ArcGIS® 9

Using ArcGIS® Survey Analyst

CONTRIBUTING WRITERS
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Introducing ArcGIS Survey Analyst

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Geographic information systems (GIS) technology allows large amounts of thematic information to be stored for discrete features, such as parcels, road centerlines, water mains, and electrical utilities. There is often little information about the quality of the mapped locations of these features. ESRI® ArcGIS® Survey Analyst, the surveying extension for ArcGIS software, adds a broad set of measurement-based processing and analysis tools for improving the spatial accuracy of vector-based features and determining the spatial quality of GIS feature locations.

Survey Analyst is an application that allows you to store and work with survey measurements collected from field notes, survey equipment and data collectors. By using Survey Analyst, surveyors and GIS professionals can cooperate to add value to the following key GIS operations in your organization:

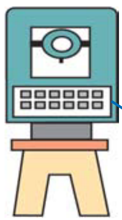
- Integrate survey measurements in your geodatabase.
- Improve the accuracy of mapped features.
- Map new features based on surveyed points.
- Organize survey data in projects.
- Maintain data about and report on the spatial accuracy of surveyed points.

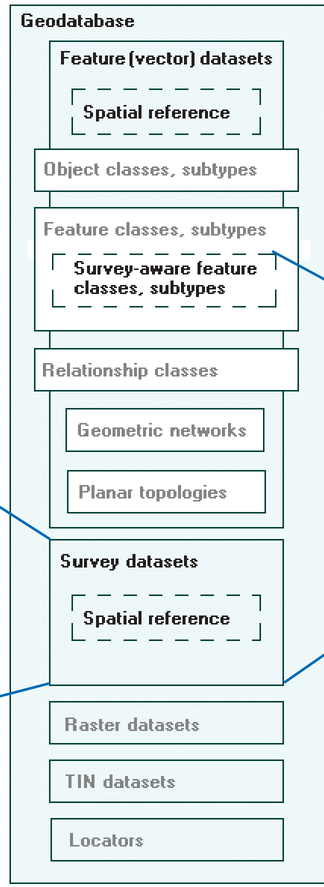
What is Survey Analyst?

The Survey Analyst extension enhances vector GIS data by adding a *survey dataset* to the geodatabase. Using Survey Analyst, you can manage survey information in a survey dataset. Within the survey dataset, you can import raw survey data from data collectors or enter coordinate geometry (COGO) measurements from survey plans and field sketches.

You can select the feature classes in your geodatabase that you want to participate with the survey information in the survey dataset; these are called *survey-aware feature classes*. *Measurements* are processed in computations that define coordinates for survey points—these are used as control for the geometry of features stored in survey-aware feature classes.

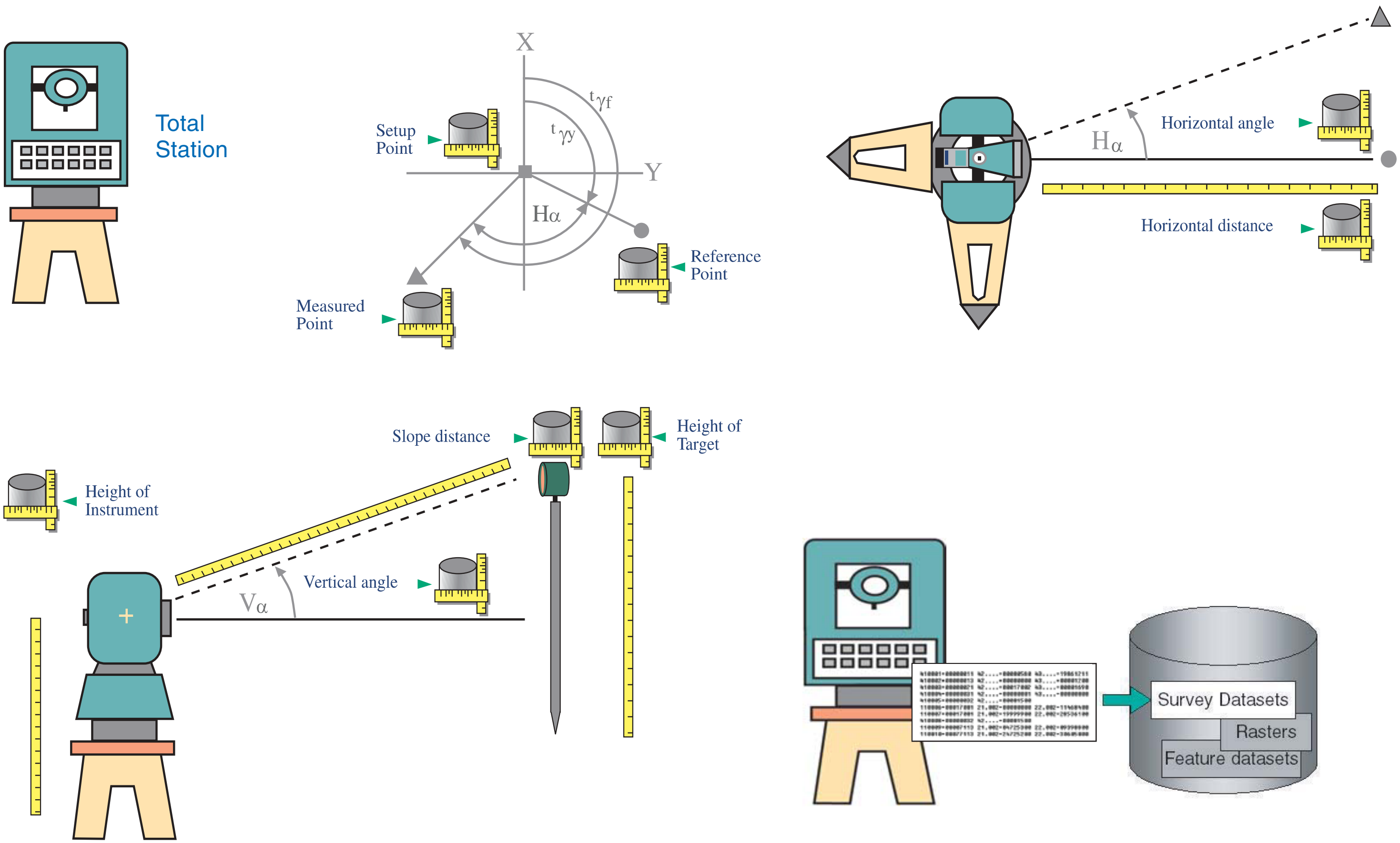
Survey points can subsequently be used to both define and improve the accuracy of your feature geometry.





Adding measurements from the field

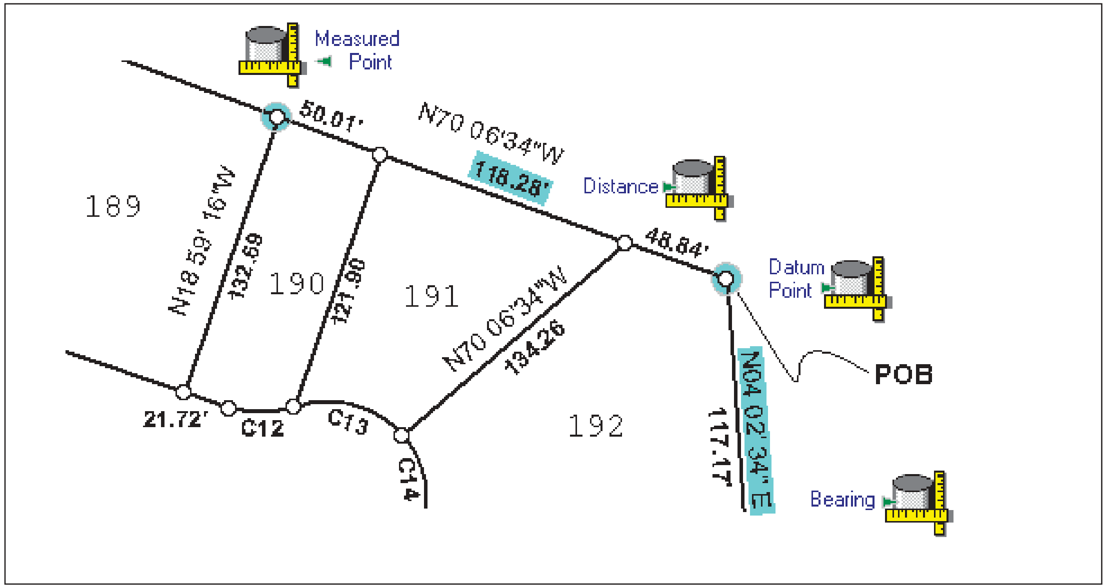
Survey Analyst helps you manage measurements collected in electronic or paper field books, for instance—vertical, horizontal, and slope distances between points; height of instrument; height of target; vertical and horizontal angles between lines of sight; temperature; and pressure.



You can import and work with the measurements collected in the field using survey equipment.

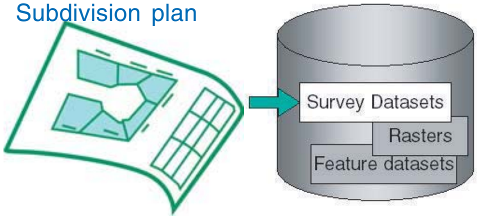
Defining points with coordinate geometry

The *bearings* and distances displayed on parcel boundaries of subdivision plans can be stored in the survey dataset and used in COGO computations to define new coordinate locations. The measurements captured by surveyors in field sketches, such as taped distances, can also be used to define point locations using COGO.



CURVE TABLE			
CURVE	DELTA	RADIUS	ARC LENGTH
C13	46° 12' 52"	45. 00'	36. 30'
C14	69° 04' 21"	45. 00'	54. 25'

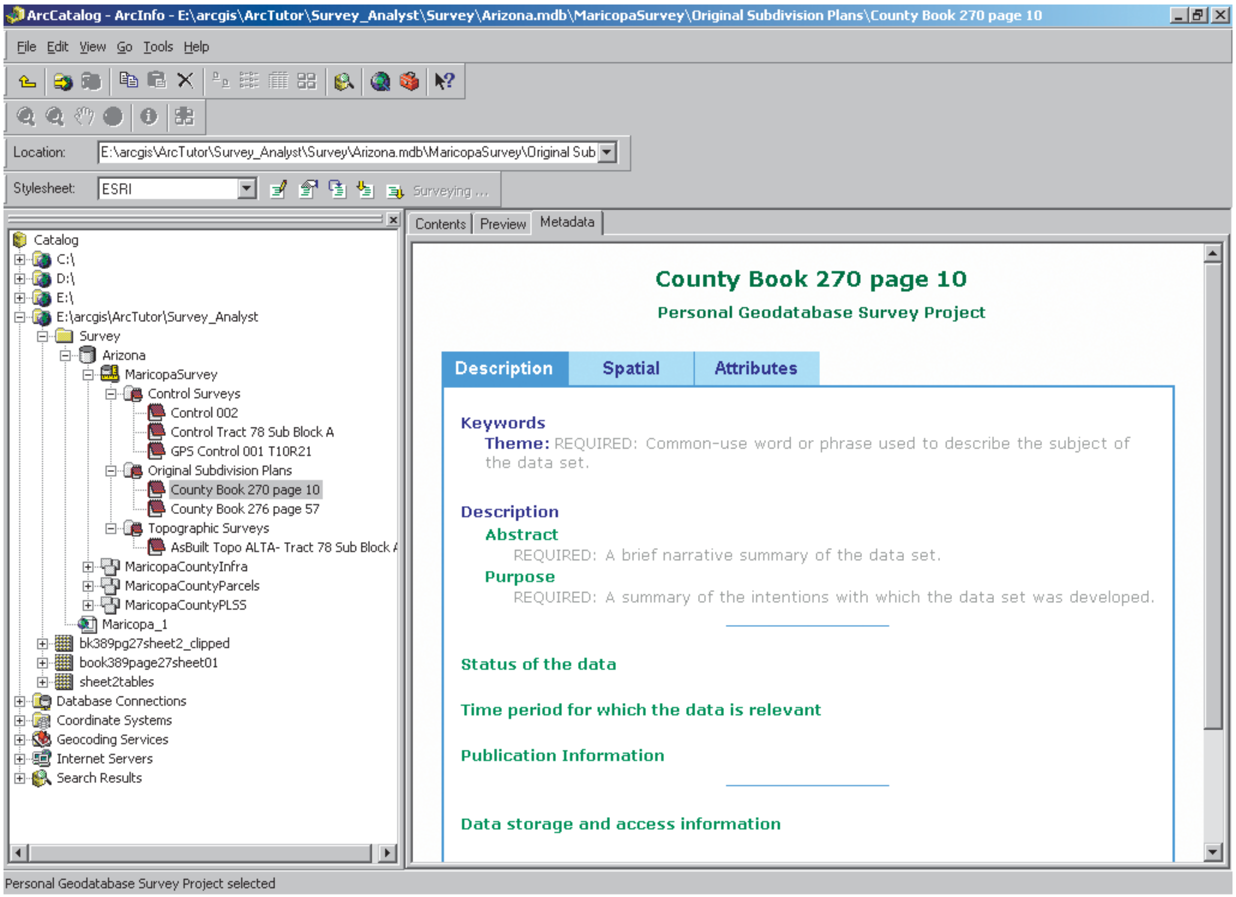
Subdivision plan



You can enter coordinate geometry from plans and field sketches to define survey point locations that are used to locate feature geometry.

Organizing survey data in projects

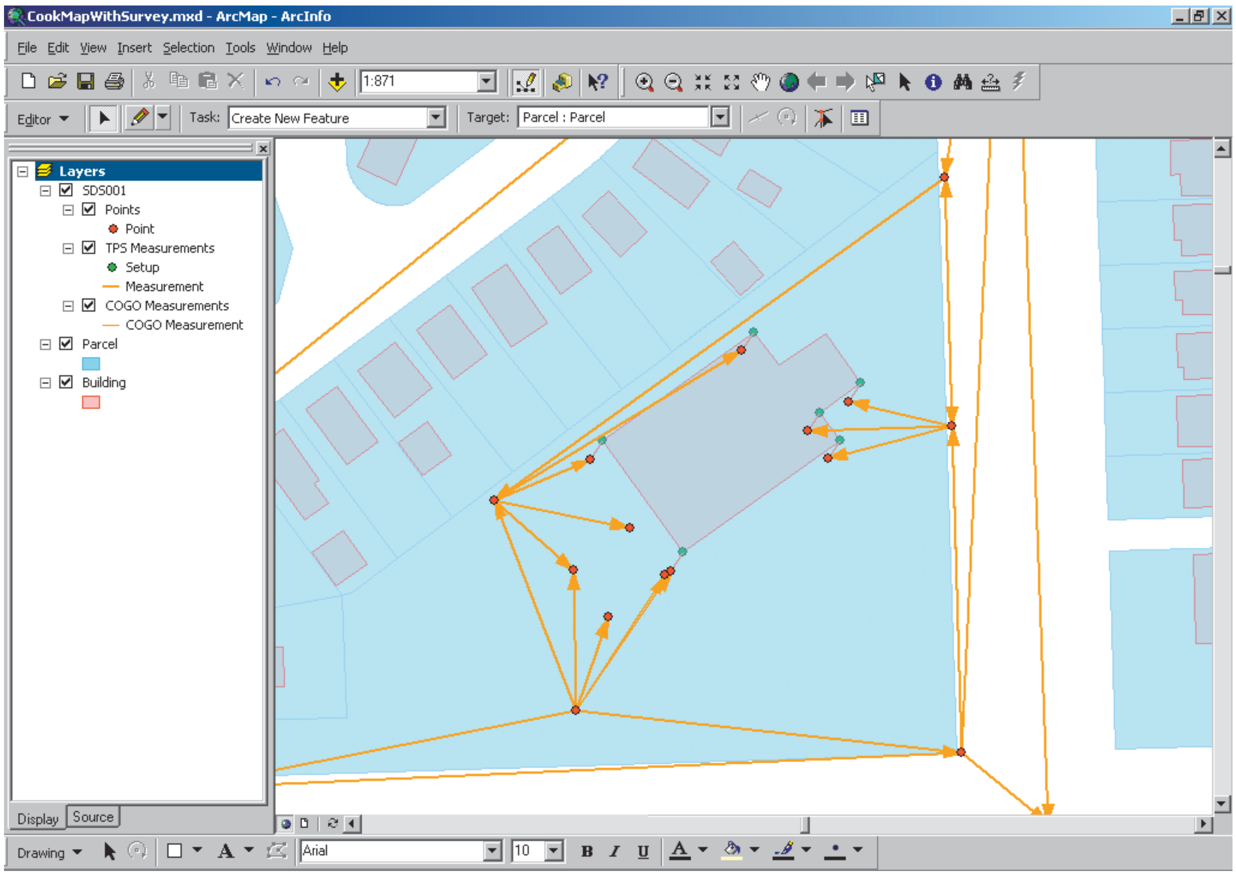
As with all geographic information, you create and view survey datasets using ArcCatalog™. Create new *projects* and *project folders* within survey datasets, and structure your projects in a way that makes the most sense for your organization. A project defines a specific task for capturing survey data, and it can be any survey activity from a field control survey to data entry from a subdivision plan. Project folders let you group projects together, and you can also make subfolders within any folder.



Whenever you start a new job, you create a survey project in a survey dataset as a place to store your data. This example illustrates a geodatabase named Arizona that contains a number of vector and raster datasets plus a survey dataset named MaricopaSurvey, which has a number of project folders.

Linking survey points to feature coordinates

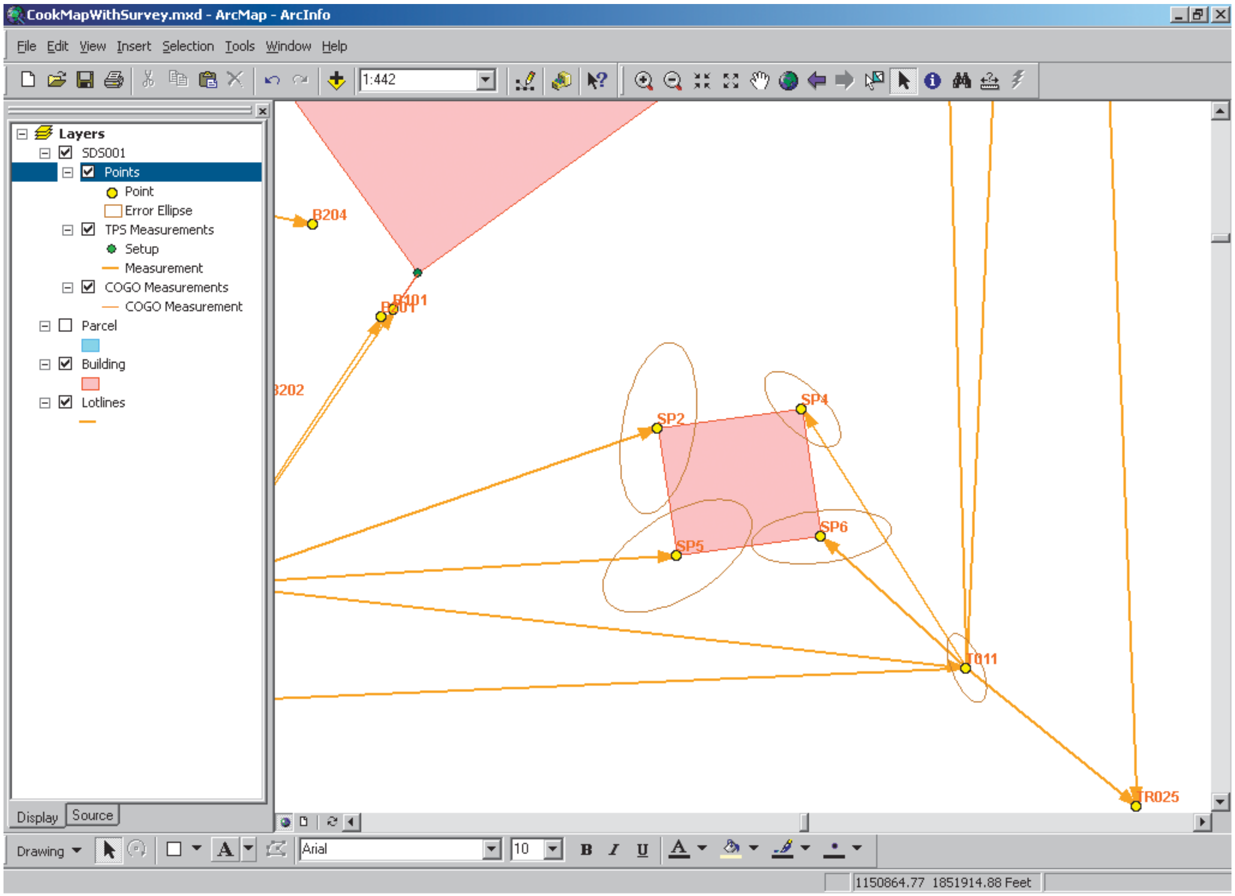
Survey Analyst represents measurements and survey points in ArcMap™ using *survey layers.* Features stored in survey-aware feature classes can be associated with survey points in the survey dataset—you can link survey points to feature vertices, and linked feature vertices can optionally be snapped to the location of survey points. When the location of survey points are updated, you can synchronize the location of features based on these new positions. Links are displayed on the map as *link-lines*.



Survey Analyst links the vector-based features in the geodatabase with the measurements, computations, and survey points stored in the same geodatabase. Features can be snapped to survey points.

Viewing error ellipses

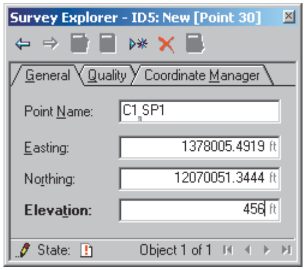
Many sources of GIS data are analog maps converted to digital formats through digitizing, scanning, or manual COGO entry. Spatial quality for individual features is not retained using these methods. Survey Analyst provides statistical information about the spatial quality of survey points, and this information can be transferred to other survey points by the method of *error propagation*. Survey Analyst allows you to calculate spatial quality for features linked to survey points.



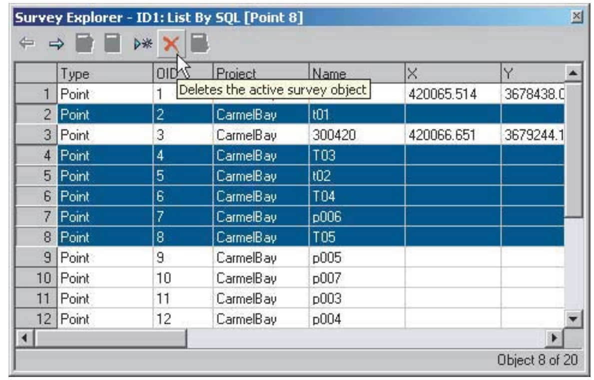
Survey Analyst stores information about spatial accuracy for survey points. This information can be be imported, computed, or propagated through computations and displayed as error ellipses. The size and angle of the ellipse represents the relative magnitude and direction of the error.

Exploring survey information

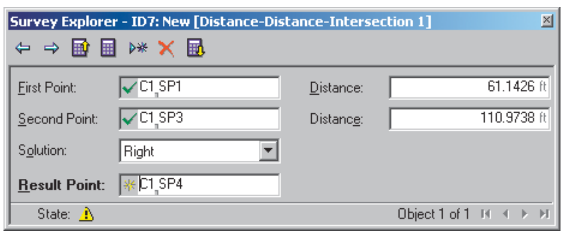
The *Survey Explorer* is the main interface for working with your stored survey information.



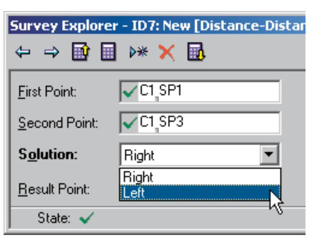
Add new coordinates and survey points.



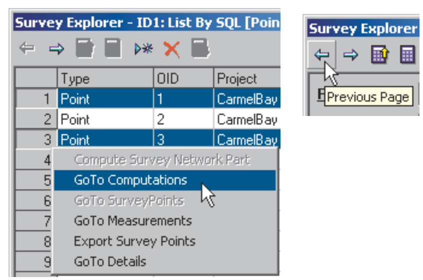
Delete survey objects after selecting them from a list.



Insert new measurements and define new computations.



Correct problems in existing computations.



Explore and navigate from a set of data to related information in the survey dataset.

Tips on learning how to use Survey Analyst

If you're new to GIS, remember that you don't have to learn everything about Survey Analyst and ArcMap to get immediate results. Begin learning to use the basic parts of Survey Analyst by reading Chapter 2, 'Quick-start tutorial'. The Survey Analyst extension comes with the data used in the tutorial, so you can follow along step-by-step on your computer.

Finding answers to your questions

Like most people, your goal is to complete your tasks while investing a minimum amount of time and effort learning to use software. You want intuitive, easy-to-use software that gives you immediate results without having to read pages of documentation. When you do have a question, however, you want the answer quickly so that you can complete your task. That's what this book is all about—getting you the answers you need, when you need them.

This book describes the survey tasks—from basic to advanced—that you'll perform with Survey Analyst and ArcMap. Although you can read this book from start to finish, you'll likely use it more as a reference. When you want to know how to perform a particular task, such as creating a new COGO traverse, just look it up in the table of contents or index. There you'll find a concise, step-by-step description of how to complete the task. Some chapters also include detailed information that you can read if you want to learn more about the concepts behind the tasks. You may also refer to the glossary in this book if you come across any unfamiliar terms or need to refresh your memory.

About this book

This book is designed to introduce the use of survey data in ArcMap. The topics covered in the various tasks and the tutorial in Chapter 2 assume you are familiar with using the editor in ArcMap and the fundamentals of GIS. If you have never used a GIS before or feel you need to refresh your knowledge, please take some time to read *Getting Started with ArcGIS* and *Building and Editing Geodatabases*, which you received in your ArcGIS™ package. It is not necessary to do so to continue with this book, but you should use these as references if you encounter tasks with which you are unfamiliar.

Chapter 2 provides a quick-start tutorial to help you familiarize yourself with Survey Analyst.

Chapter 3 provides information about the concepts behind measurements, computations, and points.

Chapter 4 describes how to organize survey information using Survey Analyst.

Chapter 5 explains how to use symbols and labels to create maps with survey data. It also discusses reliability and how to produce visual representations for associations with features.

Chapters 6 and 7 present the Survey Explorer and explain how it is used for exploring and editing computations, points, and measurements.

Chapter 8 illustrates linking to, and editing, feature geometry.

Chapter 9 offers methods on how to work effectively with the computation network and how to do point analysis.

Chapter 10 provides information about managing survey data in multiuser geodatabases.

Getting help on your computer

In addition to this book, Survey Analyst software's online Help system is a valuable resource for learning to use the software.

Contacting ESRI

If you need to contact ESRI for technical support, see the product registration and support card you received with Survey Analyst or refer to 'Contacting Technical Support' in the 'Getting more help' section of the ArcGIS Desktop Help system. You can also visit ESRI on the Web at *www.esri.com* and *support.esri.com* for more information about ArcMap, ArcGIS, and the Survey Analyst extension.

ESRI education solutions

ESRI provides educational opportunities related to geographic information science, GIS applications, and technology. You can choose among instructor-led courses, Web-based courses, and self-study workbooks to find educational solutions that fit your learning style. For more information, go to *www.esri.com/education*.

Quick-start tutorial

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IN THIS CHAPTER

- **Exercise 1: Organizing the tutorial data**
- **Exercise 2: Exploring the survey dataset**
- **Exercise 3: Working with survey data**
- **Exercise 4: Creating COGO computations**
- **Exercise 5: Updating computations and linked features**
- **Exercise 6: Exporting survey point data**

ArcGIS Survey Analyst has the tools you need to enter survey data and coordinate geometry (COGO) into survey datasets. You can import the data you've collected from a total station or enter the tape measurements recorded on a field sketch or a survey plan. Completing the exercises in this chapter will provide you with the basic knowledge to use these capabilities.

Tutorial scenario

Your organization is building a geodatabase for Maricopa County, Arizona. The geodatabase represents parcels and physical infrastructure. Your field crew has performed a survey to relocate some parcel boundary monuments and to fix the location of buildings for an existing subdivision. Coordinated locations of section corners in the area were used as control for the field survey. You will use a survey project in your geodatabase to import measurement data for the boundary monuments that were found, and for some corners of buildings on the site of the survey. You will use this information to update the geometry of an existing subdivision block in your geodatabase and add a new building based on tape measurements recorded in the field.

You will use a second project to add values recorded on the original subdivision plan. The survey points computed in this second project will be exported for use by the field crew to locate any monuments that were not found in the first field survey. You will use georeferenced images of the original subdivision survey plans as a background for your work.

Introduction to the tutorial

To use this tutorial, you need to have the Survey Analyst extension and ArcGIS installed. You also need to have the tutorial data installed on a local or shared network drive on your system. Ask your system administrator for the correct path to the tutorial data if you do not find it at the default installation path. The default installation path is arcgis\ArcTutor\Survey_Analyst, on the drive where the tutorial data is installed.

Details of the datasets that you will use in this tutorial are described in the following tables.

Geodatabase	Description
Arizona	Database containing the data that you will use and edit (located in Maricopa County, Arizona)

Feature datasets	Description
MaricopaCountyParcels	Parcel data
MaricopaCountyInfra	Physical infrastructure data
MaricopaCountyPLSS	Public Land Survey System (PLSS) data

Survey dataset	Description
Arizona	Survey data

Survey folder	Description
Maricopa County	Folder representing all survey data in the county

Survey project	Description
Carmel Bay	Project for managing and entering field-based survey data
Carmel Sub Plan	Project for managing and entering plan-based survey data

Feature classes	Description
Parcels	Parcel polygons
ParcelLines	Parcel polylines
Buildings	Building polygons
T2SouthR5East_Sect	PLSS sections
T2SouthR5East_Qtr	PLSS quarter sections
T2SouthR5East_Cnrs	PLSS corners
T2SouthR5East_Lns	PLSS quarter-quarter section lines
T2SouthR5East_Polys	PLSS quarter-quarter sections

Images (TIFF)	Description
Book389Page27Sheet01	Final subdivision plan for Carmel Bay at Ocotillo
Book389Page27Sheet02	Sheet 2 Extract
Sheet2Tables	Sheet 2 Extract curve tables

The tutorial scenario is fictitious, and the field survey data has been simulated. The basic source data can be retrieved online from the Bureau of Land Management's Geographic Coordinate Database (GCDB) and from the public record of Maricopa County, as detailed below:

Source
The Bureau of Land Management's map server for the GCDB (URL: http://www.geocommunicator.gov/lsi/)

Source
Maricopa County Recorder of Deeds online site (URL: http://recorder.maricopa.gov/recorder.htm)

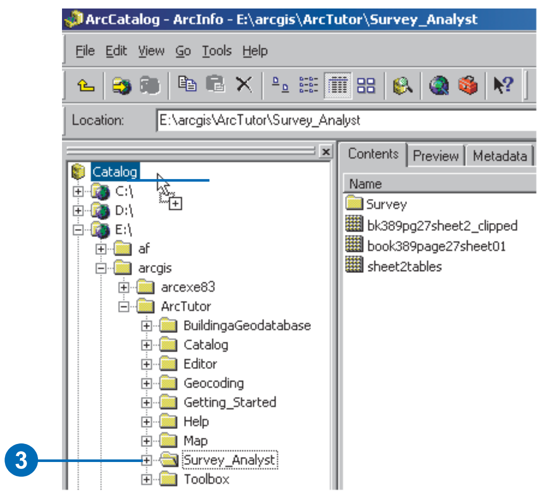
The datasets have been simplified by ESRI for the purposes of the tasks in this tutorial; they are presented solely for educational and training purposes. ESRI does not invite reliance on this data for any other purpose, and the user of this data should exercise their own professional judgment when acting on its content.

This tutorial lets you explore the basic capabilities of ArcGIS Survey Analyst. The complete tutorial will take you two to three hours to complete. You can also complete the exercises separately if that is more convenient for you.

Exercise 1: Organizing the tutorial data

Before you can begin this tutorial, you must first find and organize the tutorial data that you will need. Using ArcCatalog, browse for and create a new folder connection to your data:

1. Click the Start menu, point to Programs, point to ArcGIS, and click ArcCatalog.
2. Navigate to the location of the tutorial data (the default path is \arcgis\ArcTutor on the drive where ArcGIS is installed).
3. Click the Survey_Analyst folder and drag it onto the top-level node of the Catalog tree.

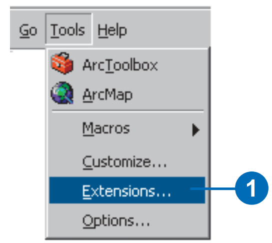


Your new folder connection is now listed in the Catalog tree. Folder connections simplify the task of navigating to your most frequently used datasets. You will now be able to access all the data needed for this tutorial through this new connection.

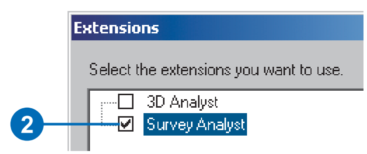
Enabling the Survey Analyst extension

Before continuing, you must enable Survey Analyst for use in ArcCatalog.

