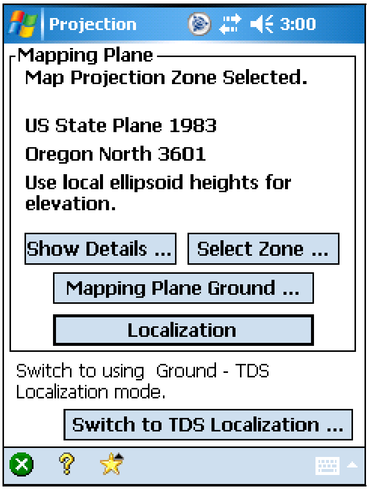
- If your horizontal projection mode is set to Ground – TDS Localization, then your coordinate system is not referenced to a geodetic datum. When you do your first remote rover setup, we will set the default mapping plane. At this point your coordinate system is set. You then need to complete a localization with two or more control points. After this point, your localization is solved. When you do subsequent setups from this network GPS server, the base reference position should be accurate with respect to other base reference positions in the network, so you may continue to survey with the coordinate system you solved initially.
- If your horizontal projection mode is set to Mapping Plane, then your coordinate system is referenced to a geodetic datum. When you set the mapping plane coordinate system, we have all the parameters we need to transform from the network GPS

coordinates to your mapping plane coordinates. Therefore, a localization is not required in this case.

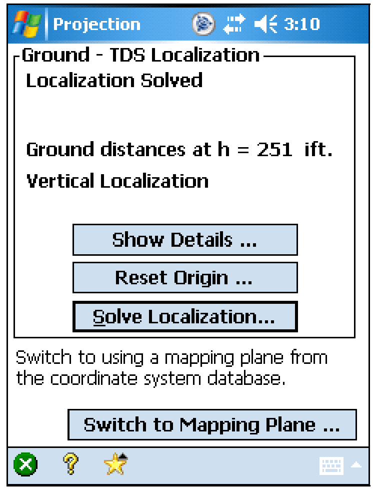
- If your job already contains geodetic coordinates which were measured from an autonomous setup, and you are continuing the survey using coordinates from the network GPS, you will need to re-solve the localization to get results in the proper local system. This is the case for both Ground – TDS Localization and Mapping Plane horizontal projection mode.
- If your job already contains geodetic coordinates which were measured from an initial accurate base setup, then you can continue to survey using the network GPS coordinates. This is only the case when the initial accurate base setup and the network GPS coordinates are in a consistent coordinate system. The network GPS server operator should be able to tell you what coordinate system and datum the network coordinates are surveyed in.

Note: The guidelines above assume that all of the receivers in the network GPS have coordinates that are accurate with respect to each other. This is usually the case, especially for any networks that support VRS or some other networked RTK service. However, it is possible that the base stations in a network have not been accurately tied to each other. In this case, the geodetic coordinates from one base may not match the geodetic coordinates from another base. The network GPS server operator should be able to specify the accuracy of the different stations with respect to each other.

Projection Mode Configuration

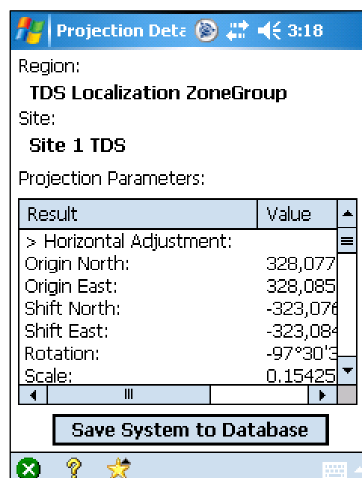


Mapping Plane Mode



TDS Localization Mode

The projection mode can be configured or changed from the Survey > Projection screen, which will look different depending on the current projection mode.



Tapping Show Details will open the Projection Details screen that lists the details of the current projection.

Mapping Plane Mode

Tapping Select Zone opens the Select Coordinate System screen to select either a mapping plane zone or a localized site from the coordinate system database file (Page 251).

Tapping Mapping Plane Ground opens the Ground Coordinates screen. This screen helps you use ground level scaled coordinates when the underlying coordinate system is a conformal mapping plane zone selected from the database (Page 254).

Tapping Localization opens the Solve Localization routine. This routine is described on Page 282 for when running the GPS module and on Page 349 for when running the Basic GPS module.

Tapping Switch to TDS Localization will switch from Mapping Plane mode to TDS Localization mode.

TDS Localization Mode

Tapping Reset Origin will open the screen to manually key in the parameters for the default map projection zone used in the localization adjustment as described on Page 249.

Tapping Solve Localization will open the Solve Localization routine. This routine is described on Page 282 for when running the GPS module and on Page 349 for when running the Basic GPS module.

Tapping Switch to Mapping Plane will switch from TDS Localization mode to Mapping Plane mode.

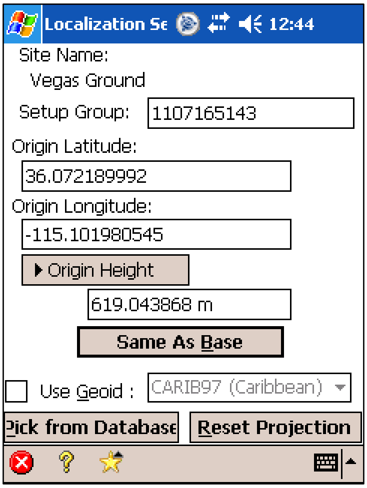
Localization Default Zone

When your horizontal projection mode is Ground – TDS Localization, there is usually no need for you to setup the map projection zone used. Survey Pro will initialize a default map projection, scaled for ground distances, when you set the first RTK base in the survey.

You can reset this default zone in two ways. First, you can key in parameters by hand, or you can select a Ground – TDS Localization coordinate system from the database. The Localization Set Zone screen can be used to modify the default map projection zone used. You may wish to do this when your base is more than 100 m higher or lower than the survey area in order to have the correct ground scale factor used. The Select Coordinate System screen can be used to select a zone or site record from the TDS Localization region collection in the coordinate system database.

Localization Reset Origin

The Localization Set Zone screen is used to manually key in the parameters for the default map projection zone used in the localization adjustment. You can also open the Select Coordinate System screen where you can choose a record from the coordinate system database file.



1. Go to Survey > Projection > Set Zone to open the Localization Set Zone screen.
2. Enter the Setup Group for the zone. The setup group is used to associate this zone with the autonomous base setup. The setup group should usually be the same as the current RTK base.
3. Enter the Origin Latitude and Origin Longitude for the zone. The origin coordinate is usually at the same location as the RTK base.
4. Enter the Origin Height for the zone. The origin height is used to calculate the zone's scale factor to configure this zone for ground distances. Alternatively, you can toggle this control and enter the Origin Scale directly.
5. Check the Use Geoid checkbox if you want to use a geoid model with this zone and then select a geoid model from the dropdown list to use with the coordinate system. When this box is unchecked, no geoid will be used with the coordinate system.

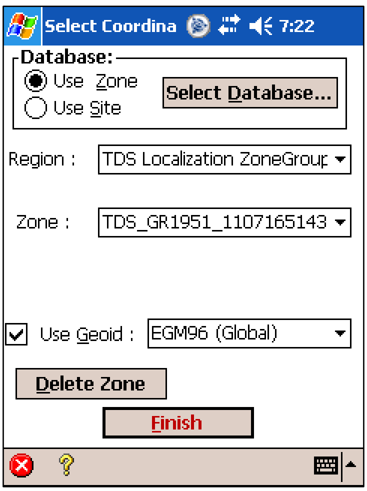
Note: If you have an RTK base configured in Survey Pro, and if you wish to set up this localization zone to match the setup group and location of that base, tap Same As Base to fill in all the parameters on this screen.

Localization Select Zone

You can store and select any coordinate system in the database file using Save System to Database on the Projection Show Details screen. Coordinate systems stored in Ground – TDS Localization mode are put in a special region called TDS Localization region. To select Ground – TDS Localization coordinate systems from the database, open the Select Coordinate System screen from the Localization Set Zone screen. The procedure for selecting a coordinate system is the same as the Mapping Plane mode case, which is described below.

Mapping Plane Select Zone

Use the Select Coordinate System screen to select either a mapping plane zone or a localized site from the coordinate system database file. This screen is also used to open the Key In Zone wizard where you can key in the parameters of a custom map projection and datum.



1. Open the Select Coordinate System screen. This may be done automatically by the Start GPS Survey wizard, or when you tap Select Zone... on the Horizontal card of the Projection screen when in mapping plane mode.
2. Select the type of database record you wish to choose in the Data Base box. To pick a map projection zone from the database, tap Select Database Zone. To pick a localized map projection site from the database, tap Select Database Site.
3. If you are picking a map projection zone, select the Zone Group from the drop down list.
4. Select the Zone or Site from the drop down list.
5. If you have selected a zone with a datum, the datum name will be displayed. If you have selected a zone without an attached datum, such as the database UTM zones, you must select a Datum from the drop down list.
6. If there is a default geoid attached to the zone or site, Use Geoid is checked and the geoid model is selected in the drop down list. You can choose to use this geoid, or you can change the geoid model used by this zone or site.
7. Tap Finish to set the selected zone or site and the selected geoid (if Use Geoid is checked) as the current coordinate system.

Note: If you change the geoid model used by a site record, and if that site record has a vertical adjustment solved, then you will be prompted that the vertical adjustment parameters will be cleared.

- Use the Delete Zone / Site button to delete zones or sites from the database. You can only delete user created sites, you cannot delete the original 'system' records in the database.
- Use the Key In Zone button to open the Key In Zone screen where you can configure a custom map projection and datum.

Key In Zone

Use the Key In Zone screen to create a custom map projection and a custom datum transformation to add to the coordinate system database file. You can then select this zone as the coordinate system to use in your job.

1. Pick the Zone Type for the new map projection zone. Supported zone types are:
   - Transverse Mercator
   - Lambert 1 parallel
   - Lambert 2 parallel
   - Stereographic (oblique and polar)
   - Oblique Mercator Angle
2. Pick the Datum Type for the new map projection zone. Choices for datum are:
   - Pick from Data Base. Select this choice to use a datum from the coordinate system database.
   - Custom Molodensky. Select this choice to enter a custom three-parameter datum transformation.
   - Custom Similarity. Select this choice to enter a custom seven-parameter datum transformation.
3. Select the Azimuth type for the new map projection zone. Choices are:
   - North Azimuth. Select this choice to have a north azimuth grid.
   - South Azimuth. This choice to have a south azimuth grid.

4. Select the Grid direction for positive coordinates in the new map projection zone. Choices for grid direction are:
   - North\East Grid. Select this choice to have coordinates increase positive in the north and east directions.
   - South\West Grid. Select this choice to have coordinates increase positive in the south and west directions.

Note: The geodetic calculation engine and the Survey Pro coordinate geometry engine are separate components. While the geodetic engine can properly handle southwest grid systems, Survey Pro can only operate on a northeast grid system. However, since a southwest grid with a south azimuth is a mirror image of a northeast grid with a north azimuth, Survey Pro can handle this configuration with the following work around: You must set the Azimuth Type to North Azimuth on the Units card of the Job, Settings screen. You then treat north as south and east as west, and the coordinates will be correct for a southwest grid and south azimuth zone.

5. Tap Next to enter the zone parameters for the new map projection.
6. Key in the five or six parameters for your new map projection zone.
7. If your zone is Oblique Mercator Angle, the next screen is used to pick the Origin and Azimuth values.
8. Tap Next to select the datum. The screen that opens will depend on the datum type you specified on the first screen.
9. If you selected Pick from Data Base, pick the database Datum from the list. If you selected either Custom Molodensky or Custom Similarity, then select an ellipse for the new datum. You can select Ellipse from Data Base to use an ellipsoid record from the database, or you can select Key In Ellipse to input parameters for a custom ellipse.
10. Tap Next to open the next screen. If you are using a database datum, the next screen displays the parameters for the new map projection zone and you can Store the record.

11. If you are using a custom datum, enter the datum translations from WGS84 to Local.

Note: Note the sign of the datum shift and rotation parameters. Survey Pro requires you enter the datum transformation parameters in the direction of WGS84 to Local. If your datum parameters are given as local datum to WGS84, you will need to invert the conversion parameters before entering into Survey Pro.

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12. Tap Next. If you are using a Custom Molodensky datum, the next screen will be the final screen where you can Store the record.
13. If you are using a Custom Similarity datum, enter the rotation from WGS84 to the local datum. Also enter the scale, in parts per million from WGS84 to the local datum.
14. Tap Next to open the final screen where you can review the parameters for the new map projection zone and where you can Store the record to save it in the coordinate system database file.

Mapping Ground Coordinates

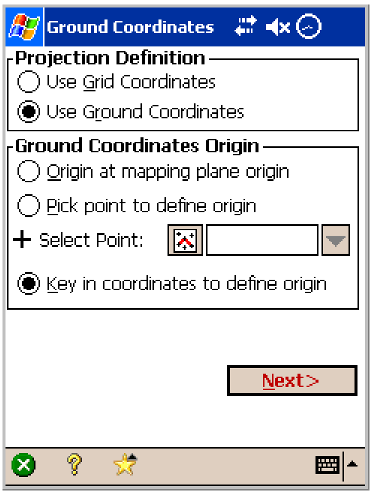
Ground Coordinates in mapping plane mode is a mechanism to use ground level scaled coordinates when the underlying coordinate system is a conformal mapping plane zone selected from the database. This function is useful if you must work with a specified map projection zone, but you wish to work with distances in a ground scale.

You can switch to Ground Coordinates using any Mapping Plane mode zone or localized site. You can not use Ground Coordinates when the horizontal projection mode is Ground – TDS Localization. In this case, the default map projection is already configured to produce ground scale coordinates.

The following section describes how to setup Ground Coordinates. This section explains the Ground Coordinate parameters, how to switch between grid and ground coordinates in the job file, and how to set the conventional survey scale factor to properly reduce EDM distances when in either mode.

Switching from Grid to Ground

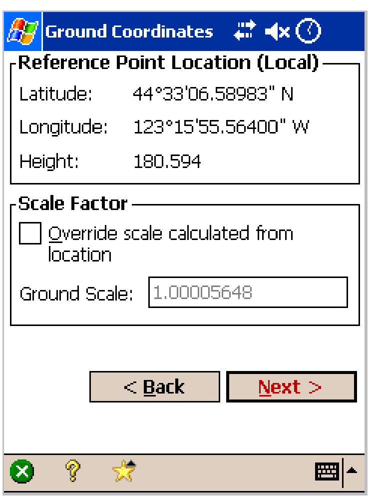
1. Any time a Mapping Plane mode zone or localized site record is selected, go to the Survey > Projection screen and tap Setup Ground Coordinates... .



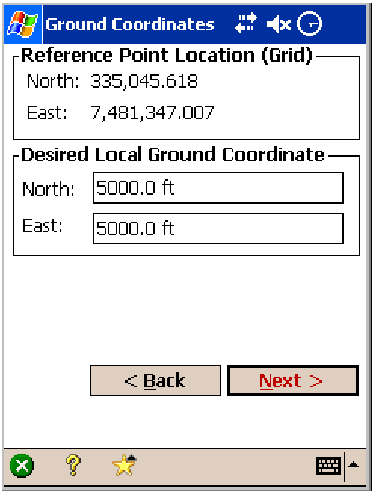
2. In the Projection Definition box, select Use Ground Coordinates.

3. Select the Ground Coordinate Origin; this is the point around which the scale factor will be applied. The recommended procedure is to select or key in a project location close to the survey area. It is most important that the origin be close to the height of the survey area for proper ground scale. You can also choose to apply the ground scale factor at the map projection origin with any height scale factor you wish.

4. Tap Next>. If you are using a keyed in origin point, enter the coordinate of the origin and tap Next>.

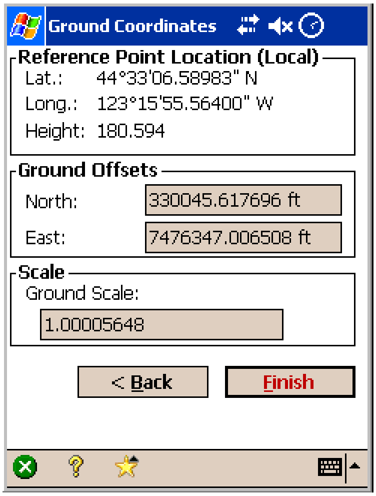


5. The next page will display the local geodetic coordinate of the origin Reference Point and the Ground Scale factor calculated for that point. The scale factor is the inverse of the combined scale factor for the selected map projection zone at the origin reference height, and it is automatically calculated based on your reference position. If you wish to use a different scale factor, tap Override scale calculated from location and enter your value in the Ground Scale Box. Tap Next>.



6. Enter the Desired Local Ground Coordinate. This will be the local plane coordinate of the origin Reference Point. It is recommended that you use a recognizably different coordinate range to distinguish the values from the grid coordinates. For example, a UTM coordinate of (4,997,000, 356,000) could become (5000,5000). The local coordinate you enter here is subtracted from the scaled grid coordinate of your reference point to get the Ground Offsets. Tap Next>.
7. Review the Ground Coordinate parameters: Reference Point Location, Ground Offsets, and Ground Scale. When you are satisfied with the setup, tap Finish.
8. If your projection record is a map projection zone, the ground coordinate parameters will be added to the zone record to create a zone based site. If you are already using a site record, the parameters will simply be applied. In both cases, the Adjust with Projection wizard will open with the Results screen to show the updated job file points. Tap Apply to update the coordinate system and job file points.

Note: If your projection is a zone based site, then the localization parameters will automatically be converted into the corresponding ground coordinate values. You do not have to resolve the localization.



9. If the conventional Survey Scale factor is not set to 1.0, you will be prompted to set it to 1.0. Using Ground Coordinates, EDM distances correspond 1:1 to grid distances.

Switching from Ground to Grid

1. When Ground Coordinates are set, go to the Survey > Projection screen and tap Setup Ground Coordinates
2. In the Projection Definition box, select Use Grid

Coordinates.

3. Tap Accept to switch back to the mapping plane grid coordinate system, and open the Adjust with Projection wizard at the Results screen. Tap Apply to set the coordinate system and update the job file points.

Note: If your projection is a zone based site, then the localization parameters will automatically be converted back to the map projection values. You do not have to resolve the localization.

4. Switching back to mapping plane grid coordinates, the conventional Survey Scale Factor is usually set to 1.0. You will be prompted to update the scale to the correct value to reduce EDM measured distances to the mapping plane.

Coordinate System Database

Survey Pro uses a Coordinate System Database file (*.CSD) to store the map projection and datum transformation parameters for many different coordinate systems around the world. Also, horizontal and vertical localization adjustments can be stored as site records in the database. Below is a list of the terminology used to describe the different records in the coordinate system database.

- **Zone**: Is the basic record type. A zone record specifies the type of map projection and its parameters. Usually there is a datum, ellipsoid, and geoid record from the database already attached to the zone.
- **Site**: Is a zone record with a horizontal and/or vertical localization adjustment added. Localizations are usually used to correct GPS positions starting from an autonomous base. They can be computed from control points or from manual input of parameters. Coordinate systems with Ground Coordinates set are also site records. A Ground Coordinates site record may or may not have a horizontal and/or vertical localization adjustment.
- **Zone Group**: Is a collection of zone and/or site records used to keep the database organized and user selection easier.

- **Datum**: Is a type of datum transformation and its parameters. There is always an ellipsoid record from the database already attached to the datum.
- **Ellipsoid**: Are the two parameters specifying the ellipsoid of the datum.
- **Geoid**: Is a geoid model and its associated data file.

Managing GPS Coordinates in Survey Pro

Survey Pro for Windows CE uses a binary file with the extension *.job. A .JOB file point record will contain a point name, plane location (N, E, Z), and a description. It may also contain geodetic coordinates for points calculated, imported, or measured with GPS, as well as poly lines, alignments, layers, attributes, base maps, and automatic line work structures.

Edit Points

You can edit all of a point's values using the Edit Points screen from the Job menu. This is described in more detail in the User's and Reference Manual. Below are some special instructions for editing geodetic coordinates.

1. Select the point you want to edit and tap Edit, or double tap the point in the list to open the edit screens.
2. The three cards of the Edit Point screen display the current properties and the plane and geodetic locations of the selected point.
3. On the Geodetic card, you can tap Advanced to open the Edit GPS Point Flags screen. This screen allows you to edit the flags associated with GPS points:
    - Set up group: This flag identifies groups of points collected from the same autonomous base setup. For more information on set up groups, see Page 288.