1. Click Tools and click Extensions.



2. Check the Survey Analyst check box.

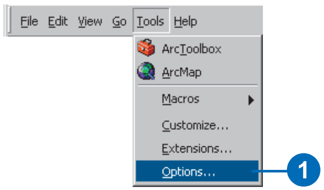


3. Click Close.

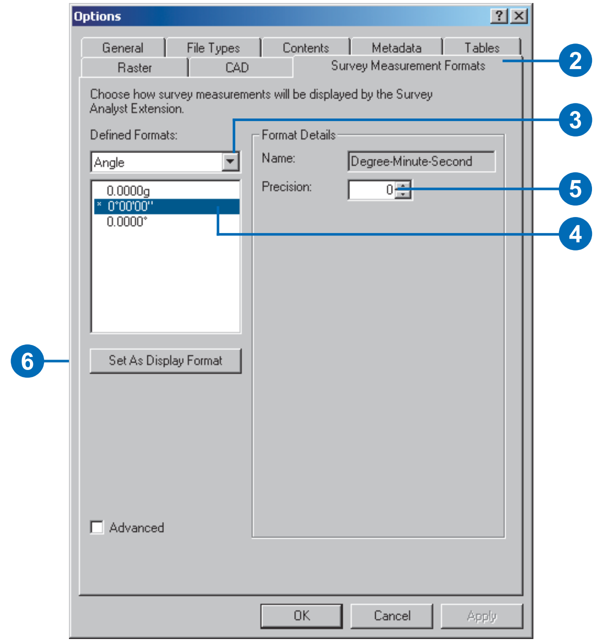
Defining the display units

Different units are available for displaying lengths and angles. You will define these for the units displayed in ArcCatalog.

1. Click Tools and click Options.



2. Click the Survey Measurement Formats tab.
3. Click the Defined Formats dropdown arrow and click Angle.
4. Click the Degree-Minute-Second option to select it.
5. Change the precision to 0. You will work in whole units of seconds.
6. Click Set As Display Format.



7. Click the Defined Formats dropdown arrow and click Length.
8. Click the second 0.000ft in the list for US Feet, and click Set As Display Format.
9. Click OK.

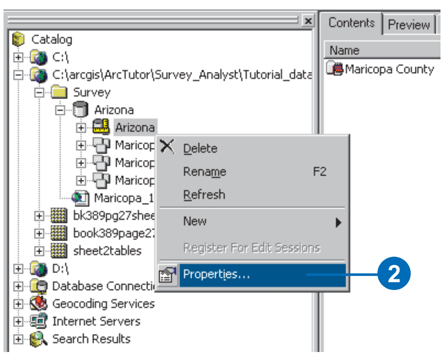
You are now ready to start exploring the survey dataset and working with your survey information. All of the survey information will be displayed using the units you've specified.

Exercise 2: Exploring the survey dataset

Survey information is stored in the geodatabase in survey datasets. A survey dataset is a comprehensive collection of survey points, measurements, and computations. You define a single survey dataset to provide *survey-awareness* for each logical group of feature datasets and feature classes. The survey dataset covers the extents of your management area.

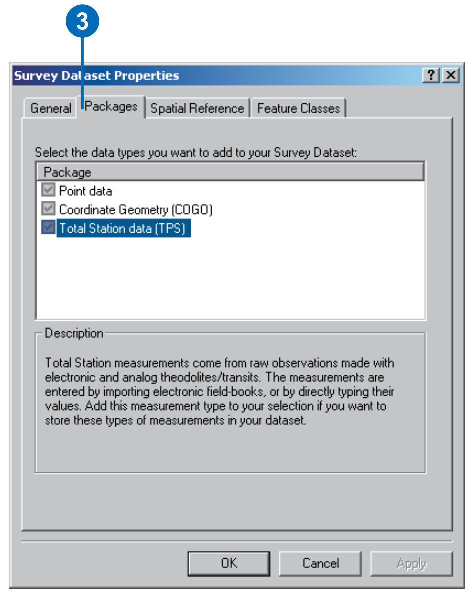
Viewing the survey dataset properties

1. In ArcCatalog, click the plus sign next to your new folder connection. Click the plus sign next to the Survey folder. Click the plus sign next to the Arizona geodatabase.
2. Right-click the Arizona survey dataset and click Properties.



The Survey Dataset Properties dialog box appears.

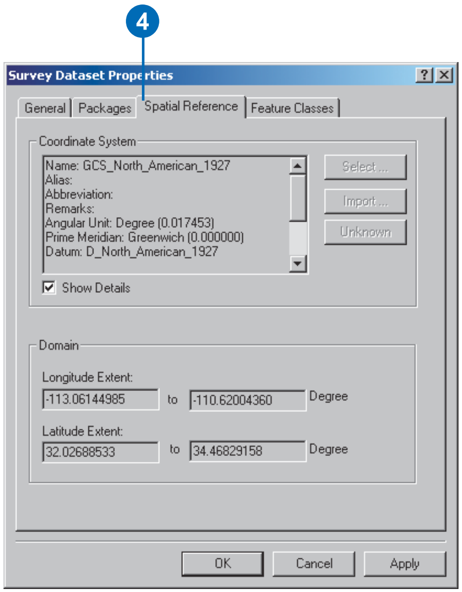
3. Click the Packages tab.



The packages are the survey data types that can be stored in the survey dataset. In this tutorial, you will be importing and working with field survey data from total positioning station (TPS) equipment, and you will also be using and storing COGO.

Once packages are added, you cannot remove them from the survey dataset.

4. Click the Spatial Reference tab.

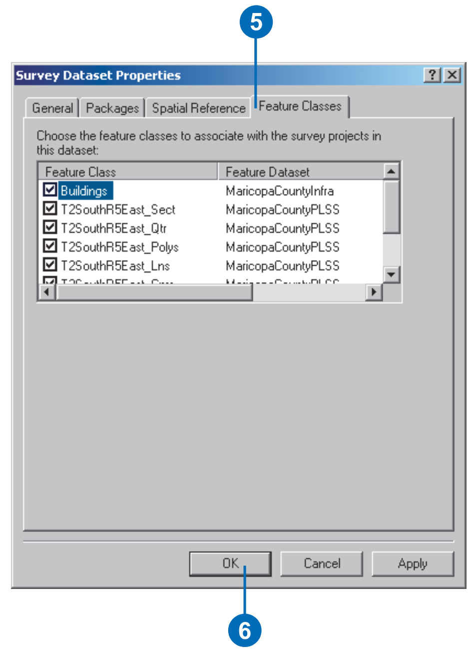


This survey dataset has a geographic coordinate system—North American Datum 1927. The latitude and longitude extents of the survey dataset are represented in decimal degrees and cover the state of Arizona.

Once defined, a dataset's spatial reference cannot be changed.

Now you will view the feature classes in the Arizona geodatabase that are *survey-aware* and participate with your survey dataset.

5. Click the Feature Classes tab.



Survey-aware feature classes have enhanced characteristics that enable the features they contain to be synchronized with the locations of survey points.

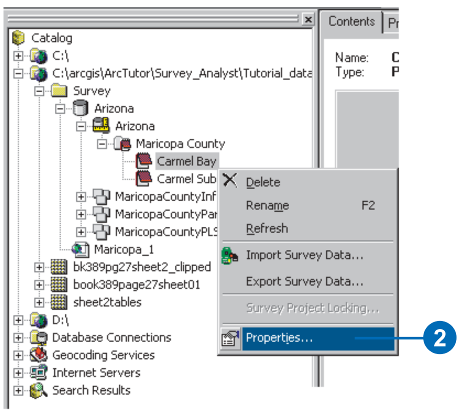
All the feature classes in this geodatabase are survey-aware.

6. Click OK.

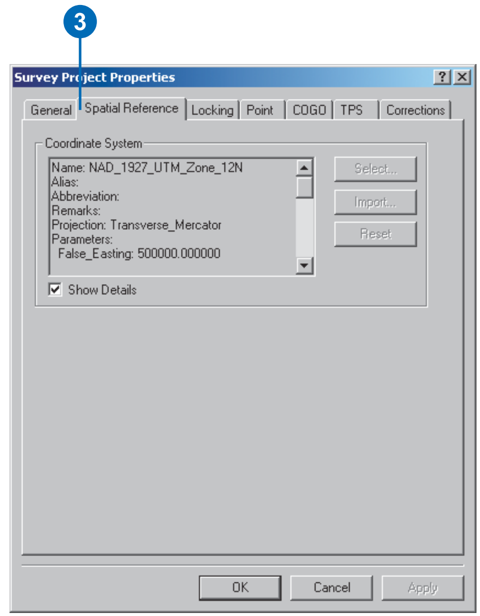
Survey datasets can contain a large amount of survey information from many different sources. Survey projects are used to organize your survey data into logically structured and manageable groups of measurements, survey points, and computations. You always add new survey data through survey projects.

Viewing the survey project properties

1. In ArcCatalog, click the plus sign next to the Arizona survey dataset. Click the plus sign next to the Maricopa County survey folder.
2. Right-click the Carmel Bay survey project and click Properties.



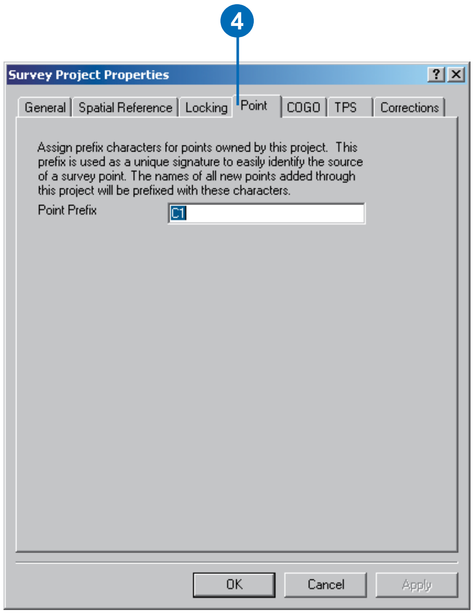
The Survey Project Properties dialog box appears.



3. Click the Spatial Reference tab.

   Each survey project can have its own projected coordinate system.

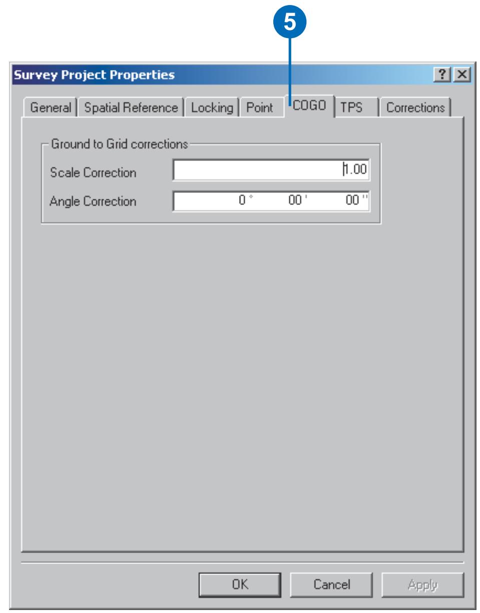
4. Click the Point tab.



Different points from different projects may have the same name. Since all points in the survey dataset are shared between projects, they need to be uniquely identified. Do this by assigning a string to each survey project. Each point name is associated with this string, which is called a *prefix*.

If needed, you can change this string. Survey Analyst notifies you if this string is already in use by a different project. Leave the string as C1 for this project.

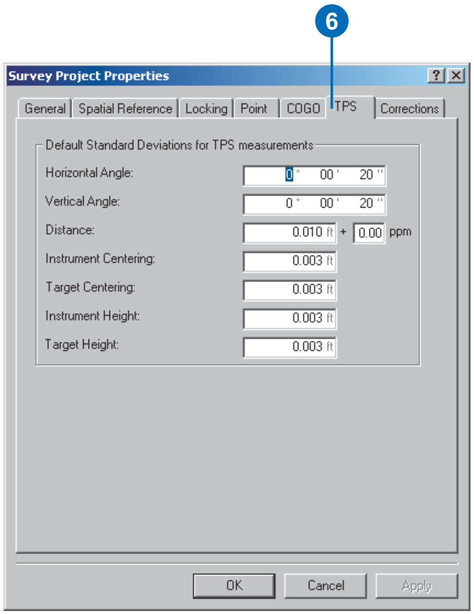
5. Click the COGO tab.



The Scale Correction applies a scale factor to all distances entered in COGO computations. The original unscaled distance values are stored.

The Angle Correction value for the Ground to Grid corrections applies a rotation of entered directions during coordinate geometry computations. The original unrotated direction measurement values are stored.

6. Click the TPS tab.



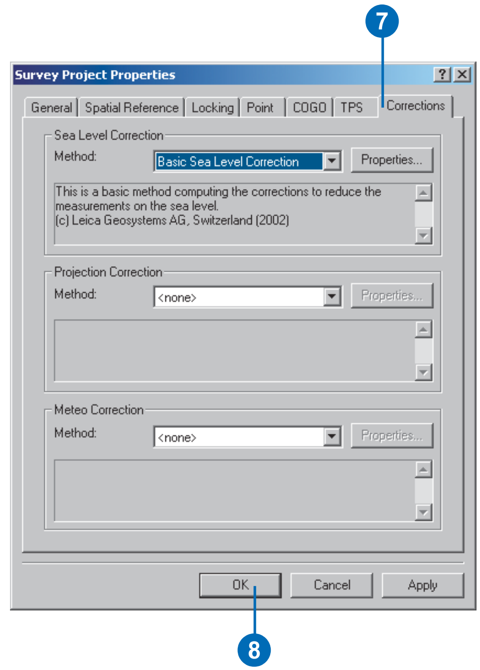
Standard deviations are used to define the expected level of precision in calibrated measuring devices.

The values on this tab are the default standard deviations assigned in new computations that use measurements from total station equipment. When working with specific computations, you can either accept or change these standard deviations.

If needed, on this property tab you can also change the defaults used by projects.

You do not need to change the default standard deviations for this project.

7. Click the Corrections tab.



These correction methods are used in computations to take into account the effects of meridian convergence, meteorological conditions, and height above sea level on the computed coordinates. The original measurement values entered into the system are not altered by these corrections.

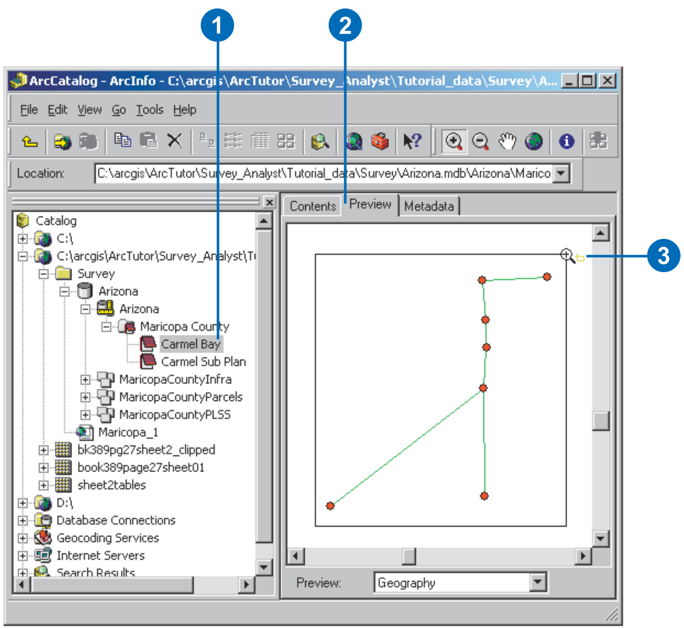
You do not need to change or assign correction methods for this project; only the Basic Sea Level Correction is required.

8. Click OK.

Previewing the data for survey projects

Next you will preview the data for the survey projects in the survey dataset. Previewing the data provides a visual representation of the survey measurements in the survey dataset.

1. Click the Carmel Bay survey project.
2. Click the Preview tab to see the survey data for this project and click the Zoom tool on the Geography toolbar.
3. Click and drag a box around the measurements and survey points to get a closer view of the data.



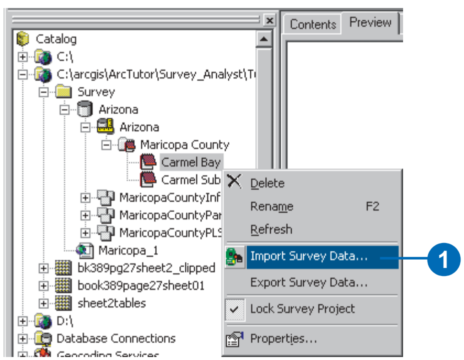
Importing from a data collector file

The information stored in the data collectors from field equipment devices is added to survey projects using the Import Survey Data Wizard.

You will use the Import Survey Data Wizard to browse for a Geo Serial Interface (GSI) file and bring this data into your survey dataset.

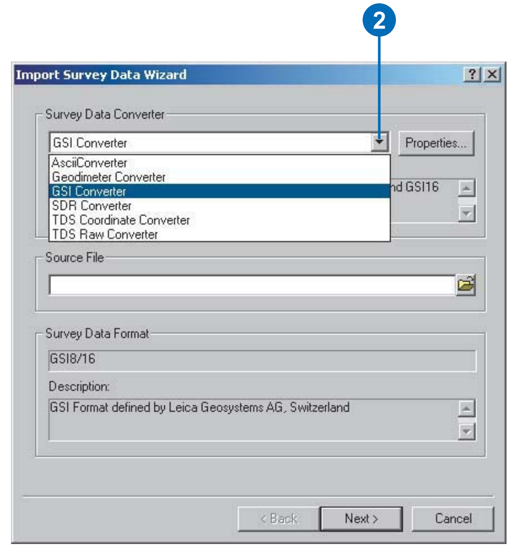
Using the Import Survey Data Wizard

1. Right-click the CarmelBay project and click Import Survey Data.

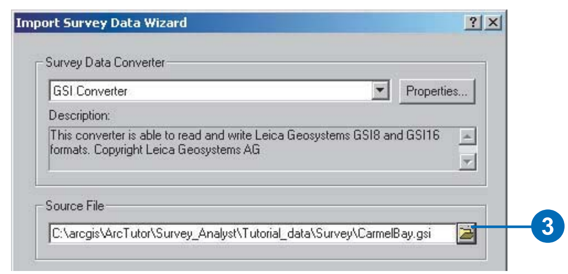


Survey Analyst provides a set of converter types that allows the data from these different formats to be imported. You will import a GSI file format.

2. Click the dropdown arrow and click GSI Converter.



3. Click the Browse button and navigate to the CarmelBay.gsi file located in the Survey folder where you installed the tutorial data.

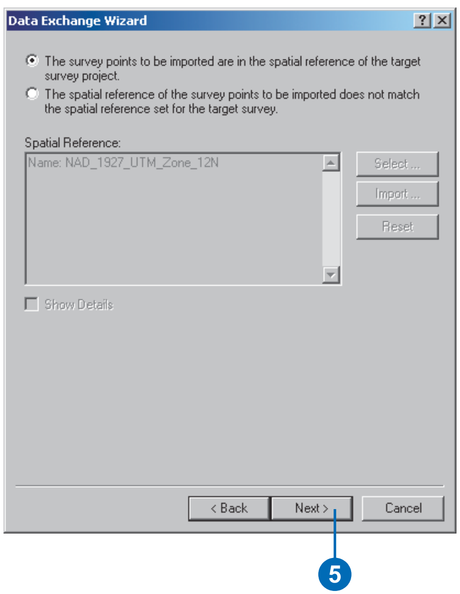


4. Click Next.

   If the source data has coordinates, they may not be in the same coordinate system as your project. In this case, you can select the coordinate system of your source data, and the importer will project it into the coordinate system of your survey project.

   The data in the the CarmelBay.gsi file is in the same coordinate system as the CarmelBay project. You will keep the default option.

5. Click Next.

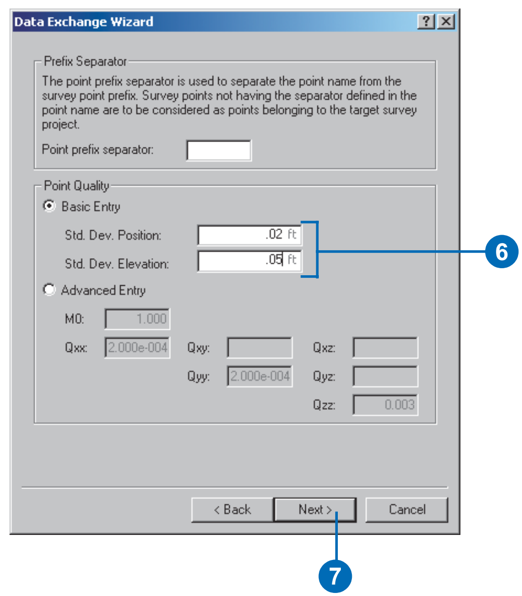


The source file data can be connected with control point locations. These points may be in the source file itself or in an existing survey project. They are always identified by a name.

A source file point naming convention can take advantage of the prefix system of Survey Analyst to uniquely identify control points that already exist in the survey dataset. In these source files, the prefix of the name is separated from the rest of the name by a single character separator. In this panel, you can choose the separator that is used in the import file. The coordinates in the CarmelBay.gsi file do not depend on points in an existing project, so you will accept the default and not use a separator.

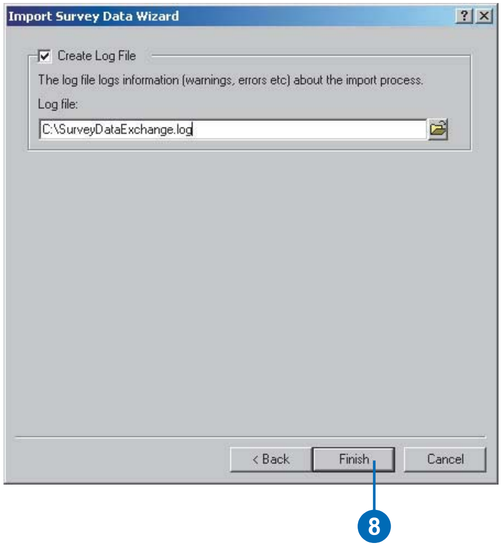
6. Type ".02" for standard deviation in x,y coordinates and ".05" for standard deviation in elevation. These values denote the expected precision of the measurements based on the equipment and techniques used in the field.

7. Click Next.

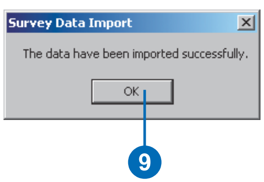


You can choose to generate a log file that reports the results of the import.

8. Choose a log file path and name and click Finish.



9. Click OK on the Survey Data Import message.



The additional measurements from the GSI file are now stored in the survey dataset. These will be managed and used in the Carmel Bay survey project.

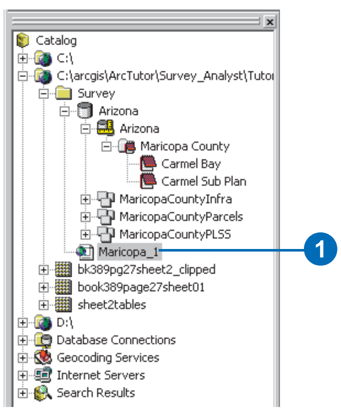
Exercise 3: Working with survey data

Survey layers let you symbolize and label survey points and measurements on a map. A map document displaying the Carmel Bay survey project has already been created. You will add a new survey layer to this existing map of the area and refine its properties for the Carmel Sub Plan project.

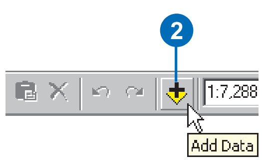
First you must open the map document. You will do this from ArcCatalog.

1. Double-click the Maricopa_1.mxd map document.

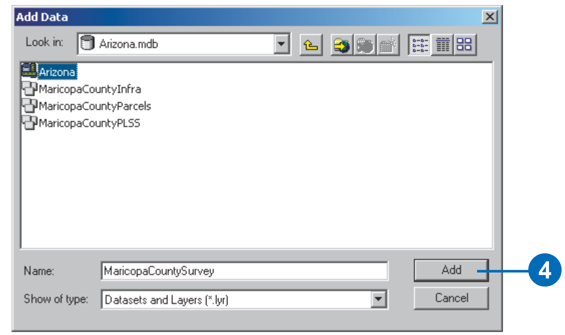
   ArcMap starts and displays a map of the survey area.



2. Click the Add Data button.

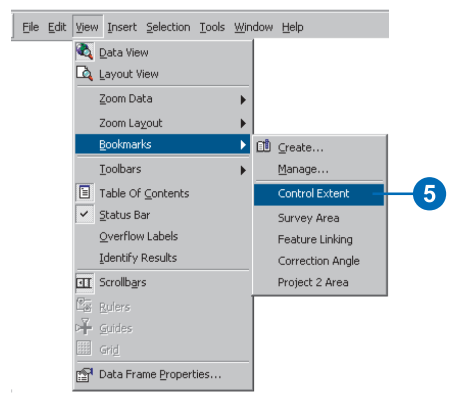


3. Navigate to the Arizona geodatabase where the Arizona survey dataset is located.
4. Click the Arizona survey dataset and click Add.



   The survey layer appears in the table of contents.

5. Click View, point to Bookmarks, and click Control Extent.

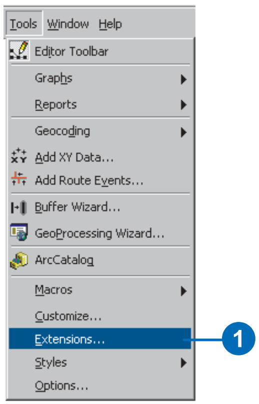


This bookmark displays the survey area at a larger scale.

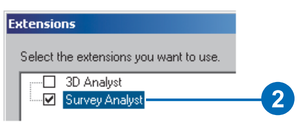
Enabling the Survey Analyst extension

Before continuing, you must enable Survey Analyst for use in ArcMap.

1. Click Tools and click Extensions.



2. Check the Survey Analyst check box.

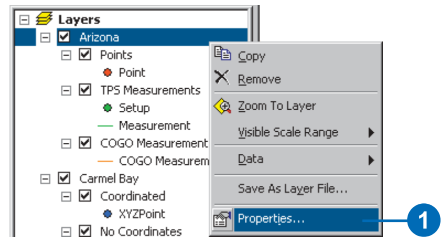


3. Click the Close button.

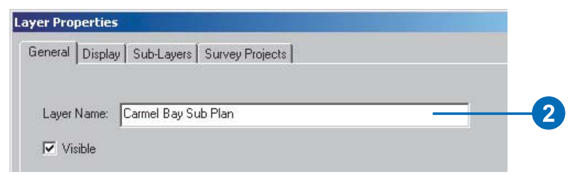
Setting the survey layer properties

A survey layer provides flexibility in displaying survey information in a way that is meaningful for your task. You'll change the properties for the new survey layer to best represent the Carmel Sub Plan project.

1. Right-click the Arizona survey layer and click Properties.

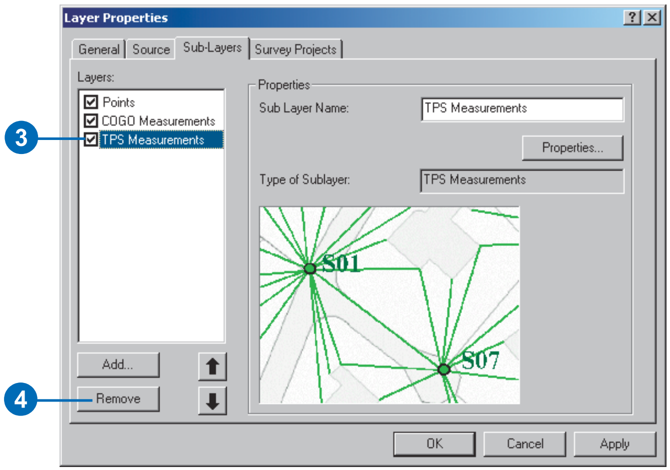


2. Type "Carmel Bay Sub Plan" as the Layer Name on the General tab.



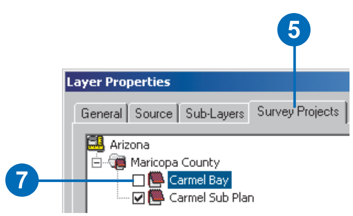
A survey layer has a sublayer for each of the data types supported by the survey dataset. You can control the number of sublayers displayed in the survey layer. The total station measurements are not needed for the Carmel Bay Sub Plan survey project, so the sublayer that represents these is not required. Therefore, you need to remove the sublayer representing total station measurements.

3. Click the Sub-Layers tab and click TPS Measurements.
4. Click the Remove button.



The survey layer can be used to display data from all the projects of the survey dataset, or it can be used to display data from a specific set of survey projects. You'll ensure that when other new projects are added to the survey dataset, this survey layer will only display the Carmel Sub Plan project.

5. Click the Survey Projects tab.
6. Click the plus sign next to the Maricopa County survey folder.

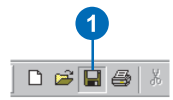


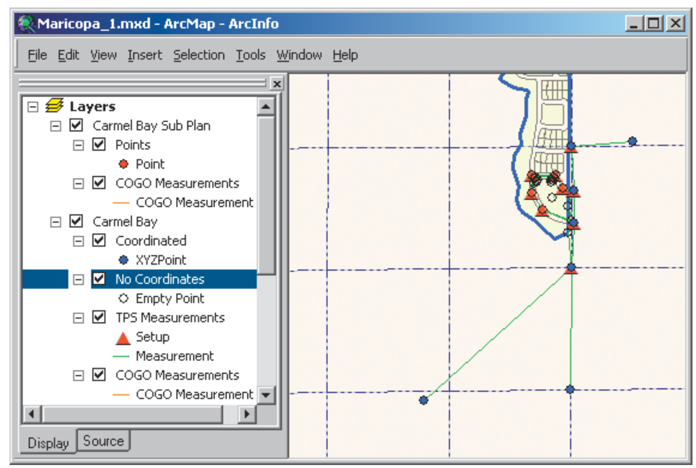
7. Uncheck the Carmel Bay project and verify that the Carmel Sub Plan project is checked.
8. Click OK on the Layer Properties dialog box.

Saving your map document

Now you will save the changes you have made to the map document so that you do not need to repeat this section if you choose to stop this tutorial and continue at a later time.

1. Click the Save button.





Map displaying the survey information in the Arizona survey dataset.

Working with the Survey Explorer

The previous section describes how you can visualize measurements and survey points in the map. This important map visualization is complemented by the equally important functionality provided through the Survey Explorer. The Survey Explorer is used to view and enter the numerical values required for computing coordinates.

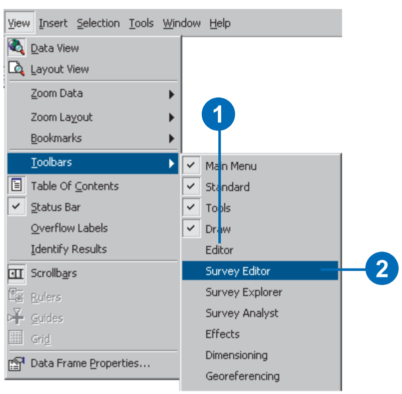
Adding the required toolbars

Before you can use the Survey Explorer, you need to add the Editor and Survey Editor toolbars to ArcMap.

1. Click View, point to Toolbars, and click Editor.

   The Editor toolbar appears in ArcMap.

2. Add the Survey Editor toolbar the same way.



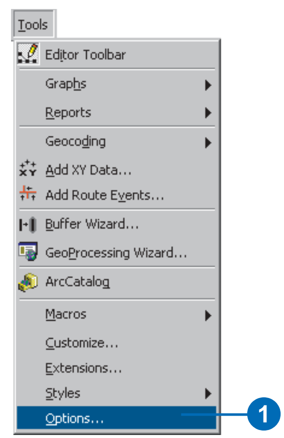
3. Click the Survey Editor toolbar's title bar and drag it to the top of the ArcMap application window. This will dock the toolbar.

You can dock the Editor toolbar the same way.

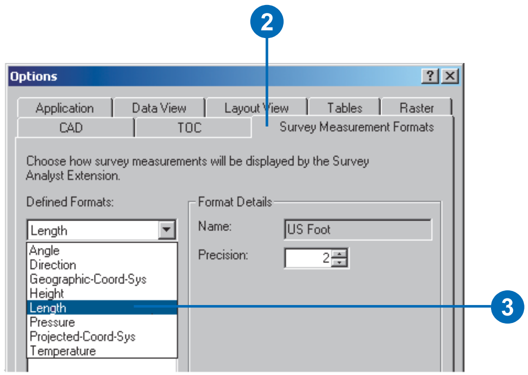
Setting the display units for length measurements

Since the measurements you are working with are in feet, you will need to change the display units for the new COGO computations that you will create.

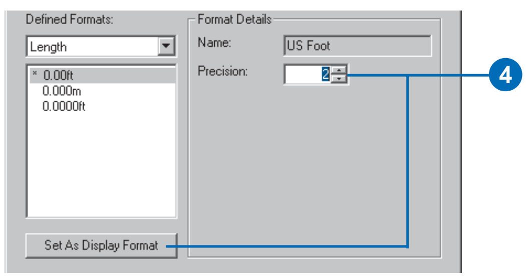
1. Click the Tools menu and click Options.



2. Click the Survey Measurement Formats tab.
3. Click the Defined Formats dropdown arrow and click Length.



4. Click 0.00ft, type “2” for precision, click Set As Display Format, then click OK.

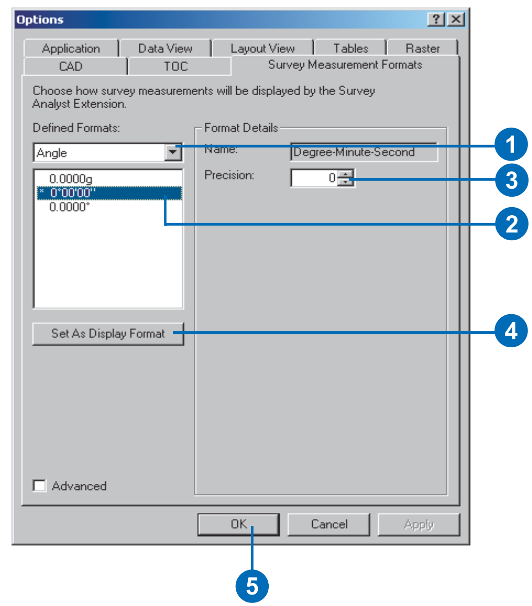


All length measurements that appear while using the Survey Explorer and Survey Analyst commands will be displayed to two decimal places in units of feet.

Setting the display units for angle measurements

Next, you will repeat these steps to change the units for directions.

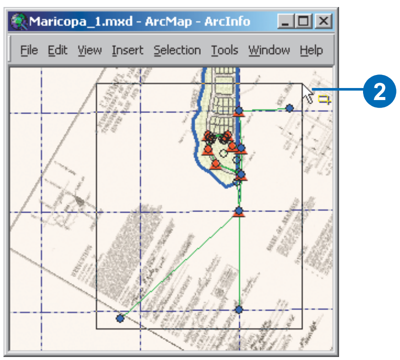
1. Click the Defined Formats dropdown arrow and click Angle.
2. Click the Degree-Minute-Second option to select it.
3. Change the precision to 0. You will work in whole units of seconds.
4. Click Set As Display Format.
5. Click OK.



Listing points in the Survey Explorer

1. Click the List Survey Objects tool.

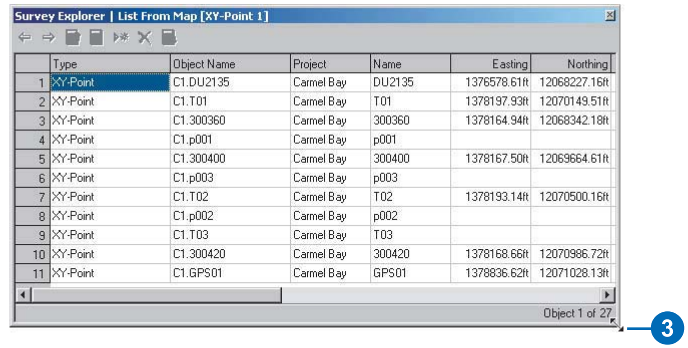
2. Click and drag a box around all the survey points in the current map extents.



The Survey Explorer opens, displaying a list containing all the survey points in the map extents.

Next, you will resize the Survey Explorer so that you can see more columns in the list.

3. Move the mouse pointer to the bottom-right corner of the window. Click and drag the corner until the easting and northing values are visible.



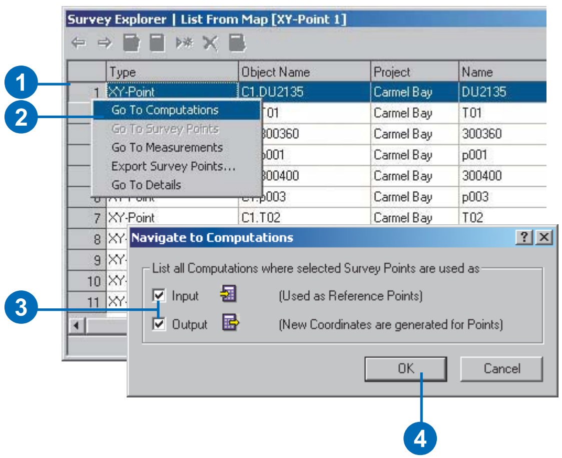
Note that certain survey points do not have easting and northing values. These points resulted from the import of the GSI file. This file has no coordinates; it contains measurements between coordinated points stored in the survey dataset.

The importer automatically computed provisional locations for the newly measured points by using the raw measurements in the file.

The two point sublayers for the Carmel Bay survey layer are used to distinguish between the coordinated points and the empty points, which still need to be computed.

Finding stored computations with the Survey Explorer

1. Click the leftmost column of the row in the Survey Explorer list that represents the point DU2135.
2. Right-click the row and click Go To Computations.
3. Check Input and Output to find computations that both use or create coordinates for the selected survey point.
4. Click OK.

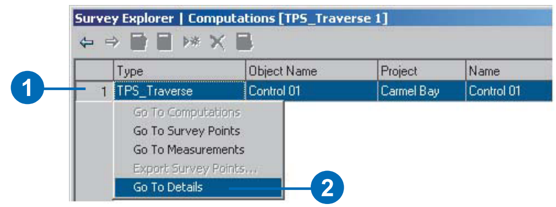


The Survey Explorer displays a new list containing a field traverse computation. This computation is a control traverse that used DU2135 as a reference point for orientation.

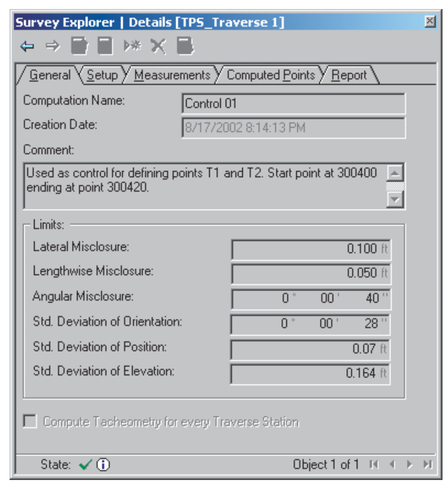
Next, you will view some of the details of this stored computation.

Navigating to the details of a stored computation

1. Click the leftmost column of the Survey Explorer list for the Control 01 computation.
2. Right-click the row and click Go To Details.

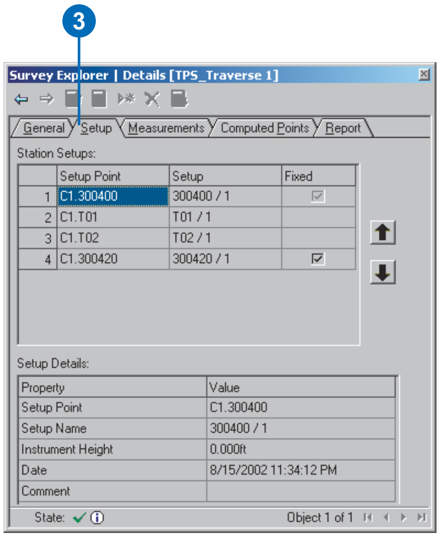


The Survey Explorer displays a detailed view of the field traverse computation. The General tab displays information that identifies the computation and its allowable limits.



The General tab provides information to identify the computation and its limits.

3. Click the Setup tab.

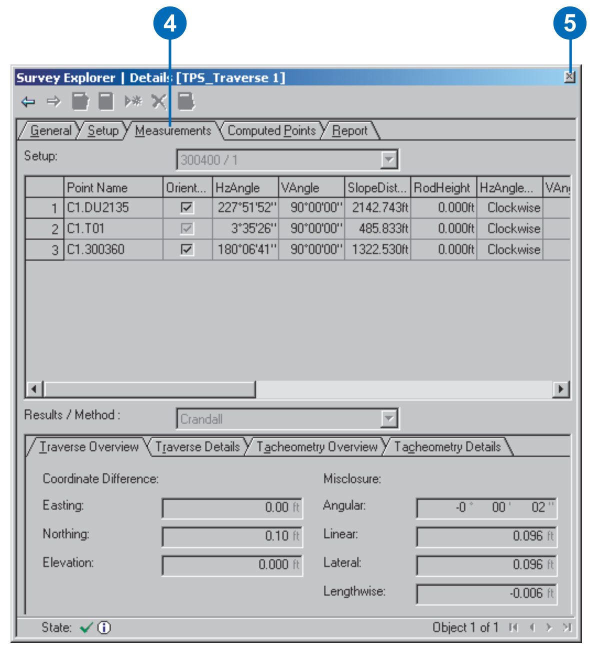


The Setup tab displays all the instrument setups processed in this traverse.

4. Click the Measurements tab.

Values for the measurements from the different setups are displayed. The Compass method is used for adjusting the misclosure—or closure error—for this traverse.

5. Close the Survey Explorer.



You have now learned a little bit about using the Survey Explorer by importing instrument setups and measurements. In the next exercise, you will build on this by adding your imported instrument setups and measurements to a new computation.

Editing survey data

Computing coordinates and analyzing coordinate quality is the most important feature of Survey Analyst.

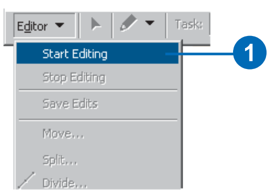
In this exercise, you will define computations to calculate coordinates for points, link a parcel block feature to points, and update the feature's location. To do this, you will add your imported measurements to a new computation.

Starting an edit session and setting the editing environment

Before you start defining computations, you need to start editng and set your editing environment. You will add a new type of task to the standard set available in the Editor toolbar and also set the Target project for your edits.

Adding an edit task

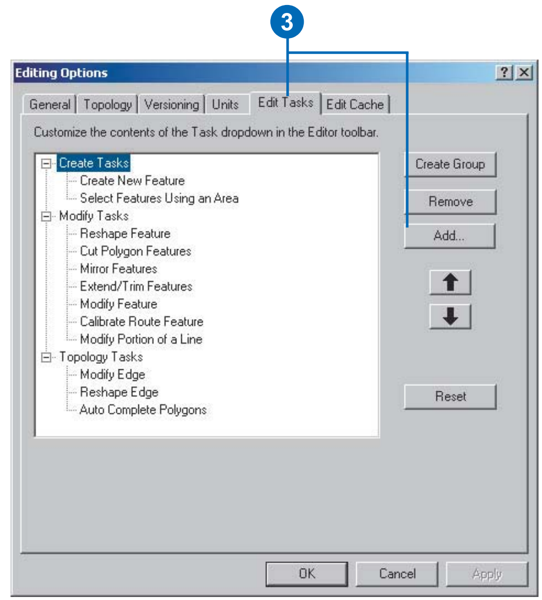
1. Click the Editor menu and click Start Editing.



   If the Starting To Edit In A Different Coordinate System dialog box appears, click Start Editing.

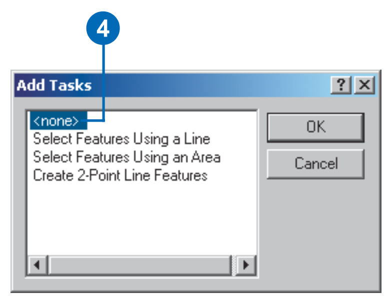
2. Click Editor on the Editor toolbar and click Options.

3. Click the Edit Tasks tab and click Add.



4. Click <none> in the Add Tasks dialog box and click OK.

5. Click OK in the Editing Options dialog box.



Creating a new field traverse computation

To calculate coordinates for the measured points, two traverse computations will be used. The first traverse has already been defined; this is the computation you found in the previous exercise. It was used to extend control into the project area, and it created two new survey points: T1 and T2.

You will now create a second field traverse computation to calculate coordinates for control points T3–T7. Additional measurements were also imported as part of the GSI file and were used to calculate coordinates for building corners and found parcel corner monuments in the project area.

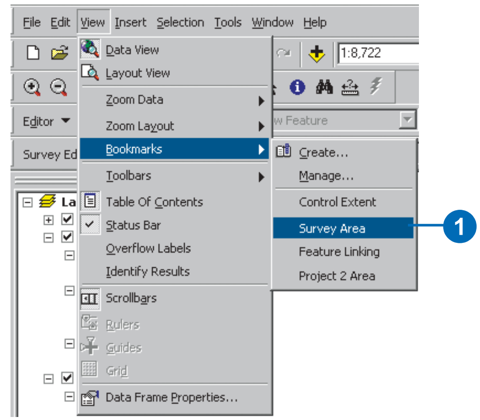
Setting the target project

Before you start defining new computations, you must set the project that will own the points, measurements, and computations that will be stored.

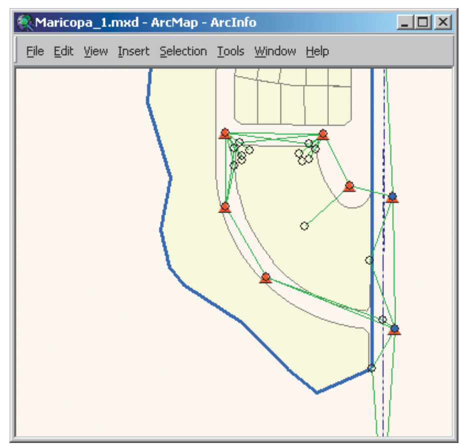
1. Click the Project dropdown arrow and click Arizona - Carmel Bay.

Zooming to the Carmel Bay project area

1. Click View, point to Bookmarks, then click Survey Area.



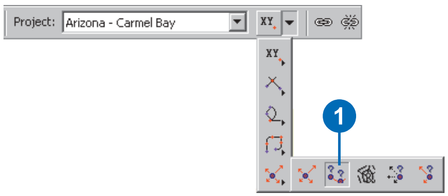
The Survey Area bookmark changes the map display to show the area of the second traverse.



Map extents showing the area of the second traverse

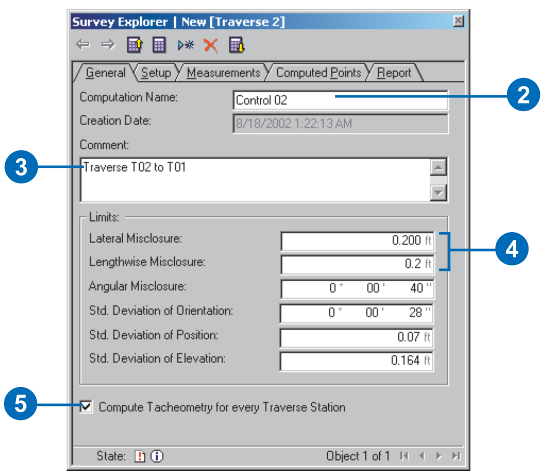
Defining the second traverse and side-shots

1. Click the tool palette dropdown arrow, point to the TPS Computations button, and click the Traverse button.

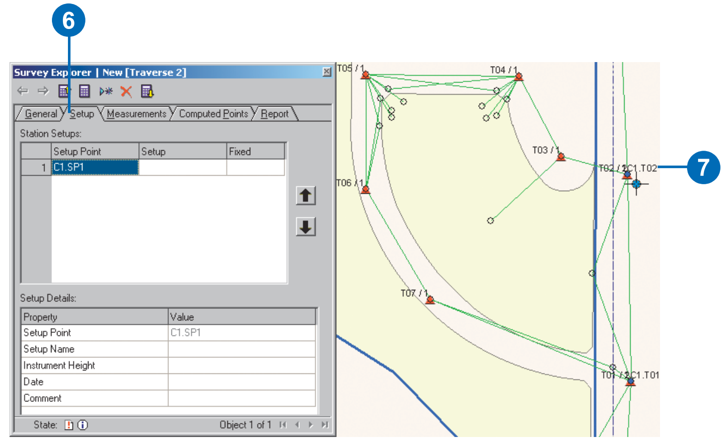


The Survey Explorer appears with pages for a new field traverse.

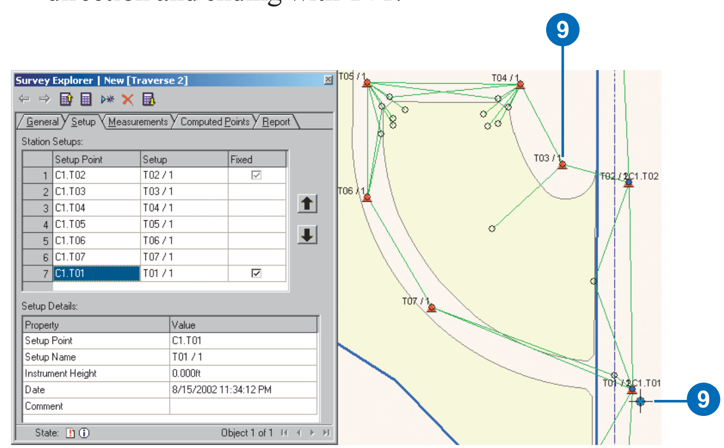
2. Type “Control 02” for the traverse name.
3. Type “Traverse T02 to T01” for the comment.
4. Type “0.200” for Lateral Misclosure and “0.2” for Lengthwise Misclosure.
5. Check Compute Tacheometry for every Traverse Station.



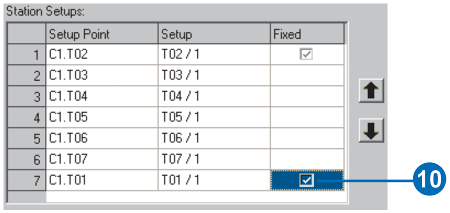
6. Click the Setup tab.
7. Snap to and click T02 on the map.



8. Press Enter twice to accept the default name and Fixed option.
9. Add the remaining traverse setups—shown as red triangles on the map—working in a counterclockwise direction and ending with T01.



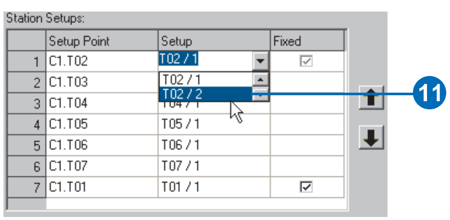
10. Click T01 on the map and check Fixed.



The final traverse setup will participate in this traverse as a fixed closure point.

Each survey point can have many instrument setups. There are two setups at the T1 and T2 points. The first setups at these points were used for the initial control traverse—Control 01. The second setups at each of these points were imported during the import exercise; these are the setups that must be processed in this traverse. This traverse is presently using the first setups for T01 and T02. You will now change these to the correct setups.

11. Double-click the Setup field for T02, click the dropdown arrow, and click T02 / 2.

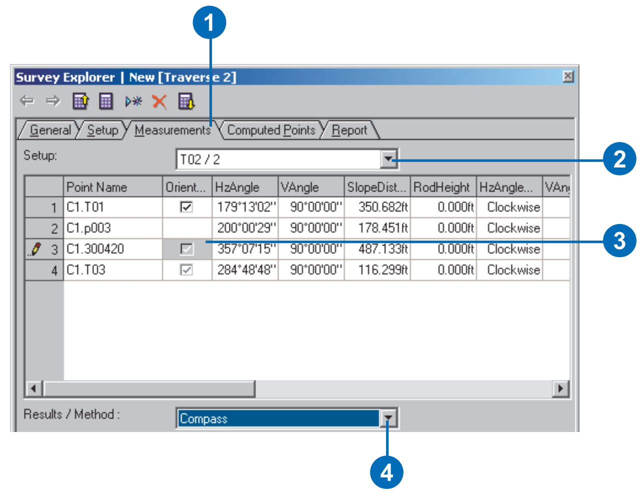


12. Double-click the Setup field for T01, click the dropdown arrow, and click T01 / 2.

Defining orientation and computing

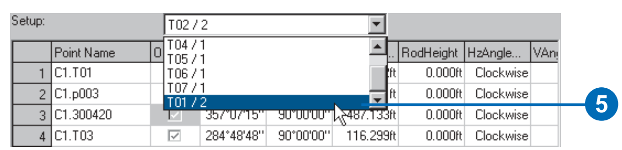
You will now view the measurements and define the points that were used for orientation during the field survey. You will do this for each of the setups.

1. Click the Measurements tab.
2. Click the Setup dropdown arrow and click T02 / 2.
3. Check 300420 in the orientation field.
4. Click the Adjustment method dropdown arrow and click Compass.

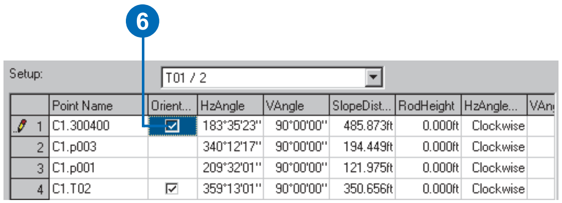


You will next ensure that the correct orientation points are being used for the setup at T01.

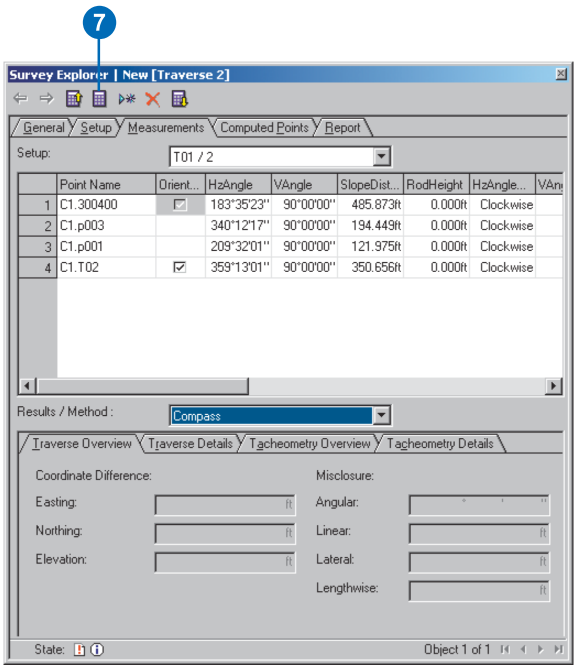
5. Click the Setup dropdown arrow and click T01 / 2.



6. Check 300400 in the orientation field.



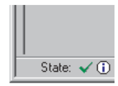
7. Click the Compute button on the Survey Explorer toolbar.



Coordinates for the second traverse have been computed, including the locations for the building corners and found monuments. The survey points have coordinates and are labeled and displayed with a different symbol.

Viewing the traverse misclosure information

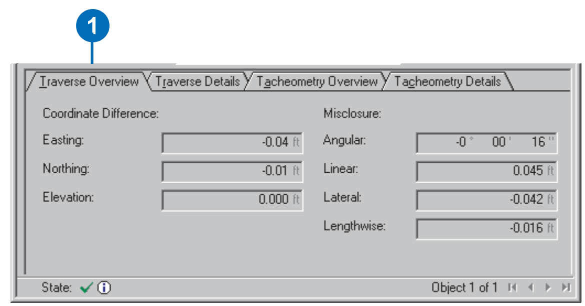
If the computation results are within the limits you defined, the computation is marked as valid. This is indicated by the check mark in the lower-left portion of the computation page.



The computation has a valid state.

Additional information concerning the traverse misclosure is also available. You will now verify these results.

1. Click the Traverse Overview tab.



The details of the traverse misclosure are displayed.

Saving your edits

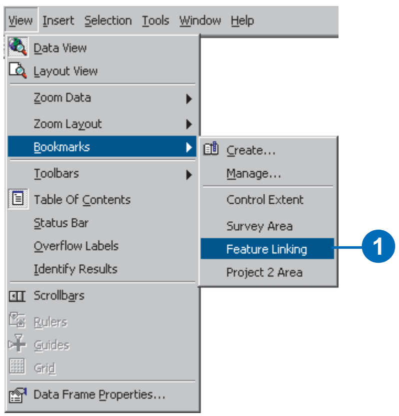
Now that you have successfully added the second computation to the geodatabase, you can save your edits.

1. Click the Editor menu and click Save Edits.

Editing features using survey points

Now that you have computed survey point locations for the found monuments and building corners, you will associate these coordinated locations with the features in the feature layers. You will start with the subdivision block in the parcel layer. First you will set the map to a bookmark of the area.

1. Click View, point to Bookmarks, and click Feature Linking.



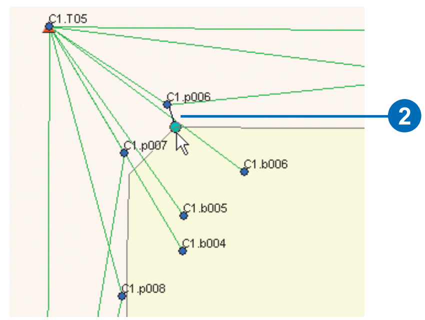
Using the Link tool

You can link the vertices of features to survey points without changing the location of features. The geometry of the feature stores the link information of the associated survey points. You will now make a link from a survey point to a feature vertex for the subdivision block.

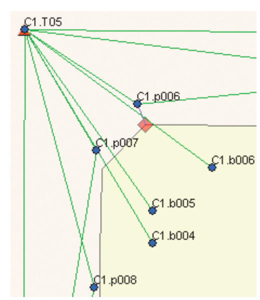
1. Click the Link tool on the Survey Editor toolbar.

The Link tool will work together with the snapping environment of the Editor.

2. Snap and click C1.p006, then click the parcel feature vertex closest to this point.



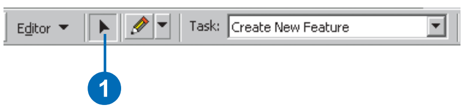
The symbol for the vertex of the feature is updated, and a link-line is displayed between the survey point and the feature vertex.



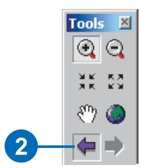
Using the Link command

Instead of using the Link tool for each of the feature vertices, you will link the remaining survey points using the Link command. This command will search for survey points to link within a defined distance of each feature vertex.

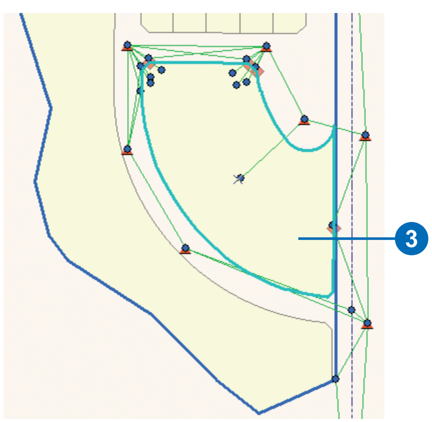
1. Click the Edit tool on the Editor toolbar.



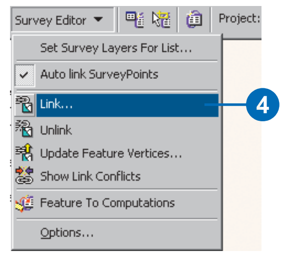
2. Click the Go Back To Previous Extent button on the Tools toolbar.



3. Select the subdivision block.

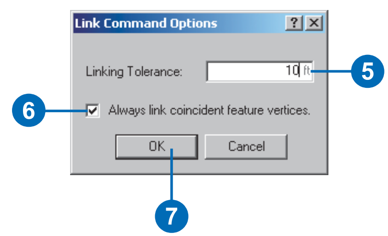


4. Click the Survey Editor dropdown arrow and click Link.



The dialog box for the Link command options appears. Use a linking tolerance of 10 feet. This is the distance that is used at each feature vertex when the command searches for survey points to link.

5. Type 10 in the Linking Tolerance box.
6. Check Always link coincident feature vertices.
7. Click OK.

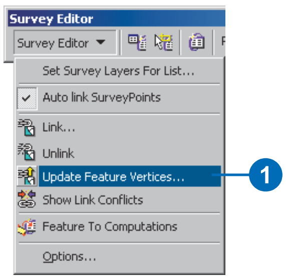


Now all of the survey points used to define the locations of parcel corners have been linked to the subdivision block in the parcel layer. The link-lines between the feature vertices and survey points are displayed, and the symbols at the feature vertices are udpated.

Using the Update Feature Vertices command

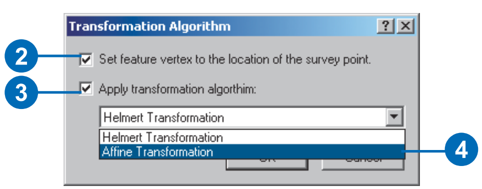
Until now, you have made no changes to the locations of features. You will now use the survey points and links to change the location of the subdivision block.

1. Click Survey Editor and click Update Feature Vertices.



The Transformation Algorithm dialog box appears. You can select the type of transformation applied to the unlinked feature vertices when the geometry update is applied.

2. Check Set feature vertex to the location of the survey point.
3. Check Apply transformation algorithm.
4. Click the dropdown arrow on the Algorithm, click Affine Transformation, then click OK.

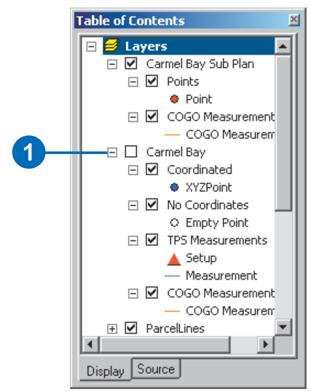


The parcel block is updated so that the linked vertices share the same locations as the survey points. In addition, the locations of the unlinked vertices have been transformed to provide a relative match with the surveyed vertices.

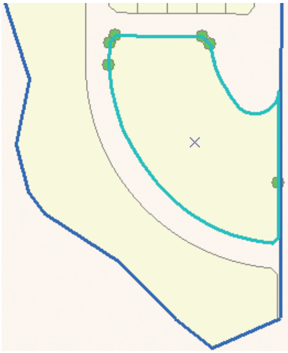
Turning off the survey layer

The symbols of the linked feature vertices are changed to indicate that these vertices share locations with survey points. You will now turn off the survey layer so you can easily see how the symbols have changed.

1. Uncheck the Carmel Bay survey layer in the map's table of contents.



The map displays only the features and the link symbols for the vertices of the linked feature.



Saving your edits and your map document

Now that you have updated the parcel feature in your geodatabase, you can save your edits.

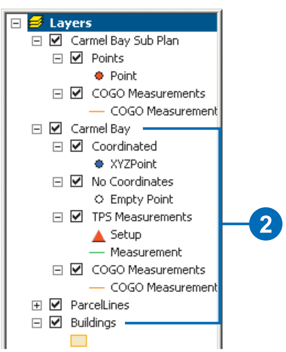
1. Click Editor in the Editor toolbar and click Save Edits.
2. Click the Save button to save your map document.

Exercise 4: Creating COGO computations

Your field crew was not able to measure all the building corners directly from the total station equipment. To completely define the geometry for buildings, a tape measure was used in the field to measure between the building corners. These values were recorded in a field sketch. Based on the values from these field sketches, you will now use COGO computations to add a new building to the buildings layer.

First, you must return to the spatial bookmark for the new building and turn on the Carmel Bay survey layer and the Buildings layer.

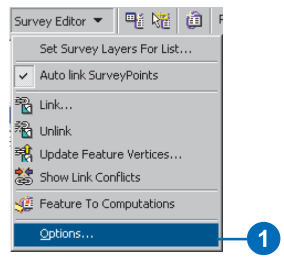
1. Click View, point to Bookmarks, and click Feature Linking.
2. Check the Carmel Bay survey layer and the Buildings feature layer in the map's table of contents.



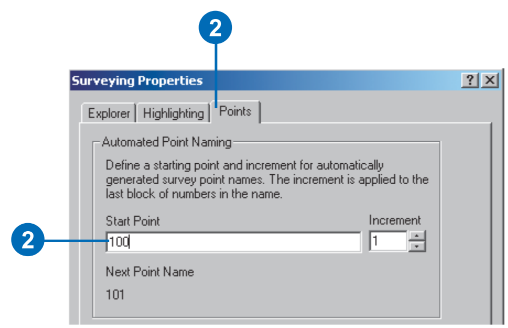
Setting up a point naming increment

The names of survey points in this survey project start with an alphanumeric character and also have a numeric value at the end of the character string. The system can automatically generate these survey point names and increment the numeric value. You will now specify that the new points entering the system will start from 101.

1. Click Survey Editor and click Options. The Surveying Properties dialog box appears.



2. Click the Points tab and type "100" for the Start Point.

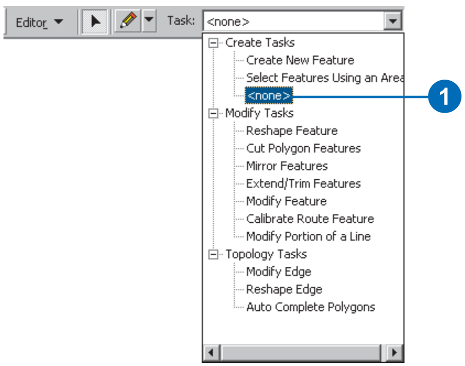


3. Click OK on the Surveying Properties dialog box.

Adding a building using COGO computations

Coordinate geometry computations can be used together with the Editor's edit tasks and target layer. You have the option to add a sketch vertex for each new survey point created. Instead of using this option, you will create the survey points for the building and, as a second step, create the new building feature. Next, you will turn off the option to create an edit sketch.