- GPS Control Point H/V: These flags identify points to be included in the localization control point list and whether to use those points for the horizontal and/or vertical solution. For more information on set up groups, see Page 288.

4. If you change either the plane or geodetic location, and the point has geodetic coordinates, will be warned of the possible consequences, and, depending on your projection settings, prompted to rectify the plane and geodetic coordinate before accepting.

Import

You can use File > Import or File > Import Control to add point, line, and coordinate system values from a number of input file types. This section describes importing geodetic coordinates and coordinate systems into the job file.

Import Job (Control)

You can use the Import or Import Control screens and set the Type to Job Files to add points to your job from another job file. Points from the imported job will be copied into your current job file. The imported job file can also be used to set the coordinate system of the current job file:

- If the imported job has a coordinate system set and your current job does not, you will be prompted if you want to set the coordinate system from the imported job file.
- If the imported job and the current job have different coordinate systems set, then you will be prompted that they are different; you can cancel the import or import the points but keep the current job projection.

Import ASCII File

You can use the Import screen and set the Type to Text Files to add points to your job from an ASCII text file. The ASCII Import Wizard allows you to import Plane, Geodetic (DMS), and Geodetic (decimal) coordinates. When you import Geodetic (DMS) and Geodetic (decimal) coordinates Survey Pro will use the following rules to set the plane location:

- If you have a valid coordinate system solved Survey Pro will calculate the plane location for each geodetic point imported. Survey Pro will set the northing, easting, and elevation for any points that could be transformed without error.
- If you do not yet have a valid coordinate system solved, Survey Pro will set the plane location to (0.0, 0.0, 0.0). You would then have to use the Adjust with Projection wizard in some manner to rectify the geodetic to plane coordinates.

Import .GPS File

You can use the Import screen and set the Type to GPS File to merge geodetic coordinates from a .GPS file generated using Survey Pro DOS.

1. Open the job with the project's plane coordinates. You can open the *.CR5 file directly and it will be converted into a .job file or you can open a new .job file and import the CR5 coordinates.
2. Go to Job > Import. For file Type, select, (*.GPS) and pick the *.GPS file associated with the plane coordinates.
3. Specify the units of the *.GPS file (for the heights) and tap OK.
4. The GPS coordinates and control point flags for each point in the *.GPS file will be merged with the plane coordinates for the corresponding points.
5. If you have more than one *.GPS file associated with a set of coordinates, you can import them one at a time. The coordinates from each .GPS file will be assigned a unique set up group so you can use them for different localization solutions.

Note: If duplicate points are found, you will be prompted to overwrite or rename. If you choose to rename, a new point is created with the original plane coordinate and the new geodetic coordinate.

ForeSight DXM, SPSO, TGO, and TTC

There are a number of software applications that will work with Survey Pro .job and .raw files containing geodetic coordinates and GPS measurement vectors. This section contains a brief description of the work flow for downloading field work and uploading coordinates using one of the software applications designed specifically for TDS GPS raw data:

- ForeSight DXM (DXM)
- Spectra Precision Survey Office (SPSO)
- Trimble Geomatics Office (TGO) or Trimble Total Control (TTC).

ForeSight DXM

Using DXM, you can download Survey Pro job and raw files, open job files or regenerate job files from RAW data. You can use the DXM Manage Data function to move data, including coordinate system definitions, between DXM projects and Survey Pro jobs.

Using DXM, you can create new Survey Pro job files from other job files or from the project, and upload them to the data collector. Jobs created from a job or project that has a coordinate system will have the same coordinate system. Points with geodetic coordinates will have geodetic coordinates in the uploaded job.

Spectra Precision Survey Office

Using SPSO, you can download Survey Pro raw and job files from your data collector and import them into a SPSO project. You can have SPSO download and automatically import any *.RAW or *.job files directly from the data collector into your project, or you can download them onto your PC using ActiveSync and import them from a location on disk.

The SPSO download and import process defaults to download and import the .RAW file. When you import the .RAW file, the coordinate system, user entered points, and all of the observation vectors taken in the survey will be imported into the project. The coordinates for measured points will then be calculated in your SPSO project from the measurement data. You can also import a .job file into the project. When you import a .job file you will get only the coordinate system and the point coordinates; you will not get the measurement vectors from the .job file.

SPSO export will create a .job file of selected project points including any defined coordinate system. You can export this file to a location on disk and move it to the appropriate data collector manually, or you can export and upload to the data collector in one step directly from SPSO.

Note: SPSO will only import GPS measurement vectors from Survey Pro .RAW files that were collected with an EPOCH25 GPS receiver or with a Trimble GPS receiver when the Trimble System Extension module was authorized in Survey Pro at the time of data collection.

TGO / TTC

Using TGO or TTC, you can download Survey Pro job and raw files to your hard drive, convert them into Trimble DC files, and import them into a TGO or TTC project. For both TGO and TTC, the download is done with a common Trimble component called 'Data Transfer'. Once downloaded, the file is automatically converted into the Trimble DC format and imported into the TGO/TTC project. You can also convert and import a file already on disk using the Import function.

TGO / TTC download and import requires you to choose the .job or .raw file separately. For most purposes, you will just need to import the .raw file. When you import the raw file, the converted DC file contains the coordinate system, the points, and all of the measured vectors from those points. When you import the .job file, the converted DC file contains just the coordinate system and the plane location of the points.

TGO export and upload will create a job file and send it to the data collector. The job file will contain the coordinate system definition and plane location of any selected points. The geodetic location of any

GPS measured points is not uploaded to the data collector from TGO or TTC. However, this is not a problem since the coordinate system definition is uploaded, and this will define the transformation from plane to geodetic.

Note: TGO will only import GPS measurement vectors from Survey Pro .RAW files that were collected with an EPOCH25 GPS receiver or with a Trimble GPS receiver when the Trimble System Extension module was authorized in Survey Pro at the time of data collection. TTC will import GPS measurement vectors from any Survey Pro .RAW file, regardless of the type of GPS receiver used to do the data collection or the modules authorized in Survey Pro at the time of collection.

GPS Module

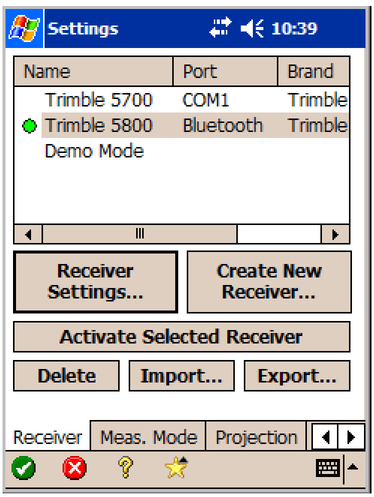
Survey Pro can be sold with either the standard GPS module or the Basic GPS module. This section outlines the procedures for using Survey Pro with the GPS module. If using the Basic GPS module, refer to Page 329.

The GPS module allows you to control a GPS receiver for both real time and post processing data collection. This section describes how to start a GPS survey and how to use GPS data collection and stake out. In this section, you will learn:

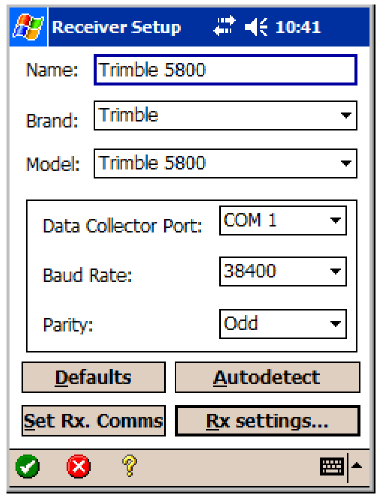
- How to create a profile and manage GPS settings.
- How to start an RTK survey, or an RTK simultaneous with post processing survey.
- How to select a projection mode to convert geodetic positions (latitude, longitude, height) to your local coordinates (Northing, Easting, Elevation).
- How to set up the RTK base receiver and configure the base reference position.
- How to set up the RTK rover receiver.
- How to solve a horizontal and vertical localization coordinate system adjustment, and when a coordinate system adjustment is required.
- How to switch between grid and ground coordinates when surveying on a selected mapping plane.
- How to collect data with GPS.
- How to stake out with GPS.
- How to use the Adjust with Projection wizard to update the job file points when the coordinate system changes.
- How to use the Adjust with Projection wizard to adjust selected points from one coordinate system to another.
- How to use the Projection Calculator to calculate convergence and/or scale factors for a selected mapping plane zone.

Receiver Settings

Using either RTK or post processing data collection is controlled by the type of receiver you choose to connect to. The Job > Settings > Receiver screen is used to manage receiver profiles for RTK and post processing receivers. You must create a receiver profile for each different brand and model you want to use as an RTK base, RTK rover, RTK NTRIP rover, or post processing only receiver.



Receiver Settings



Receiver Setup

1. Go to the Job > Settings > Receiver and tap Receiver Settings to open the Receiver Setup screen. Alternatively, you can tap Create Receiver or Receiver Settings when prompted to connect to a receiver during Start GPS Survey (Page 273).

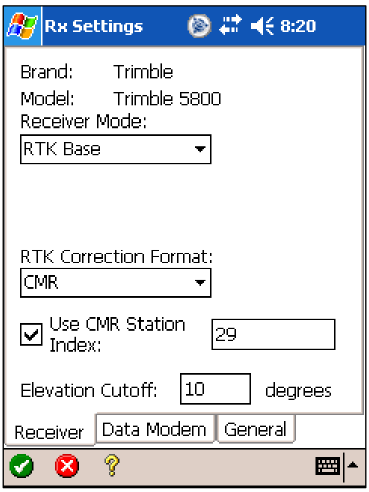
2. Enter a Name for this receiver profile, choose the Brand and Model, and select the communication settings.

3. Tap Rx Settings to connect to the receiver and open the Receiver Settings screen where you can configure the specific properties of the receiver profile using up to three cards.

4. When you are done configuring the receiver settings as described below, tap OK to close the Rx Settings screen, and OK again to create or update the receiver profile.

This receiver profile is now ready to use in a GPS survey. You should now set the RTK and/or post processing settings on the Measure Mode, Projection, and Post Processing cards of the Job > Settings screen, see page 269.

Receiver Settings – Receiver Mode



1. Select a receiver mode for this profile. You can choose from:

   - RTK Base: Select this mode to use the receiver as an RTK base. To configure an RTK base, you must set the RTK Correction Format on this card, and you must setup the data link parameters on the Data Modem card.

   - RTK Rover: Select this mode to use the receiver as an RTK rover where the base corrections are supplied directly to the rover over the data link. To configure an RTK rover, you must set the RTK Correction Format on this card, you must setup the data link parameters on the Data Modem card, and you can also specify any Rover Options on this card. Choices for Rover Options are:

     - None: No special operation of the rover.

     - GGA Outputs: This option will enable NMEA GGA strings to be sent out the modem port at regular intervals. Use this option if you are connecting to a GPS network server that does not use NTRIP (see page 225) to manage logging into the network.

     - VRS non-NTRIP: This option will enable NMEA GGA strings to be sent out the modem port at regular intervals, and will configure the receiver for VRS rover operation. Use this option if you are connecting to a GPS network server that does not use NTRIP to get VRS corrections (see page 225).

- NTRIP Rover: Select this mode to use the receiver as an RTK rover where the base corrections are to be supplied to the rover by connection to an NTRIP service (see page 225). To configure an NTRIP rover, you must setup the Windows Networking modem parameters on the Data Modem card (see below).

Note: You do not need to select the RTK Correction Format for an NTRIP rover because this will be determined by the NTRIP service you pick at rover setup time.

- Post Processing: Select this mode to use the receiver to log data for post processing. You can do either static or kinematic (stop and go) post processing data collection control with Survey Pro. You do not need to setup the data link parameters for post processing receivers.
    - Select the RTK Correction Format if this is required
    - Select any Rover Options if this is required
    - Select whether or not to use a CMR station index for base or rover setup if this is required.
    - Set the elevation cutoff desired for data collection. This is the angle below which satellites will not be used.

Receiver Settings – Data Modem

1. Select the specific type of data link in the Data Modem drop down list.
2. Configure any settings required for this modem

Note: There are many different Data Modem types available. The content of this drop down list will depend on the brand and model of receiver selected. The settings to configure on this page will depend on the specific Data Modem selected. If you are using a device that is not listed in the Data Modem drop down, then you can choose to use the 'Generic Serial' device and simply set the correct port, baud rate, and parity for this device.

Receiver Settings – General

The controls on the Receiver Settings – General card will vary depending on brand and model. Please see the documentation that came with your GPS receiver for details on the different settings that may be available. If using a Bluetooth GPS receiver, refer to the Bluetooth section on Page 316.

RTK Settings

If you are using Survey Pro for RTK, or RTK simultaneous with post processing data collection, the following cards of the Job > Settings screen are used:

Measure Mode: is where you select the type of GPS raw data to store for each point. You can also set measurement acceptance criteria. These settings are described in detail in the Reference Manual.

Post Processing Settings

If you are using Survey Pro for RTK simultaneous with post processing, or post processing data collection, the Post Process card of the Job > Settings screen applies.

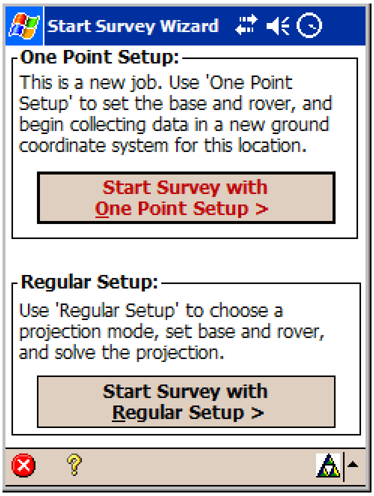
You can specify how to deal with autonomous positions and select a special layer to store autonomous points on. These settings are described in detail in the Reference Manual.

Start GPS Survey

The Start GPS Survey wizard is used to start any RTK survey. This wizard will guide you through the steps required to choose a coordinate system, set up your equipment, solve an adjustment, and start collecting data or staking out points. The Start GPS Survey wizard can be used for any RTK setup, regardless of your coordinate system requirements, and your base and rover equipment configuration.

The steps required to complete the Start GPS Survey wizard will depend on the coordinate system and equipment you are using. All the possible steps are described below.

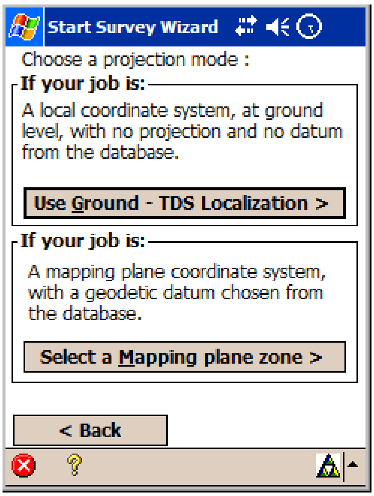
Start GPS Survey – Choose One Point Setup



One point setup is a special case of the Start GPS Survey wizard. You can use one point setup mode only when you have a brand new job with only one point. When you use one point setup, Survey Pro will use Ground - TDS Localization mode, and automatically solve the localization adjustment to give you ground level coordinate system with the origin at your first point. When you choose one point setup, there are no additional steps required to solve your coordinate system, all you have to do is complete base and rover equipment setup and you are ready to survey.

Start GPS Survey - Choose Projection Mode

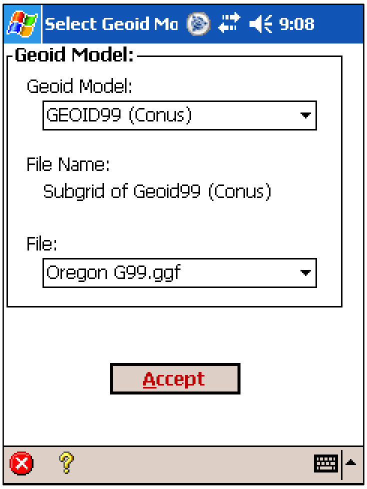
The Start GPS Survey Choose Projection mode screen is used to choose the horizontal projection mode. There are two choices:



Choose to Use Ground – TDS Localization when your survey is a ground level site with no projection and no datum to relate the local coordinates to geodetic. When you choose Ground – TDS Localization, the next step will be base and rover setup, and solving the localization adjustment.

Choose to Select a Mapping Plane Zone when your survey coordinate system is a conformal mapping plane defined in the coordinate system database. When you choose Mapping Plane mode, your next step will be to select a coordinate system from the database (Page 250). Then, you will proceed with base and rover setup. If you set the base on a known point, you do not need a localization adjustment and you will be ready to collect data after rover setup. If you start from an autonomous base, you must solve a localization adjustment.

Start GPS Survey – Choose Geoid

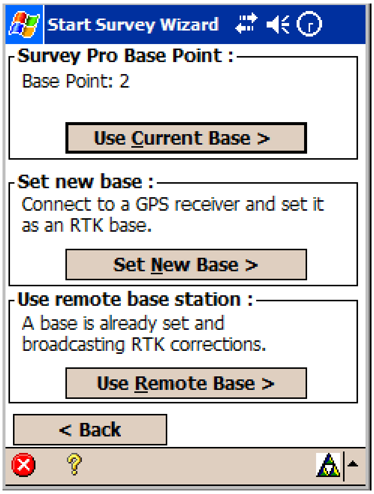


Use the Select Geoid Model screen to select a geoid model and data file to use with either the Ground - TDS Localization or Mapping Plane zone. This screen only appears as part of the GPS Start Survey wizard when a geoid is not currently assigned.

1. Select a Geoid Model to use from the list.
2. If there are no data files for the selected geoid model, the File control will display "No .ggf files for this geoid." If there is only one data file for the selected geoid, the File control will display that .GGF file name. If there are multiple data files for the selected geoid, select the geoid you wish to use from the list. When there is a geoid file displayed, the File Name control displays the data file name from the .GGF file header.

 - Tap Accept to set the geoid for the current projection record and/or change the data file used by the current geoid model.

Start GPS Survey – Choose Base Setup



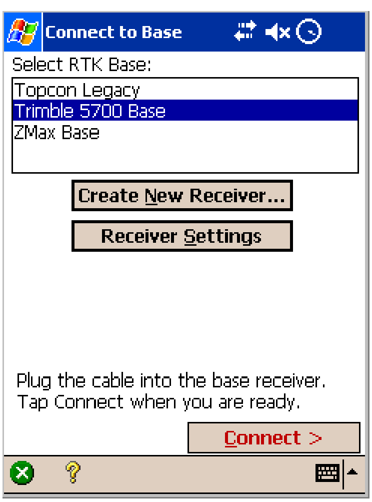
The Start GPS Survey Choose Base Setup screen is used to select how you will set your GPS base. There are three choices:

- Use Current Base: This option can be used when you have already set a base station with this data collector. When you tap Use Current Base, the Start GPS Survey wizard will display the next screen required for setup. If rover setup is not complete, or if you answer yes at the prompt to reset the rover, you are prompted to select an RTK rover or an NTRIP rover receiver, and then the Rover Setup screen is opened. If rover setup is complete, but you must still solve your projection, the Start GPS

Survey – Solve Localization screen is opened. If the complete setup is already done, the Data Collection screen (Page 302) is opened.

- Set New Base: This option is used when you wish to connect to a GPS base receiver, set it as an RTK base, and configure the base reference position in Survey Pro. When you select Set New Base, you are prompted to select a base receiver and then the Base Setup wizard is opened.
- Use Remote Base: This option is used when there is already a base set up and broadcasting corrections. This includes using the rover with a network GPS service. Choose this option to setup a rover receiver and configure the base position in Survey Pro. When you select Use Remote Base, you are prompted to select an RTK rover or an NTRIP rover receiver, and the Rover Setup screen is opened.

Start GPS Survey – Connect to Receiver



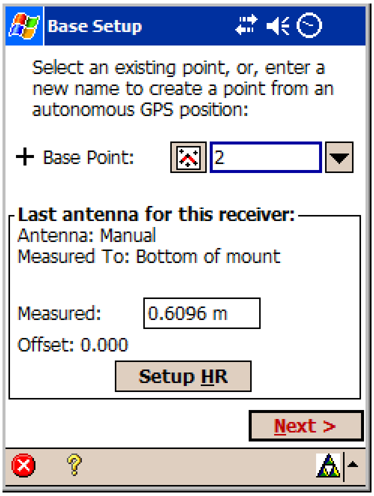
Before the Base Setup, Rover Setup, or Data Collection screens are opened, you will be prompted to connect to the appropriate receiver.

The Connect to Receiver screen is used to display a list of all of the receivers of the appropriate type (base, rover, or post processing) you can connect to. If you have used this type of equipment with this data collector before, then the receiver you last used is remembered and you can proceed simply by tapping Enter or Connect>. If you need to create a new receiver or change the receiver settings, you can tap Create New Receiver to open the Receiver Setup screen, or tap Receiver Settings to open the Job > Settings > Receiver screen.

Start GPS Survey – Base Setup

The Base Setup wizard is used to setup an RTK base receiver, and to configure the base reference position in Survey Pro.

Base Setup One – Pick Point



The first step of the Base Setup wizard is to pick a point for the base reference position, and measure the antenna height at the setup.

1. Set the base receiver antenna over the point.
2. Tap Setup HR to select your antenna type and measure the slant or vertical height of the antenna.
3. Enter a name for the Base Point. You can select an existing point from the job or you can enter a new point name for the job. If you select:
    - An existing point with geodetic coordinates, the GPS base receiver is set with this coordinate, and the base reference position is configured in Survey Pro.
    - An existing point with plane only (N,E,Elev) coordinates when the coordinate system is solved, the plane coordinate is transformed into geodetic, the GPS base receiver is set with this coordinate, and the base reference position is configured in Survey Pro.
    - A new point, or, an existing plane point when no projection is solved, you start from an autonomous position. You will GET an autonomous position from the GPS receiver for your first base setup. You then SET this reference position in the GPS receiver and configure the base position in Survey Pro.

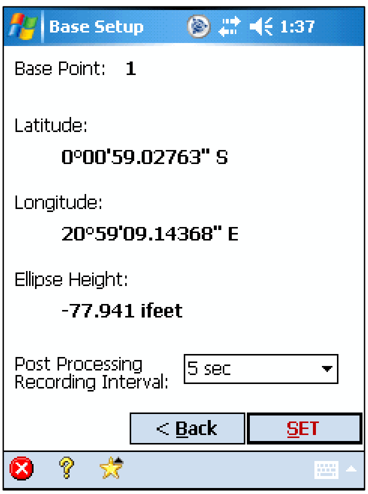
Note: It is strongly recommended that you use only one autonomous GPS base position in a job. If you must use multiple autonomous setups in a single job, you will be prompted to setup and select a separate site record for each setup group.

4. Tap Next>.

The final step of the Base Setup wizard will depend on the base point chosen. If the base (lat, lng, ht) is known or can be computed, the final step is to SET the base at the known geodetic position. If the base (lat, lng, ht) is not known, the final step is to GET an autonomous position to SET the base with.

Base Setup Two – SET

The Base Setup Set screen is used when the geodetic coordinate of the chosen base reference point is known or can be calculated.

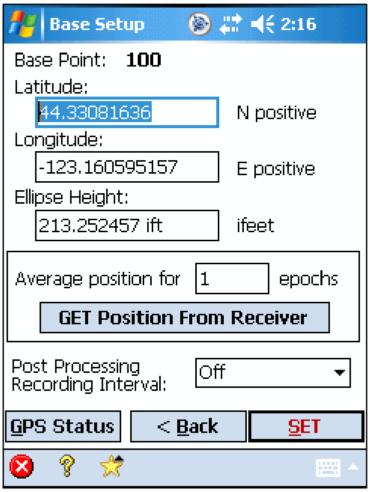


5. If you are not post processing, leave the Post Processing Recording Interval field set to Off. If you are post processing, select the desired recording interval in this field. The receiver will open a file (with the next available default name), start recording GPS raw data, and record the station and antenna information for this static session.

6. Tap SET to start the base receiver broadcasting this reference position and GPS observations over the radio link, and to configure the base reference position in Survey Pro.

Base Setup Two - GET and SET

The Base Setup GET and SET screen is used when the geodetic coordinate of the base reference position is not known. In this case, you must GET an autonomous position from the GPS receiver and then you can SET this as the reference position.



7. Tap GET Position From Rx to get an autonomous position from the receiver. If you wish to get an averaged position, enter a number in Average position [n] epochs before GET.

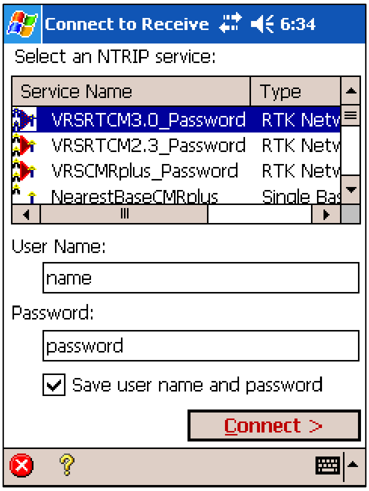
8. If you are not post processing, leave the Post Processing Recording Interval field set to Off. If you are post processing, select the desired recording interval in this field. The receiver will open a file (with the next available default name), start recording GPS raw data, and record the station and antenna information for this static session.

9. Check the results displayed in the edit boxes. If it looks good, tap SET to start the base receiver broadcasting this reference position and GPS observations over the radio link, and to configure the base reference position in Survey Pro.

Start GPS Survey – Rover Setup

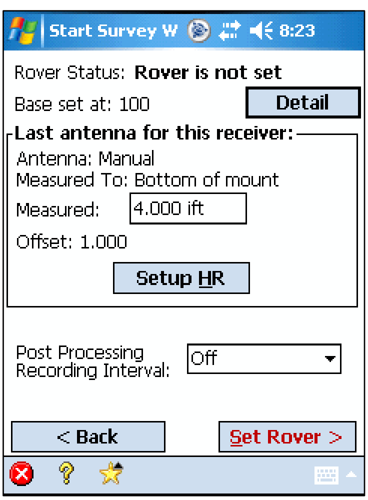
The Start GPS Survey Rover Setup screen is used to setup an RTK rover receiver, and to configure or check the base point reference position in Survey Pro. Before proceeding to the Rover Setup screen, you will be prompted to connect to an RTK rover or an NTRIP rover receiver. Connecting to a rover receiver uses the same screen used for the base receiver, described above on page 273. If you select an RTK rover receiver, you will proceed directly to the Rover Setup screen. If you choose an NTRIP rover, you will first be prompted to choose an NTRIP service before you proceed to the Rover Setup screen

Rover Setup – Select NTRIP Service



1. Select a service from the Select an NTRIP service list box.
2. If this service requires a user name and/or password, enter these values in the User Name and/or Password edit fields.
3. If you wish to persist this user name and/or password, check the Save User Name and Password box.
4. Tap Connect> to log onto the RTK network server and use the selected service.

Rover Setup – Set Rover



1. Tap Setup HR to select your antenna type and measure the slant or vertical height of the antenna.
2. If you are not post processing, leave the Post Processing Recording Interval field set to Off. If you are post processing, select the desired recording interval in this field. The receiver will open a file (with the next available default name), start recording GPS raw data, and record the station and antenna information for this static session.
3. Tap SET Rover to setup the receiver as an RTK rover. The rover will then wait to receive the base reference position over the data modem link. If you have already configured the base with this data collector, then the base reference position from Survey Pro will be checked against the position received at the rover.

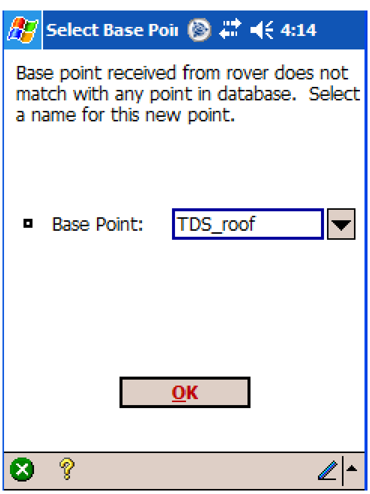
If you have not yet configured the base reference position in Survey Pro, it will be configured with the position received at the rover.

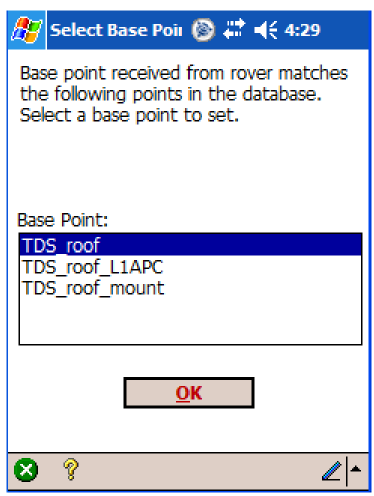
Rover Setup – Set Base Reference Position

When you are using a remote base station, and the base reference position is not yet known to Survey Pro, you must complete the Base Setup wizard for the remote base position in order to store the base position in Survey Pro and update the raw data.

Similarly, when you set the rover and the remote base position received at the rover is different than the one set in Survey Pro, or when you are doing RTK surveying and the rover detects that the base position has changed, you will be prompted to complete the Base Setup wizard for the remote base position.

1. Choose a name for the remote base point. If the base reference position received at the rover matches a single point in the job file, then the prompt to choose a point name is skipped, and you go to the next step. If the base position does not match any points in the job file, you are prompted to choose a name for the new base point to store. If the base position matches more than one point in the job file, then you are prompted to select from among a list of possible points.





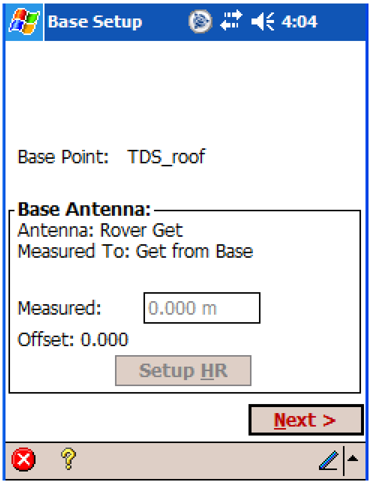
2. Review the antenna details for the remote base position. Most base receivers broadcast their antenna height along with the reference position. However, some do not. The different scenarios are outlined below:

- When the rover receives the base antenna information, Survey Pro displays the antenna height received. The antenna Measure To displays Get From Base.

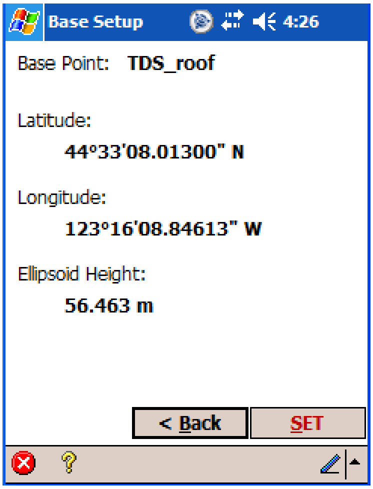
Note: When the rover receives the base antenna information, and the base point exists in the job file, Survey Pro checks the agreement between the base antenna phase center position broadcast minus the broadcast antenna, and the height of the point in the job file. If there is a misclosure, you are prompted, and you must update the height of the base point in the job file in order to complete the Base Setup wizard.

- When the rover does not receive the base antenna information, and the base point exists in the job file, Survey Pro calculates the antenna from the base height and the reference position antenna phase center height. The antenna Measure To displays Calced. by SP, and the Measured field displays the calculated value.
- When the rover does not receive the base antenna information, and the base point is new in Survey Pro, you are prompted to enter the known antenna height in order to store the new point on the ground, or leave the antenna height at 0.0 to store the new point at the base antenna phase center. The antenna Measure To will display Entered in SP, and the Measured edit box is enabled for you to enter the value.

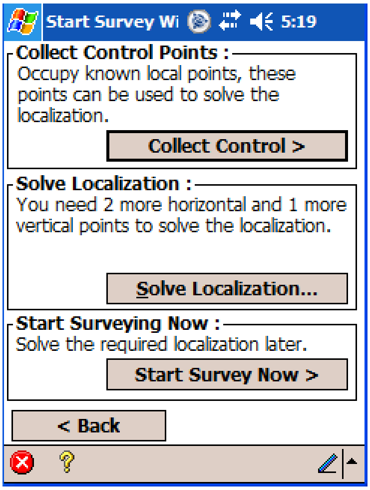
1. Tap Next>.



2. Review the base reference position to be stored in Survey Pro. Tap Set to accept the remote base receiver antenna and position and update the raw data, and continue with the RTK survey.



Start GPS Survey - Solve Localization



The Start GPS Survey Solve Localization screen is displayed when you need a horizontal adjustment to solve your coordinate system. A horizontal adjustment is required to solve your coordinate system any time you begin a survey from an autonomous base position. This is always the case when your projection mode is Ground – TDS Localization, since your first base setup is always from an autonomous GPS position. This may be the case when your projection mode is Mapping Plane, when you set your first base on a new point. A vertical adjustment is often desired, although not required before data collection can begin.

The horizontal and vertical adjustments are usually solved together. First, tap Collect Control> to occupy some existing local points as GPS Control points. Next, tap Solve Localization ... to open the Solve Localization wizard to calculate the horizontal and vertical adjustment parameters (Page 288).

After you successfully solve the localization adjustment, the Start GPS Survey wizard will close, and the GPS Data Collection screen will open (Page 301). You are now ready to measure and store new points in this job.

You can also choose to start the survey without solving the localization, and complete the required adjustment later. Tap Start Survey Now > to apply a temporary localization and begin data collection. Any time during the survey, you can occupy the required control points and solve the localization parameters. The GPS data collected points will be updated to the proper local coordinate after the localization is solved.

Solve Localization

When you start a GPS survey from an autonomous base position, you need to solve a localization to adjust GPS measurements into local coordinates. This is the case for both horizontal projection modes. Using Ground - TDS Localization, you need to solve a localization to relate your arbitrary GPS start point into your non-geodetic local system. Using a Mapping Plane, you need to solve a localization to shift the autonomous GPS start point into accurate geodetic coordinates.

In either horizontal mode, the procedure is the same. Starting from an autonomous GPS base setup, you measure GPS positions on control points with know local plane (N,E) coordinates. The parameters for a 2D similarity transformation are calculated with a least squares solution using the control points. These parameters are added to the zone record (the default Ground - TDS Localization mode zone or the selected Mapping Plane mode zone) to create a zone based site record.

Vertical localization, with or without a geoid model, uses the same field procedure. Starting from an autonomous GPS base setup, you measure GPS positions on control points with know local elevations. The vertical adjustment parameters are calculated from the control points. The vertical adjustment will be either a shift to correct geoid elevations to local elevations, or an inclined plane to correct for vertical shift and tilts.

Note: If you are starting a new job from an autonomous GPS base setup using one point setup, you do not need to solve a localization adjustment. The default map projection will be scaled to ground, and oriented with grid north equal to geodetic north at your first base station.

Localization with Control Points

Horizontal localization is a simple 2D similarity transformation from mapping plane coordinates in an intermediate system to coordinates in your local system. In Ground - TDS Localization mode, the intermediate system is the default map projection initialized for ground distances at the base height. In Mapping Plane mode, the intermediate system is the inaccurate coordinates calculated on the selected map projection from the autonomous GPS base.

Vertical localization is a correction from measured ellipsoid heights or geoid elevations calculated from heights, into local elevations. This correction can be a simple shift or a three-parameter inclined plane.

Localization with Control Points: Summary

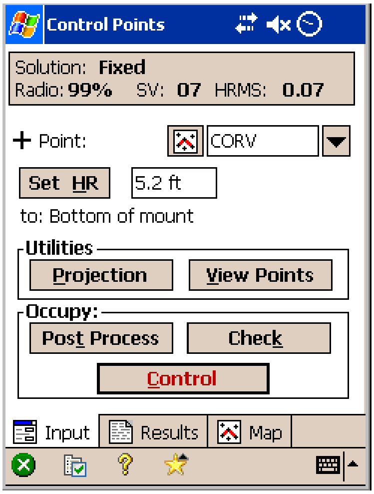
Take GPS measurements to at least the minimum number of control points. In Ground – TDS Localization mode, at least two horizontal control points are required. In Mapping Plane mode, at least one horizontal control point is required. In Localization (+Geoid) mode at least three vertical control points are required when there is no geoid model, and one vertical control point is required when there is a geoid model.

1. Tap Solve Localization... to open the Solve Localization wizard.
2. Select the points to use for horizontal and vertical control and tap Solve>.
3. Verify solution residual or misclosure quality. Tap Next> to review the parameters and tap Accept to finish setup.
4. Occupy additional local points as check points to verify solution quality. If desired, additional points can be added as control points and included in solution.

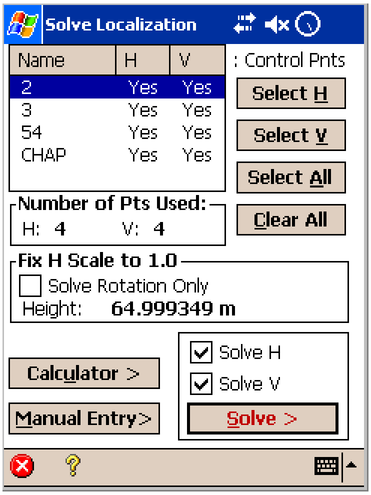
Note: When you resolve the localization, all of your job file points will automatically be readjusted using the Adjust with Projection wizard (Page 311). Therefore, your local coordinates derived from GPS measurements will always be calculated using the latest coordinate system solved.

Detailed Procedure

Since the field procedure is the same for both horizontal and vertical localization solutions, the instructions below cover both cases.



1. From the Control Points screen, select a control point to occupy and enter the name into the Point control. Horizontal control points must have a valid northing and easting coordinate in the local system. Vertical control points may have a valid horizontal coordinate (although it is not used in the calculation) but must have a valid elevation.
2. Level the rover antenna over the point and tap Control Point to begin data collection.
3. When you are happy with the measurement, tap Accept.
4. Check the Results tab for details of the previous measurement. Check the Map tab to see the number and position of control points for this set up group.
5. Collect a minimum of one control points to solve horizontal localization on a mapping plane. Collect a minimum of two control points to solve a horizontal localization in an arbitrary ground system with no projection and no datum. Collect a minimum of three vertical control points to solve vertical localization. Collect one vertical control point to solve just the localization vertical shift when using a geoid model.
6. When you have collected the minimum number of control points, tap Projection and Solve Localization to open the Solve Localization wizard.



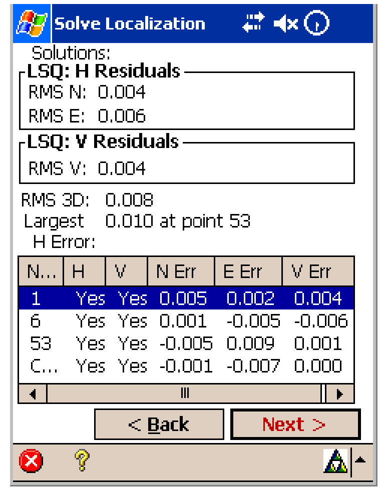
7. In the list box, control points collected will be identified with an H and/or V. Points marked H will be used to solve horizontal localization. Points marked with a V will be used to solve vertical localization. You can select or deselect any point by highlighting that point and then: tap the H and/or V column beside that point; press H and/or V on the keyboard.

Note: If your base was set up on a known point, that point is an eligible control point. If your base was set up on a new point, then it is not visible on the control point list.

8. If you wish to hold the scale of the GPS measurements, but you want the localization adjustment to correct for a rotation, check the Solve Rotation Only control in the Fix H Scale to 1.0 box.

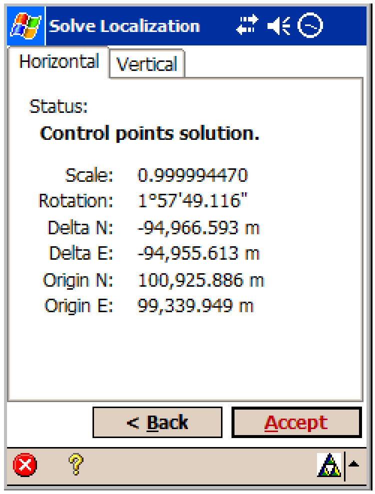
9. Double check the selection of control points and tap Solve >. The localization parameters are computed using the selected control points, and the next screen is opened with solution RMS values.