1. Click the Task dropdown arrow on the Editor toolbar and click <none>.

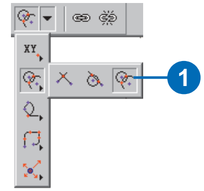


2. Click the Project dropdown arrow and click Arizona - Carmel Bay.

Using the distance-distance intersection computation

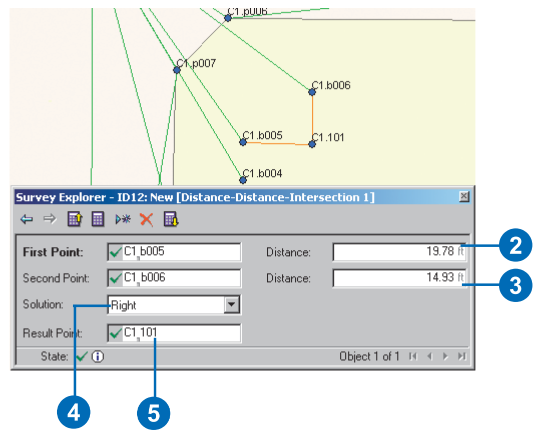
The first COGO computation will be an intersection of distances in order to define the coordinates of one of the building corners.

1. Click the tool palette dropdown arrow, point to the COGO Intersections button, and click the distance-distance intersection button.



The Survey Explorer appears and shows the distance-distance COGO computation.

2. Type "b005" as the first point, press Enter, type "19.78" in the first distance field, and press Enter again.
3. Type "b006" as the second point name, press Enter, type "14.93" in the second distance field, and press Enter.

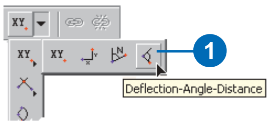


4. Press Enter, accepting the default Right solution. There are two possible solutions when you are intersecting two distances. When you look along a straight line from the first point to the second point, the new point to compute is on the right-hand side.
5. Press Enter to accept 101 as the name of the new survey point.

Using the deflection angle distance computation

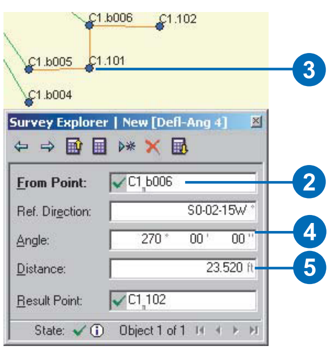
On the field sketch for the building, an assumption is made that the building walls are *orthogonal* to each other. For the next measured building corner, this assumption is used in the deflection angle distance COGO computation.

1. Click the tool palette dropdown arrow, point to the COGO Basic Computations button, and click the Deflection-Angle-Distance button.



The Deflection-Angle-Distance computation is displayed in the Survey Explorer.

2. Type “b006” as the from point and press Enter.
3. Click survey point 101 on the map to define the reference direction.
4. Type “270” as the deflection angle and press Enter.
5. Type “23.520” as the distance and press Enter.

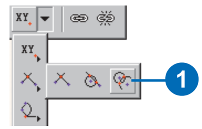


6. Press Enter to accept 102 as the new point name.

Adding the final building corner

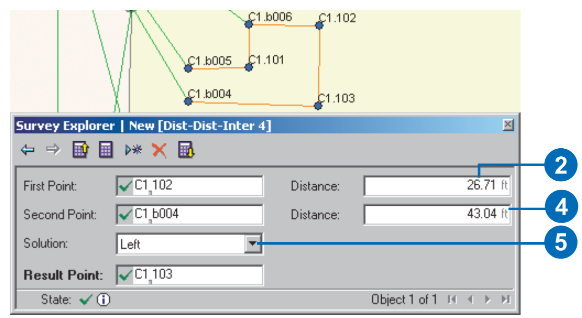
You will now add a second distance-distance intersection computation to add the final building corner.

1. Click the tool palette dropdown arrow, point to the COGO Intersections button, and click the Distance-Distance intersection button.



The first point of the new computation is, by default, the last point that was computed.

2. Press Enter to accept point 102 as the first point, type “26.71” as the first distance, and press Enter.
3. Type “b004” as the second point name.
4. Type “43.04” as the second distance.
5. Click the Solution dropdown arrow and click Left.

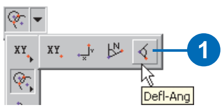


6. Press Enter to accept 103 as the new point name.

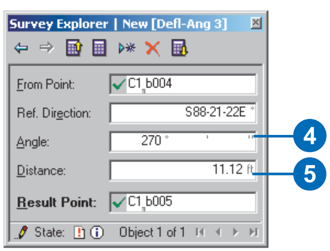
Using the final closing distance as a check

The tape measurements made around the building perimeter have been used to define its location. You will now add the closing tape measurement distance to calculate a second check coordinate.

1. Click the tool palette dropdown arrow, point to the COGO Basic Computations button, and click the Deflection Angle Distance button.

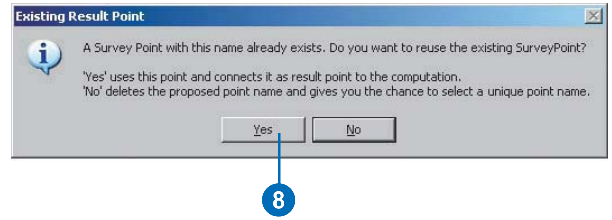


2. Type “b004” as the from point and press Enter.
3. Click the survey point called 103 on the map to define the reference direction.
4. Type “270” as the deflection angle and press Enter.
5. Type “11.12” as the distance and press Enter.
6. Type “b005” as the Result Point.



7. Press Enter to compute the new coordinate.

The Existing Result Point message box appears:

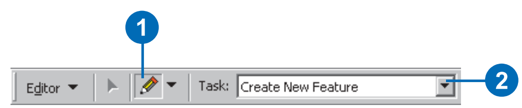


8. Click Yes to indicate that the calculated coordinate should be added to the existing survey point.

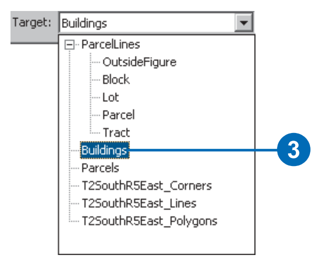
This coordinate will be used in the next exercise as a check on the other tape measurements around the building perimeter, but first you will create the new building feature.

Creating the building feature

1. Click the Sketch tool on the Editor toolbar.
2. Click the Task dropdown arrow and click Create New Feature.

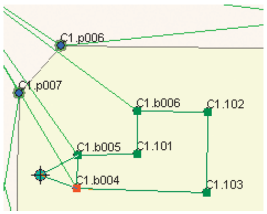


3. Click the Target dropdown arrow and click Buildings.



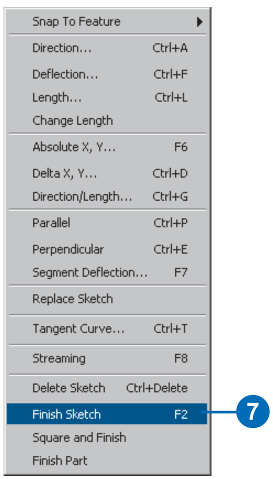
4. Snap to and click point b005.

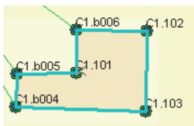
5. Repeat step 4 in sequence for each of the following points: 101, b006, 102, 103, b004.



6. Right-click the map. The Sketch context menu appears.

7. Click Finish Sketch in the Sketch context menu.





Comparing coordinates of a survey point

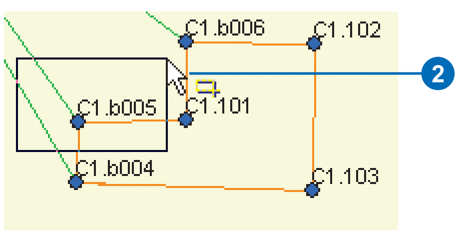
New computations can use existing survey points as targets for computed coordinates. In the previous exercise, you selected the existing point b005 as a result point for a COGO computation. This was based on a check measurement that was used to compute a second coordinate for b005.

In this exercise, you will use this check measurement to ensure that no mistake was made in the other tape measurements. You will do this by viewing and comparing the sets of coordinates computed for b005.

Navigating to survey point details

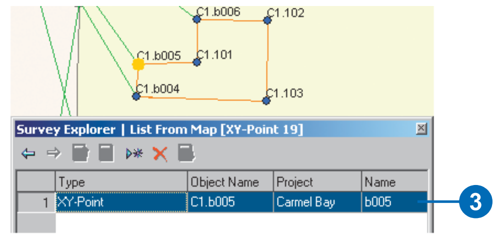
1. Click the Survey Object List tool in the Survey Editor toolbar.

2. Click and drag a box around point b005.



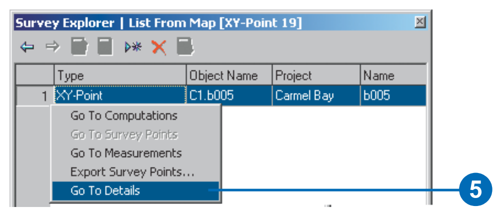
The Survey Explorer displays a single row list showing the survey point b005.

3. Click the row for b005 to select the point.



The survey point is highlighted on the map.

4. Right-click the first column in the selected row. The Survey Explorer column context menu appears.
5. Click Go To Details.



The Survey Explorer displays the detail page for b005.

Comparing and averaging coordinates of a survey point

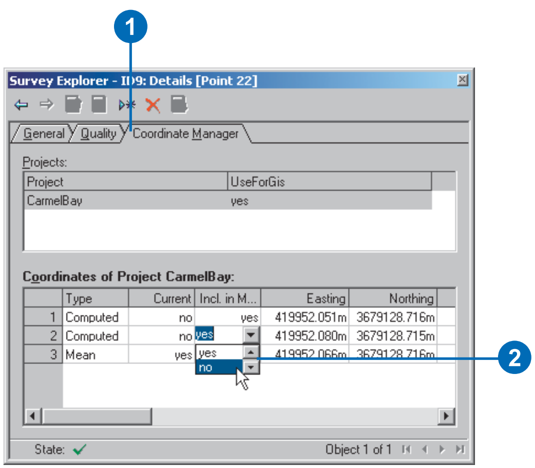
When two coordinates for a point are computed, their average value is automatically determined and used as the current coordinate for the point. You will use the final tape measurement to b005 as a check measurement. This measurement is not required to contribute to the average coordinate for b005.

You will now compare the coordinates computed for b005 and remove the second coordinate from the computed mean for this survey point.

1. Click the Coordinate Manager tab.

   The difference in the coordinates is acceptable as a check on the tape measurements around the building perimeter. This indicates that no mistakes were made in reading the tape measurements.

2. Double-click the Include in Mean column for the second computed coordinate, click no, then press Enter.

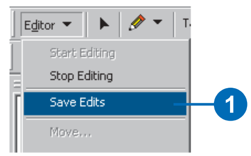


The mean value is updated. The current coordinate is the coordinate computed from the total station measurement.

Saving your edits

Now that you have added field survey measurements, computations, survey points, and a new building feature to your geodatabase, you can save your edits.

1. Click the Editor menu in the Editor toolbar and click Save Edits.

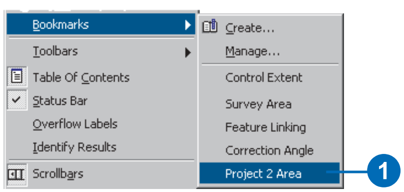


Entering COGO from plan data

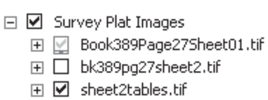
When your organization does not have coordinates for the parcel corners represented on a subdivision plan, using COGO computations is one method to calculate them. You will now use the dimensions available on Sheet 2 of the Carmel Bay subdivision plan to get approximate coordinates for a parcel monument. Since these computed coordinates will be based on the survey points measured by your field crew, they can be used to more easily find physical evidence of this parcel corner, which could not be found during the first field survey.

First you will need to go to the Project 2 Area bookmark.

1. Click View, point to Bookmarks, and click Project 2 Area.



2. Check Survey Plat Images in the table of contents.



Changing the automated point management settings

Computations can use the survey points created and owned by other projects. When these survey points are used, a copy of the coordinate is made for exclusive use in your project. Since survey points may have many coordinates, you need to define the coordinate that should be copied for your project. You can automate the choice for this coordinate. Since there are only two projects in the map, the project that owns all existing points is Carmel Bay.

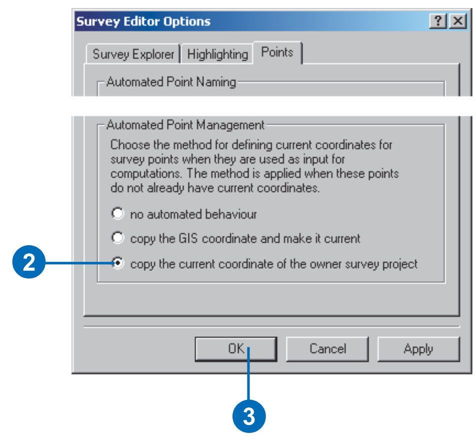
You will now choose to always copy the current coordinate of the owning project when using survey points from other projects.

1. Click Survey Editor and click Options.

   The Survey Editor Options dialog box appears.

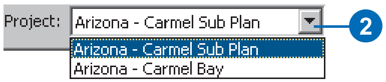
2. Click the Points tab and click copy the current coordinate of the owner survey project.

3. Click OK.



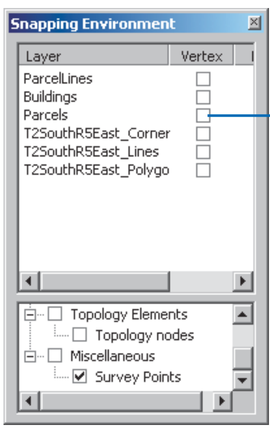
Creating a station and offset computation

1. Click the Task dropdown arrow on the Editor toolbar and click <none>.
2. Click the Project dropdown arrow and click Arizona - Carmel Sub Plan.

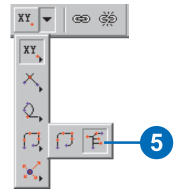


3. Click the Editor and click Snapping.

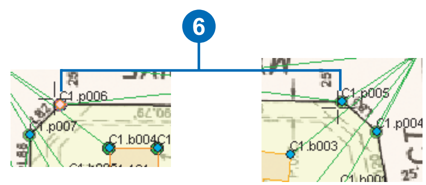
   The Snapping Environment dialog box appears.
4. Uncheck Vertex for Parcels.



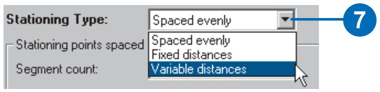
5. Click the tool palette dropdown arrow, point to the COGO Advanced Computations button and click the Station and Offset button.



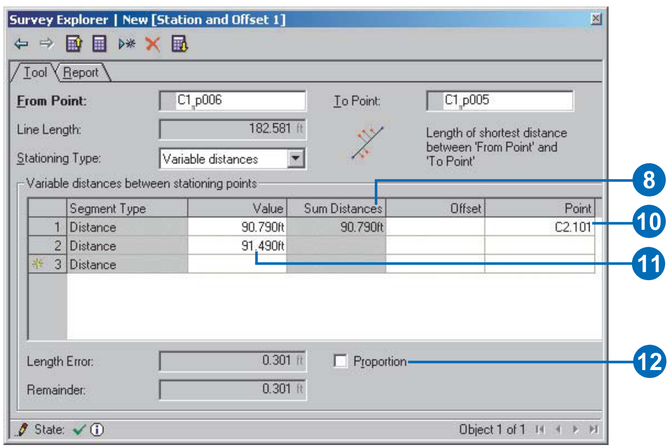
   The Survey Explorer displays the new station offset computation. You will use this computation to define a point on line between points p006 and p005.
6. Click p006 on the map, then click p005.



7. Click the dropdown arrow for stationing type, click Variable distances, and press Enter.



8. Press Enter and type "90.79" for the distance value.
9. Press Enter twice to move to the Point field.
10. Type "101" for the point field and press Enter.
11. Press Enter twice, and in the Value field type "91.49".
12. Check Proportion.



A survey point is computed online between p006 and p005. The difference between the computed closing distance and entered distance is proportioned.

Saving your edits

You have successfully added a plan-based COGO computation to the geodatabase.

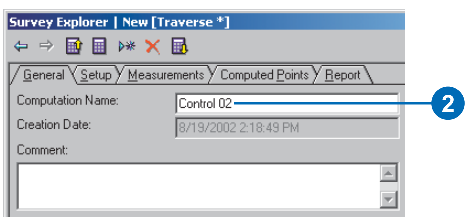
1. Click the Editor menu and click Save Edits.

Exercise 5: Updating computations and linked features

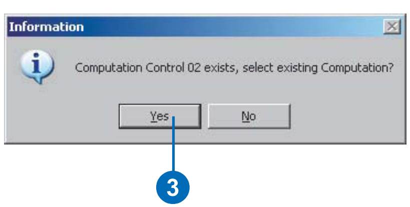
In the exercise 'Working with survey data', you learned how to find stored computations. In this exercise you will discover a different method to navigate to an existing computation. You will find and make a change to the second control traverse—Control 02. You have determined that the measurement to the point 300420 is erroneous and should be disabled.

Editing the Control 02 traverse

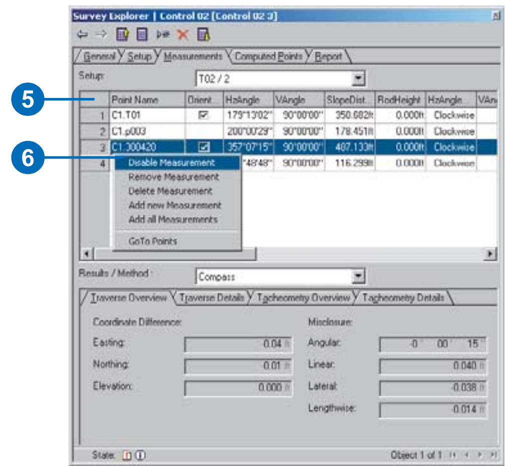
1. Click the tool palette dropdown arrow, point to TPS Computations, and click Traverse.
2. Type "Control 02" in the Computation Name box and press Enter.



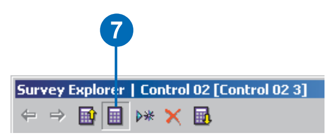
3. Click Yes to view the Control 02 traverse.



4. Click the Measurements tab.
5. Click the leftmost column of the row for the measurement to 300420.
6. Right-click the row and click Disable Measurement.



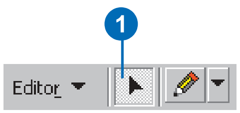
7. Click the Compute button on the Survey Explorer toolbar.



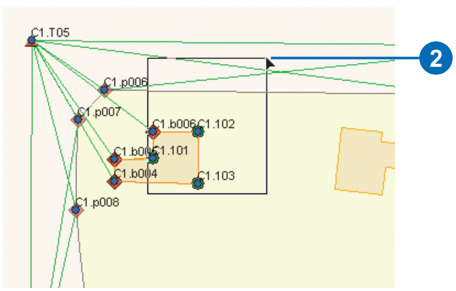
Updating the linked features

All the survey point locations are updated based on this change in the computation. You will now update the linked features to match this update in the survey points.

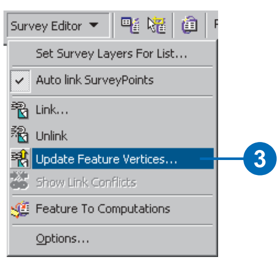
1. Click the Edit tool in the Editor toolbar.



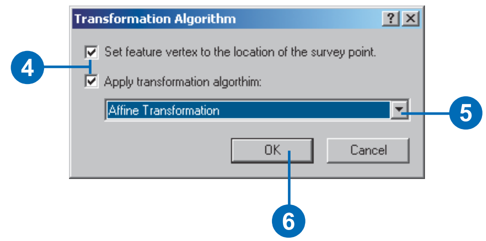
2. Select the linked features by dragging a box around the building and parcel feature.



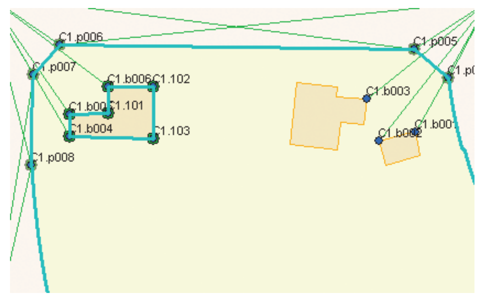
3. Click the Survey menu in the Survey Editor toolbar and click Update Feature Vertices.



4. Check Set feature vertex to the location of the survey point, and check Apply transformation algorithm.
5. Click the Transformation dropdown arrow and click Affine Transformation.
6. Click OK.



The feature locations are updated based on the recomputed locations of the survey points.



Saving your edits

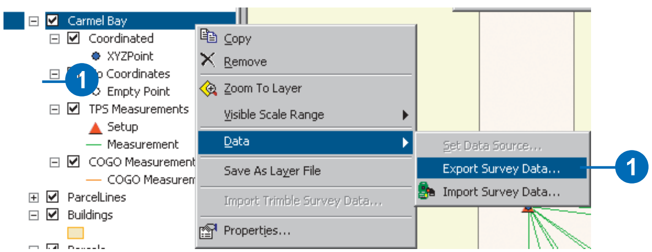
You have now updated your stored computations and the geometry of linked features.

1. Click the Editor menu and click Save Edits.

Exercise 6: Exporting survey point data

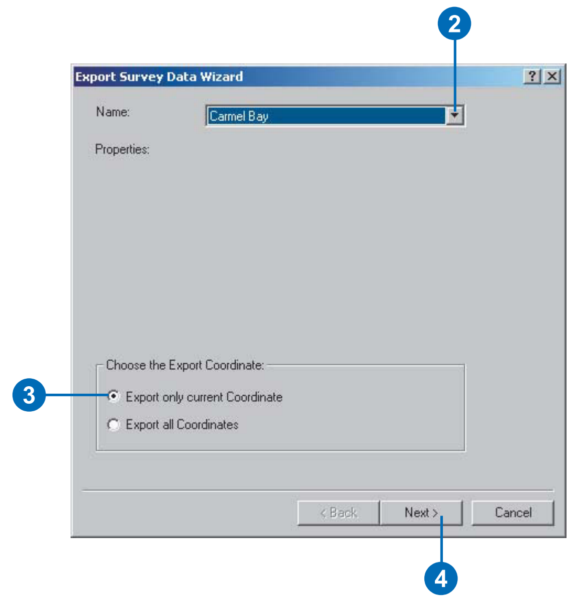
To support the work of your field crew, you need to be able to supply coordinates for locating positions in the field. In this exercise you will export the survey points that you computed. These coordinates can be made available for field work. For instance, they can be transferred onto a PCMCIA card or data collector, or directly to the field instrument.

1. Right-click the Carmel Bay survey layer, point to Data, and click Export Survey Data.

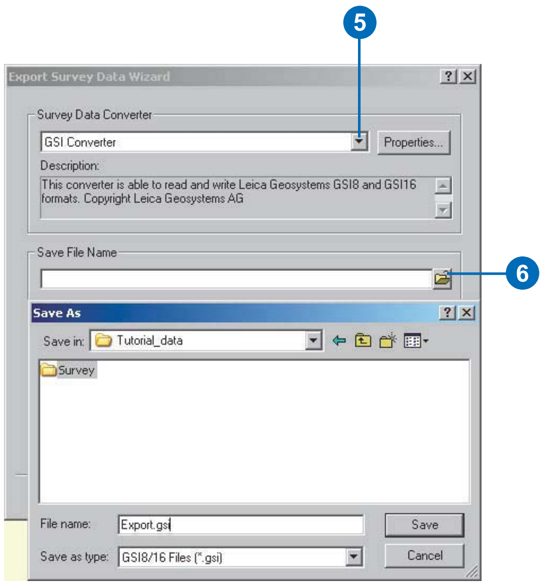


In the first page of the Data Exchange wizard, you will choose the project from which you want to export coordinates.

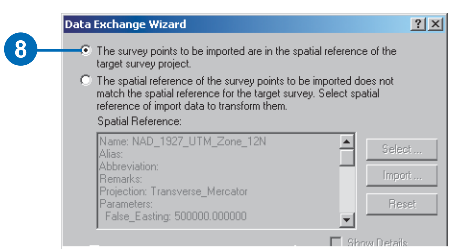
2. Click the Name dropdown arrow and click Carmel Bay.
3. Click the Export only current Coordinate option to only export the current coordinate for survey points.
4. Click Next.



5. Click the dropdown arrow for Survey Data Converter and click GSI Converter.
6. Click the Browse button, type “Export” in the File Name box, then click Save.

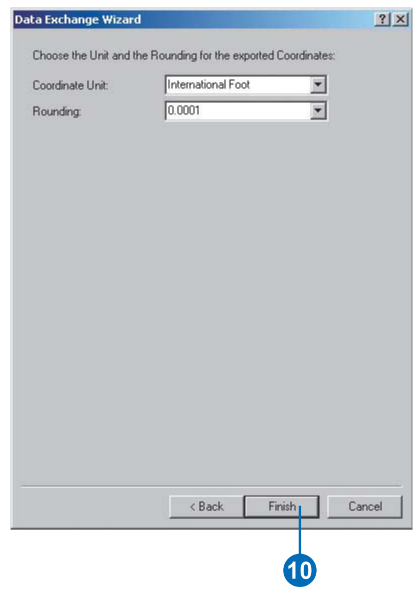


7. Click Next on the Export Survey Data Wizard dialog box.
8. Click the option for the coordinates to remain in the same spatial reference as the survey project from which you are exporting data.



The points will be exported based on the coordinates system of Carmel Bay Sub Plan. The second option allows you to export into a different coordinate system. Choosing this option would project all the coordinates to your selected spatial reference. For this export, this is not required.

9. Click Next.
10. Accept the default units and coordinate precision and click Finish.



Survey Analyst concepts

3

IN THIS CHAPTER

- **Survey data in the geodatabase**
- **The survey project**
- **Modeling survey points and coordinates**
- **The survey dataset**
- **Survey-aware feature classes**
- **Modeling computations**
- **Modeling measurements**
- **Modeling survey object dependencies**
- **Least squares adjustment—overview**
- **Survey points, measurements, and the spatial reference**

Surveying is the science of collecting measurements to determine the relative spatial locations of points on or near the surface of the earth. Relative spatial locations are represented by coordinates. Coordinates stored in a GIS are used to represent physical objects that depict natural and man-made features on a map.

To establish coordinates for points, surveyors use precise field instruments, procedures, and computations. They measure slope, horizontal and vertical distances between points, and angles between lines of sight.

Measurements, computations, survey points, and coordinates, collectively called *survey objects*, are stored in a *survey dataset* in the geodatabase.

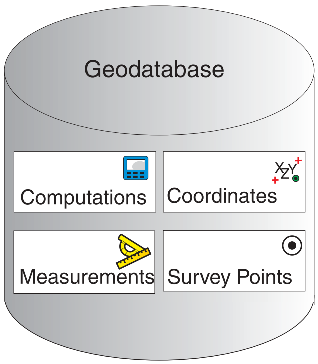
In addition to storing these objects, Survey Analyst can track dependencies between computations. Computations define points that can be used as input for other computations. These dependencies are modeled in Survey Analyst as a *computation network*.

Physical objects are represented in a geodatabase as features stored in feature classes. Survey Analyst enhances feature classes with *survey-awareness*, allowing stored features to be associated with survey data.

This chapter explains the survey data model, describes the computation network, and presents the concept for associating GIS features with survey data.

Survey data in the geodatabase

Like other geographic information, survey measurement data can be managed in a GIS using database management system (DBMS) tables. It is possible to store this information as an integral part of the geodatabase. This chapter presents the key concepts and an overview of the survey data model based on the four data types: measurements, survey points, coordinates, and computations.



The survey data model includes four data types that are used to analyze and solve problems related to the processing of survey data stored in the geodatabase.

A survey dataset is a comprehensive database of survey information and can be managed as an integrated layer with traditional GIS layers in a geodatabase.

A survey dataset contains four object classes:

- *Survey points*: named locations that are observed through various surveys. Survey points can be observed multiple times and by many surveys over time. One goal is to improve the location of survey points with new survey measurements.
- *Coordinates*: survey points can have many coordinates associated with their location, especially as new surveys are performed through time. The location of each survey point is improved and becomes more accurate with each new survey. A survey point can have multiple coordinates, but there is always one coordinate that is used for publication to the GIS layers or used in computations. GIS feature geometry can be linked to the location of the survey point. Thus, feature geometry can be improved over time as the survey point's coordinates are more accurately located.
- *Measurements*
- *Computations*

Collectively, the computations, measurements, coordinates, and survey points are called survey objects, and are stored in tables called *survey classes*.

Coordinates for the named survey points are calculated through a series of survey measurements and computations. This forms the core of the survey information collected and computed using Survey Analyst.

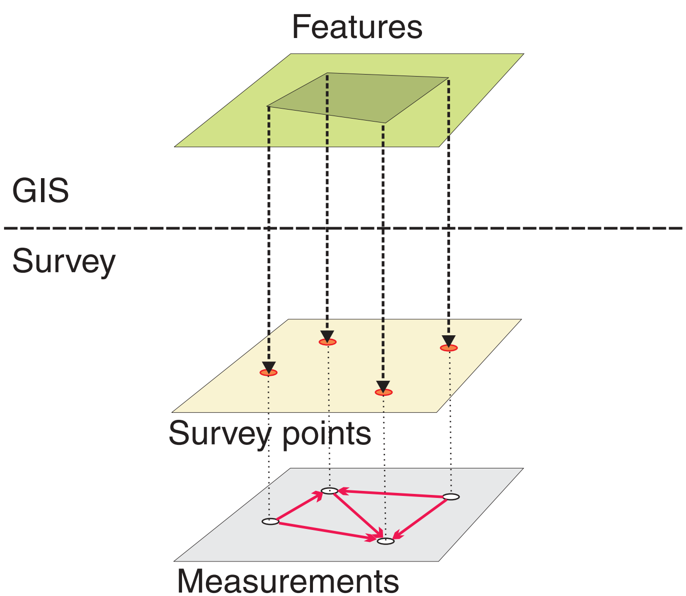
Survey Analyst is a system for surveyors to use field surveys and other sources of survey measurement information to calculate and update coordinates of survey points.

The four data types—survey points, coordinates, measurements, and computations—are managed in one comprehensive dataset. Each new survey adds records to this dataset and is used to update the GIS coordinate for each survey point. A new survey can result in new survey points being added as well.

Each new survey is managed as a survey project and is used to incorporate new survey information in the single comprehensive survey dataset.

A key part of the Survey Analyst user interface is the toolset used to create new survey projects, import the new survey data into the survey dataset, perform computations, and update the survey point locations.

In addition to comprehensive survey data management, the other key goal of Survey Analyst is to incrementally improve the accuracy of GIS feature geometry in the geodatabase as the survey accuracy is improved. This is done by linking features to survey point locations. During the initial design stage, you declare that selected feature classes are survey-aware. Feature geometry in survey-aware feature classes can be linked and optionally adjusted to move feature coordinates to survey point locations. And, over time, as the survey point locations are improved, feature geometry can be adjusted as well.



Survey measurements are used to compute survey points. Survey points are used to update the geometry of survey-aware features.

Performing a survey

A typical work flow for a surveyor starts with gathering preliminary information. The first phase of a survey often includes activities such as the following:

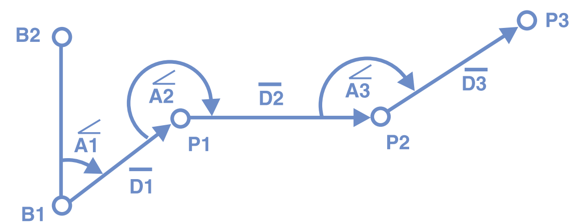
- Performing an initial reconnaissance survey in the field
- Identifying existing physical control points
- Finding coordinates for these control points based on an official source
- Deciding on a coordinate system
- Deciding on the equipment and methods that should be used based on the required coordinate accuracy for the survey

The second phase of a survey focuses on the collection of the measurements and other information from the field. This data is captured electronically or on paper and usually comprises sketches and field books.

The third phase requires calculating coordinates for measured locations by entering and processing them in well-known computations, such as the traverse. The sequence of steps performed to collect the data in the field usually determines the set of computations that are used to calculate the coordinates.

The coordinates computed in surveys may be used for the following purposes:

- Further numerical analysis
- In the case of cadastral surveys, further legal boundary analysis
- Subsequent work in the field
- Creation of plans for submission to a government authority or a private client



ImportPoint [(X1,Y1) → B1]

ImportPoint [(X2,Y2) → B2]

Computation1 [Traverse (Course1 (B1, $\angle A1$, B2, $\overline{D1}$)) → P1

(Course2 (P1, $\angle A2$, B1, $\overline{D2}$)) → P2

(Course3 (P2, $\angle A3$, P1, $\overline{D3}$)) → P3]

The third phase of a survey project requires calculating coordinates by processing measurements collected in the field.