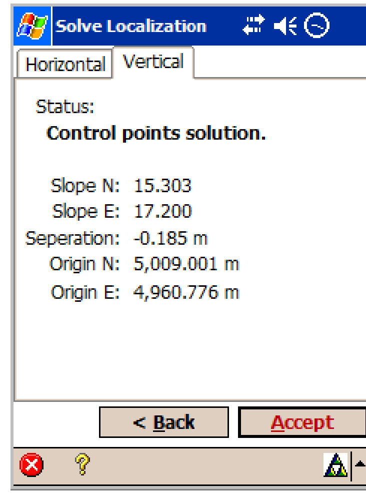
10. For both horizontal and vertical, the solution type and RMS value from the control points are displayed. The solution type will be one of:



- Unique: the solution was calculated using the minimum number of control points or fewer. In this case, there is no least squares solution to provide residuals, so the numbers in the N Err, E Err, and/or V Err columns are misclosures calculated from the control points that ***are not used*** in the solution.
- LSQ: the solution was calculated with more than the minimum number of control points. In this case, the least squares solution can produce residuals, and the N Err, E Err, and/or V Err columns show residuals for the points that ***are used*** in the solution.

11. If you are not happy with the solution residual or misclosure values for any point, you can change the control points used by tapping in the H and/or V columns. This will change Next> to Solve>. Tap Solve> to recalculate the solution and update the residual / misclosure display.
12. When you are happy with the solution quality, tap Next> to review the parameters.
13. Examine the scale and rotation values to verify they are reasonable. See the explanation of localization parameters (Page 288) to determine what is reasonable.





14. When you are happy with the solution, tap Accept to set the horizontal and/or vertical adjustment. The Adjust with Projection wizard will open to show you a preview of the changes to the geodetic points. Tap Accept to update the coordinate system in the job and raw data, and to apply the adjustment to the points.

Manual Entry of Parameters

Manual entry of parameters is used when you already know the appropriate horizontal and vertical localization parameters for a site. Use manual entry of parameters to key in the site parameters and set it as the current coordinate system.

1. Tap Solve Localization to open the Solve Localization wizard and then tap Manual Entry>.
2. Enter the Scale, Rotation, Translations, and Origin of the horizontal system.
3. Enter the Slope N, Slope E, Separation, and Origin of the vertical adjustment.
4. Tap Solve> to show the horizontal and vertical parameters entered.
5. Review the results and tap Accept when you are done.

Localization Parameters Explained

Before you accept a localization solution, you should evaluate the parameters and the quality of the solution. This section describes the meaning and the expected values for the six horizontal and five vertical localization parameters. Guidelines for the quality and geometry of control points plus the solution redundancy and residuals are also described.

Horizontal

Ground - TDS Localization Mode:

Scale: is the scale difference between the intermediate mapping plane and the local system. Scale should be very close to 1.0. A value of 1.0 corresponds to ground level distances at the base reference height.

Scale values are often reduced to parts per million in order to relate the factor to a distance. One ppm (the sixth decimal place i.e. 1.000001 or 0.999999) is equal to 1mm in 1km. This is well below RTK precision. Fifteen ppm (1.000015 or 0.0.999985) is equal to 15mm in 1km. This is a usual RTK precision, so anything in this range is expected. A scale value significantly greater or smaller than 1.0 may indicate problems with the control point accuracy and/or the control measurement precision. It might also indicate a base reference height too high or low for the survey area, or a scale bias in the control point local coordinates.

Rotation: is the rotation between the localization map projection zone and the local system. The rotation represents the difference between grid north and geodetic north at the meridian passing through the origin of the localization transformation. Because most local coordinate systems are not referenced to a geodetic azimuth, any number could be a valid parameter here.

Origin: is the coordinate on the intermediate mapping plane of the centroid of the control points. It is calculated by average of the mapping plane (y,x) coordinates of all control points.

Translation: is the shift from the Origin to the centroid of the control points in the local coordinate system.

Mapping Plane Mode:

Scale: is the scale difference between the intermediate mapping plane using the autonomous GPS position and the actual mapping plane control coordinates. Scale should be very close to 1.0. A value of 1.0 corresponds to grid distances on the selected conformal mapping plane.

A scale value significantly greater or smaller than 1.0 may indicate problems with the control point accuracy and/or the control measurement precision. It might also indicate a scale bias in the control point plane coordinates, which you may want to correct by solving a fixed scale transformation.

Rotation: is the rotation between intermediate mapping plane using the autonomous GPS position and the actual mapping plane. The rotation should be very close to 0.0. A rotation value significantly greater or smaller than 0.0 may indicate problems with the control point accuracy and/or control measurement precision. It might also be an orientation bias of the mapping plane control system that you wish to solve for.

Origin: is the coordinate on the intermediate mapping plane of the centroid of the control points. It is calculated by average of the mapping plane (y,x) coordinates of all control points.

Translation: is the shift from the Origin to the centroid of the control points in the local coordinate system. This value represents the shift introduced by the inaccurate autonomous GPS starting position, and is usually less than 10m, the accuracy of an autonomous GPS position.

Vertical:

Slope: is the North and East tilt of the inclined plane adjustment. These values are given in parts per million, and represent the radian angle values of the deflection between the ellipsoid normal and the local gravity vector. This tilt approximates what a geodosist would call 'deflection of the vertical'.

Separation: is the shift between the local elevation and the vertical reference surface (geoid elevations when using a geoid model or ellipsoid height when using localization vertical only).

Origin: is the local coordinate of the first point used in the control point list. The slope values are applied from this point.

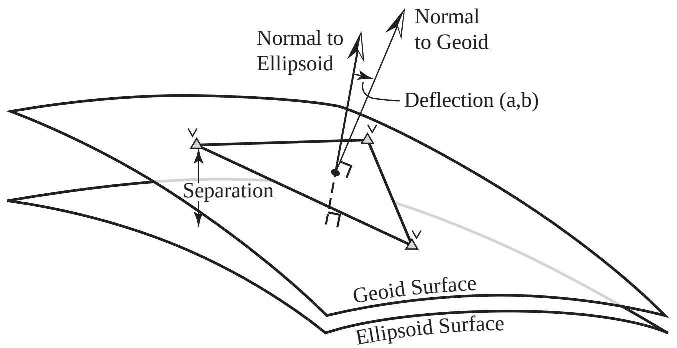


Fig. 9: Vertical Localization
Three control points calculate a plane to model the deflection and shift between the geoid and ellipsoid surface.

Vertical Calibration and Geoid Modeling

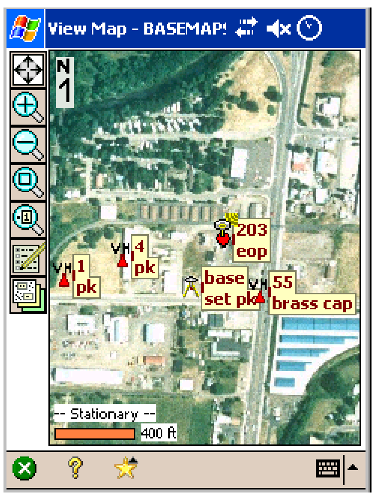
If you do not use a geoid model, vertical localization will solve for slope and separation using the measured heights and the control elevations. If you do use a geoid model, vertical localization will solve for the separation between the geoid elevation and your control elevation. Geoid elevations are computed from measured heights and geoid undulation using the height equation (see Page 240):

$$h = H + N$$

Quality of Localization Solutions

Starting from an autonomous GPS base position and solving a localization with control points is similar to starting a conventional survey from an unknown setup and solving a resection. The quality of the solution depends on both the precision of the measurements to the control points and the accuracy of the control point coordinates. When solving a localization with control points, the following guidelines should be followed:

- Quality of control points: the control point coordinates should be at least as precise as the specified survey requirements.
- Geometry of control points: the control points should be distributed evenly surrounding the survey area.



Poor Control Point Geometry

Good Control Point Geometry

The illustration on the left shows an example of poor GPS control point geometry. The points do not surround the survey area, and they are nearly co-linear, which is a big problem for the vertical adjustment. The illustration on the right shows an example of good control point geometry. The points surround the survey area, and form a nearly equilateral triangle for the vertical solution.

- Check points: after solving for localization parameters with a minimum number of control points, you should occupy an independent checkpoint to verify the solution quality. If you desire, this point can be added as a control point and used for subsequent solutions. If the checkpoint measurement is within the tolerance, this step should not be necessary.
- Redundancy and residuals: After solving localization parameters with more than the minimum number of control points, you should examine the solution residuals. The residuals should be close to the measurement precision of your instrument and the control points.

Ground - TDS Localization Explained:

When the horizontal projection mode is Ground - TDS Localization, a default map projection is automatically set up to produce ground coordinates at the base station height. The Ground - TDS Localization mode default map projection is an oblique stereographic map projection with the following parameters:

- Origin is at the initial base station location
- False northing and false easting of 100000.0 m
- Scale at the origin of the stereographic map projection zone is calculated to produce ground scale distances at the height of the first GPS setup. This projection scale factor is simply the inverse of the ellipsoid scale factor for the reference height (see Page 237).

  Origin Scale (k_{map}) = (R+h)/ R

$$R = \frac{a}{(1 - e^2 \sin^2 \phi)^{\frac{1}{2}}}$$

Localization Setup Groups

When you set up different base stations with autonomous positions from a GET, each position is only accurate to +- 30m (+- 10 m with Selective Availability (SA) turned off). Geodetic coordinates measured from your first autonomous base will not be accurately connected to geodetic coordinates from a different autonomous base. Although the localization parameters will accurately transform both sets of data to the local coordinate system, it is not possible to compare the geodetic coordinates from the different sets of data.

Survey Pro solves this problem by assigning a set up group each time a new autonomous base is set. A set up group is a unique flag attached to each point record generated by GPS. Setup groups are assigned as follows:

- When you set a new base point with an autonomous GET, Survey Pro creates a new set up group for this point.
- When you collect geodetic measurements, each new point is assigned the set up group of the current base station.
- When you set the base on an existing point with geodetic coordinates, the point’s existing set up group is used as the new base station set up group.
- When you set the base on a point with existing plane coordinates and compute geodetic coordinates using the ‘Move Base’ algorithm, the existing coordinate system’s set up group is used as the new base station set up group.

One Point Localizations Explained

When you want to open a new job and start a ground level survey with no existing coordinates or control, you should use the Start GPS Survey wizard one point setup option. After you set your base and rover, you will be ready to collect data in a coordinate system with the following properties:

- The coordinate system is scaled to ground level. Distances measured with an EDM will be 1:1 with GPS measured coordinates. Ground level is set automatically at the base reference position. If your base is set at a height considerably higher or lower than your survey area, use the Localization Set Zone screen (Page 249).
- The coordinate system is oriented with grid north equivalent to geodetic north at the base point. This means if you did a sun shot at the base reference position; your solar azimuth would be equivalent to grid azimuth along this meridian. If you did a sun shot east or west of the base position, the solar azimuth would differ from grid azimuth by meridian convergence.

- The coordinate system has its origin at the local northing and easting of the first base position. The localization Translation values would be the offset between the default map projection's origin (100000, 100000)m and the local coordinate of the base.

Localization Calculator

Note: The Localization calculator is used to provide the field procedure for a workflow supported in Survey Pro versions prior to 3.5. This routine is similar to using the Start GPS Survey wizard one point setup mode, except that rotation is calculated parallel to a selected map projection.

1. After choosing the projection settings and configuring the base and rover receivers, go to the Survey > Projection screen.
2. Tap [Solve Localization...] to open the Solve Localization wizard and then tap [Calculator>].

Note: The vertical card will be the vertical manual parameter screen described in the previous section.

3. Leave the scale at 1.0. For an explanation of the scale factor or to review the reference height used for ground scale, tap the [Calc Scale] button.
4. Calculate the rotation for this setup. Tap [Calc. Rotation] to open the Localization Calculator. If you have not already selected a mapping plane, you will be prompted to do so now.
5. Tap [Solve Rotation>] to calculate rotation for the localization origin in the selected map projection zone.
6. Examine the results. The Rotation is the negative of meridian convergence between the central meridian of the selected map projection zone and the base point.
7. If you set your base up on a known point, then the base station coordinates are already entered into the Base Station Local Coordinate fields. Tap [Solve>] to calculate the localization

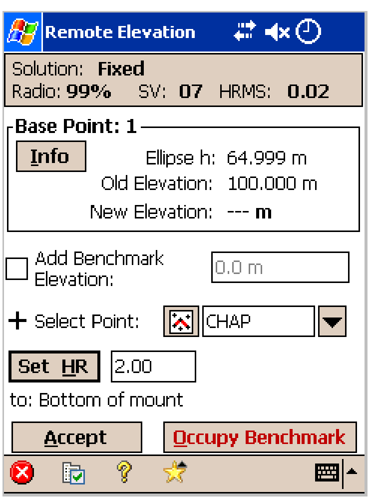
parameters. Tap Accept to finish setup and return to the Projection screen.

8. If you set your base up on a new point, you need to tap Occupy Control. You will be prompted to make sure your Scale and Rotation are correct before the Control Points screen is opened. You need to select and occupy a single control point. When you are done, tap Accept to return to the Solve Localization screen and the calculated coordinates are returned to the North and East fields.

9. Tap Solve>. Examine the results and tap Accept when you are done. You will be prompted to name the new localization site and save the record in the database.

Remote Elevation

If you set your base on a point with known elevation, you can begin collecting data right away. However, if your base station is on a new point, then you should calculate the elevation of the base and create or update a vertical site before collecting new data. This can be done in conjunction with horizontal localization, or you can use the Remote Elevation screen.



You can use the Remote Elevation screen to occupy a vertical benchmark with the rover. Applying the results of the occupation will update the base point elevation and create a new one-point vertical localization without entering the Solve Localization wizard. This procedure will not effect the horizontal localization adjustment.

The following conditions must be met in order to use the Remote Elevation routine.

- The base and rover must be set.
- You must be using a geoid model as part of your vertical coordinate system.
- The horizontal coordinate system must be solved.

1. Open the Survey > Remote Elevation screen.
2. If your benchmark is not in the job file, select the Add Benchmark checkbox, enter the Elevation, and specify a new point number in the New Point field.

> Note: You cannot enter a new elevation for an existing point using the Remote Elevation routine.

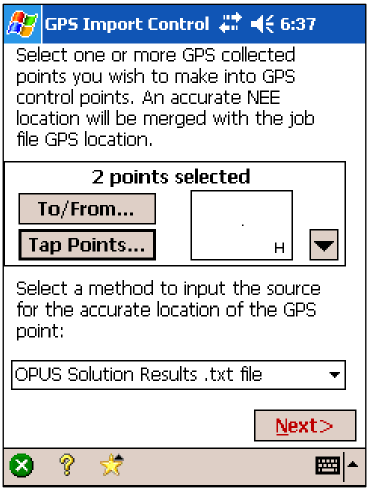
3. If your benchmark is a point in the job file, enter the point name.
4. Occupy the benchmark with the rover and tap Occupy Benchmark to access the Occupy Control Point screen and begin measurements to the point.
5. When you are satisfied with the measurement, tap Accept. You will return to the Remote Elevation screen and the base station's newly calculated elevation is displayed. The occupied benchmark point has now been added to the job file as a GPS control point.
6. If the new base elevation is acceptable, tap Accept from the Remote Elevation screen to open the Adjust with Projection wizard, which will show a preview of the points to be adjusted, including the update to the base position elevation. Tap Apply to update the vertical coordinate system in the job file, and apply the adjustment to the job file points.

Import GPS Control

In some cases, you can occupy a GPS control point in the field during data collection, but you do not have the correct mapping plane local north, east, elevation coordinate for that control point. In this case, you can not solve the localization in the field. However, it is possible to solve the localization after the field work has been completed, and Survey Pro will update all of the GPS collected points with the proper local coordinate.

You can use the Import GPS Control function when your horizontal projection mode is set to Mapping Plane. This function automates the process of taking a data collected point, and merging it with the proper local north, east, elevation coordinate from some external source to create a GPS control point. Three common work flow scenarios are:

- You start a survey with your base on a new autonomous position. You set the base to log data for post processing while you do your RTK. In the field, you tap Start Now> and begin your survey without solving a localization. You then submit the post processing data file to the NGS' OPUS service and get back the calculated local coordinate. You then wish to adjust the survey to match the calculated coordinate for your base.
- You start a survey with your base on a new autonomous position. You occupy one or more NGS control monuments during the survey, but you do not have the data sheet with the published north, east, elevation coordinate in the field. You get back to the office and download these data sheets from the NGS web site, and you wish to solve a localization using these points as control.



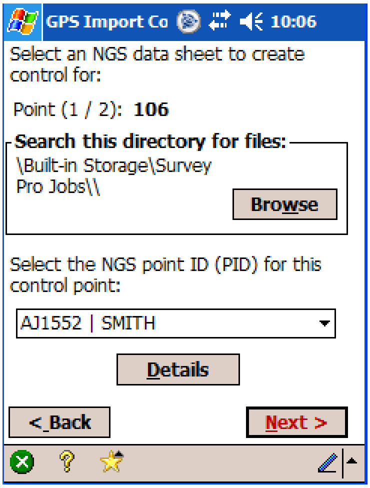
- You start a survey with your base on an autonomous position. You occupy one or more control points during the survey, but you do not have the proper north, east, elevation coordinate in the field. You get back to the office and you calculate the proper coordinate for these points by some method such as an adjustment of post processed baselines, or from another crew's job file measurement to the same point. You then wish to solve a localization using these points as control.

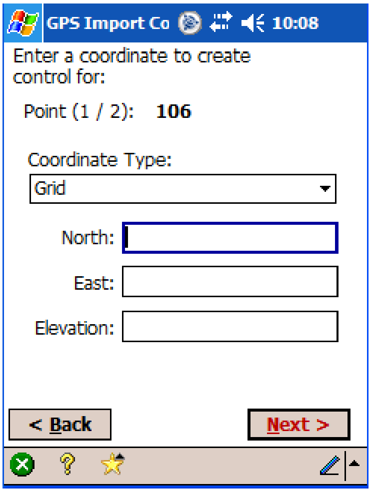
1. Open the Survey > Import GPS Control screen.
2. Select the points you wish to make into GPS control points. You must select points that have geodetic (LLH) coordinates.
3. Select a method to input the source for the accurate location of the control point. Your choices are: NGS Data Sheet .txt file; OPUS Solution Results .txt file; Key In Coordinate

Note: To use an NGS data sheet, download the data sheet for one or more desired points from the NGS web site, open the *.htm data sheet files using your web browser, and then click on File > Save As. Specify to save the file as a plain text file, and make sure the file has a .txt extension. To use an OPUS solution results file, open the email containing the solution report with your email editor, and then click on File > Save As. Specify to save the file as plain text, and make sure the file has a .txt extension. Then copy any desired .txt files to the data collector; the Survey Pro Jobs directory is the default location, but you may place these files anywhere you wish on the data collector.

4. Tap Next>
5. For each point selected on the previous screen, enter the source for the accurate local coordinate. If you are using an OUPS solution report or an NGS data sheet, pick the desired item from the drop down list. If you want to see additional details on any item, tap Details. If you are keying in each local coordinate,

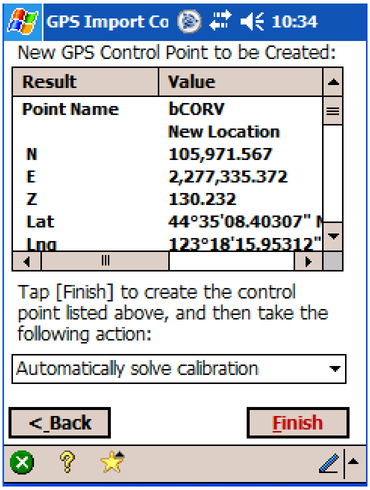
choose the Coordinate Type and key in the North, East, and Elevation, or the Latitude, Longitude, and Height.

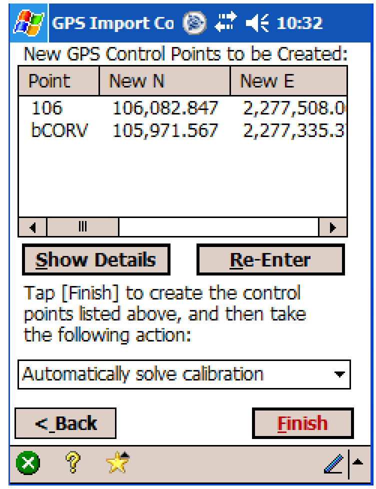




6. Tap Next > after you have entered the local coordinate for each point. After the last point, the wizard will advance to the final screen.

7. Examine the preview of the control points to be created. When you are creating a single control point, the complete details are listed on this screen. To edit the input, tap < Back. When you are creating multiple control points, a summary is listed on this screen. To see the complete details on a selected point, tap Show Details. To edit the input for any point, select that point from the list and tap Re-Enter.





8. Choose an action to take after Survey Pro creates the GPS control points selected. You can choose from:

   - Automatically solve localization (calibration): Use this option to create the selected GPS control points, and automatically solve the localization, without opening the Solve Localization wizard. The Readjust with Projection screen opens showing you a preview of the update to the job file coordinates to be applied with the new localization solution.

   - Open the solve localization (calibration) wizard: Use this option to create the selected GPS control points and then open the Solve Localization wizard. You can then use the Solve Localization wizard to complete the localization solution. This option is useful if you are creating multiple control points and you wish to view the residuals of the localization solution prior to accepting.

   - Solve the localization (calibration) later: Use this option to create the selected GPS control points and exit. You can tap Survey > Projection > Solve Localization at any time after this to finish solving the localization using the created control points.

9. Tap Finish to create the GPS control points and take the selected action.

RTK Data Collection

Once your horizontal and vertical projections are solved, you are ready to collect data. The different measure mode settings and data collection options are described below.

Measure Mode

1. From the Data Collection screen or from any GPS stake out screen, tap Settings to open the Job > Settings > Measure Mode card.
2. Select the Accept filter.
   - Fixed RTK only will reject all positions that are not fixed. Code, Float, or Fix will allow you to accept any position except autonomous or invalid data.

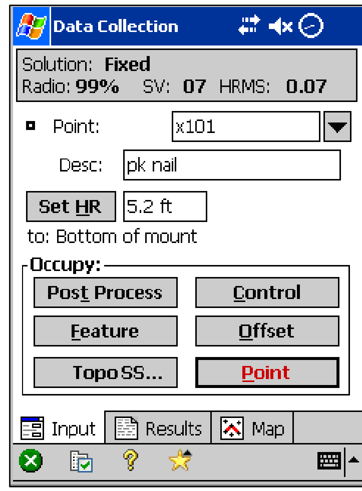
Note: If you are collecting simultaneous RTK and post processing data, you can accept an autonomous position based on the Job/Settings, Post Process card. If enabled, you will either be prompted to put the autonomous position on a separate layer, or it will automatically be stored on a separate layer.

3. Set the Acceptance Criteria.
   - Acceptance Criteria is used to check each solution you accept. If the measurement exceeds the criteria, you will be prompted to accept or reject the point. Check this box if you want to enable criteria checking. Enter a maximum value for HRMS, VRMS, and/or PDOP in the fields. Only fields with a non-zero value will be used for criteria checking.
   - To accept data points automatically using the selected criteria, check the Auto Accept box at the bottom of this page.
4. Tap OK to return to the Data Collection screen.

Data Collection

The GPS Data Collection screen is used to add points to the job file. There are several methods to collect data.

Occupy Point



Use this method if you want to occupy a point with the rover for any amount of time. When you start a point occupation, the receiver will be put in static mode for the most precise measurement possible, and the event will be recorded in the post processing log file.

1. Go to the Survey > Data Collection screen.
2. Enter a point name in the Point field.

Note: If you have Store GPS Raw Data set to + Rx Raw (or + OBN for Ashtech users), your point name must be a valid Site Id for the receiver model. If your point name is not valid, you will be prompted to change it.

3. Enter a Description.
4. If your antenna height has changed, enter a new value in the Rover field to update the value in Survey Pro and in the receiver. If your antenna type and measure to method have changed since Rover setup, then tap Setup HR to change and update it.
5. Tap Point to begin measurement. If the Point name is a new point for the job file, the Occupy Data Points screen will open. If the Point name already exists, you will be given up to three choices: overwrite, use next available name, or occupy the point as a check point. If you choose overwrite or use next available, then the Occupy Data Points screen will open. If you choose to occupy the point as a check point, the Check Control Point screen will open.
6. In each case, the receiver will be put into static mode and the post processing event will be logged to the data file and a site occupation begins.
7. The Occupy Data Point screen (or Check Control Point screen) is updated with the local coordinate calculated from the

measurement. When you are satisfied with the measurement tap Accept to return to the Data Collection screen

8. Check the Results tab for details on the last measurement. Check the Map tab to see the points plotted as they are stored.

Topo SS

Use this method if you want to store a point at the current rover position. When you tap Topo SS, Survey Pro will check the current position against the measurement criteria. If the position is good, then Survey Pro will store the point. You may be prompted for description, layer, and/or attributes depending on your settings.

Offset Point

Use this method if you cannot occupy a point directly, but you can occupy a location close by and provide an azimuth and distance to the point.

1. Go to the Survey > Data Collection screen.
2. Tap Offset to open the Offset Shots screen.

Note: You can enter the offset data before or after you occupy the reference point with GPS.

3. Tap Occupy GPS to occupy the GPS reference point. You will be prompted for a point name to store the reference point. The receiver is set to static mode and a site occupation begins. When you are happy with the measurement, tap Accept to return to the Offset Shots screen.
4. Enter the distance from the GPS reference point to the offset point. You can enter the distance by hand or you can get it from the selected conventional instrument by tapping Shoot Laser.

Note: You have to switch to conventional mode to configure the laser range finder or total station.

5. Enter the direction (azimuth/bearing) from the reference point to the offset point. You can enter a direction in one of the following ways:

   - Using the horizontal angle returned from the conventional instrument if you took a shot.
   - Occupying a point on line with the reference point and the offset point. After you occupy the reference point, tap Direction from Two Points and then occupy a point on line with the reference point and the offset point. When you are done occupying the on line point, you will be prompted for the direction to your offset point.
   - Entering a value by hand, such as when you measure the offset direction with a compass.

6. Tap Store to store the offset point.

7. Store any number of additional offset points from this GPS reference point. The shot data for each point is recorded in .RAW data. Tap Close when you are done storing points.

Feature Collection

Use this method if you want to continuously collect multiple points using either a measurement interval or by manually accepting each point. You can select from six different data collection modes.

1. Go to the Survey > Data Collection screen.

2. Enter a point name in the Point field. If this point already exists, you will be prompted to overwrite or choose the next available point.

> **Note:** If you have Store GPS Raw Data set to + Bl,CV or + Bl,CV + Rx Raw, feature collection will not store base line records because there is no discrete site occupation of each point. Therefore, the point name does not need to be a valid Site Id.

3. Enter a Description.

Note: For continuous data collection (except Manual: multi descriptions), once the first point is accepted, all additional points will be stored with the same description, layer, and attributes. When using Manual: multi descriptions mode, you will be prompted for description, layer, and attributes (if set) after every point.

4. Tap Feature. On the Feature Collection screen, select a Method. An explanation of the selected method is displayed at the bottom of the screen. See the Reference Manual for more information.
5. If you select a continuous method, or the Hold Still method, you must specify an appropriate Interval.
6. Tap Start to begin measurements. The Occupy Data Points screen displays the local coordinate.
7. When you are ready to begin continuous collection, tap Topo SS.
8. If you are using a continuous interval, Accept disappears and points are stored when the interval is exceeded.
9. If your mode is Manual, tap Accept when you want to collect a point. If your mode is Manual: multi descriptions, you will be prompted for a description, layer, and attributes (if set) for each point.
10. If you want to see a list of points stored so far, tap View Points.
11. If you wish to store points at any time during your continuous interval, tap Topo SS.
12. Tap Done to end feature collection and return to the Data Collection screen.

Note: When doing continuous data collection, if your interval is exceeded, but your acceptance criteria or RMS criteria are not met, then you will be prompted to Accept the point anyway or to Wait for the measurement to pass. If you choose to Wait, and then Cancel, you will be prompted to Accept the point anyway or to Exit.

Occupy Control Point

Use this button to open the Control Points screen (Page 283), where you can occupy a control point for the localization adjustment, or occupy a check point to verify the current coordinate system solution.

Post Process

Use this button to open the RTK Rover Session screen. This screen is used to start and stop point occupations in the post processing log file. Use the RTK Rover Session screen when you wish to perform additional occupations on the same point name, without affecting the point's coordinates in Survey Pro.

RTK Stake Out

Stake out with GPS is very similar to stake out with conventional instruments. See the Reference Manual for details on the different staking procedures. Below is a description of the two special features of stakeout with GPS.

Roving/Occupying

When you first start any GPS staking screen, measurements are started in the GPS receiver in dynamic (moving) mode. This is necessary as you navigate to the design point, and is indicated on the screen with the toggle button in the >Roving position.

When you arrive at the design point, if you want to take a more precise measurement, you need to switch to >Occupying mode. This will switch the receiver from motion to static mode.

Post Processing

Post processing data collection involves logging GPS raw data to a file, and then combining the data from multiple receivers. Software on the PC is used to process the base line measurements. This section describes how to collect GPS raw data for post processing with Survey Pro. In this section, you will learn:

- How to start a static post processing session.
- How to start a stop and go post processing session.
- How to set the station information and antenna height for both static and stop and go point occupations.
- A general description of the data processing to compute precise measurements from the data files.

Field Procedure

Enable Post Processing

1. Create a post processing receiver profile (Page 222).

Note: For simultaneous RTK and post processing data collection, receiver recording will be started automatically when you configure the RTK base and rover and specify a post processing recording interval. If you wish to do post processing only data collection, you need to complete the next step as well.

Start Recording in Receiver

2. Go to the Survey > Post Processing screen. You will be prompted to choose a receiver from the available post processing receivers. Tap Connect and the Post Processing screen will open.

Note: If you are currently connected to the RTK base or rover receiver, you will not be allowed to enter the Post Processing screen. If you tap Post Processing when connected to the RTK base or rover, Survey Pro will check the receiver to see if it is currently logging data. If it is, you will be prompted if you wish to stop data logging on this receiver. If the receiver is not logging data, you will be prompted if you wish to clear the RTK setup so you can set this receiver as a post processing only receiver.

3. Select the desired Recording Interval.
4. Choose Start Static if you want to configure a receiver to record raw data at a stationary setup. Choose Start Stop/Go if you want to configure a receiver to do stop and go data collection.

Static Data Collection

1. Choose if you wish to store point in: Receiver and job file or the Receiver file only. If you choose to store the point in Receiver and job file, then the Point must be a unique point name in the Survey Pro job and you will be prompted to put the point on the

autonomous layer. If you choose to store the point in the Receiver file only, the Site ID can be any valid name for the receiver and you are not prompted for layer or attributes.

2. Enter a Description for this point.

Note: If the Site ID or Description is not valid for your model of receiver, you will be prompted to modify them.

3. Tap Set HR to select an antenna type and enter the slant or vertical measurement.
4. Tap Apply to send the current station and antenna information to the receiver. This button may be renamed or disabled depending on the receiver model.
5. Tap End Survey when you are finished recording data. This closes the current recording session and file on the receiver. If using a receiver that supports file downloads, a prompt will open asking if you want to download the file to the data collector.

Stop & Go Data Collection

1. Choose if you wish to store point in: Receiver and job file or the Receiver file only. If you choose to store the point in Receiver and job file, then the Point must be a unique point name in the Survey Pro job and you will be prompted to put the point on the autonomous layer. If you choose to store the point in the Receiver file only, the Site ID can be any valid name for the receiver and you are not prompted for layer or attributes.
2. Enter a Description for this point.

Note: If the Site ID or Description is not valid for your model of receiver, you will be prompted to modify them.

3. Tap Set HR to select an antenna type and enter the slant or vertical measurement.
4. Enter a Duration for this session. If you enter 0 or if you check Log Until Stop, the session will continue until you tap Stop.

5. Tapping Apply / Start will send the current Site ID and antenna information to the receiver to update the session in progress. If you are storing the point in Survey Pro, you will be prompted for the autonomous layer and attributes (if set) at this point.

Note: When connected to certain receivers, this button will be labeled Start when roving and Apply with occupying.

6. When you are ready to move to a new point, tap Stop. Once you have occupied the new point, tap Start.

Note: If you are using this screen with the current RTK rover, you can store points only on the receiver's file. To store points in the receiver and in Survey Pro, use a regular RTK data collection routine and set the raw data setting to include + Rx.

7. When you are finished collecting data and want to close the file, exit to the Main Menu and tap Survey | End GPS Survey.

Office Procedure

1. Use the software supplied by the receiver manufacturer to download the files from receiver or the data collector onto your PC.
2. Use your GPS baseline processing software to combine the raw data from different receivers and generate GPS base lines.

Note: See the documentation supplied with your PC software for details on downloading and processing GPS raw data from the receiver's internal memory.

Projection Utilities

Survey Pro has a number of tools to help you work with map projections and coordinate system. This section describes the Adjust with Projection wizard and the Projection Calculator tools.

Adjust with Projection

The Adjust with Projection wizard is used to adjust job file points from one coordinate system into another. Any time you change the job file coordinate system, the Adjust with Projection wizard will run the job file points through the adjustment and show you a preview of the results. When you accept the results, the coordinate system is updated, and the point coordinates are updated in the job file.

The Adjust with Projection wizard can be opened in three different ways: Updating the localization adjustment or ground site parameters; Changing the coordinate system zone or site; Manually selecting points using the Adjust with Projection wizard opened from the Survey menu when in GPS mode.

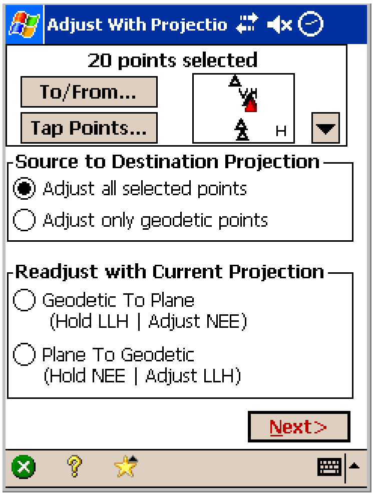
- When you update the localization adjustment or ground site, Survey Pro will automatically calculate the adjustment to all of the effected job file points and open the Adjust with Projection Results screen. When you tap Apply to accept the change, Survey Pro will update the job coordinate system and apply the adjustment to the points. This behavior is the result of the following functions in Survey Pro: Solve Localization wizard, Remote Elevation, Setup Ground Coordinates wizard.
- When you change the coordinate system, Survey Pro will open the Adjust with Projection Prompt Adjust screen. This screen displays details about the nature of the coordinate system changes between the old and new system. You can choose to proceed with the adjustment, or to not adjust points. If you choose not to adjust points, the coordinate system is updated, but no point coordinates are changed. If you choose to proceed with the adjustment, Survey Pro will show the Preview screen, and update both the coordinate system and the points in the job file when you tap Apply. This behavior is the result of the following functions in

Survey Pro: Select Coordinate System, changing horizontal projection mode on the Job > Settings > Projection screen.

- When you go to the Survey > Adjust with Projection screen, Survey Pro will open the Adjust with Projection Select Points screen There are two different methods to adjust points. Depending on your choice, you will select the source and destination coordinate systems, the adjustment will be calculated, and Survey Pro will show the Results screen. When you tap Apply, the point coordinates will be updated, but this routine will not change the coordinate system settings.

Adjust with Projection – Select Points

The Adjust with Projection Select Points screen is used to select job file points for adjustment, and to choose which type of projection adjustment to apply. The Select Points screen is the first step of the wizard when opened from the Survey menu. There are two different adjustment modes, each with two options to adjust points:



Source to Destination Projection: Use this mode when you wish to update the plane coordinates of points by choosing two coordinate systems from the database. The source coordinate system defines the current locations and the destination coordinate system defines the resulting locations. There are two options in this mode:

Adjust all selected points: use this option to adjust all selected points. Points with geodetic coordinates will be transformed into the destination coordinate system using their WGS84 values. Points with plane only coordinates will be transformed into temporary WGS84 coordinates using the source coordinate system, then transformed into new plane locations using the destination coordinate system.

Adjust only geodetic points: use this option to adjust only selected points with geodetic coordinates. Points with geodetic coordinates will be transformed into the destination coordinate system using their WGS84 values.

Readjust with Current Projection: Use this mode when you wish to update locations using the current coordinate system. There are two options in this mode:

Geodetic to Plane: use this option when you want to update the plane location of all points with geodetic coordinates. The WGS84 value of any selected point with geodetic coordinates will be transformed into a new plane value using the current coordinate system.

Plane to Geodetic: use this option when you want to update the geodetic locations of all selected points. The plane value of all selected points will be transformed into a new WGS84 value. Any points that already have geodetic coordinates will be updated. Any points that were plane only will become geodetic points.

- Select points for adjustment.
- Choose the adjustment mode and options.
- Tap Next

Adjust with Projection – Select Coordinate System

The Adjust with Projection Select Coordinate System screen is used to select the source and destination coordinate system when your adjustment mode is Source to Destination Projection, or to view details of the current projection when your adjustment mode is Readjust with Current Projection. This screen is only used when the wizard was opened from the Survey menu. This screen is similar to the Select Coordinate System screen (Page 250), with the following additional controls:

Source / Destination Projection Record: is where you select what kind of record to select from the database. Along with the zone and site choices, you can also choose to use the Current Projection.

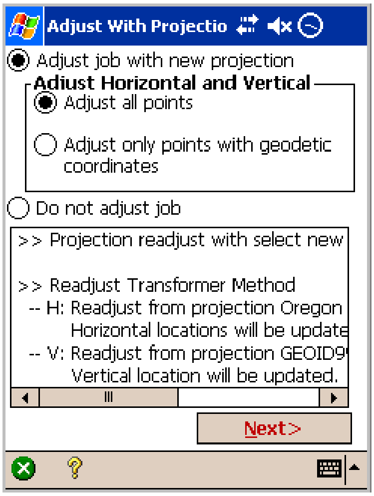
Details: opens the Projection Details screen where you can view the parameters of the coordinate system.

1. Select the type of record to use.
2. Select the record from the database, or use the current job file record.
3. Tap Next>.

Adjust with Projection – Prompt Adjust

The Adjust with Projection Prompt Adjust screen is only shown when the wizard opens automatically when you change the coordinate system. This will be the case when you select a zone or site using the Select Coordinate System screen, when you change or remove the geoid using the Select Coordinate System screen, or when you change the horizontal projection mode on the Survey > Projection screen. The Prompt Adjust screen describes the difference between the two coordinate systems, and gives you the option to adjust or to not adjust the job.

1. Choose to Adjust job with new projection or Do not adjust job.

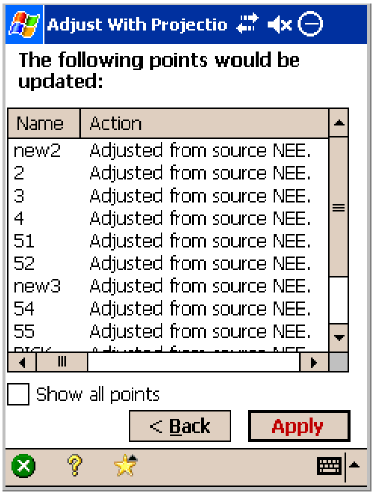


   - If you pick Do not adjust job, then the Next> button is hidden and the Done button shows. Tap Done to update the coordinate system but not change any job file points.
   - If you choose to Adjust job with new projection, you may have the choice to Adjust all points or to Adjust only points with geodetic coordinates. These two cases are described in the Select Points section. The criterion used to determine if this choice is allowed is based on the nature of the change between the current and the new coordinate system. This may be different for the horizontal and vertical dimension. The title of the box will indicate the dimension considered for this setting.

2. Tap Next> to open the Preview screen.

Adjust with Projection – Results

The Adjust with Projection Results screen is used to preview the results of the adjustment before anything is applied to the job file. The default view is to list the action and results only for points that will be updated in the adjustment. You can tap Show all points to update the list to show the reason unchanged points are not adjusted.



1. Review the results.
2. Tap Apply to update the job.

Projection Calculator

You can use the Projection Calculator to calculate combined scale factor for scaling conventional distance measurements to the mapping plane. You can also use the Projection Calculator to calculate meridian convergence for reducing geodetic azimuths (such as a sun shot) to grid bearings.

Scale Factor Calculator

1. Go to the Survey > Projection Calculator screen.
2. Choose a point on the mapping plane for scale computation in the Select Point control. Tap Solve Scale>.
3. Enter a height to compute Ellipsoid Scale Factor. This calculation uses the height of the point above the ellipsoid to correct for the effect of the terrain above the reference surface.
4. Tap Solve> to calculate the combined scale factor with the selected values. The combined scale factor is displayed in the Ground to Grid box. The inverse combined factor is displayed in the Grid to Ground box.
5. Tap Accept when you are done. Both numbers are saved in the Past Results list so you can use them in other calculations.