The survey project

The survey data model includes the *survey project*. The survey project represents a unit of work, and is used as a logical structure that owns and manages a group of measurements, points, coordinates, and computations that function and belong together.

The survey project is the geodatabase equivalent of the electronic and paper artifacts collected and generated through the survey project phases described in the previous section. Survey projects are used for managing survey workflow as part of a comprehensive survey database.

As subsequent field surveys collect more measurements from the field, additional survey projects are created to enter this new information into the geodatabase.

When creating a survey project, you give it a name and define its coordinate system. Once added to the geodatabase, a survey project is a candidate for owning any new survey data added to the geodatabase.

Measurements

FromTo	Type
B1-B2	Reference Direction
B1-P1	Angle
B1-P1	Distance
P1-B1	Reference Direction
P1-P2	Angle
P1-P2	Distance
P2-P1	Reference Direction
P2-P3	Angle
P2-P3	Distance

Coordinates

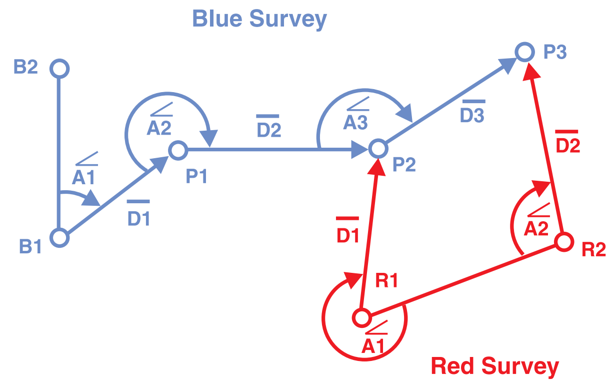
PointName	Type	Coordinate
B1	Imported	xyz
B2	Imported	xyz
P1	Computed	xyz
P2	Computed	xyz
P3	Computed	xyz

Computations

Name	Type
Computation1	Traverse

The information collected for each survey is grouped into separate units of work called projects.

In this example, the data collected for the Red survey is added to a survey project called Red.



Through time, surveyors collect discrete sets of survey data that can be accumulated into a single dataset.

Survey Projects

ID	Name	Coordinate System
1	Blue	NAD_1927_UTM_Zone_12N
2	Red	NAD_1927_StatePlane_Arizona_Central

ImportPoint [(X1,Y1) → R1]

ImportPoint [(X2,Y2) → R2]

Computation1 [AngleDistance (R1, $\angle A1$, R2, $\overline{D1}$)) → P3

Computation2 [AngleDistance (R2, $\angle A2$, R1, $\overline{D2}$)) → P2

Measurements

FromTo	*Type*
B1-B2	Reference Direction
B1-P1	Angle
B1-P1	Distance
P1-B1	Reference Direction
P1-P2	Angle
P1-P2	Distance
P2-P1	Reference Direction
P2-P3	Angle
P2-P3	Distance
R1-R2	Reference Direction
R1-P2	Angle
R1-P2	Distance
R2-R1	Reference Direction
R2-P3	Angle
R2-P3	Distance

Coordinates

PointName	*Type*	*Coordinate*
B1	Imported	xyz
B2	Imported	xyz
P1	Computed	xyz
P2	Computed	xyz
P3	Computed	xyz
R1	Imported	xyz
R2	Imported	xyz
P2	Computed	xyz
P3	Computed	xyz

Computations

Name	*Type*
Computation1	Traverse
Computation1	AngleDistance
Computation2	AngleDistance

Records added as a result of new survey activity are referenced in the geodatabase as a survey project.

Modeling survey points and coordinates

Surveyors identify physical locations in the field by naming the points that they measure. In the survey data model, named locations are known as survey points.

In different surveys, the same physical locations can be computed with different coordinates. For instance, the named location P2 in this example has one set of coordinates measured in the Blue survey and another set measured in the Red survey. This is also the case for the point called P3.

Survey points represent multiple coordinates, and are modeled as separate tables in the database.

There is a one-to-many relationship between survey points and coordinates.

Survey Points

Point Name	GIS Coordinate	ID
B1	XYZ	101
B2	XYZ	102
P1	XYZ	103
P2	XYZ	104
P3	XYZ	105
R1	XYZ	106
R2	XYZ	107

Weighted mean from Red and Blue projects

Coordinates

Survey Point ID	Type	Coordinate
101	Imported	xyz
102	Imported	xyz
103	Computed	xyz
104	Computed	xyz
105	Computed	xyz
106	Imported	xyz
107	Imported	xyz
104	Computed	xyz
105	Computed	xyz

The GIS coordinate

You can define a single coordinate for a survey point that is the best representation for its location. This coordinate is called the *GIS Coordinate*. Any number of survey projects can contribute to this value. It may be the coordinate from a single survey project, or it may be the weighted average from a number of different projects.

The current coordinate

Just as there is a GIS coordinate to represent the best overall coordinate for a survey point from many projects, there is also a best coordinate representation within each project, called the *current coordinate*. A current coordinate is required when the same project computes or imports more than one coordinate for a particular survey point. In this example, the Green project has two computed coordinates for point P2.

Coordinates

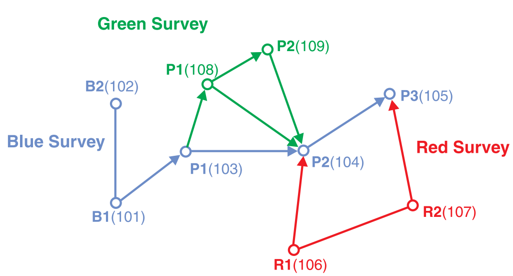
ID	Project ID	Survey Point ID	Type	Coordinate	Current
1	1	101	Imported	xyz	yes
2	1	102	Imported	xyz	yes
3	1	103	Computed	xyz	yes
4	1	104	Computed	xyz	yes
5	1	105	Computed	xyz	yes
6	2	106	Imported	xyz	yes
7	2	107	Imported	xyz	yes
8	2	104	Computed	xyz	yes
9	2	105	Computed	xyz	yes
10	3	103	Imported	xyz	yes
11	3	108	Computed	xyz	yes
12	3	104	Computed	xyz	yes
13	3	109	Computed	xyz	yes
14	3	104	Computed	xyz	no

Current coordinate (row 12)

Noncurrent coordinate (row 14)

Survey Points

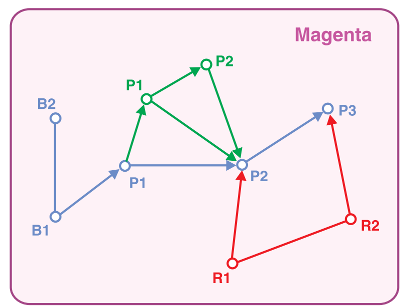
Project ID	Point Name	GIS Coordinate	ID
1	B1	XYZ	101
1	B2	XYZ	102
1	P1	XYZ	103
1	P2	XYZ	104
1	P3	XYZ	105
1	R1	XYZ	106
1	R2	XYZ	107
3	P1	XYZ	108
3	P2	XYZ	109



When defining the GIS coordinate, only the current coordinate of each survey project is used in the weighted average. Within the project, the current coordinate is used for any computations that require the survey point as input. In this example, Blue P2's GIS coordinate is the weighted mean of coordinates with ObjectIDs 4, 8, and 12.

Working with multiple projects

Although measurements and survey points can be owned only by a single survey project, their database records can be shared with other projects. This means that you can create a survey project that uses existing measurements and survey points to create records for computations and coordinates.



Survey Projects

ID	Name	Coordinate System
1	Blue	NAD_1927_UTM_Zone_12N
2	Red	NAD_1927_StatePlane_Arizona_Central
3	Green	NAD_1927_StatePlane_Arizona_Central
4	Magenta	NAD_1927_UTM_Zone_12N

The Magenta project does not own new measurements and survey points. It uses the existing survey points and measurements stored in the survey dataset.

In this example, the Magenta project makes use of measurements and points from the other three projects to define a single new least squares adjustment computation and new coordinates for a predefined survey point in the Blue project.

Computation1 [**Least Squares Adjustment**

Input : (P1,R1,R2,B1,P1,P2, $\overrightarrow{\text{P1-P1}}$, $\overrightarrow{\text{P1-P2}}$, $\overrightarrow{\text{P1-P2}}$, $\overrightarrow{\text{P1-P2}}$, $\overrightarrow{\text{P2-P2}}$, $\overrightarrow{\text{R1-P2}}$)

Output : (P2)]

Coordinates

ID	Project ID	Survey Point ID	Type	Coordinate	Current
1	1	101	Imported	xyz	yes
2	1	102	Imported	xyz	yes
3	1	103	Computed	xyz	yes
4	1	104	Computed	xyz	yes
5	1	105	Computed	xyz	yes
6	2	106	Imported	xyz	yes
7	2	107	Imported	xyz	yes
8	2	104	Computed	xyz	yes
9	2	105	Computed	xyz	yes
10	3	103	Imported	xyz	yes
11	3	108	Computed	xyz	yes
12	3	104	Computed	xyz	yes
13	3	109	Computed	xyz	yes
14	3	104	Computed	xyz	no
15	4	103	Copied	xyz	yes
16	4	106	Copied	xyz	yes
17	4	107	Copied	xyz	yes
18	4	101	Copied	xyz	yes
19	4	108	Copied	xyz	yes
20	4	109	Copied	xyz	yes
21	4	104	Computed	xyz	yes

Survey Points

Project ID	Point Name	GIS Coordinate	ID
1	B1	XYZ	101
1	B2	XYZ	102
1	P1	XYZ	103
1	P2	XYZ	104
1	P3	XYZ	105
1	R1	XYZ	106
1	R2	XYZ	107
3	P1	XYZ	108
3	P2	XYZ	109

Computations

Project ID	Name	Type
1	Computation1	Traverse
2	Computation1	AngleDistance
2	Computation2	AngleDistance
3	Computation1	Traverse
4	Computation1	Least Squares

The Magenta project copies coordinates from survey points and computes a new coordinate for P2 of the Blue project.

The survey dataset

Through time, surveyors collect discrete sets of survey data that can be accumulated into a single dataset—a survey dataset. The *survey dataset* is a comprehensive collection of survey information in the geodatabase. It consists of tables that store records for the four survey data types (survey classes).

Computations

Project ID	Name	Type
1	Computation1	Traverse
2	Computation1	AngleDistance
2	Computation2	AngleDistance

Survey Points

Project ID	Point Name	GIS Coordinate	ID
1	B1	XYZ	101
1	B2	XYZ	102
1	P1	XYZ	103
1	P2	XYZ	104
1	P3	XYZ	105
2	R1	XYZ	106
2	R2	XYZ	107

Measurements

Project ID	FromTo	Type
1	B1-B2	Reference Direction
1	B1-P1	Angle
1	B1-P1	Distance
1	P1-B1	Reference Direction
1	P1-P2	Angle
1	P1-P2	Distance
1	P2-P1	Reference Direction
1	P2-P3	Angle
1	P2-P3	Distance
2	R1-R2	Reference Direction
2	R1-P2	Angle
2	R1-P2	Distance
2	R2-R1	Reference Direction
2	R2-P3	Angle
2	R2-P3	Distance

*

Coordinates

Project ID	Survey Point ID	Type	Coordinate
1	101 (B1)	Imported	xyz
1	102 (B2)	Imported	xyz
1	103 (P1)	Computed	xyz
1	104 (P2)	Computed	xyz
1	105 (P3)	Computed	xyz
2	106 (R1)	Imported	xyz
2	107 (R2)	Imported	xyz
2	104 (P2)	Computed	xyz
2	105 (P3)	Computed	xyz

Survey Projects

ID	Name	Coordinate System
1	Blue	NAD_1927_UTM_Zone_12N
2	Red	NAD_1927_StatePlane_Arizona_Central

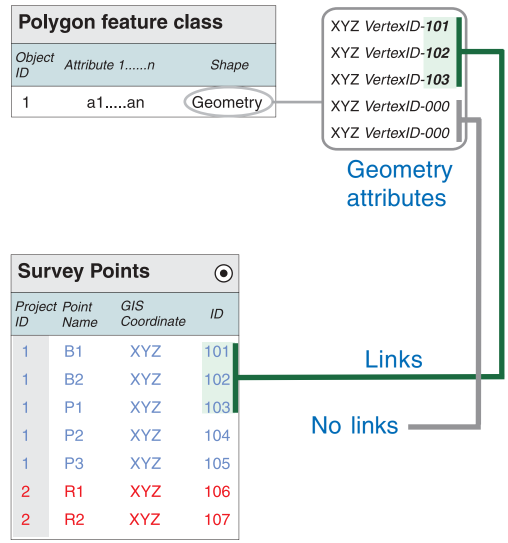
A basic depiction of the core tables of a survey dataset

Survey-aware feature classes

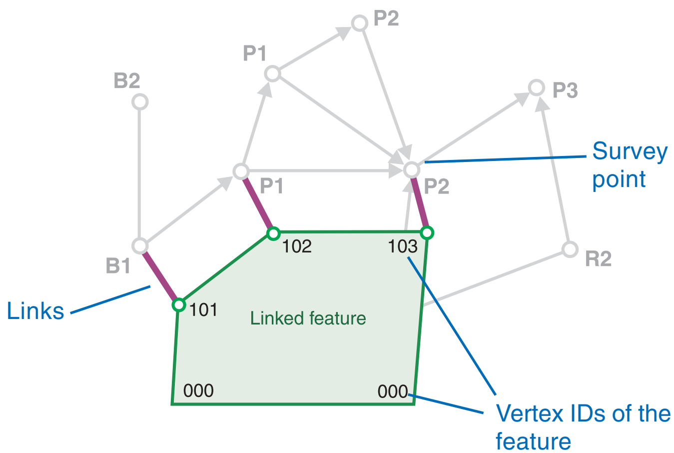
One key benefit of having a survey dataset as part of your geodatabase is that you can associate the geometry of features with the stored survey data.

Features that are associated with survey data are called *survey-aware features*. Similarly, the feature classes in the geodatabase that contain these features are called *survey-aware feature classes*.

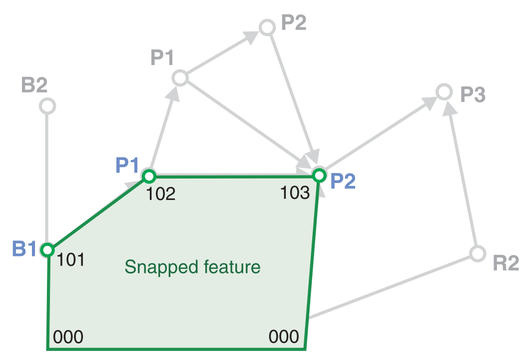
The survey points stored in the survey dataset provide a framework of coordinate control for the geometry of survey-aware features. You can make links between each survey point's GIS coordinate and the vertex of one or more features. A linked feature vertex does not need to share the same location as the survey point.



Links are maintained in the geometry attributes of features. Each linked vertex stores a VertexID number that matches the unique identifier of its linked survey point. Vertex IDs are positive integers; 0 means no link.



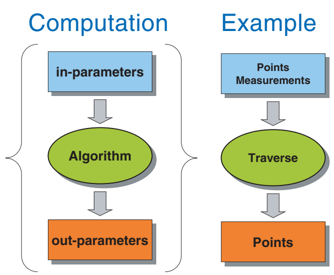
Survey points can be linked to survey-aware features.



Using links, features can be snapped to survey points.

Modeling computations

A *computation* is a process that requires a predefined set of input parameters to apply a set of rules and an algorithm to calculate output parameters.



Computations store references to survey points and measurements. These are used as input parameters to calculate new coordinates for survey points.

For a specific kind of computation, the type and number of input parameters are predefined. The computed coordinates can be added either to new survey points or to existing survey points. Computations store references to existing survey points and measurements, and use these measurement values and coordinates to calculate new coordinates. After a computation has been processed successfully for the first time, new coordinates are stored and referenced as the output of the computation.

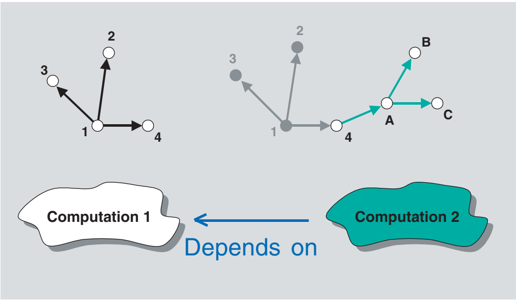
Computation states

If a computation's input measurements or points are altered, the computation and its output coordinates will be *out-of-date*. The computation must be recomputed to become *valid*. Recomputing also updates the output coordinates.

Out-of-date and valid are two *states* for computations. They can also be *incorrect* when predefined limits are exceeded, or *incomplete* when they do not have all the required input.

Computation dependencies

A dependency between two computations occurs when one computation uses the results of another. Survey point coordinates are often calculated in a sequence—the output coordinates of computations are used as input for others. This creates computation dependencies.

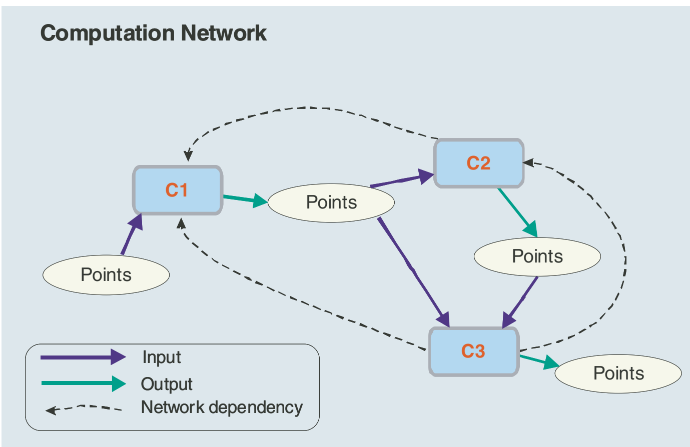


Computation 2 is dependent on point 4. Since point 4 is defined by Computation 1, Computation 2 depends on Computation 1.

Computation networks

A computation network is a sequence of computation dependencies—the output points of some computations are used as the inputs for one or more others.

A computation network models this sequence of computations, by tracking dependencies and managing the associated changes in computation states.



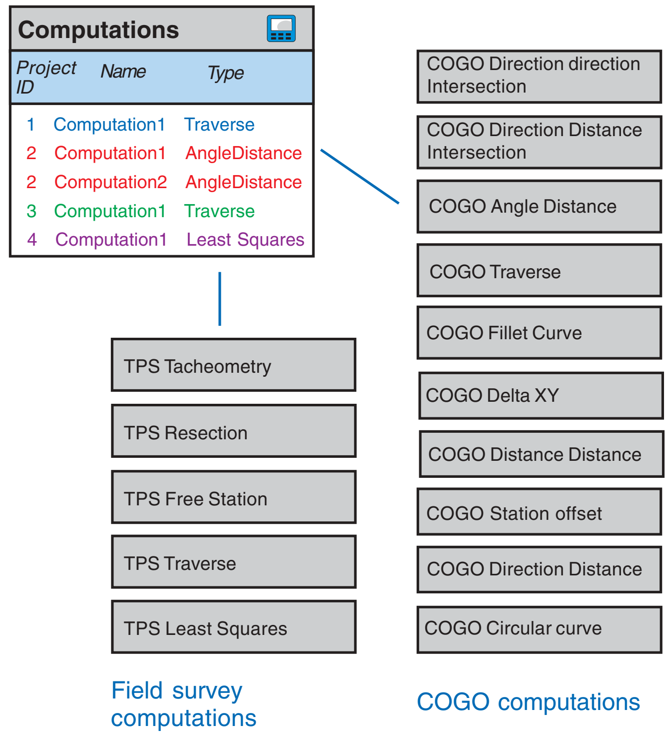
The computation network maps dependencies between computations in a survey project.

Using the functions of Survey Analyst, you can rerun individual computations or entire networks. When reprocessing a network, the system detects all the source computations that are out-of-date and updates downstream computations, setting their states to valid.

During this process, some dependent computations may be assigned incorrect states. In these cases, the relevant downstream computations are not processed and remain in the out-of-date state.

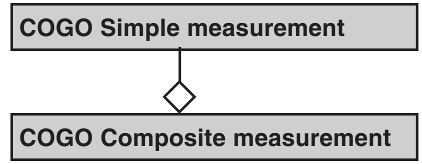
Multiple computation types

Since there are many different kinds of computations with a wide variety of formats for their required inputs and outputs, each type of computation has its own table in the survey dataset.



Modeling measurements

Survey Analyst defines two primary surveying systems for modeling measurements. The first models coordinate geometry, and the second models measurements from theodolite-based field equipment (TPS). All measurements can be modeled in two categories: *simple measurements* and *composite measurements*. This section describes these measurement categories for both coordinate geometry and TPS surveying systems.

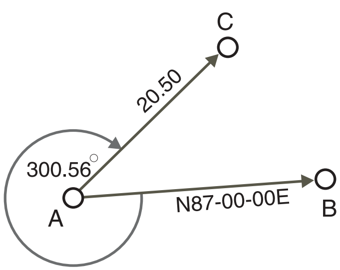


A COGO composite measurement depends on COGO simple measurements for its definition.

Modeling COGO measurements

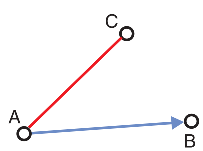
Values that define vectors, directions, lengths, and *orthogonal offsets* are modeled using *COGO simple measurements.*

A *COGO composite measurement* is used to represent measurements that are dependent on others. For example, a deflection angle requires a direction for the angle value to be meaningful.



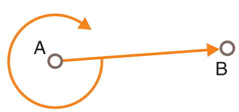
COGO Simple measurement

Project ID	From point	To point	Type	Direction	Distance	ID
01	A	B	Direction	N87E	–	201
01	A	C	Distance	–	20.50	202



COGO Composite measurement

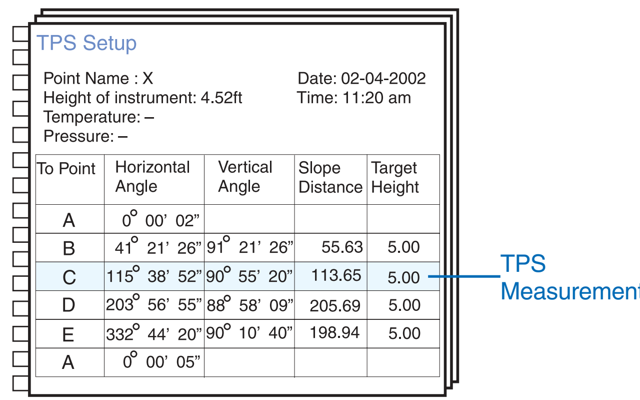
Project ID	From point	To point	Type	Value	Simple Meas ID	ID
01	A	C	Angle	300.56	201	501



The example shows how a composite measurement requires a simple measurement to represent a deflection angle.

Modeling field measurements

Another example of a *simple measurement* is an entry in a field book that represents observations from a theodolite: a slope distance, vertical angle, horizontal angle, and a height of target. This type of simple measurement is called a *TPS measurement.*

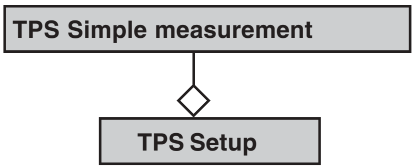


To Point	Horizontal Angle	Vertical Angle	Slope Distance	Target Height
A	0° 00' 02"			
B	41° 21' 26"	91° 21' 26"	55.63	5.00
C	115° 38' 52"	90° 55' 20"	113.65	5.00
D	203° 56' 55"	88° 58' 09"	205.69	5.00
E	332° 44' 20"	90° 10' 40"	198.94	5.00
A	0° 00' 05"			

Field measurements from a theodolite are modeled as a field book with pages of recorded observations. Each line entry is a TPS measurement, and each set of entries represents a single instance of an instrument setup.

A *composite measurement* is a group of simple measurements that are related and applied as a group. In the case of field measurements, a group of field book entries that belong together define a single setup of the instrument. This type of composite measurement is called a *TPS setup*.

Each observation (slope distance, vertical angle, horizontal angle, and height of target) is recorded as a TPS measurement and is added to the TPS setup.



A TPS setup is comprised of a set of TPS measurements.

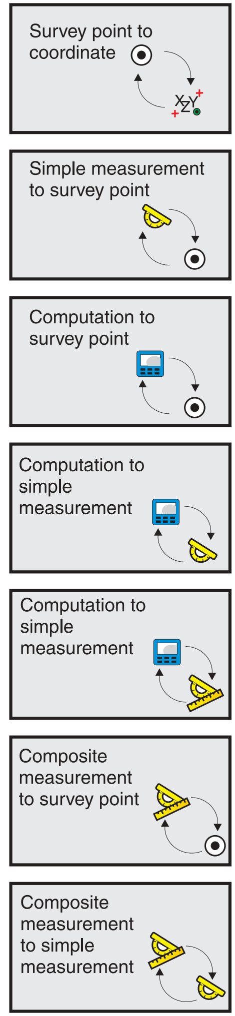
Modeling survey object dependencies

As discussed in this chapter, a relationship between survey points and coordinates exists. There are also other relationships between measurements, computations, coordinates, and survey points. These relationships define dependencies between survey objects. It is necessary to be aware of these dependencies when working in the Survey Analyst environment.

The following list of dependencies are enforced and maintained by the survey dataset as a set of relationship tables:

- A survey point can contain multiple coordinates.
- Many computations can define coordinates for the same survey point.
- Many survey points can be created or used by one computation.
- Many measurements can start and end at the same two survey points.
- The same measurement value can be used between many pairs of survey points.
- Many computations can use the same measurement.
- Many measurements can be used in a single computation.
- Multiple simple measurements are used within a composite measurement.
- Many composite measurements can use the same simple measurement.

These relationship tables in the survey dataset manage and enforce the dependencies between survey object classes.



Relationship tables for survey object classes

Least squares adjustment—overview

The techniques and algorithms supported by the least squares computation provides the most rigorous method available for processing the observations in a *survey network*.

If you are familiar with these techniques, this section provides a review of the basics. If you are new to these concepts, treat this section as an introduction—it is recommended that you refer to the literature listed in the References section of this book.

What are measurements?

A *measurement* is an observed numerical value that is an estimate of the true size of a quantity.

Measurements are best described by comparing measuring with counting. Put simply, counting determines exact numbers and measuring does not. For example, if several people are each asked to count the number of fish in a tank, their counted values are either right or wrong. There is no uncertainty in the result because the exact number of fish in the tank is a realistic, known target.

By contrast, consider the following scenario: several people are each, in turn, given a tape measure and asked to calculate the volume of water in the fish tank by measuring the length and breadth of the tank, and the depth of the water. They are asked to do this as accurately as possible and to estimate fractions of the measurement unit of the tape measure.

Each person will derive a different volume. Which of these is correct? Unlike the exact quantity of fish, there is no exact quantity for the volume of water with which to compare results.

Most calculated volumes for the tank are likely to be close to the true value, while some others may be incorrect due to mistakes in one or more of the tank's measurements. Uncertainty in measurements is an accepted truth. It exists because:

- The observer makes estimates.
- There is imperfection in the measuring equipment.
- The environment in which equipment and observer operate affects the measurement.
- The behavior of equipment, observer, and the environment cannot always be predicted.

These last four points can be categorized into two groups: *measurement error*, and mistakes. If you measure with care, mistakes can be avoided. However, the same measurements will always contain error. As illustrated in the fish tank example, a measurement with a mistake is not useful for calculating the volume of water. It should be removed, and the quantity remeasured. However, a measurement with error is expected. You expect the different measurers to obtain different values for the volume of water.

Surveyors recognize and work within this environment of mistakes and errors. To get close to the true value of the measured quantity, it is important to identify and remove mistakes, and to apply mathematical and statistical methods to deal with measurement error.

Measurement error

Measurement error is classified as either *systematic* or *random.*

Systematic error follows a mathematical or physical law and can be corrected to comply with a known standard. Corrections are always applied the same way—for example, if a tape measures a standard 100-foot baseline as 99.89 feet, then every measurement of this magnitude has a systematic error of 0.11 feet. A correction of 0.11 feet is always added to the measured value. Surveyors calibrate measurement equipment to reduce systematic error.

Random error is arbitrary; it follows the laws of statistics and probability—the size and sign of the error cannot be predicted. Random error is handled within the context of the following assumptions:

- A plus sign error will occur as frequently as a minus sign error.
- Small errors will occur more frequently than large errors.
- The chance for large errors to occur is small.

When there are a large number of repeated measurements of a specific quantity, a pattern of random error distribution emerges. After the mistakes are removed and the systematic errors accounted for, the statistical model is based on a theoretical *normal probability distribution*. For more information, see the 'Stochastic Model' section later in this chapter.

Coordinate quality—precision versus accuracy

Surveyors are required to assess and control the quality of their work. One level of quality assessment for surveyors is based on their published coordinates. Since measurements are used to define coordinates, measurement error gets propagated into the calculated coordinates.

Assessment of quality is based on the *precision* and *accuracy* of measured values.

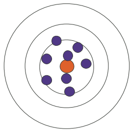
Precision is the closeness to one another of a repeated set of observations of the same quantity. It is a measure of the control over random error.

Accuracy can be defined as closeness to a theoretical truth.

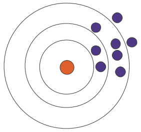
A frequently used example that distinguishes accuracy from precision is the grouping of darts on a target. Like repeated observations of the same quantity, these dart throws can be:

- Precise and accurate
- Precise but inaccurate
- Accurate but imprecise

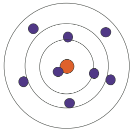
Using the bulls-eye as the true value, you can visualize the center of gravity for each of these groupings.



This grouping of dart throws is both precise and accurate.



This grouping is precise but inaccurate.



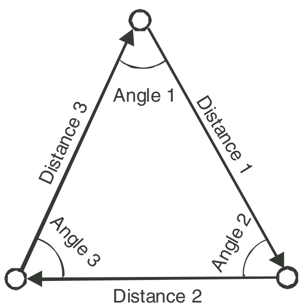
This group of dart throws is imprecise but it is accurate. Its center of gravity falls close to the bulls-eye.

It is apparent that though the second grouping is precise, accuracy without precision is closer to the truth than precision without accuracy. Naturally, both precision and accuracy are desirable. Precision and random error are directly related. When the size of random errors decreases, the precision increases. Similarly, accuracy and systematic error are directly related. When systematic errors can be correctly predicted, the result is an increase in accuracy.

Redundancy in measurements

It becomes evident that uncertainty caused by random error is reduced by repeating measurements of the same quantity. However, this is not enough to detect systematic error. For instance, repeated taped distances between the same two building corners will not detect that the tape measure has not been correctly calibrated.

It is common practice for a surveyor to establish a network of measurements in which each survey point has been measured from a number of other survey points. This results in improved quality in the final coordinates. The more redundancy you have in a measurement network, the better your chances will be of detecting and controling problems. Redundancy occurs when the number of measurements is greater than the number of parameters to be calculated. A simple example of this is the set of measurements between the three points of a triangle, as depicted in the figure below.



This triangle has redundant information. All of the measured angles and distances are useful for describing the triangle's geometry, but they do not define a unique solution. Where redundancy like this exists, a least squares adjustment solves for a best-fit solution.

Since there are extra measurements, a unique solution that exactly fits the triangle is not possible. For example, the angles of a triangle should add up to exactly 180 degrees, but due to error as described in the previous sections, this will not occur. The least squares adjustment is the ideal tool for solving for an optimal solution where redundancy exists in your measurement network.

Least squares adjustment

Since redundancy exists in measurement networks, a method is needed to correct the measurements to make them fit the conditions as well as possible. In the example of the preceding section, the conditions are defined by the geometry of a triangle. The amount by which each measurement must be corrected is called the *measurement residual*.

The *least squares adjustment* method defines a best-fit solution by finding a minimum for the sum of the squares of the measurement residuals.

The final measurement residuals are called the *least squares corrections*.

Least squares adjustment models consist of two important components: the *mathematical model* and the *stochastic model*. The *mathematical model* is a set of relations between the measurements and the unknown coordinates. The *stochastic model* describes the expected error distribution of the measurements.

Mathematical model

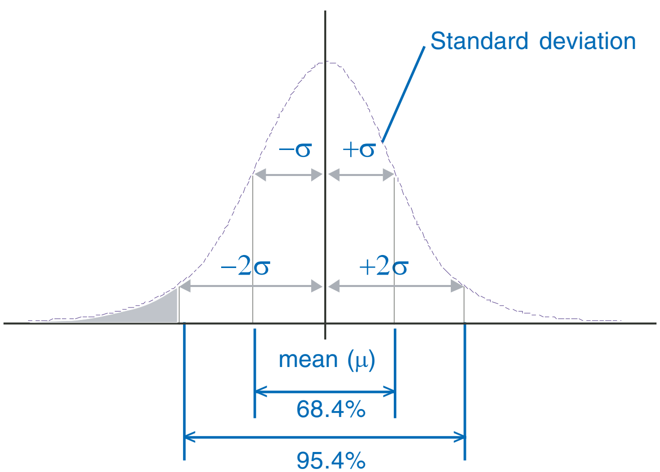
In your surveys, the measurements are often not the final quantities that you require. Measurements are processed in computations to define coordinates for survey points. Through computations, coordinates are expressed as a function of the measurements. Each computation, therefore, defines a mathematical model. In the case of the least squares adjustment, the mathematical model forms a basis for the least squares adjustment.

A least squares adjustment requires the location, orientation, and scale of the measurement network to be defined.

In case of a network where measurements are reduced to two dimensions, there are two translations, one rotation, and one scale factor. In this case, at least two reference points are required (two Eastings and two Northings). This places a minimum set of four constraints on the solution for defining location, orientation, and scale.

Stochastic model

The stochastic model of a least squares adjustment describes the statistical (stochastic) deviations of measurements. The variation in measurements of a single quantity, as described in the preceding sections, is modeled by assuming a *normal probability distribution*. This distribution is based on the mean μ and the standard deviation σ of a measured quantity.



This graphic shows the normal probability distribution curve. The normal distribution is based on the mean and standard deviation of a measured quantity.

The mean μ is a mathematical representation for the best expected value of the measured quantity. The standard deviation σ is a measure of the dispersion or spread of the probability, and characterizes the precision of the measurement. The square of σ is called the *variance*.

By definition, there is a 0.684 probability that normally distributed stochastic variables will fall within a window limited by $-\sigma$ and $+\sigma$. For a window limited by -2σ and $+2\sigma$ this probability is 0.954.

It is possible for two or more measurements to be correlated. This means that a deviation in one measurement will influence the other. This correlation is reflected in the computed coordinates.

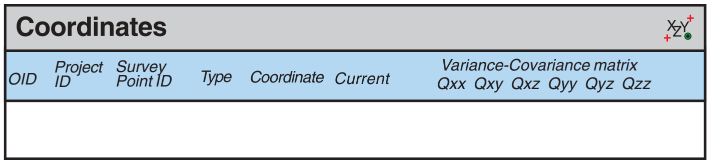
The correlation between coordinates x, y, and z is mathematically expressed in a 3x3 matrix, called a *variance–covariance matrix*.

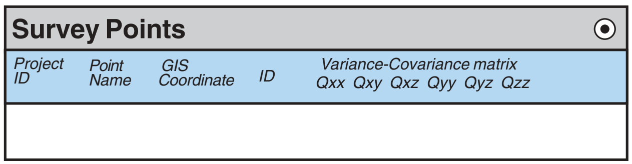
$$\begin{pmatrix} Qxx & & \\ Qxy & Qyy & \\ Qxz & Qyz & Qzz \end{pmatrix}$$

In the data model for the survey datasets, the variance–covariance matrix is used to express the probability distribution for survey point coordinates and provides a quantitative estimate of survey point quality. Since the martix is symmetrical, the values of the variance–covariance matrix can be expressed as six attribute values in the tables for the survey points and coordinates.

For each measurement, a standard deviation σ is chosen. The value for σ is based on knowledge about the measurement process (conditions in the field and type of instrument) and experience.

The precision of the coordinates computed in the adjustment depends on the precision of the measurements and on the propagation of this precision through the mathematical model.





The variance–covariance matrix is modeled as six attributes in the survey points and coordinates tables.

The least squares adjustment formulae

The (linearized) mathematical model is expressed as follows:

$$\underline{y} = Ax + \underline{e} + a$$

with

$\underline{y}$ = (m) vector of observations;

$\underline{e}$ = (m) vector of corrections;

A = (m x n) design matrix;

x = (n) vector of unknowns;

a = (m) vector of constants.

The stochastic model is:

$$Q_y = \sigma^2 Q = \frac{1}{\sigma^2} P^{-1}$$

with

Q_y = (m x m) variance-covariance matrix;

σ^2 = a-priori variance-of-unit-weight;

Q = (m x m) weight coefficient matrix;

P = (m x m) weight matrix.

The least squares criterion is:

$$\underline{e}^t P\underline{e} = \text{minimum}$$

The solution is:

$$\underline{x} = (A^t PA)^{-1} A^t P(\underline{y}-a)$$

$$s^2 = \frac{\underline{e}^t P\underline{e}}{m-n}$$

with

$(A^t PA) = N$ = (n x n) normal matrix;

s^2 = a-posteriori variance-of-unit-weight.

The variance–covariance matrix of the unknown values is given as:

$$Q_x = \sigma^2 N^{-1}$$

As shown in the preceding formulae, the least squares approach requires a set of linear equations.

The solution for the vector of unknown $\underline{x}$ is available after a series of iterative updates $d\underline{x}$ of the approximate values x^0:

$$\underline{x} = x^0 + d\underline{x}$$

After each iteration, the new solution is compared with the previous one. If the difference between the two solutions is negligible, the iteration process converges and is ended with the final values defined by the results of the last iteration.

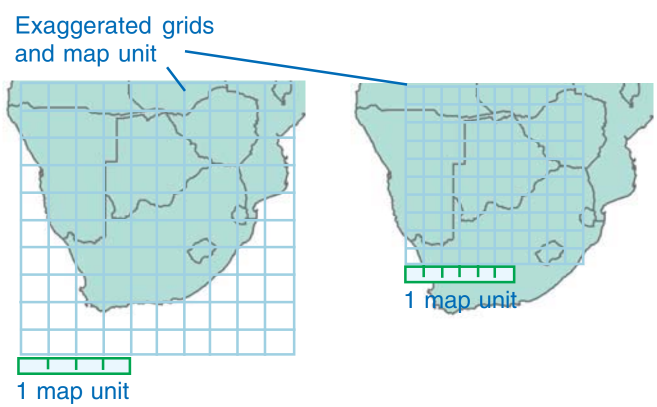
Survey points, measurements, and the spatial reference

The geodatabase stores information about the geometry or shape of an object as a field in a table. This shape field represents a geometry type (point, line, polygon, or multipoint) and a sequential set of x and y coordinates that optionally contain z and m values and vertex IDs.

Geometry stored in a shape field requires a *spatial reference* to relate it to the surface of the earth. The spatial reference has two components: a coordinate system and a spatial domain.

The *coordinate system* is used to project coordinates from a mathematical approximation of the earth's surface, called the *ellipsoid*, to the planar surface of a map.

The *spatial domain* is the minimum and maximum value for the geometry attributes. The extent of this domain defines the precision at which geometry attributes (x, y, z, m, ID) can be stored as integers. There are a finite number of integers available in the system, so the x and y spatial domain is analogous to a square grid that always contains the same number of rows and columns (approximately two billion, or 2 to the power of 31).



The extent of the spatial domain affects the precision with which geometry can be stored.

Precision and the spatial extent are inversely proportional. Since the x and y values must correspond to the intersection of lines in this theoretical grid, the larger the chosen extent, the lower the precision of the geometry attributes.

The spatial reference for features in the geodatabase is stored as a property of a feature dataset or standalone feature class. Similarly, the spatial reference for survey points and measurements is stored as a property of a survey dataset. Each survey project also has its own *coordinate system* but does not require a spatial domain. This is described in the next section.

For more information about spatial references, see the ESRI Press book *Understanding Map Projections*.

Maintaining numerical precision

When processing survey data in computations, it is important to maintain numerical precision. Since the coordinates stored in the shape field are snapped to an integer grid, they do not provide sufficient precision for this purpose. Therefore, the survey data model enforces the maintenance of x,y,z coordinates in separate fields of double precision. Only these fields are used when performing computations. (Measurement values are also stored in fields of double precision.)

Additionally, the survey projects in the survey dataset each have independent coordinate systems.

An update of a feature based on links to survey points results in the feature vertices being snapped to the geometry of the survey point.

Survey Points

Project ID	Point Name	GIS Coordinate	ID	Shape
1	B1	XYZ	101	Point Geometry
1	B2	XYZ	102	Point Geometry
1	P1	XYZ	103	Point Geometry
1	P2	XYZ	104	Point Geometry
1	P3	XYZ	105	Point Geometry
2	R1	XYZ	106	Point Geometry
2	R2	XYZ	107	Point Geometry
3	P1	XYZ	108	Point Geometry
3	P2	XYZ	109	Point Geometry

Survey points have a point geometry field to represent a mapped location for the GIS coordinate.

Survey point geometry is stored using the spatial reference of the survey dataset.

Summary

This chapter presents a number of different concepts that are helpful to understand before you start using the software. The remaining chapters will expand your knowledge of Survey Analyst with practical information and sets of tasks for applying these concepts.

Organizing survey data

4

IN THIS CHAPTER

- **Managing and exploring survey data in ArcCatalog**
- **Creating survey datasets**
- **Using scalar references and defining measurement units**
- **Creating and managing survey projects**
- **Importing survey measurements and points**
- **Previewing survey data**
- **Exploring and viewing survey properties and metadata**

As you work with survey information in Survey Analyst, you will want to import, organize, and explore the data.

ArcCatalog allows you to browse through the information stored in your survey dataset. This data can be managed in projects and folders. In this chapter, you will learn how to organize your survey data by:

- Creating a new project in a survey dataset
- Working with scalar references and defining custom measurement units
- Viewing and changing project and dataset properties
- Importing survey data
- Previewing measurements and points stored in your projects
- Reading and writing metadata about a project or dataset

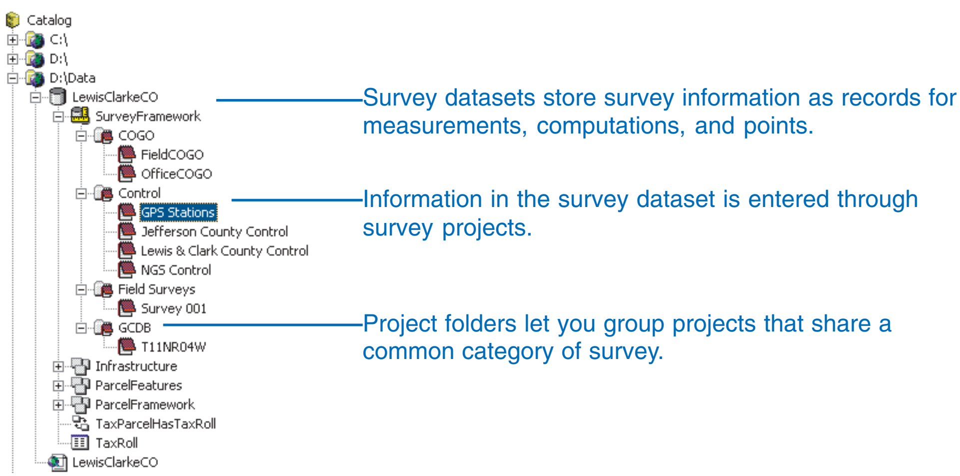
Managing and exploring survey data in ArcCatalog

In ArcCatalog, you can look for the *survey dataset* you want to explore and browse through its contents. Survey datasets store records for survey *measurements*, *computations*, and *survey points*. They also manage *coordinates* and spatial quality information for survey points.

The survey dataset contains information from one or more survey projects; each time you add new information to a survey dataset, you add it through a survey project.

Survey projects represent a single framework of survey point control, and each project owns a subset of the measurements and survey points stored in the survey dataset.

Folders can be used to organize *survey projects* into logical groups, such as topographic surveys, cadastral field surveys, and detail surveys.



Understanding survey datasets

A survey dataset is a collection of computations, measurements, and survey points that are shared within a predefined geographic area. It provides a framework of survey points to the geodatabase for use as control on the geometry of features in feature classes.

When creating a survey dataset, you will be required to:

- Define a spatial reference
- Specify measurement packages
- Choose specific feature classes to be *survey-aware*

The following sections describe these properties.

Spatial reference

When creating a new survey dataset, you need to define its *spatial reference*. The spatial reference describes a coordinate system, *spatial domain*, and numerical *precision* for representing stored geometry. Before you define the spatial reference, it is important to identify the combined geographic extents of all the survey-aware feature classes in your geodatabase that you want to associate with your survey dataset.

When choosing a survey dataset's spatial domain, note that:

- The survey dataset domain should be made as large as the total extent of your management area.
- A feature class can only be made survey-aware for one survey dataset.
- Survey datasets are mutually exclusive—they do not share data.

Consider, for example, that since survey datasets do not share *survey-aware feature classes* or survey data, it is unlikely that you will create overlapping survey datasets within the same geographic region. Similarly, you are not likely to choose a spatial domain that only partially covers the spatial domain of a survey-aware feature class.

In most cases, a survey dataset will be defined for each logical group of feature datasets that covers a discrete geographic region in the geodatabase.

You can read more about spatial references and spatial domains in *Building a Geodatabase*, or in Chapter 3, 'Survey Analyst concepts'.

Packages

When creating a survey dataset you also need to specify the categories of survey information that will be stored in the survey dataset. These categories of survey information are called packages. For instance, there is a package to handle COGO measurements, and a package to handle measurements from the theodolite family of field measuring devices.

Before choosing packages, you need to determine the types of data that you will be entering into the survey dataset. Selecting only the required packages minimizes the number of system tables created in the survey dataset. New packages can be added to a survey dataset after it has been created; it is not possible, however, to remove packages from a survey dataset.

Survey-aware feature classes

When creating a survey dataset, you can elect the feature classes in the geodatabase that must be associated with your dataset. Creating these associations makes the feature classes survey-aware. Once the survey dataset has been created, new feature classes can be added. If required, you can also remove survey-aware feature classes from the survey dataset.

Creating survey datasets

New survey datasets are created using the New Survey Dataset wizard. Packages define the different categories of survey measurements that you need to use in the survey dataset, such as COGO or total station measurements. The wizard lets you specify the packages that should be included in the survey dataset. ▸

Tip

Naming the dataset

The survey dataset name cannot begin with a number.

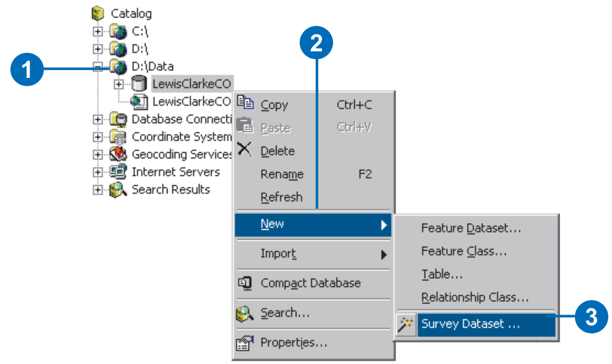
Tip

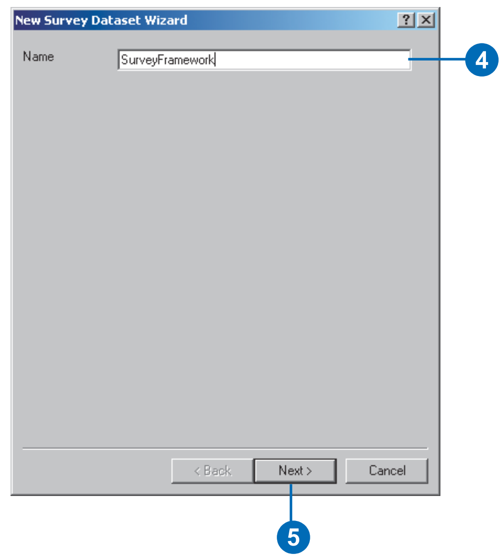
Specifying Packages

You do not need to specify the data type packages while using the wizard. These can be defined later on the survey dataset properties dialog box.

Creating a new survey dataset

1. Right-click on the geodatabase in the ArcCatalog tree in which you want to create a new survey dataset.
2. Point to New.
3. Click Survey Dataset.
4. Type a name for the survey dataset.
5. Click Next. ▸



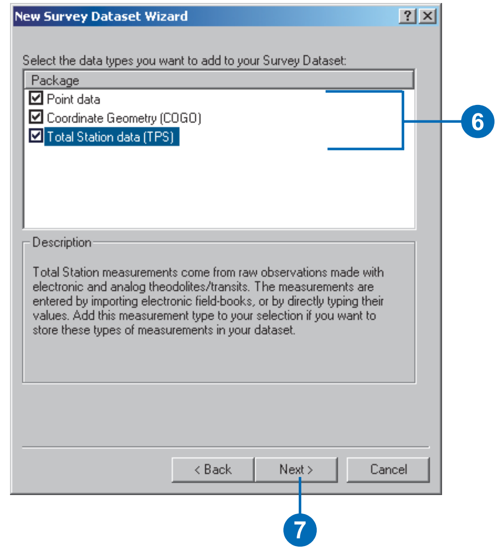


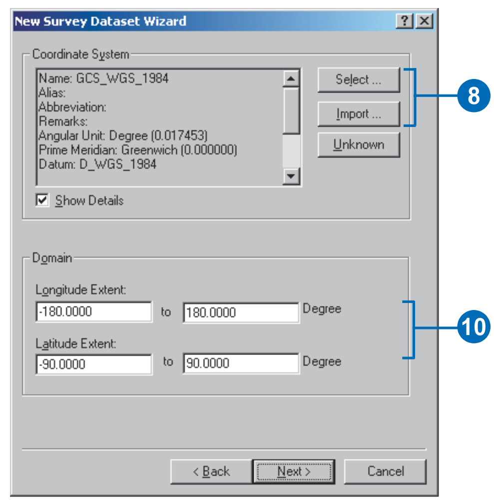
The survey dataset requires a spatial reference. This includes a geographic or projected coordinate system and x,y coordinate domains. The precision defined by the x,y coordinate domain of survey datasets is used only for displaying the points and measurements on the map. The survey point coordinates and measurements used in computations are not dependent on this precision. For this reason, there are no domain extents necessary for the z and m geometry attributes when defining the spatial reference for survey datasets.

See Also

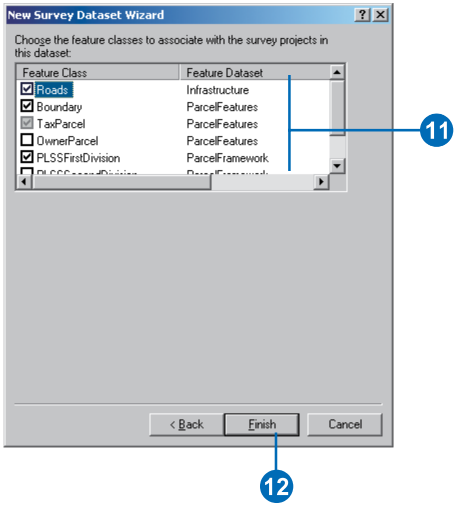
For further information about spatial references, domain extents, and how these affect precision, see Building a Geodatabase *and Chapter 3, 'Survey Analyst concepts'.*

6. Check the measurement data types that you will use in the new survey dataset. These define the data type packages.
7. Click Next.
8. Click Select or Import to choose a spatial reference for the survey dataset.
9. Navigate to the spatial reference that you want to select, or navigate to the feature class or feature dataset from which you want to import the spatial reference. Click Add.
10. Type the latitude and longitude extents to define the x, y domain of the survey dataset. ►





11. Check the feature classes that you want to make survey-aware.
12. Click Finish.



Using scalar references and defining measurement units

Scalar references are used to define units for measurements based on a common standard. For instance, there 360 degrees but 400 gradians in the full arc of a circle.

In order to provide a standardized method to define units in Survey Analyst, a common base unit is used for measurement values of angle, distance, temperature, and pressure.

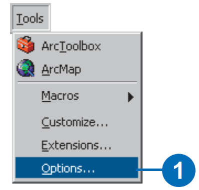
The base units are:

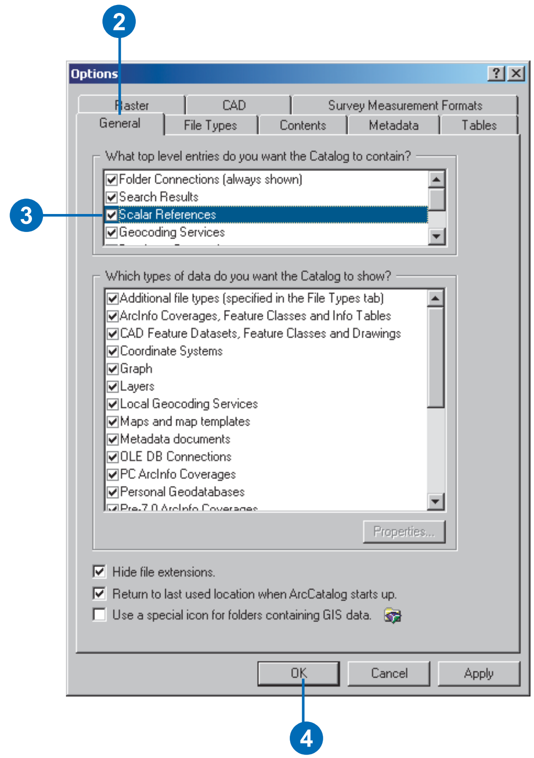
- *Radian* for angle
- International meter for distance
- Degrees Celsius for temperature
- Millibar for pressure

Adding the scalar references to the Catalog entries

1. Click the Tools menu and click Options.
2. Click the General tab.
3. Check Scalar References.
4. Click OK.

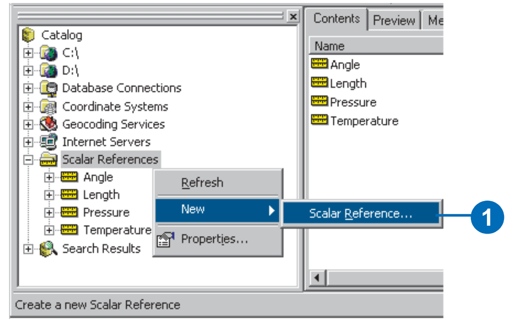
   The scalar references node appears in the Catalog.

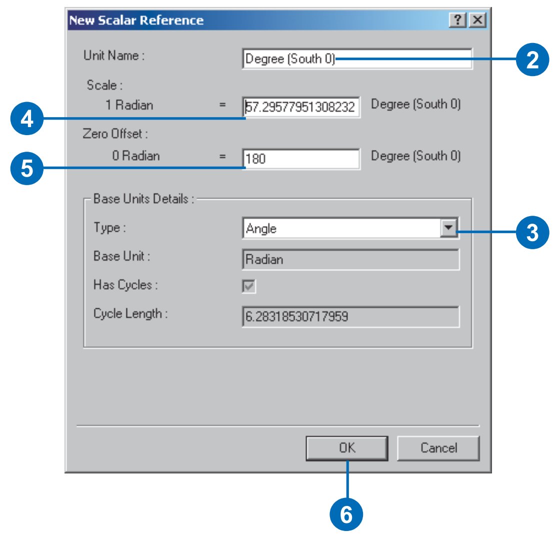




Creating a new scalar reference to define south azimuth

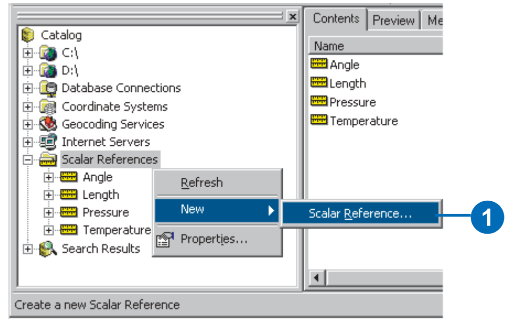
1. Right-click Scalar References in ArcCatalog, point to New, and click Scalar Reference.
2. Type a unit name for the new scalar reference.
3. Click the Base unit Type dropdown arrow and click Angle.
4. Type the number of radians for each base unit. In this example, there are 57.29577951308232 degrees in one radian.
5. Type a value for the zero offset. In this example, south azimuth is 180 degrees offset from north at zero degrees.
6. Click OK.

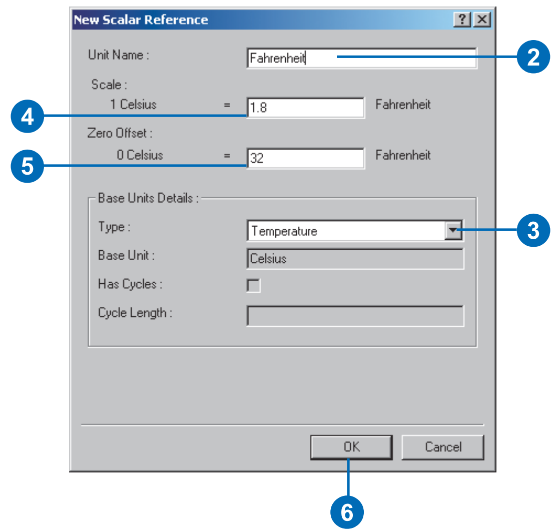




Creating a new scalar reference to define Fahrenheit

1. Right-click Scalar References, point to New, and click Scalar Reference.
2. Type a unit name for the new scalar reference.
3. Click the Type dropdown arrow and click Temperature.
4. Type the number of degrees celsius for each base unit. In this example, there are 1.8 Fahrenheit degrees in 1 Celsius degree.
5. Type a value for the zero offset. In this example, zero degrees Celsius is 32 degrees Fahrenheit.
6. Click OK.





Displaying different measurement units

When creating and managing the projects in your survey dataset, you will use values that require a unit of measurement. Survey Analyst adds a tab to the ArcCatalog Options dialog box that allows you to define the units that are used when displaying these values.

Tip

What is the display format currently in use?

The current display format is indicated with an asterisk.

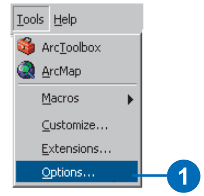
Tip

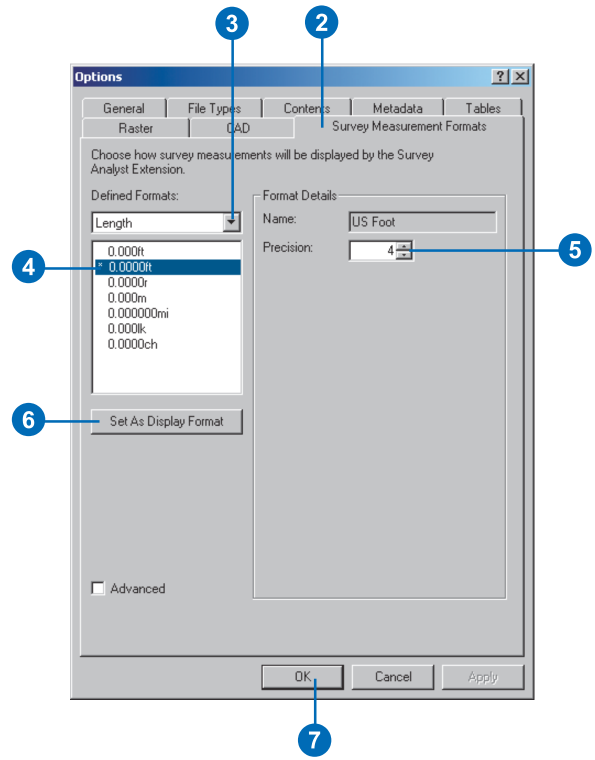
Format details

Different units can share the same abbreviation. U.S. Feet and International Feet, for example, are both abbreviated as 'ft'. The actual unit is determined from the name in the Format Details portion of the Measurement Formats tab.

Changing display units

1. Click the Tools menu and click Options.
2. Click the Survey Measurement Formats tab.
3. Click the Defined Formats dropdown arrow; click the type of unit for which you want to set the display settings.
4. Click the display unit that you want to use.
5. Type the number of decimal places to be used for displaying the units.
6. Click Set As Display Format.
7. Click OK.





Customizing unit display

It is possible that Survey Analyst does not generically support the measurement unit and display format that you require.

If this is the case, you can create your scalar reference and display format for this unit.

The previous section describes how to create a new scalar reference.

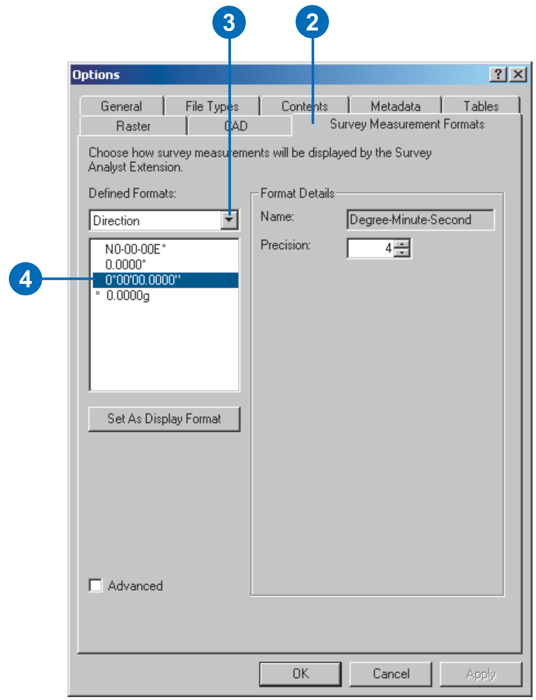
The tasks in this section show you how to change how these units are displayed.

See Also

For information on how to create a scalar reference, refer to the tasks at the start of this section.

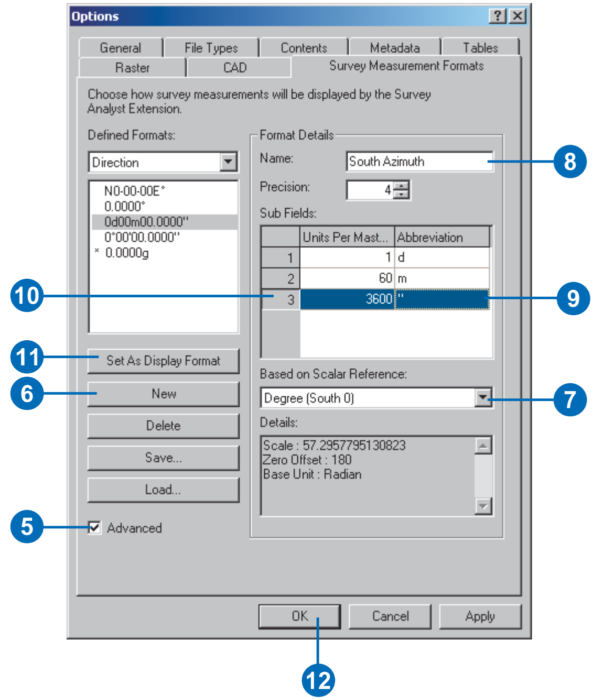
Creating a custom display for south azimuth directions using degrees and minutes

1. Click the Tools menu and click Options.
2. Click the Survey Measurement Formats tab.
3. Click the Defined Formats dropdown arrow and click the type of unit for which you want to customize the display settings.
4. Click the display unit on which you want to base the new format. ▸



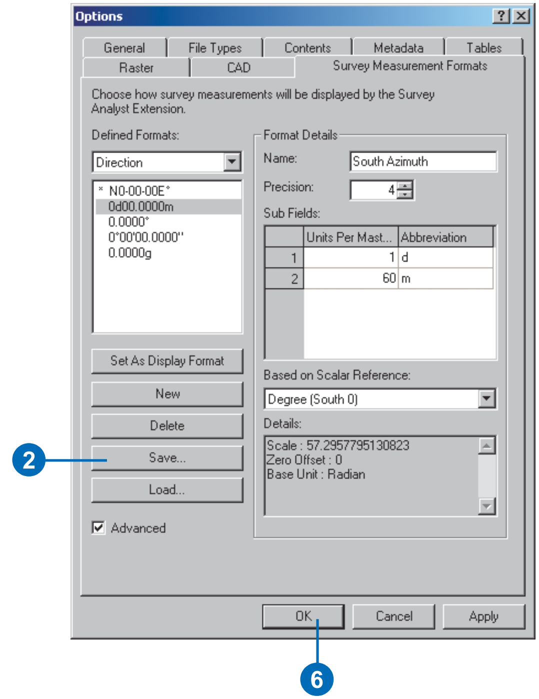
5. Check Advanced.
6. Click the New button.
7. Click the Based on Scalar Reference dropdown arrow, and click the scalar reference on which you want to base the display format. In this example, it is a scalar reference defined for south azimuth.
8. Type a name for the display format.
9. Double-click the Abbreviation field and type new abbreviations for the subfields. In this example, d is used as an abbreviation for degrees, and m is used for minutes.
10. Delete unwanted subfields by clicking the leftmost column of the subfields section and pressing Delete.

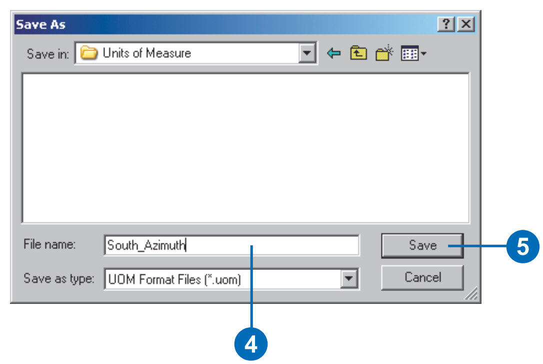
    In this example, units of seconds are not required and are removed.
11. Click Set As Display Format.
12. Click OK.