Convergence Calculator

1. Go to the Survey > Projection Calculator screen.
2. Choose a point on the mapping plane for convergence computation in the Select Point control. Tap Solve Rotation>.
3. The convergence and rotation are calculated. The convergence is displayed in the Geodetic N to Grid N box. The rotation is displayed in the Grid N to Geodetic N box.

4. Tap Accept when you are done. Both numbers are saved in the Past Results list so you can use them in other calculations.

Bluetooth & Windows Networking

Survey Pro supports Bluetooth wireless communication on data collectors with built-in Bluetooth to communicate with Bluetooth-enabled total stations, GPS receivers and cellular phones (for use as a modem when using VRS). This chapter explains the initial setup required in the Windows operating system, outside of Survey Pro, to use these devices with Survey Pro.

Bluetooth Limitations

Bluetooth can be thought of as a short-range radio link. As with any radio link of this type, communications can be interrupted by a number of reasons, including, but not limited to:

- The operating range between the devices is exceeded. (The Bluetooth range is limited to approximately 10 meters in ideal conditions.)
- Another powerful radio signal is broadcast near an active Bluetooth device.
- An object, such as your body, physically blocks the radio signal.

If the Bluetooth signal is lost, move the Bluetooth device closer to the data collector or try to eliminate the source of interference. The connection will then usually be reestablished automatically.

Note: The operating system resets the Bluetooth connection when the data collector is powered on. If the data collector is powered off while using Bluetooth, you should wait at least 10 seconds after powering it back on before using any function where Bluetooth communication will occur. This is to allow enough time for the Bluetooth connection to reset.

Warning: It is **not** recommended that Bluetooth communication be used while logging GPS data to use for post processing. This scenario requires constant and reliable communications between the data collector and the receiver, which can only occur when using a communication cable.

Bluetooth Setup in Windows

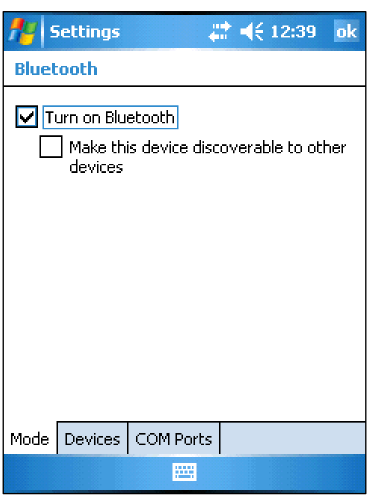
This section describes how to enable Bluetooth in Windows and create a partnership with the device the data collector will communicate with.

Bluetooth can only be used when the data collector and peripheral hardware have Bluetooth built in and the hardware is explicitly supported by Survey Pro.

Activate Bluetooth in Windows

Bluetooth must be enabled on the data collector before it can be used.

1. Exit Survey Pro if it is running to return to the Windows operating system.



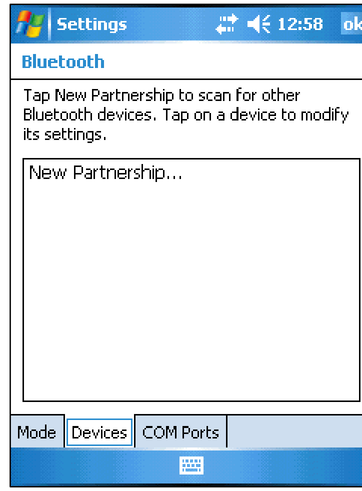
2. From Windows, tap > Settings > Connections > Bluetooth > Mode and check the Turn on Bluetooth checkbox. (It is not necessary to check the Make this device discoverable… checkbox unless you want other devices to be able to detect your data collector for non-data collecting functions.)

Discover and Bond with New Bluetooth Devices

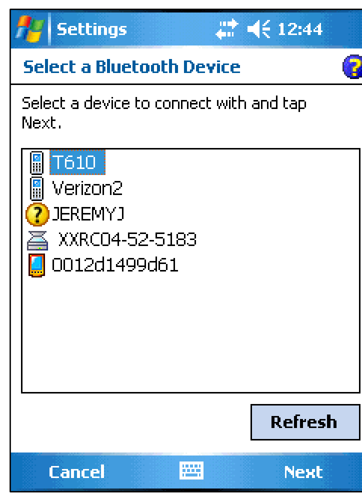
Before you can use any Bluetooth peripheral with Survey Pro for the first time, the device must be paired with the data collector.

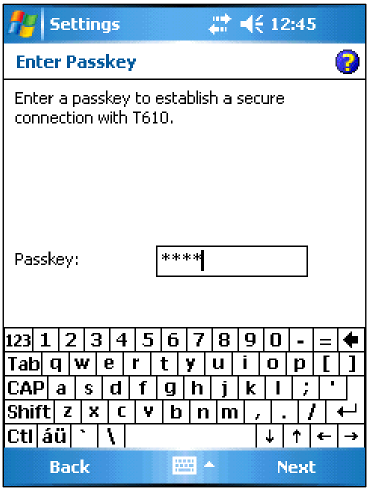
1. Exit Survey Pro if it is running to return to the Windows operating system.
2. Power on your peripheral hardware and be sure Bluetooth is activated and discoverable on that device. Also be sure you have the Bluetooth passkey available if applicable.

3. From Windows, tap > Settings > Connections > Bluetooth > Devices. With the peripheral hardware positioned within a few meters, tap New Partnership… to search for Bluetooth devices.



4. Once the search is complete, all discoverable Bluetooth devices in the area will be listed. Tap the device you want to add and then tap Next.

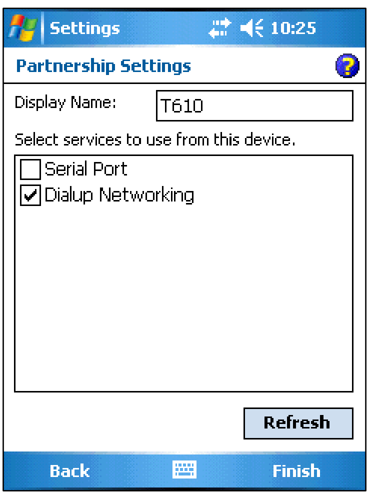




5. If connecting to a GPS receiver or a total station, enter the Bluetooth passkey if there is one or leave the field blank if no passkey is required and then tap Next and skip to Step 7.

   If connecting to a cellular phone, enter any passkey that is 3 characters or longer and then tap Next and continue to the next step.

6. Look at the cell phone. It will ask if you want to add the data collector to your devices. Answer [Yes] and then enter the same passkey using the cell phone's keypad.



7. Enter a display name for the new device or use the default name. If services are listed, select Serial Port if connecting to a total station or GPS receiver, or select Dialup Networking if connecting to a cell phone and then tap Finish.

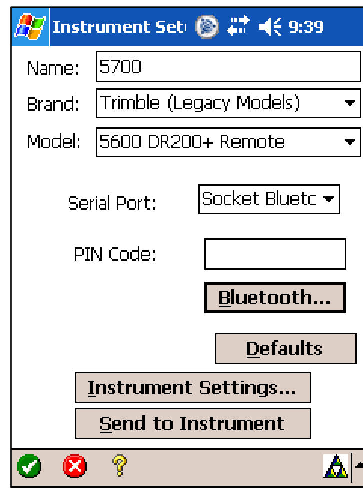
8. Repeat the above steps to add any other Bluetooth device that you want to use with Survey Pro.

9. Tap > Survey Pro to return to Survey Pro.

Bluetooth in Survey Pro

To configure a Bluetooth-enabled total station or GPS receiver to work with Survey Pro, perform the following steps from within Survey Pro:

1. Go to Job > Settings > Instrument, and edit an existing instrument profile or create a new one.
2. Select Bluetooth in the Serial Port field and confirm the correct Bluetooth peripheral is selected in the Device field.



Windows Networking

Survey Pro supports the use of a cellular phone as a modem to communicate with an NTRIP server when using VRS.

Before using VRS for the first time, it is necessary to setup Windows Networking and configure Survey Pro to use a cellular phone as a modem.

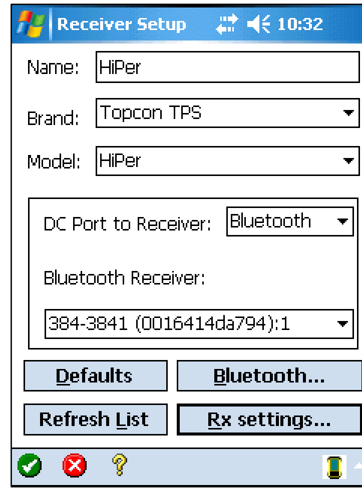
Windows Networking Setup

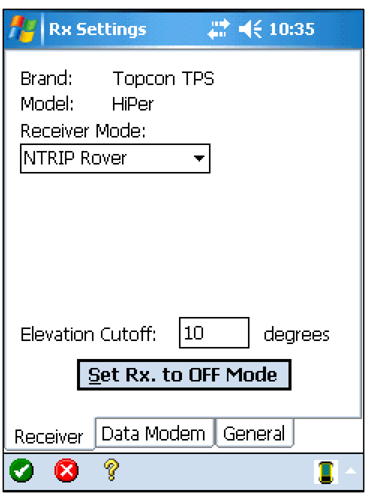
The steps below explain how to configure Windows Networking and set up Survey Pro on a data collector that has built-in Bluetooth to communicate with a cellular phone as a modem either via Bluetooth or a communication cable.

If communicating with the cellular phone via Bluetooth, it is assumed you have already gone through the process of discovering, adding, and bonding with the phone as described starting on Page 317.

1. From the Main Menu, go to Job > Settings > Receiver.
2. With the desired remote receiver activated and selected, tap Receiver Settings... .

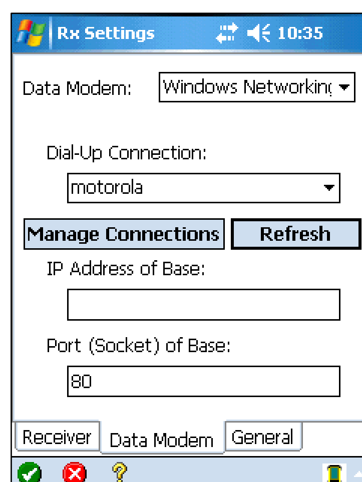
3. Tap Rx Settings....



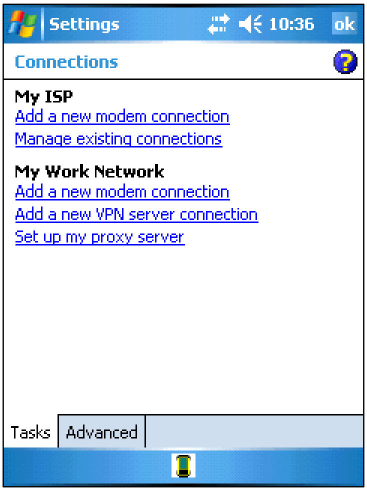


4. With the Receiver card selected, set Receiver Mode to NTRIP Rover.

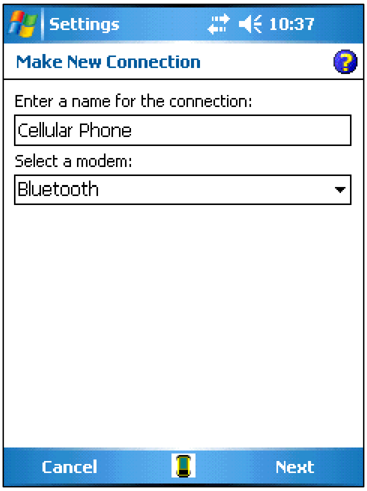
5. Select the Data Modem card.



6. Tap Manage Connections. (This will temporarily exit Survey Pro and access the Windows' > Settings > Connections > Connections screen.)



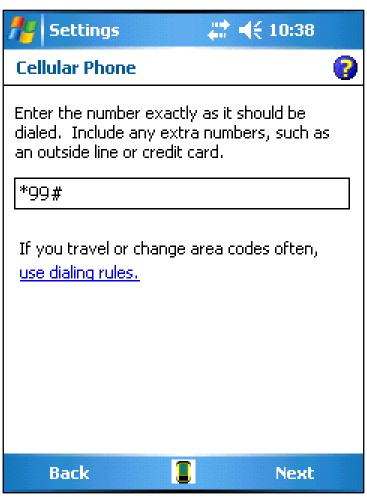
7. Under My ISP, tap Add a new modem connection.



8. Enter a name for the new connection in the first field

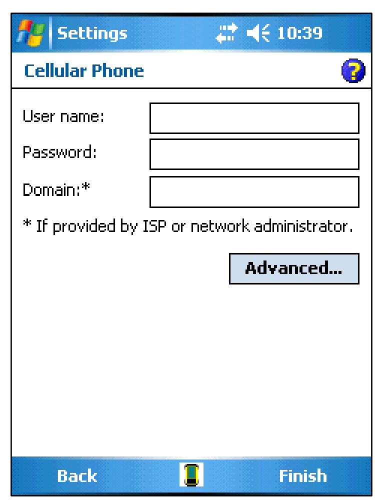
    - If communicating with the phone via Bluetooth, select Bluetooth in the second field and then tap Next and continue to the next step.
    - If the phone is connected to the data collector with a cable, select Hayes Compatible on COM1 in the second field and then tap Next and skip to Step 10.

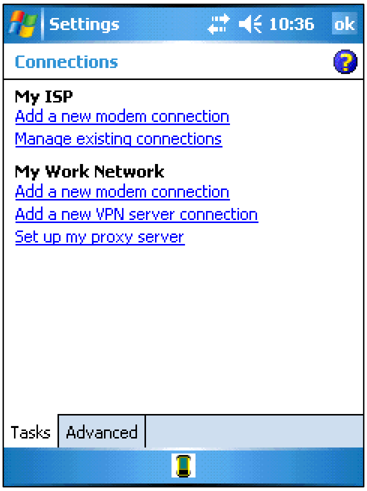
9. Select the phone you added during the Bluetooth discovery and bonding process as described in the User's Manual and tap Next.



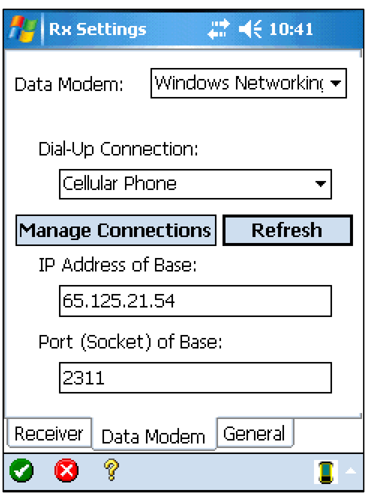
10. Enter the number provided by your cellular phone company used to access online services and tap Next.

11. If your cellular phone company requires a user name and password to connect to online services, enter them in this screen, otherwise leave the fields in this screen blank and tap Finish.





12. Tap ok to close this screen and return to Survey Pro.

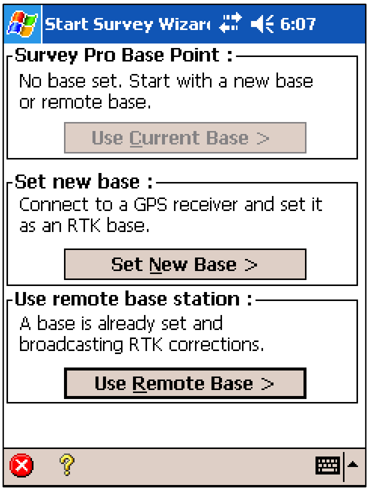


13. Select the newly-created cell phone modem for the Dial-Up Connection. Enter the IP Address of Base and Port for your VRS service provider and tap > > to return to the Main Menu.

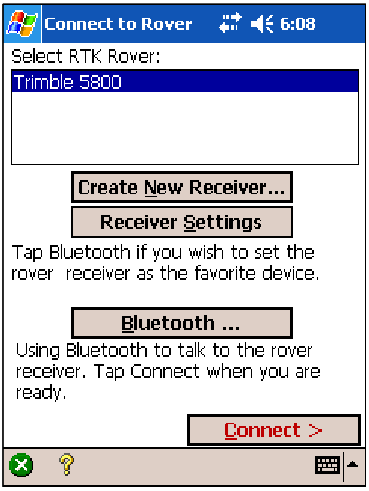
Starting a Survey with VRS

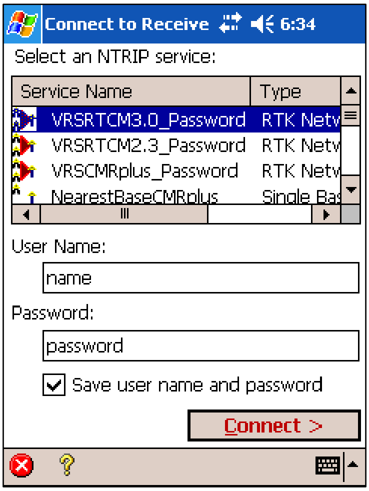
The following steps explain how to start a survey with VRS after any necessary Bluetooth steps have been performed and the Windows Networking configuration is complete. From the Main Menu, tap Survey > Start GPS Survey.

1. Tap Use Remote Base >.



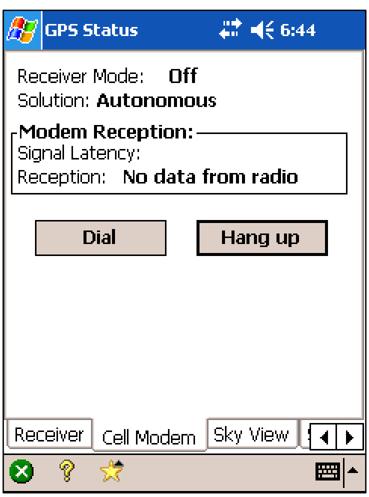
2. Confirm your rover receiver is selected and then tap Connect >. The phone should begin dialing the server.





3. Once connected, tap the desired NTRIP service. Enter your User Name and Password, if the selected service requires them and then tap Connect >. You can now complete your GPS setup.

Hanging Up and Redialing a Cellular Phone



From the Main Menu, tap Survey > GPS Status > Cell Modem card > Hang up. You should double-check that the call has indeed ended by confirming the networking icon has disappeared from the cell phone screen.

Tapping Dial will attempt to reconnect to the last connection made, including selecting the same NTRIP service, if applicable.

Basic GPS Module

Survey Pro can be sold with either the Basic GPS module or the standard GPS module. This section outlines the procedures for using Survey Pro with the Basic GPS module. If using the standard GPS module, refer to Page 265. In this section, you will learn:

- How to configure communication with the receivers.
- How to configure an RTK data modem link.
- How to use the Start Survey Wizard to start the RTK base and rover.
- How to use the Start Survey Wizard to collect GPS control and solve a localization adjustment when one is required.
- How to move the base with the Traverse Base workflow.

GPS Receiver Connections

Before RTK or post processing data collection can take place, you need to configure how the data collector will communicate with the rover receiver and the base receiver or cellular phone. Communication between these devices can be done with serial cables (wired) and/or Bluetooth (wireless).

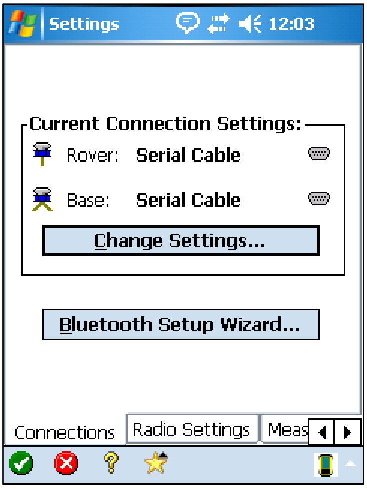
The Basic GPS module is ready to use out of the box if communicating with the base and rover receiver using a serial cable. If you wish to use the Bluetooth dongle for either the base or rover, you can use the Bluetooth Setup Wizard to automatically discover and configure the software. If you need to change back and forth between serial cables and Bluetooth, you can use Job > Settings > Connection > [Change Settings...] as described in the steps below.

Note: Only data collectors with built-in Bluetooth can communicate with GPS receivers using Bluetooth.

Serial Connection

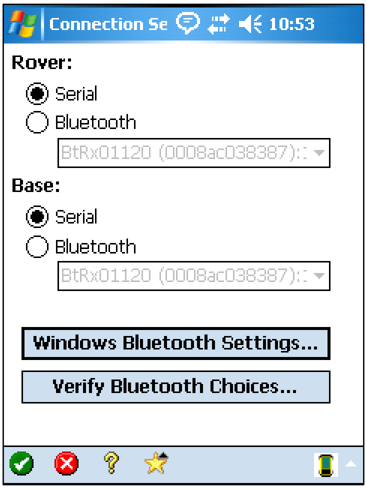
These steps describe how to configure the software when connecting to the receivers with a serial cable. This is the default setting and does not need to be configured unless it was changed.

1. If communicating with both GPS receivers using serial cables, tap Change Settings... from the Job > Settings > Connection screen.

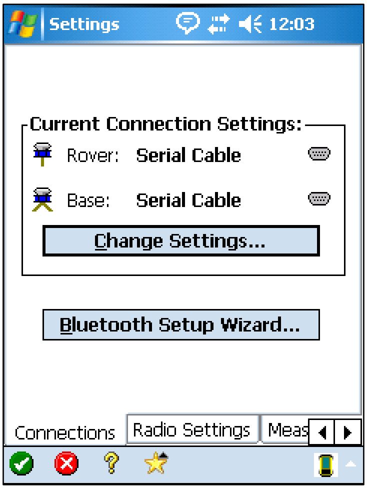


Note: You could alternatively run the Bluetooth Setup Wizard and when no Bluetooth receivers are detected, a serial connection will automatically be selected.

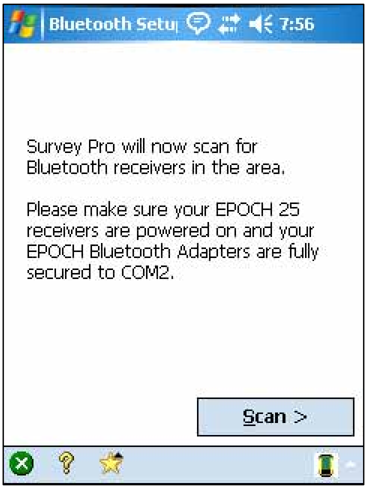
2. Select Serial for both the Rover and Base receiver and tap ✅ to finish.



Bluetooth Connection

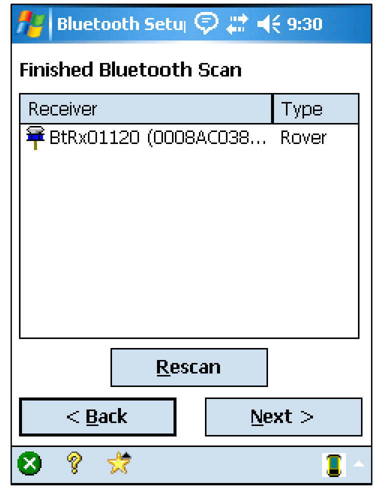


1. If communicating with one or both GPS receivers using Bluetooth, tap Bluetooth Setup Wizard... from the Job > Settings > Connection screen.

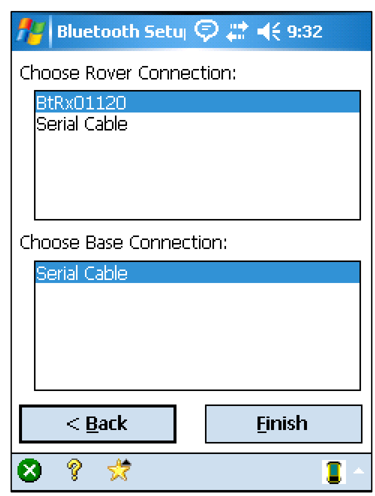


2. Be sure your GPS receivers are powered on and the Bluetooth adapters are attached to COM2 on the EPOCH 25 and tap Scan >.

3. The scan should locate only valid receivers. Tap Next > to continue.



4. The final screen displays the current connection and allows you to switch between Bluetooth and Serial if possible. If a particular Bluetooth receiver was not detected, it will automatically be configured to connect with a serial cable. Tap Finish to complete the wizard.

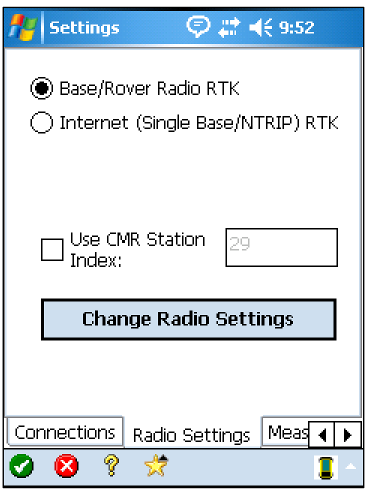


RTK Data Modem Configuration

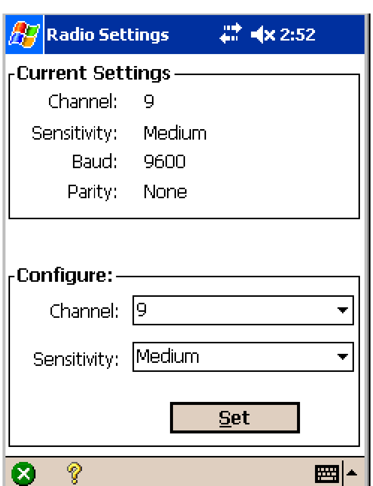
This section explains how to configure the type of data link to use between the base and rover. This is either base to rover RTK GPS using a radio modem, or Internet delivered base corrections using a cellular phone as a data modem.

Using a Radio Modem

Using a radio modem as the data link from base to rover is the most common configuration.



1. Select Base/Rover Radio RTK.
2. The Use CMR Station Index should be checked in situations where more than one base is in range of the rover, allowing it to distinguish one from the other. Enter a unique value from 0-31 in the corresponding field.



3. Tap Change Radio Settings if you need to configure the radio. The current settings are displayed in the upper portion of the screen. Make any necessary changes in the lower portion of the screen and tap Set to send the changes to the radio.

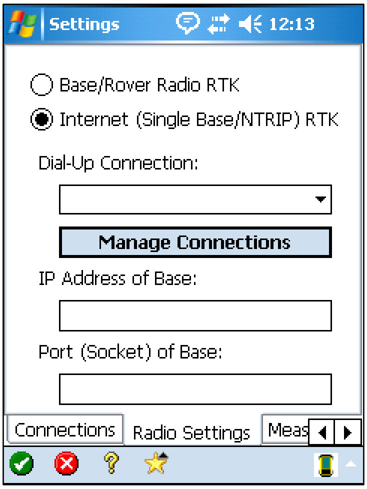
Note: some settings on the radio cannot be modified with Survey Pro. To fully program the radio modems, you need to PC software that should be supplied with the radio.

Using a Cellular Phone

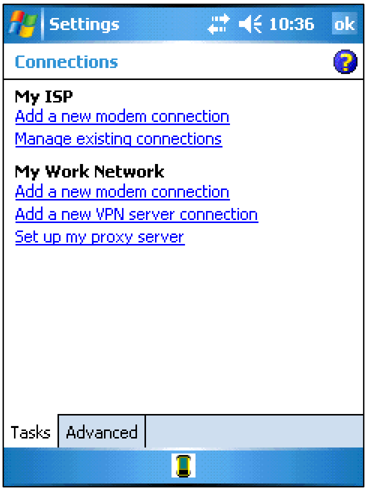
1. Open the Job > Settings > Connection screen and select the Internet (Single Base/NTRIP) RTK radio button.

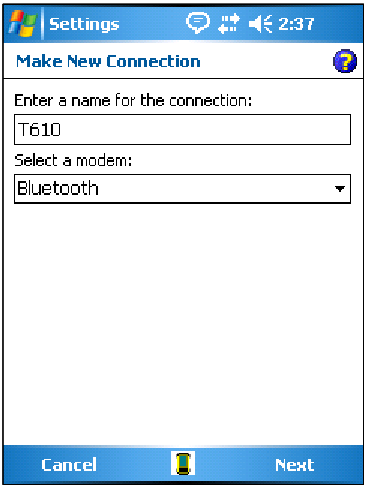
   Enter the Network IP and Network Port for the connection.

   If a Dial-Up Connection already exists, select it in the corresponding field and tap ✓ to finish and skip the remaining steps. If one needs to be created tap Manage Connections to continue.



2. Under My ISP, tap Add a new modem connection.

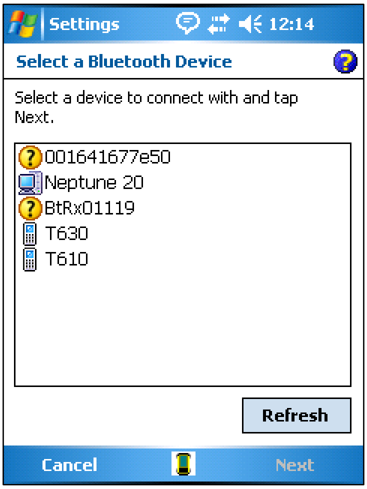




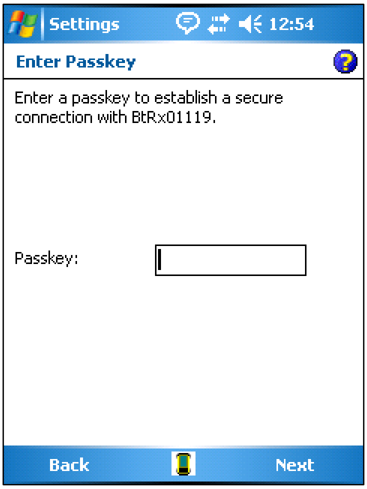
3. Enter a name for the new connection in the first field, select Bluetooth in the second field and then tap Next and continue to the next step.

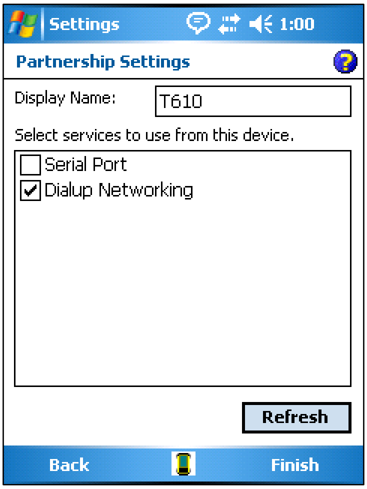
4. Confirm the Bluetooth cell phone that you want to partner with is turned on and Bluetooth is enabled and then tap New Partnership. The data collector will perform a scan for any nearby Bluetooth devices and list them on the screen when finished.

5. Select the cell phone you want to partner with and tap Next.

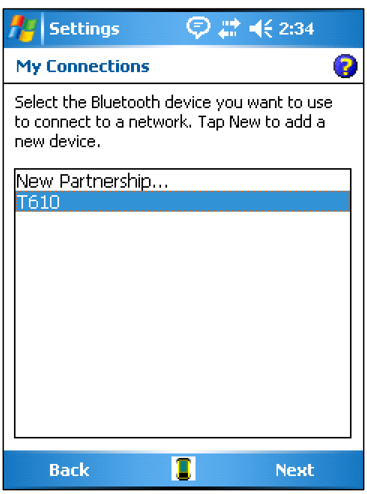


6. If the partnered device requires a passkey, enter it here, otherwise leave it blank and tap Next. When partnering with a cell phone for use as a data modem, you typically enter any key that is 3 characters or longer and then enter the same key when you are prompted on the phone from the phone's keypad.



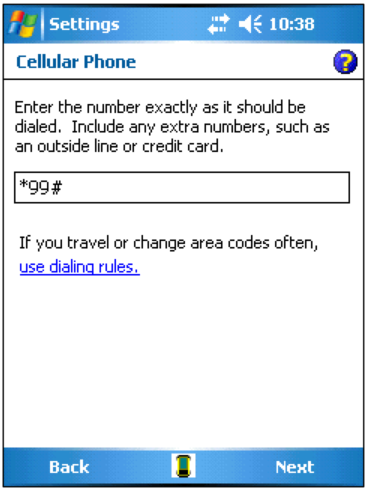


7. Check the Dialup Networking checkbox and tap Finish to continue.

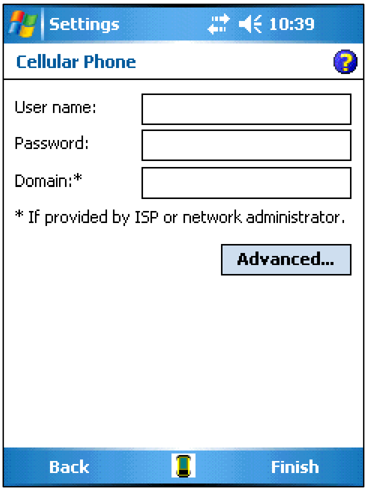


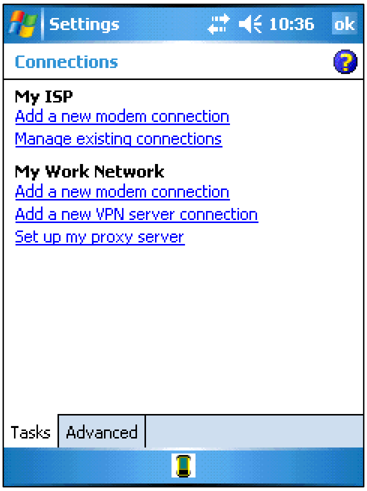
8. Select the cell phone you just added and tap Next.

9. Enter the number provided by your cellular phone company used to access online services and tap Next.



10. If your cellular phone company requires a user name and password to connect to online services, enter them in this screen, otherwise leave the fields in this screen blank and tap Finish.



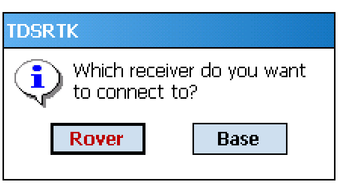


11. Tap ok to close this screen and return to Survey Pro.

Basic GPS Start Survey

To start a survey with the Basic GPS module, plug in the serial cable or connect the Bluetooth dongles and tap Survey > Start GPS Survey. The software will walk you through the rest of the process, which will be determined by the type of modem data link you are using and which receiver you are connected to.

When connected using a serial cable, the software will detect if you are connected to the base or rover and start the set base or set rover workflow accordingly.



When connecting by Bluetooth, you will be asked which receiver you are connecting to since a connection could possibly be made to either receiver.

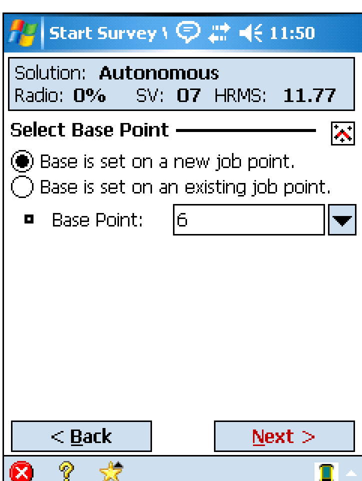
The different pages of the Start Survey wizard are described below individually. After that, the sequence of pages is described for different workflows.

Start Survey – Connect to Base and Rover

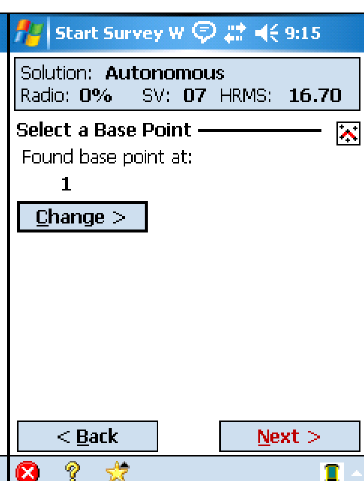
Set Up Base

1. On initial connection to the base, the base position is recorded until we get a stable average of 10 epochs. Once we have an average autonomous base position, follow the instructions on the screen by entering an antenna height. If you plan to do post processing data collection in the base receiver, select a recording interval, otherwise leave it set to Off and tap Next >.

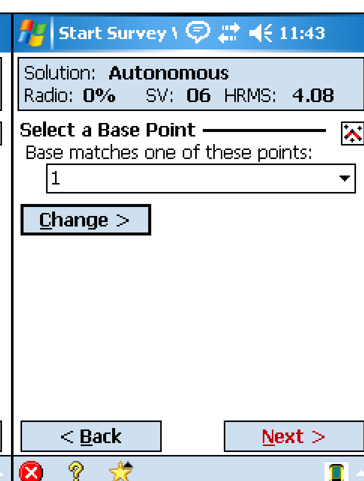
2. Once the base autonomous position is known, the job file is searched for a matching point. Any possible matches are considered eligible base points. The Setup Base Point screen will be in one of three states:



No matching base found



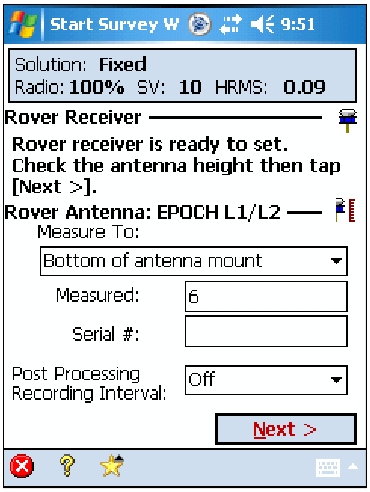
One matching base found



More than one matching base found

3. Fill in the screen and tap Next>. The base point name and the precise geodetic coordinate of the base are noted in Survey Pro. If you are doing post processing at the base, the station name, description, and antenna height are then sent to the file on the base receiver for post processing.

Set Up Rover



4. You are prompted to connect to the rover receiver or will be automatically connected if using Bluetooth. Once you connect to the rover, it will begin to monitor the data link for the base corrections. You are then prompted to enter the rover antenna height to proceed with the setup. If you want to do post processing data collection with the rover receiver, select a recording interval, otherwise leave this set to Off.

   The button at the bottom right of the screen will say Next > any time this is a remote rover setup, or if you have set the base but the projection is not fully set and solved for this survey. The button will say Finish if you have set the base and the projection is solved.

a. On Next >:

   i. If the base was not set with this wizard, takes you to Setup Remote Base screen (Page 343).

   ii. If the base was set with this wizard, writes the base and rover setup raw data, and takes you to Solve Projection routine (Page 344).

b. On Finish: Writes the base and rover setup raw data, sets the rover receiver and exits.

Start Survey – Connect to Rover (Remote Base or Internet Base)

There are two workflows when you start a survey connecting to the rover:

- The base broadcasting on a radio is already set and you wish to start the rover with the remote base. This is the case where there is more than one rover on a job site, or when you exit and restart a job and you wish to restart the survey without traveling back to the base.
- You are using the Internet to get corrections.

The workflow below is described for the NTRIP case. The remote base on a radio is similar to the Set Rover and Setup Remote Base procedure described above.

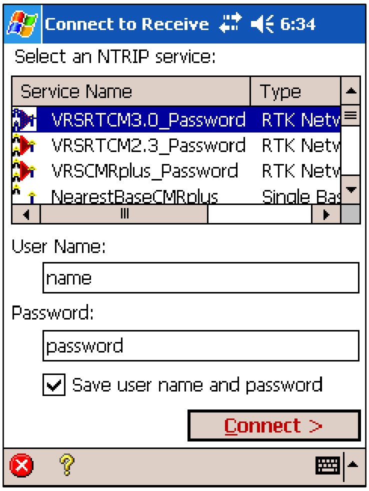
Connect to Internet

When Internet RTK is selected in the Job > Settings > Radio Settings screen, we will always attempt to connect to the rover on the start of the Start Survey Wizard. After connecting to the rover, we will dial the Internet and attempt to decode the network type.

After the network type has been decoded, if it is a single base network without an NTRIP logon protocol, we will go straight to Rover setup, if it is a NTRIP network, we will go to the NTRIP Services page.

Note: You should not use this routine to connect to a VRS service that does not use an NTRIP logon procedure. (This workflow is only supported in the standard GPS module.)

Select NTRIP Services Screen



Once connected, tap the desired NTRIP service. Enter your User Name and Password if the selected service requires them and then tap Connect >. You can now complete your GPS setup.

Setup Rover Screen

This feature is the same as the Set Rover screen (Page 341).

Setup Remote Base

1. The Setup Remote Base screen can have three different states, which are the same as the Setup Base Point screen described on Page 340.