Saving custom units of measurement

1. Follow the steps in the previous task to create a custom display unit.
2. Click Save.
3. Navigate to the location in which you want to save the unit of measurement file.
4. Type a name for the file.
5. Click Save.
6. Click OK on the Options dialog box.





Understanding survey projects

Survey projects are used to manage and work with the data stored in the survey dataset. You can use projects to define a specific occasion when survey data was collected. For instance, a project may be used to represent a field control survey or to compute the points of a subdivision plan.

Survey points, measurements, and computations in a survey dataset are created, maintained, and owned by survey projects. Ownership is assigned when the survey objects are created, and each object is owned by one project.

Survey points and measurements can be shared between projects; through a computation, one project may use points or measurements owned by another project.

Survey data is always entered through a project. You use projects to import coordinates, compute coordinates for new or existing points, or to make use of the survey points and measurements available from other projects.

Project point name prefix

Survey points are identified by a name—for instance, traverse points might be named T1, T2, T3, and so on. The same point names are often used for different points in other projects. However, since points are shared across the entire survey dataset, they must be represented uniquely within the point namespace of the survey dataset.

Each survey project has a *point name prefix* that, like the project name, is unique within the survey dataset. When making use of points from a variety of projects in the survey dataset, you can use the prefix of the survey project before the point's name, ensuring that the correct point is used.

Coordinate system

You are not limited to using the same coordinate system for all the survey projects in a survey dataset. Although the survey dataset has a coordinate system defined by its spatial reference, each project can have its own coordinate system.

The coordinate system of the survey project is used when you are working with your data in computations or importing coordinates. After they are computed, coordinates are stored in the native coordinate system of the survey project.

Project locking

When sharing a survey dataset in your organization, you may want to prevent some users from editing a given survey project. For example, the project that contains your control points should not be available for general editing. You can lock such projects to prevent them from being edited. To edit a project you need to acquire a *project lock*. You are automatically given this lock when you create a new project.

An enterprise geodatabase provides an environment for multiple users to edit GIS data without locking stored objects—rows in tables—and without duplicating data. You can create named *versions* of a geodatabase. Conflicts in GIS feature datasets are easily detected, reconciled, and posted. For more information about versioning, see *Building a Geodatabase*.

Conflicts in survey datasets are averted through project locking, which prevents simultaneous edits of a survey project.

Project locking and the multiuser environment for survey datasets is presented in more detail in Chapter 10, 'Managing shared survey data'.

Creating and managing survey projects

New survey projects are created using the Survey Project wizard, and project folders let you organize your projects.

The project requires a coordinate system, which is used when you work with your data in computations or when you import your data. ▸

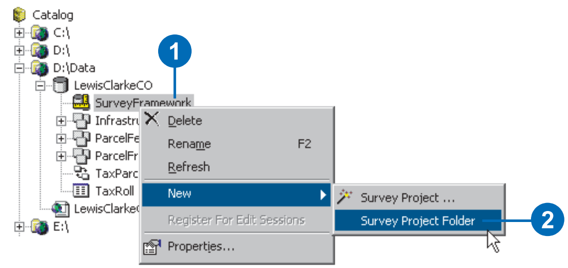
Tip

Naming the Project

Make sure the project name does not start with a number.

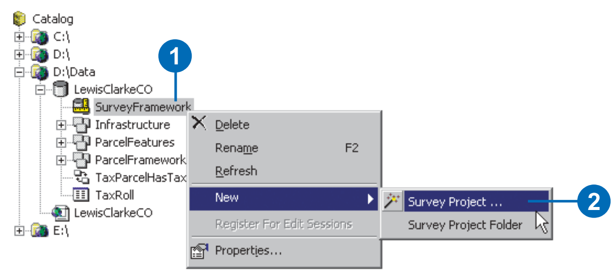
Creating a new survey project folder

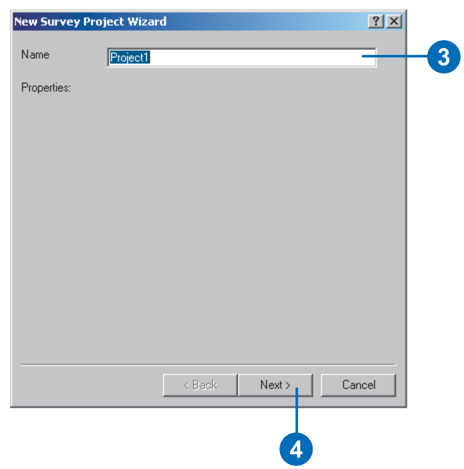
1. Right-click the survey dataset or the folder in the ArcCatalog tree in which you want to create a new folder.
2. Point to New and click Survey Project Folder.
3. Type a name for the folder.
4. Press Enter.



Creating a new survey project

1. Right-click the survey dataset or the project folder in the ArcCatalog tree in which you want to create a new project.
2. Point to New and click Survey Project.
3. Type a name for the project.
4. Click Next. ▸





Since the survey project does not store geometry, there is no dependence on a spatial reference precision, only the coordinate system portion of the spatial reference is used for the survey project.

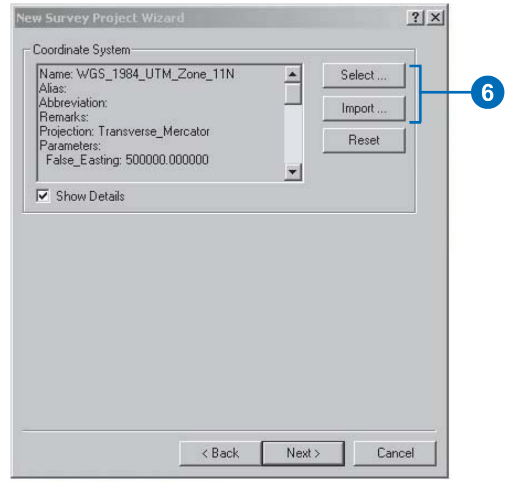
The survey project also requires a point name prefix. The wizard ensures that this is unique across all projects in the survey dataset. This allows survey points in the survey dataset to be uniquely identified even though they have the same name.

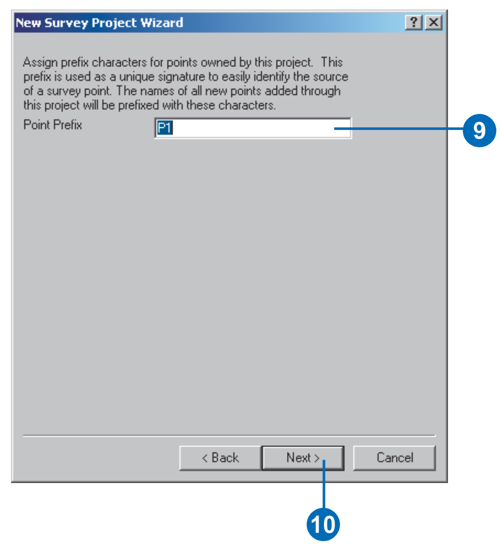
Ground-to-grid corrections are used for coordinate geometry computations. The scale correction is applied to all distance measurements entered in COGO computations, and the angle correction is applied in all computations that use direction measurements. ▸

See Also

For further information about spatial references, domain extents, and how these affect precision, see Building a Geodatabase *and Chapter 3, 'Survey Analyst concepts'.*

5. Skip to step 8 if you want to accept the default coordinate system, which is the same as the coordinate system for the spatial reference of the survey dataset.
6. Click Select or Import to choose a coordinate system for the survey project.
7. Navigate to the spatial reference that you want to select, or navigate to the feature class or feature dataset from which you want to import the spatial reference. Click Add.
8. Click Next.
9. Type the point name prefix that you want to use for this project.
10. Click Next. ▸





You can set default standard deviations that represent the measurement error inherent in the devices most often used to collect the data in your project.

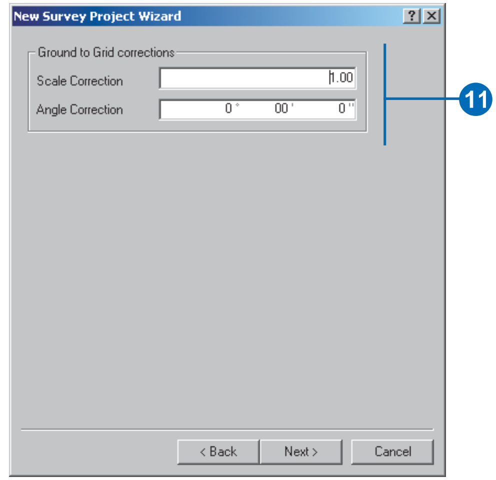
These defaults are displayed when you add measurements in new computations. If necessary, these defaults can be altered after the project has been created.

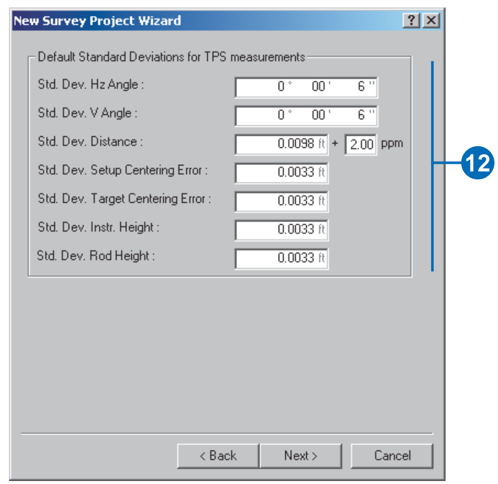
Three types of corrections can be applied in computations when calculating coordinates. These corrections are based on:

- An approximate height above mean sea level and earth radius
- The projection used by computations to account for meridian convergence
- Meteorological conditions defined by the temperature and pressure recorded for instrument setups (not required for COGO)

These corrections are defined through a project. ▶

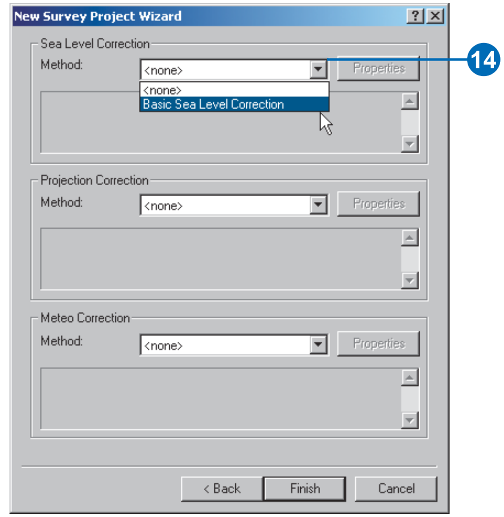
11. Type a scale correction and angle correction if you want to use values other than the default values. These defaults apply no correction to the coordinates calculated using COGO computations.
12. Type default standard deviation values for the measured angles and distances, and for centering the target and instrument.
13. Click Next. ▶





In some cases, certain of these corrections have been applied to the imported data and, therefore, do not need to be reapplied during computations. In these cases, you can choose <none> for the correction that has already been accounted for in the imported data.

14. Click the Sea Level Correction Method arrow and click the method that should be applied for computations in this project.
15. Repeat step 16 for the Projection Correction and Meteo Correction methods.
16. Click Finish.



Importing survey measurements and points

You can import data collector files recorded using a total station. In addition to a choice of different data collector formats, an ASCII import wizard allows you to import coordinates for survey points.

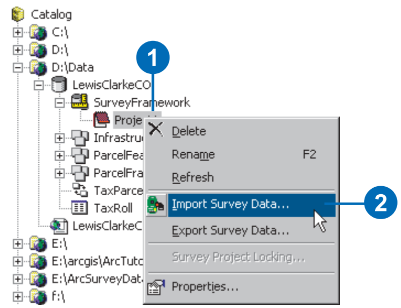
Operation codes and feature codes

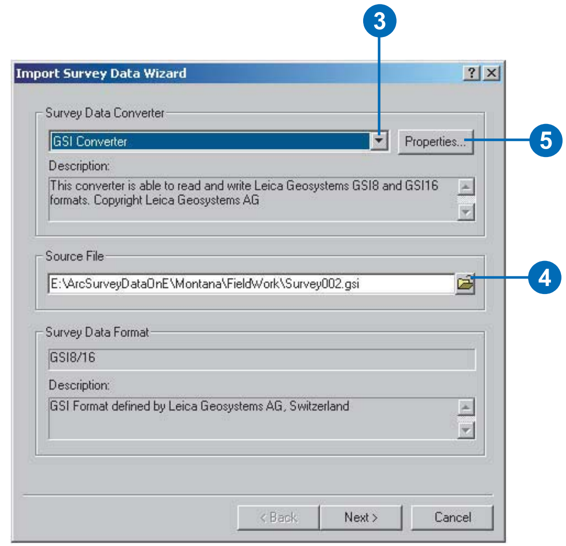
Data collector file formats include blocks of text that are used to describe methodologies used in the field. They may, for instance, define the start of an instrument setup or a sequence of measurements that follow along the edge of a street.

These blocks of text are called *operation codes*.

Another important component of data collector files is the text blocks used to describe the features surveyed in the field. These are called *feature codes*. ▸

1. Right-click the survey project into which you want to import the survey data.
2. Click Import Survey Data.
3. Click the Survey Data Converter dropdown arrow to choose the format of the file that you want to import.
4. Click the Browse button and navigate to and select the data collector file or ASCII file. You can also directly type its path and name.
5. Click Properties. ▸





These blocks of text are interpreted when the data collector file is imported.

There are many different formats of operation codes and feature codes. These require a variety of different *survey data converters*.

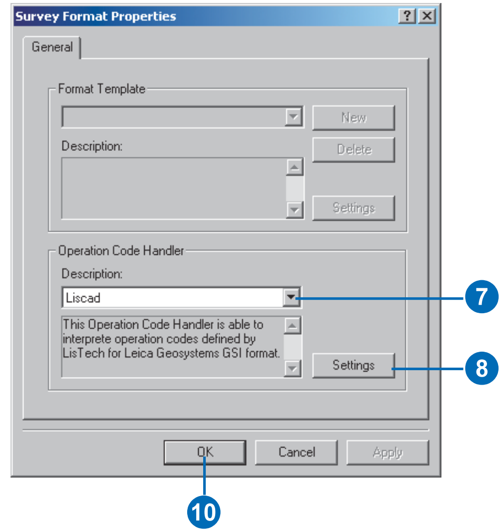
These differences occur not only between different data converter formats but also for each converter format.

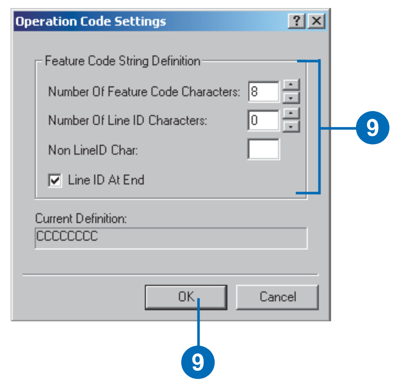
Survey Analyst supports the following survey data converter formats:

- ASCII
- Geodimeter
- GSI
- SDR
- TDS Coordinate
- TDS Raw

Survey Analyst also supports an open development environment for custom importers. ►

6. Skip to step 12 if you are importing an ASCII file format.
7. Click the Operation Code Handler dropdown arrow and choose the code handler you want to use for your selected file format.
8. Click Settings.
9. Change the Operation Code Settings specific to the code handler you selected. Click OK on the Operation Code Settings dialog box.
10. Click OK on the Survey Format Properties dialog box.
11. Skip to step 30 if you are not importing an ASCII coordinate file. ►





Defining an import template for ASCII files

Survey point data is often stored in ASCII files in a variety of different formats.

The ASCII Import wizard lets you create import templates that define the structure of these ASCII files.

When defining the import template, you specify the special delimiter characters between point attribute fields, or you interactively specify the start and end column positions for attribute fields.

You can then specify how the importer should interpret these fields and specify the units used for the coordinates.

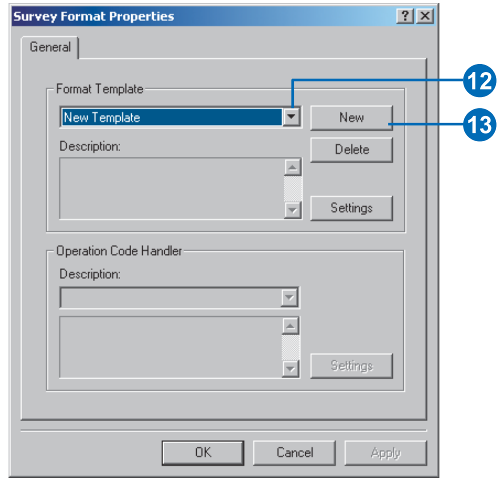
Importing coordinates from a local coordinate system

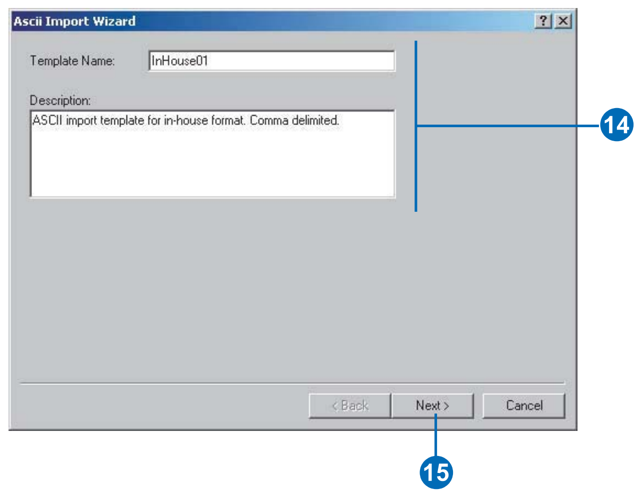
Often a field survey will start with assumed coordinates based on an unknown coordinate system. ►

12. Click the Format Template dropdown arrow to select it if you want to use an existing import template, then skip to step 29.

    Otherwise, follow steps 13–28 to create a new ASCII import template.

13. Click New to create a new template.
14. Type a name and description for the template.
15. Click Next. ►





The data exchange allows you to define a transformation to bring these coordinates into the projected coordinate system of the survey project. ▶

Tip

Ignoring lines

Instead of typing the number of lines to ignore at the top and bottom of the text file, you can also click the up and down arrows to increase or decrease this number.

Tip

Using the keyword

Use the keyword if lines in your file are tagged with a string to identify them as importable. Characters before the keyword in any line are ignored. Lines without a keyword are not imported.

Tip

Column separators

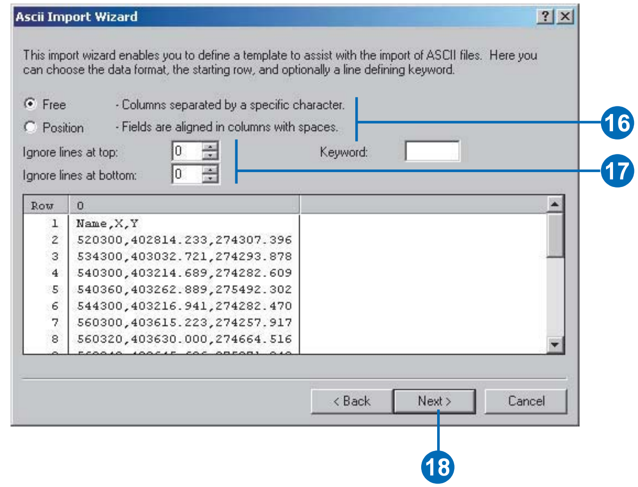
If the delimiter is not a check item, then type the delimiter character in the Other box.

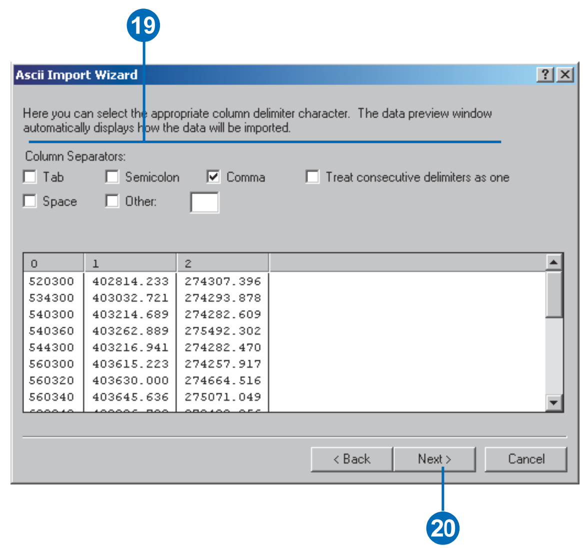
Tip

Consecutive delimiters

Check the Treat consecutive delimiters as one text box if you don't want the importer to insert zeros or nulls when no items exist between delimiters in the file.

16. Click Free for files that have a special character between coordinate fields and point name fields; otherwise, click Position to use interactive field-column definition.
17. Type the number of lines to ignore at the top and the bottom of the text file, and type a keyword if required.
18. Click Next.
19. Check all the types of delimiters that should be used to identify columns.
20. Click Next. ▶





There are also cases in which the coordinates being imported have a projected coordinate system that is different from the coordinate system of the survey project. ▶

Tip

Inserting column separators

When defining columns for fields, click the header row in the horizontal position where a field column starts or ends. Columns for characters that are not required are also created, but these are left unassigned in the following step.

Tip

Deleting a column separator

Double-click the column separator in the header row to delete it.

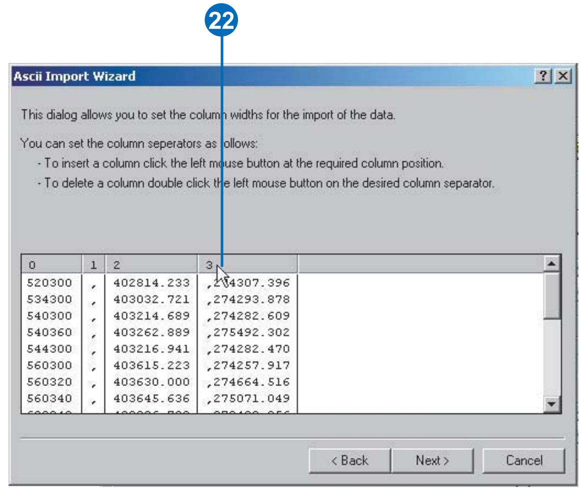
Tip

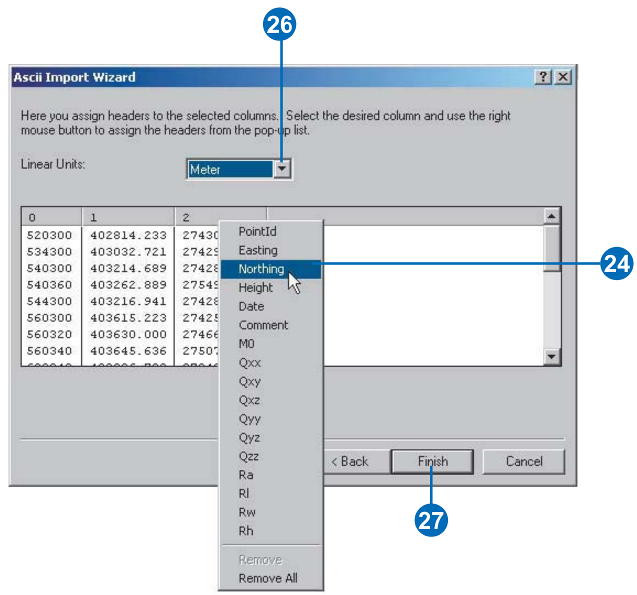
Removing a column identifier

Right-click the column header and click Remove.

21. Skip to step 26 if you clicked Position on the previous page of the wizard.
22. Click the header row in the horizontal position where two field columns should be separated.
23. Repeat step 22 for all the fields.
24. Right-click a column header and click the field type that it represents.
25. Repeat step 24 for each of the fields that should be identified for import.
26. Click the Linear Units drop-down arrow and click the unit type for the coordinates in the ASCII file.
27. Click Finish.

The template is created. ▶





In these cases, you can select the projected coordinate system for the import file.

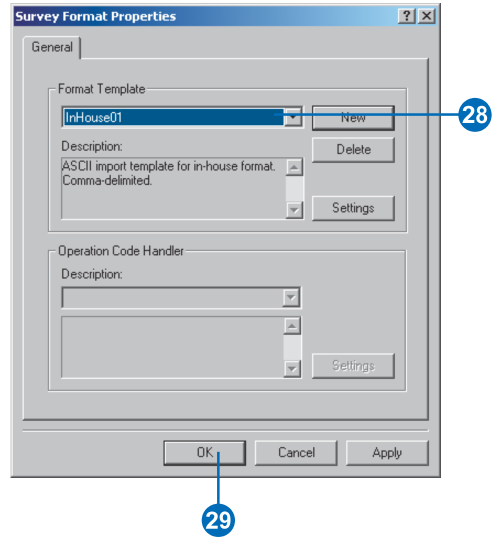
If the projected coordinate systems do not share a common geographic coordinate system, a geographic transformation must be defined.

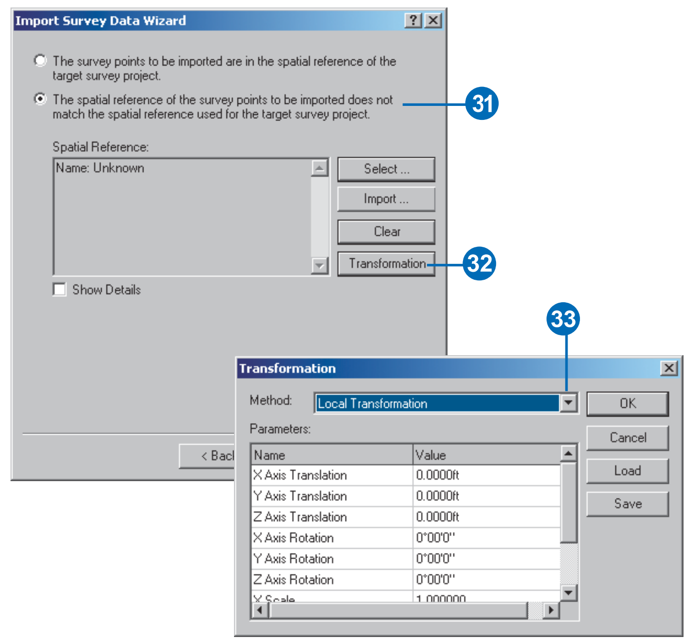
What is the point prefix separator?

While in the field, you will often use survey points that already exist in your survey dataset. To identify the survey point and its project correctly, you need to use the point prefix together with the point name. While naming these points in the field, you can separate the point name from the prefix using a separator character. ▸

28. Click the Template name dropdown arrow and click the new template you created.
29. Click OK.
30. Click Next.
31. Click the second option if you want to specify that the source file has a projected coordinate system that is different from the target project, or that it has a local coordinate system.

    Otherwise, skip to step 35.
32. Click Transformation.
33. Click the Method dropdown arrow and click the method you want to use.
34. Type the transformation parameters, if required, and click OK.
35. Click Next. ▸





The prefix separator must be specified for the importer so that it can correctly interpret the prefix and can search the correct project for the survey point identified in the importer file.

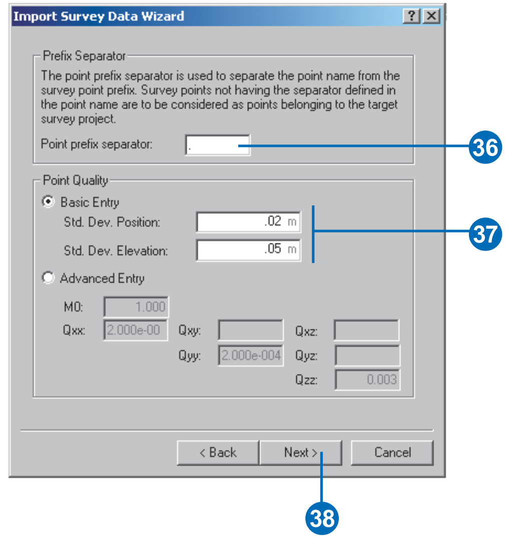
Defining default standard deviations

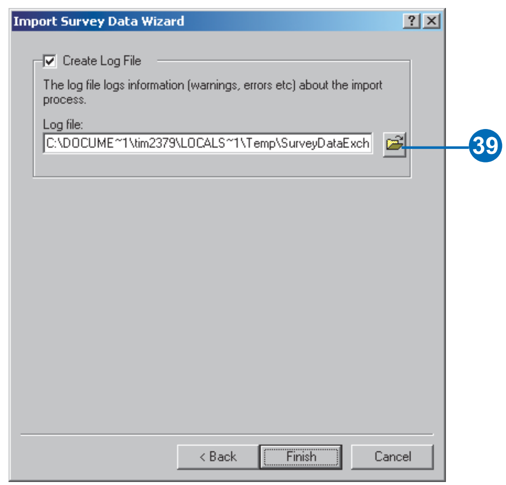
When importing survey point coordinates, it is possible to also import the error information in the form of a standard deviation or covariance matrix. When the importer does not find this error information in the import file, it can assign some default values that you define.

Creating a log file

The importer will allow you to specify the name and location of a log file that records the results of an import.

36. Type the point prefix separator string.
37. Type default standard deviations for position and elevation.
38. Click Next.
39. Click the Browse button and navigate to the location in which you want to save the log file. Provide a log file name and click OK. You can also directly type its path and name.
40. Click Finish and click OK on the Import Survey Data Wizard dialog box.





Previewing survey data

You can preview the geography of survey data in your survey datasets, folders, and projects without having to create a map.

For example, you can use the Preview tab in ArcCatalog to get visual confirmation that the correct file was imported.

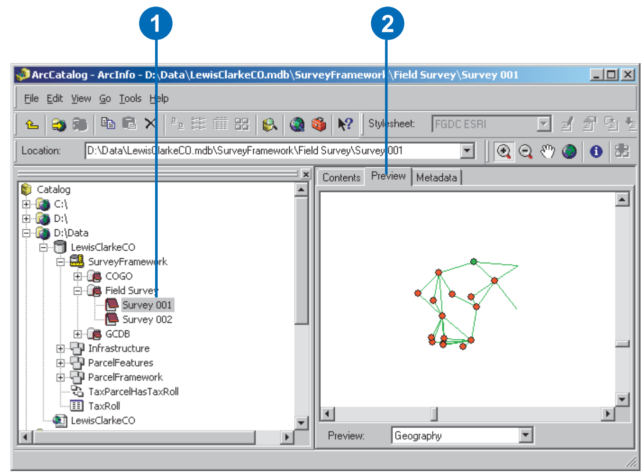
You can identify specific survey points and measurements displayed in the preview.

See Also

For more information about ArcCatalog functionality, see Using ArcCatalog.

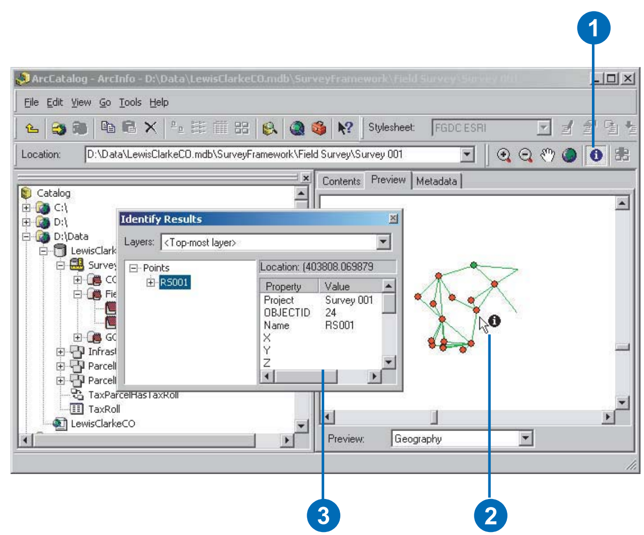
Previewing survey points and measurements

1. Click the survey dataset folder or project you want to preview.
2. Click the Preview tab.



Identifying survey points and measurements

1. Click the Identify button on the Geography toolbar.
2. Click the survey point or measurement in the preview that you want to identify.
3. View the details displayed in the Identify Results dialog box.



Exploring and viewing survey properties and metadata

To get more information about a survey project or survey dataset, go to its properties.

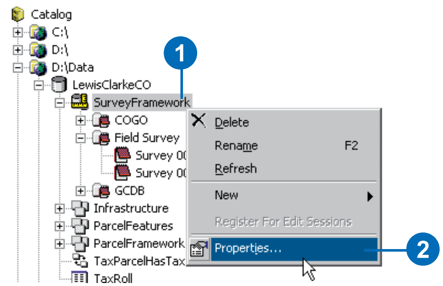
Additional documentation about the contents of a survey dataset or project is available through its metadata. This documentation can also be added using the metadata editor.