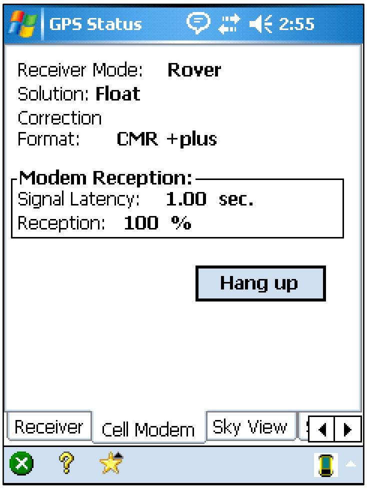
The button at the bottom right of the page will say Next > when the projection is not fully set and solved for this survey. The button at the bottom right will say Finish if the projection is solved.

2. Verify the correct antenna height is displayed on this screen and tap one of the following:

    - Tap Next > to write the base and rover setup raw data and advance to the Solve Projection routine.
    - Tap Finish to write the base and rover setup raw data, closes the start survey wizard and opens data collection or stake out.

Hanging Up and Redialing a Cellular Phone

To hang up an active connection, tap Survey > GPS Status > Cell Modem > Hang up from the Main Menu.



If a connection was made previously, the Dial will be available. Tapping it will attempt to reconnect to the last connection that was made, including selecting the same NTRIP service, if applicable.

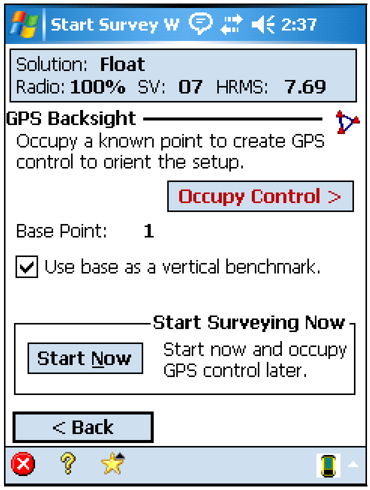
Solve Projection

The solve projection routine will appear any time the coordinate system is not solved. The conditions for a coordinate system not solved are listed below for Ground TDS Localization mode and mapping plane mode.

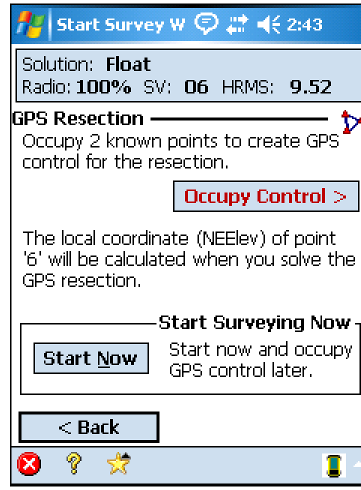
Projection Control Points Status Screen

The Collect Control Points screen appears in one of two states: GPS Backsight or GPS Resection.

- **GPS Backsight**: This state exists only in Ground TDS Localization mode and when the base is set on an existing job point with accurate NEE coordinates. One additional control point is needed to orient the setup.
- **GPS Resection**: This state exists when the base was set on a new point. A new point is a point that was created from an autonomous setup.



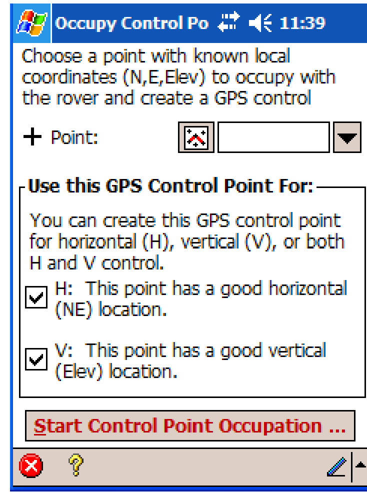
GPS Backsight Page Layout



GPS Resection Page Layout

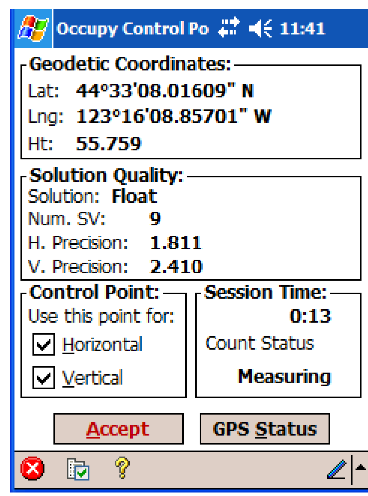
1. Tap Occupy Control > to open the Collect Control screen (Page 346). This screen is used to select an existing job file point and initiate an occupation to create a GPS control point, which will be used to solve the localization.
2. After each occupation, the screen updates.
3. When enough horizontal and vertical control is collected, the wizard advances to the Projection Check Point Status screen (Page 347).
4. If you want to start without solving the required resection, tap Start Now >. A temporary localization will be applied and you can start data collection. You must solve the localization before the local coordinates are valid. This localization will not be marked *temporary* since it was solved with the minimum amount of control.

Collect Control – Screen 1



1. Select an existing job file point
2. Designate if it is valid for horizontal, vertical, or 3D control.
3. Level the receiver over the point and tap Start Control Point Occupation. This will open the next Collect Control screen (Page 346) to monitor the occupation.

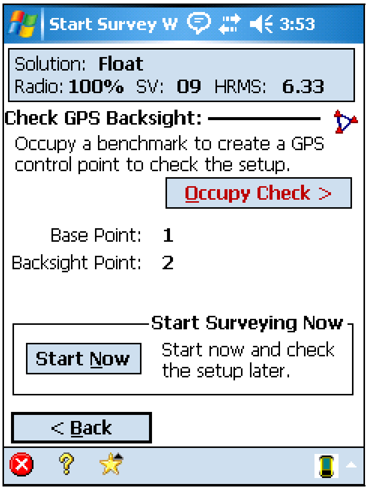
Collect Control – Screen 2



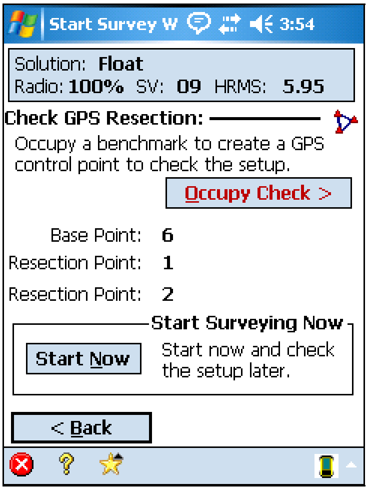
1. Review the choice of H/V control eligibility.
2. Tap Accept to end the occupation. The control point is created in the job file and the raw data is recorded. This screen and the previous screen will exit, and you will be at one of two places:
    a. If you do not yet have the minimum amount of control, you will remain on the Projection Control Point Status screen (Page 344).
    b. If you now have the minimum amount of control, you will move forward to the Projection Check Point Status screen (Page 347).

Projection Check Point Status Page

The Projection Check Point Status screen appears in one of two states: GPS Backsight, or GPS Resection. The conditions for either state are the same as the Control Point Status screen.



GPS Backsight Page Layout

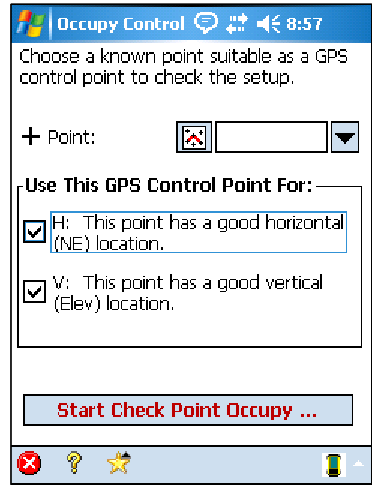


GPS Resection Page Layout

1. Tap Occupy Check > to open the Collect Check Point Prompt (Page 348). This screen is used to select an existing job file point and initiate an occupation to check the localization solved with the minimum amount, and then create an extra GPS control point, which will be used to re-solve the localization and run the blunder detection routine.
2. After each occupation, the state of the dialog updates.
3. When enough horizontal and vertical check points are collected, the wizard advances to the Solve Localization and Detect Blunders screen (Page 349).
4. If you want to start without checking the localization, tap Start Now >. In this case, the localization solved with the minimum control points will be set in the job file, and the projection readjust mechanism will run to update any job points as required. You must remember, that the solution has not been checked for quality.

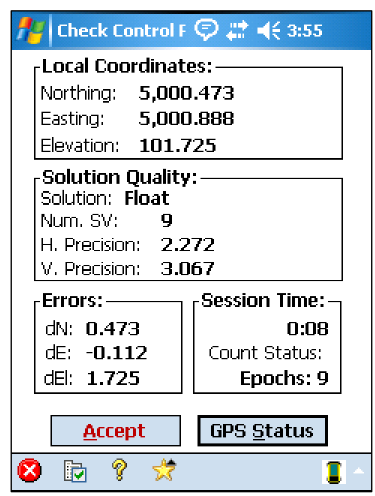
Collect Check Point Prompt

1. Select an existing job file point.
2. Designate if it is valid for horizontal, vertical, or 3D control.
3. Level the receiver over the point and tap Start Control Point Occupation. This will open the Collect Check Point screen, below, to monitor the occupation.

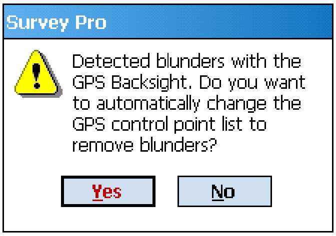


Collect Check Point Screen

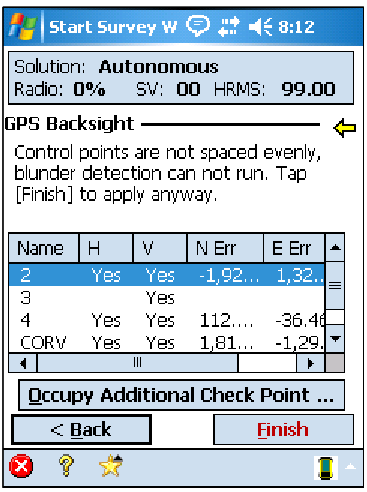
1. Examine the errors. Only the errors for the dimensions you specify for this control point (2D/1D/3D) will be shown.
2. Tap Accept to finish the occupation. The control point is created in the job file and the raw data is recorded. This screen and the previous screen will exit, and you will be at one of two places:
   a. If you do not have one extra H or V point for the localization check, you will be back at the Check Points Status screen (Page 347).
   b. If you have the required H and V points for the check, the wizard will advance to the Solve Localization and Detect Blunders screen, below.



Solve Localization and Detect Blunders



Before this page is opened, the localization is solved using all the control points, and then the automatic blunder detection routine runs to detect low quality control points.



If Yes is displayed in the H or V column, it indicates the corresponding control point will be included in the horizontal or vertical localization solution, respectively. This can be toggled between Yes (included) or blank (not included) by tapping on it. If the blunder detector detected any poor quality control, it will automatically turn off that control before this screen opens. See Page R-288 for more information on evaluating the localization parameters displayed on this screen.

The possible outcomes of the solve localization and blunder detection are:

- **Green Light**: If the localization solved and no blunders were detected, you will see a green light and the status line will show the root mean squared (RMS) error of the horizontal and vertical solution.
- **Yellow Warning Triangle**: If the localization solved and no blunders were detected, but some of the points used have a large residual error, you will see a yellow triangle and the status line will show the point with the largest horizontal and/or vertical residual.
- **Red Stop Sign**: If the localization solved, and blunders were detected that could not be clearly identified, or if you were prompted to remove blunders and you said no, then you will see a red stop sign and the status line will indicate there are possible blunders in the solution.
- **Yellow Arrow**: If the localization solved, but the control points are not spaced far enough apart to run the automatic blunder detection, then you will see a yellow arrow, and the

status line will indicate the poor geometry of the control points, or if the localization fails to solve, you will see a yellow arrow and the status the status line will indicate the failure to solve the localization.

Tapping Finish will apply the localization. If any of the horizontal or vertical control toggles are changed in this screen before tapping Finish, the button will change to Resolve, allowing you to re-compute the quality before tapping Finish.

Tapping Occupy Additional Check Point opens the Occupy Control screen, which allows you to collect another control point and add it to the localization solution.

Localization Quality of Solutions

When solving a localization using the Basic GPS module, Survey Pro will employ several mechanisms to ensure a quality solution.

- **Prompting For Extra Control Points**: The Basic GPS start survey work flow compels you to gather the minimum number of points to solve the localization, and then it prompts you to gather one more control point to be used as a check. This step provides the redundancy required to verify the quality of the solution.
- **Checking Control Point Relative Distance**: Before running the automatic blunder detection routine (described below), the relative distance between control points is checked. If control points are not spread far enough apart relative to each other, then the blunder detection will not run before solving the localization with the specified control points, and a message will appear in the results area of the localization screen. This is a good indication that the control points will not be spaced evenly around the survey are and maybe additional control points are required for this site.
- **Automatic Blunder Detection**: When the control points are spaced appropriately, Survey Pro will automatically attempt to detect blunders with the localization solution. This is done by looking at al the possible combinations of unique solutions with the available control points and checking the extra

control points for closure. This routine will usually identify the one or two bad points in a control point set, and then prompt you to automatically remove these points as control for the localization. If there is an ambiguous result for the blunder detection, you will be prompted to collect extra check points to provide the information needed to correctly identify the blunders.

- **Localization Parameter Checking**: Once the localization solution is solved, hopefully with any potential blunders identified and removed, Survey Pro will do one last automated check for localization solution quality. The scale factor of the solution is checked against a sensible tolerance, and if it is too large or small, a message will show in the results area.

In addition to the mechanisms Survey Pro uses automatically to ensure a quality localization solution, you must also use good common sense before using the final localization solution. For a detailed discussion of how to ensure the quality of the localization solution please see Page R-282 in the standard GPS section.

Connect to Base and Rover – TDS Localization 'One Point Setup'

The Start Survey Wizard will have different behavior any time the user is in Ground TDS Localization mode, and there is only one point in the job. This behavior will be similar to the workflow to perform the One Point Setup procedure that is currently supported in regular GPS mode and is described below:

Setup Base Hardware Screen

This step is the same as the regular Basic Start Survey Setup Base Hardware screen (Page 340).

1. Enter the antenna height.
2. On Next >, the base is setup to broadcast CMR+ corrections over the radio port. The wizard advances to the Setup Rover screen, below.

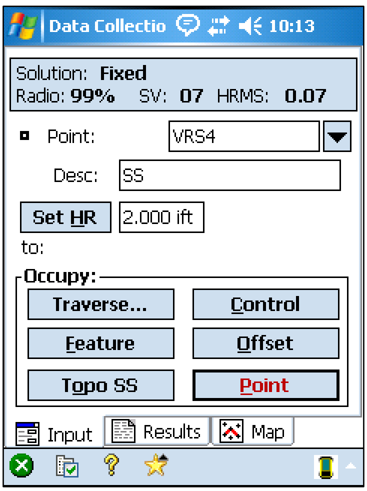
Setup Rover Screen

This screen is the same as the regular Basic Start Survey Rover Setup screen (Page 341). In this case, the button at the bottom right will always be Finish.

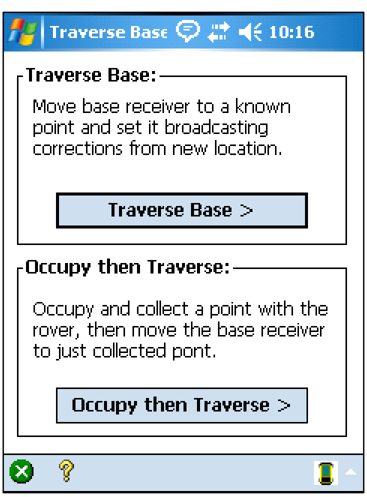
1. Enter the correct HR.
2. On Finish, writes the base and rover setup raw data; solves a one-point localization; and the wizard exits to data collection.

Traverse Base

The Traverse Base routine provides an easy method to collect a point and then move your base to that point, or to move your base to any existing point in the current job.



1. From the Data Collection screen, tap Traverse Base to open the Traverse Base screen.



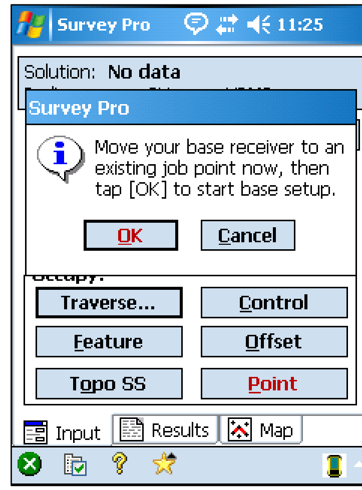
2. The Traverse Base screen provides you with the following two options:

   a. Traverse Base >: This starts a routine where you can move the base to another existing point in the current job as described below.

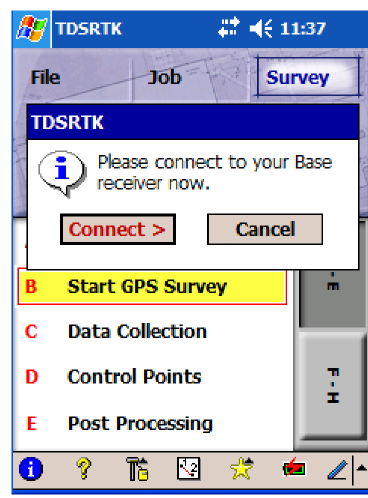
   b. Occupy then Traverse >: This starts a routine where you can first occupy a new point and then move the base to that point as described on Page 355.

Traverse Now Routine

1. Tap Traverse. This will open a prompt to move the receiver.
2. Tap OK to open the Connect to Base Receiver prompt.

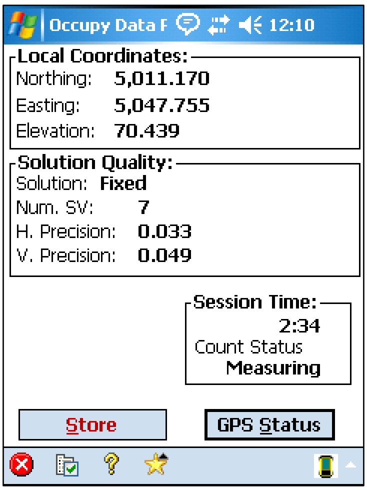


3. Tap Connect > to auto-connect to a base, which includes the check and retry prompt if connected to the rover.
4. On connection to the base receiver, we begin the steps of the Basic Start Survey wizard (Page 340).



Occupy Then Traverse Routine

1. Tap Occupy Then Traverse to open the Occupy Data Point screen.



2. Tap Store on the occupy point, you are prompted for a name and description.
3. After accepting the point, you are prompted to connect to your base receiver.
4. On successful connection to the base, including the retry prompt if we detect you are still connected to the rover, the Basic Start Survey wizard will open as described on Page 340.

Projection Solve Localization

When you go to the Projection dialog in Basic GPS mode, and tap [Solve Localization], the screen and workflow will be similar to the Basic Start Survey wizard, Solve Localization and Detect Blunders screen described on Page 349.

Post Processing

The Survey > Post Processing routine is nearly the same as with the GPS Module described on Page 307, but instead of the behavior of prompting for a receiver, we will instead do the automatic connection detection in the same way as the Basic Start Survey wizard.

References

Books:

The following books are available from various sources, including the America Congress on Surveying and Mapping:

- 5410 Grosvenor Lane, Bethesda MD, 20814
  Phone: (301) 493 0200
  Email: books@acsm.net

For a basic description of GPS hardware, field procedures, network design, planning observations:

- Van Sickle, Jan. GPS for Land Surveyors 1996, Ann Arbor. 300pp. ISBN 1-57504-041-7

For a more detailed reference on GPS datums and coordinate systems, signals, pseudo-range observable, and mathematical models:

- Hofmann-Wellenhof et al. GPS Theory and Practice, 3rd Edition 1994, Springer-Verlag Wein (Austria). 355pp. ISBN 3-211-82591-6

For an advanced discussion of GPS carrier signals, adjustment of GPS observation networks, and coordinate transformations:

- Leick, Alfred. GPS Satellite Surveying, 2nd Edition 1995, John Wiley & Sons Inc. 584pp. ISBN 0-471-30626-6

GPS Information on the Internet:

For current links on GPS constellation status, GPS and map projection references, and other geodetic information sources, go to the TDS Web site at www.tdsway.com and click on Support/Downloads > Survey Pro > Survey Pro on the Recon > GPS tips.