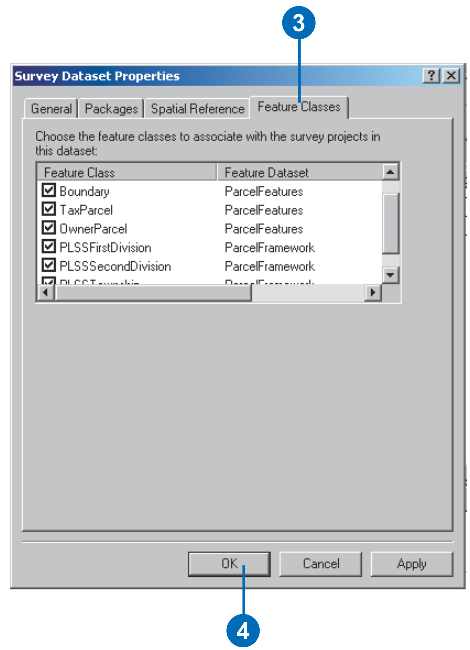
See Also

For more information about using, creating, and editing metadata, see Using ArcCatalog.

Exploring survey dataset and project properties

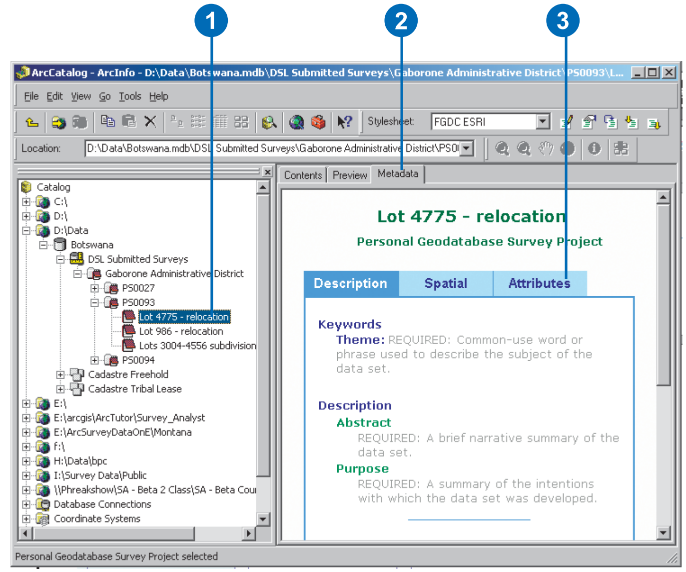
1. Right-click the survey dataset or survey project for which you want to see properties.
2. Click Properties.
3. Explore the properties using the tabs in the Survey Dataset Properties dialog box. You can change the properties for your survey dataset or project.
4. Click OK.

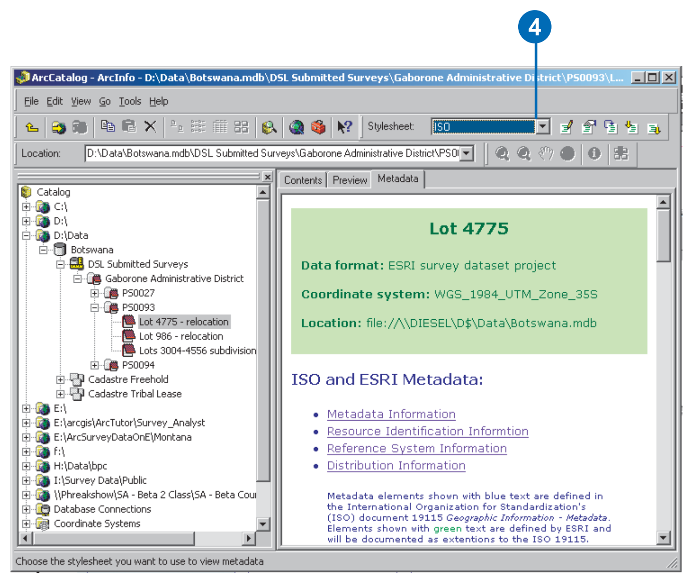




Viewing project metadata

1. Click the project or survey dataset.
2. Click the Metadata tab.
3. Click a tab on the metadata page to see a specific category of the metadata contents.
4. Click the Stylesheet dropdown arrow to change the metadata's appearance.





5

Visualizing survey data

IN THIS CHAPTER

- **Exploring survey layers**
- **Creating survey layers**
- **Working with symbols and labels**
- **Visualizing error information**
- **Using survey fields for symbology**
- **Representing projects in a survey layer**
- **Symbolizing feature links**

In ArcMap it is possible to draw, query, and edit the survey data stored in a survey dataset. Using *survey layers* to draw *measurements* and *survey points*, you can visualize *survey datasets* and *survey projects* on the map.

There are many ways to represent your survey data on the map. For instance, you can:

- Label points and measurements based on attributes, such as point name or measurement value.
- Display points and measurements in multiple sublayers using different symbols to represent different characteristics.
- Create a legend to describe the purposes of symbols.
- Display magnified error ellipses for survey points.
- Limit the display to survey objects owned or referenced by a specific set of projects.

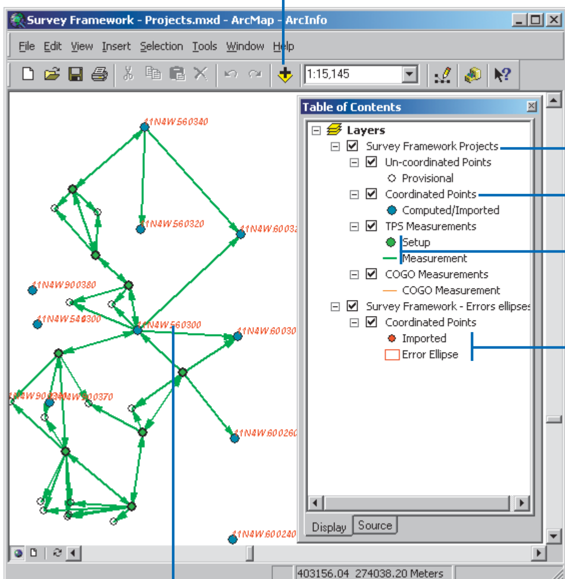
In this chapter, you'll learn about the different properties of survey layers and how to map your survey data in the most effective way for your specific task.

Exploring survey layers

You create a *survey layer* whenever you add survey datasets or survey projects to the map. Like other map layers, survey layers appear in the table of contents of a map document.

A survey layer has properties and a set of renderers for displaying different survey classes. A *group layer* has a set of *sublayers*. Multiple sublayers are typical; usually there is at least one for each of the measurement classes supported and at least one to represent the survey point class. You can choose a renderer for each sublayer to control how the survey dataset is drawn.

Click here to add a survey layer to the map.



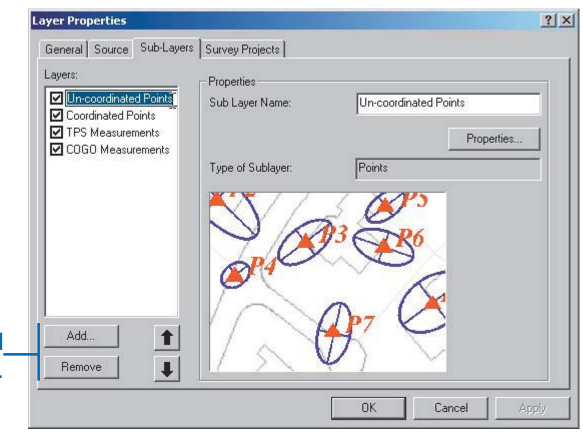
Survey layers display the points and measurements stored in the survey dataset.

Sublayers are used to draw points or measurements based on their properties.

Different symbols on the map distinguish different types of measurements.

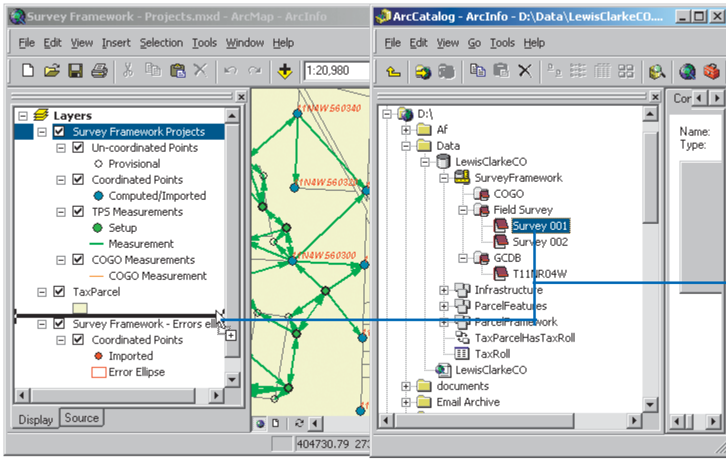
Error ellipse symbols can be defined for survey point sublayers.

Labels are used to provide descriptive text for the survey objects on the map.

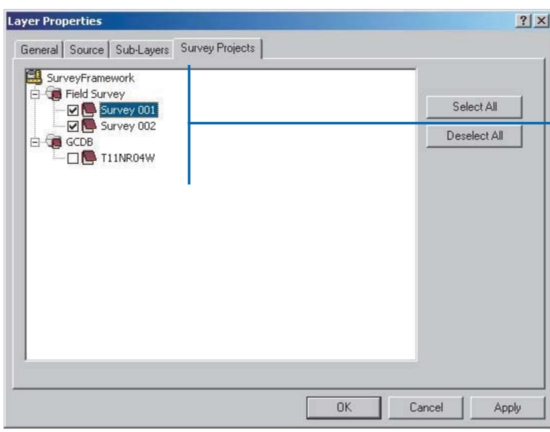


Use the Layer Properties dialog box to add and remove sublayers and change their drawing order.

Survey layers are used to represent one or more survey projects in the survey dataset. They offer a great deal of flexibility, since you can use a single survey layer for all survey projects or add a survey layer for each project. The projects represented by the survey layer are selected from the Layer Properties dialog box.



Drag and drop projects, folders, or survey datasets from ArcCatalog to ArcMap.



Use the survey Layer Properties dialog box to define the survey projects that the survey layer represents.

Creating survey layers

If you do not already have a predefined survey layer, you can create one from existing survey data. Create a survey layer by adding a project, project folder, or survey dataset to the map. ArcMap creates a new survey layer that represents the set of survey projects that you added.

Once a survey layer exists in the map, you can choose to add or remove sublayers for the supported survey classes, define a scale range at which these sublayers are visible, and define how to draw them.

Tip

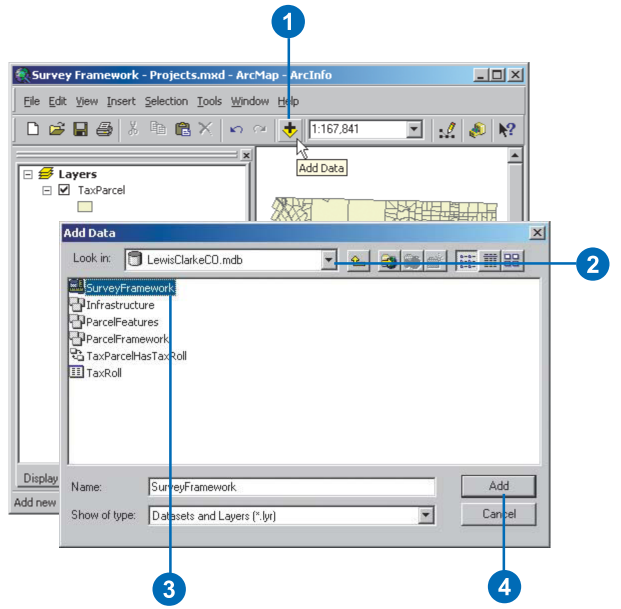
Adding a project folder

You can add all the projects in a folder to the map by clicking the Add Data button, navigating to the folder, selecting it, and clicking Add in the Add Data dialog box. You can also drag and drop the whole folder from ArcCatalog to ArcMap.

Adding a survey dataset in ArcMap

1. Click the Add Data button on the Standard toolbar in ArcMap.
2. Click the Look in dropdown arrow and navigate to the geodatabase that contains the survey dataset that you want to add to the map.
3. Click the survey dataset.
4. Click Add.

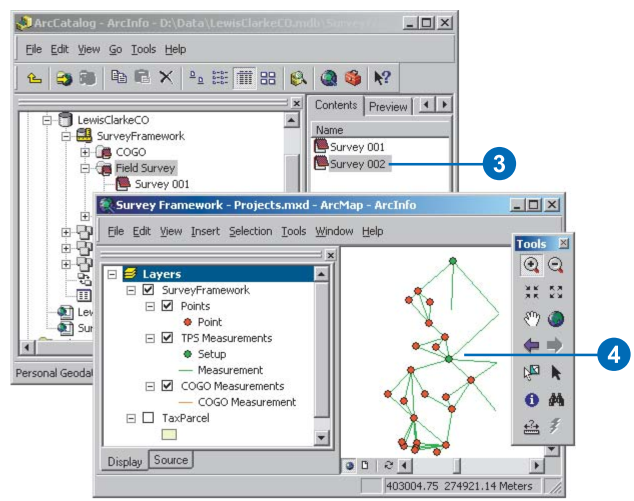
   ArcMap creates a new layer on the map that represents all the projects in the survey dataset.



Adding a survey project from ArcCatalog

1. Arrange the ArcCatalog and ArcMap windows so that you can see both on the screen.
2. Navigate to the survey project in ArcCatalog that you want to add to the map.
3. Click and drag the project from ArcCatalog.
4. Drop the project over the map display in ArcMap.

   ArcMap creates a new layer on the map that represents the project.



Tip

Layer properties

You can open the Layer Properties dialog box for a survey layer or sublayer by double-clicking its name in the table of contents.

Tip

Removing a sublayer

To remove a sublayer, click on the name of the sublayer in the Layers list and click Remove.

Tip

Drawing order of sublayers

To draw any sublayer above or below another, click the name of the sublayer in the Layers list, and use the up and down arrows to move it to the desired position. The layer highest in the list is drawn on top of all the others.

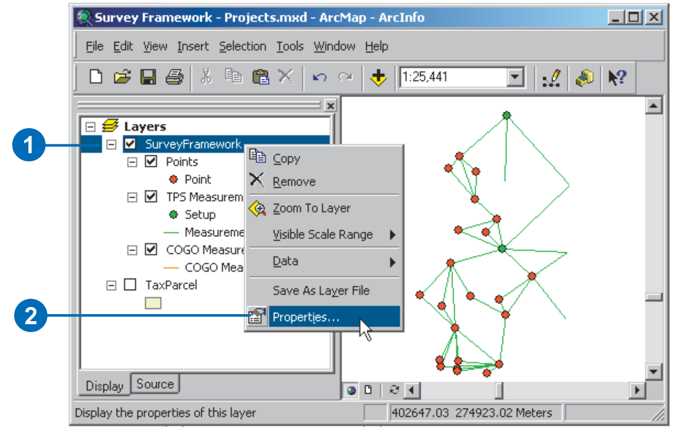
Tip

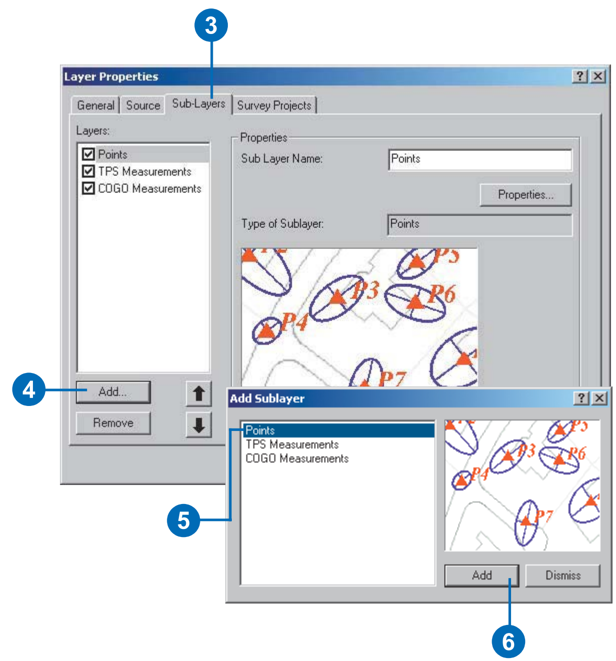
Sublayer properties

To get to the sublayer properties from the Layer Properties dialog box, click the sublayer name and click Properties.

Adding a new sublayer to a survey layer

1. Right-click the survey layer to which you want to add a sublayer.
2. Click Properties.
3. Click the Sub-Layers tab in the Layer Properties dialog box.
4. Click Add.
5. Click the name of the survey class for the sublayer type you want to add.
6. Click Add in the Add Sublayer dialog box.
7. Click OK in the Layer Properties dialog box.





Working with symbols and labels

Deciding how to represent your data on a map is one of the most important aspects of mapmaking.

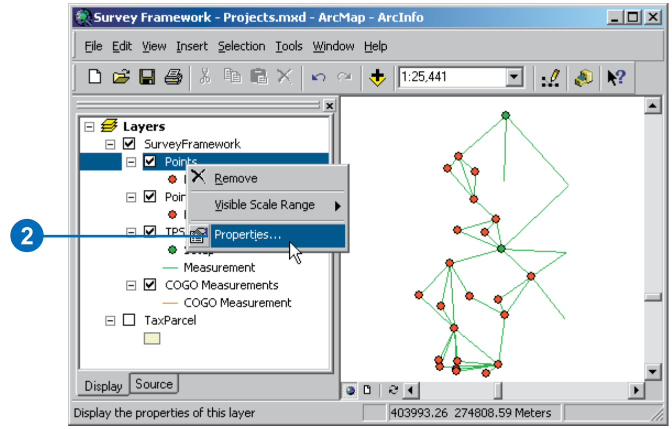
For survey data, you must consider whether the map should convey the following information:

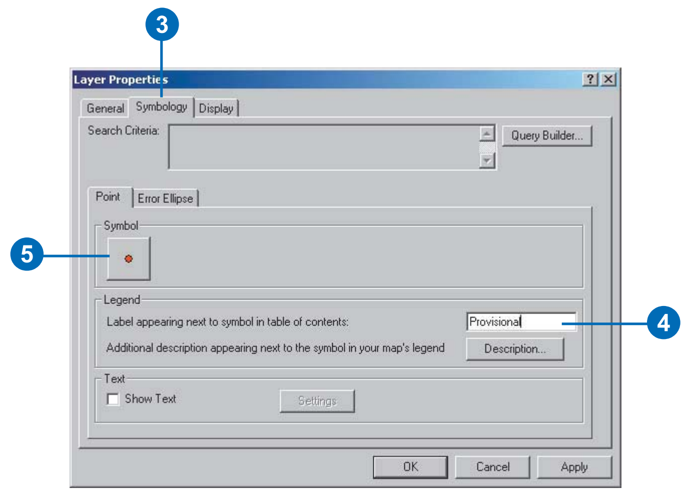
- Measurement values
- Names and elevations on survey points
- Error ellipses for coordinate reliability
- Ranges of coordinate reliability
- Ownership of survey objects by project
- How survey points are associated with features

Using symbols and labels, you can present to the map reader your survey data in a way that best communicates this information.

Creating a point sublayer symbol

1. Right-click the survey point sublayer.
2. Click Properties.
3. Click the Symbology tab.
4. Type the text you want displayed next to the symbol in the legend.
5. Click the Symbol button. ▸





Tip

Symbol Selector

You can get to the Symbol Selector dialog box quickly by clicking on the symbol in the table of contents.

Tip

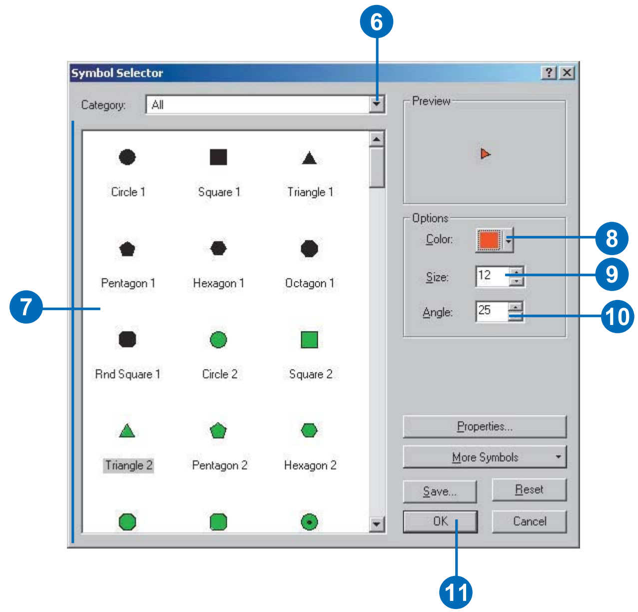
Symbol Property Editor

For more advanced symbol options, click Properties on the Symbol Selector dialog box.

See Also

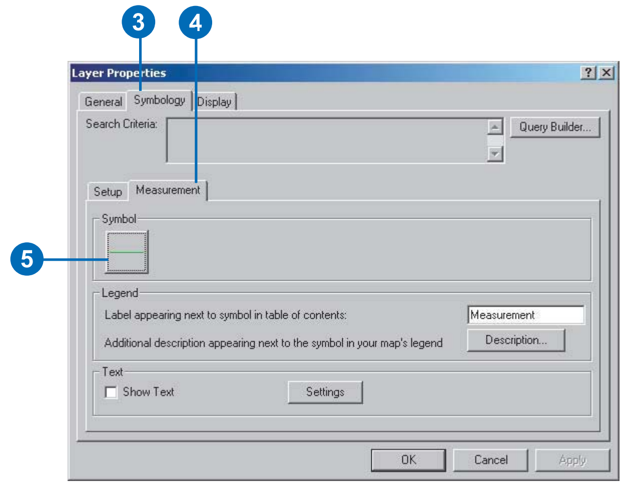
For more information about working with the Symbol Property Editor, see Using ArcMap.

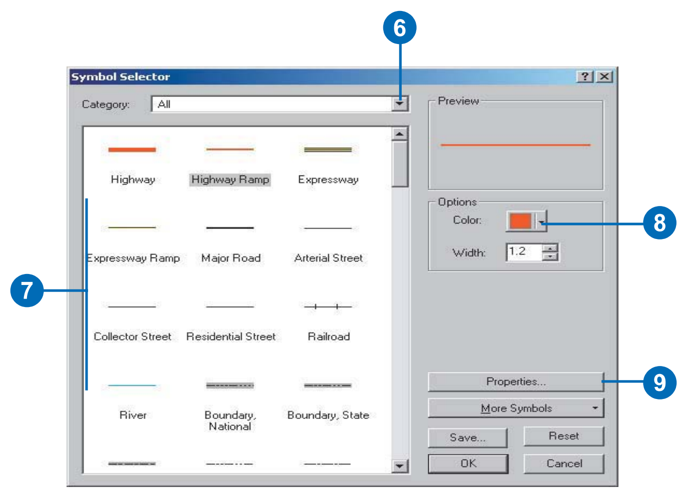
6. Click the Category dropdown arrow and select a point symbol category.
7. Scroll through the available symbols and click the symbol you want to use.
8. Click Color to choose a color for the new symbol.
9. Type a symbol size.
10. Type a symbol rotation value if you want the symbol to be rotated.
11. Click OK on the Symbol Selector dialog box.
12. Click OK on the Layer Properties dialog box.



Changing the way TPS measurements are symbolized

1. Right-click the TPS Measurements sublayer containing the symbol you want to change.
2. Click Properties.
3. Click the Symbology tab.
4. Click the Measurement tab.
5. Click the Symbol button to change the instrument measurement observations symbol.
6. Click the Category dropdown arrow and choose a line symbol category.
7. Scroll through the available symbols and click the line symbol you want to use.
8. Click Color to choose a color for the new symbol.
9. Click Properties. ▸

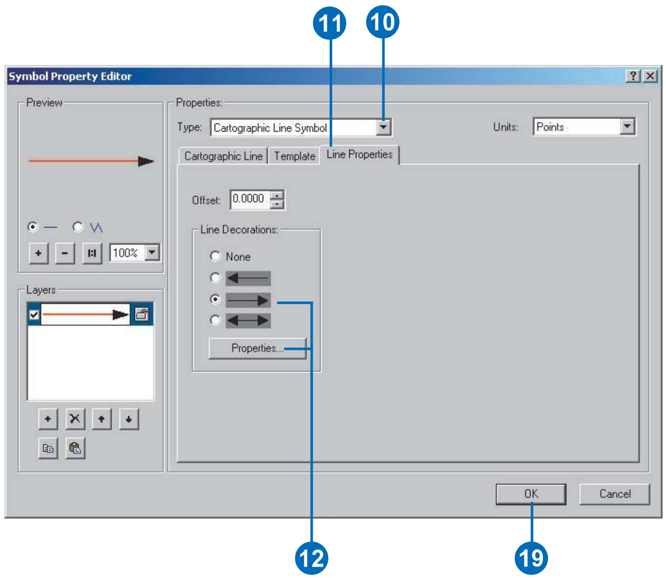


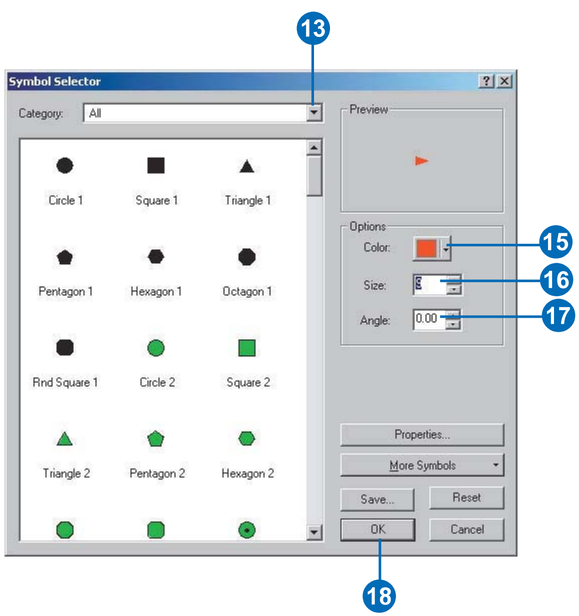


10. Click the Properties Type dropdown arrow and click the type you want to use.

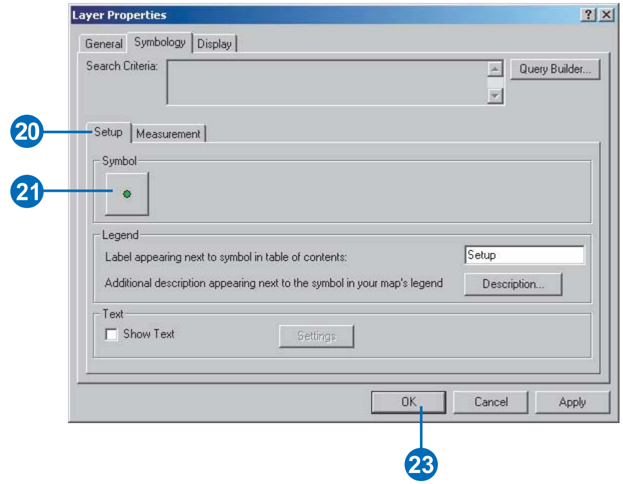
    In this example, a cartographic line symbol is chosen so that an arrowhead can be used at the endpoint of each measurement.

11. Click the Line Properties tab.
12. Click the line decoration style you want to use and click Properties.
13. Click the Category dropdown arrow and select a point symbol category.
14. Scroll through the available symbols and click the symbol you want to use.
15. Click Color to choose a color for the new symbol.
16. Type a symbol size.
17. Type a symbol rotation value if you want the symbol to be rotated.
18. Click OK on the Symbol Selector dialog box.
19. Click OK on the Symbol Property Editor. ▸



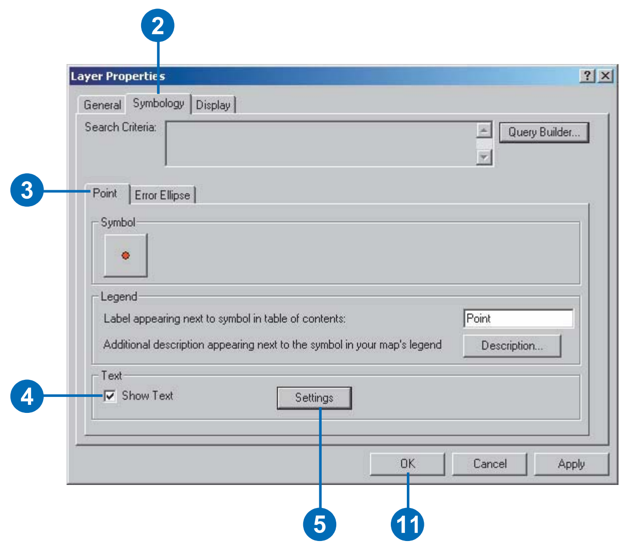


20. Click the Setup tab.
21. Click the Symbol Selector button to change the symbol for instrument setup.
22. Repeat steps 13–18.
23. Click OK on the Layer Properties dialog box.

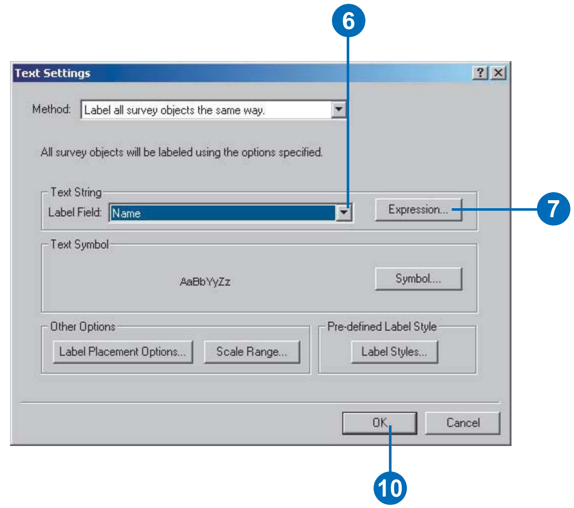


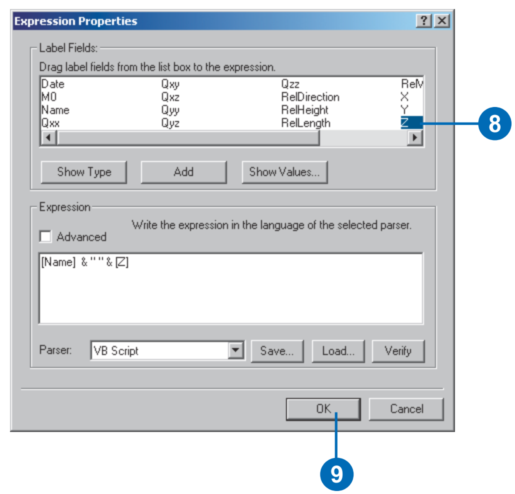
Labeling all survey points in a sublayer

1. Right-click the sublayer you want to label and click Properties.
2. Click the Symbology tab.
3. Click the Point tab.
4. Check Show Text.
5. Click Settings. ▸



6. Click the Label Field dropdown arrow and click the field you want to use as a label.
7. Click Expression.
8. Double-click, in order, any additional fields you want to add to the end of the label.
9. Click OK in the Expression Properties dialog box.
10. Click OK in the Text Settings dialog box.
11. Click OK in the Layer Properties dialog box.

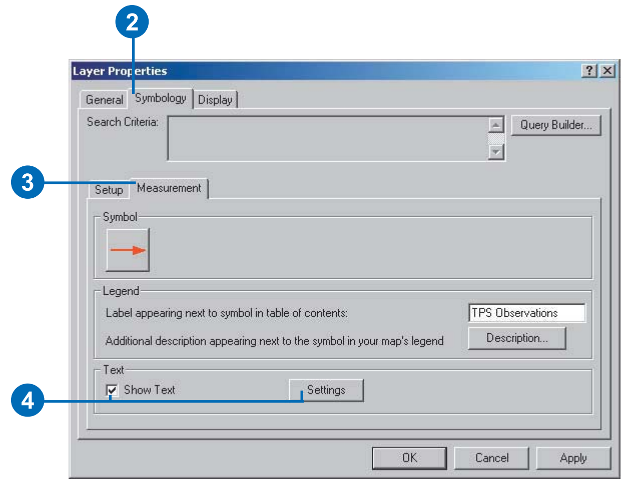


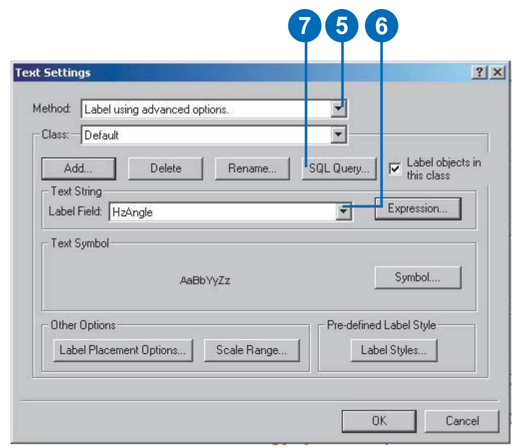


Labeling a subset of survey objects in a sublayer

1. Right-click the sublayer in the table of contents you want to label and click Properties.
2. Click the Symbology tab.
3. Click the tab for the measurement or point you want to label.

   In this example, it is the Measurement tab for total station observations.
4. Check Show Text and click Settings.
5. Click the Method dropdown arrow and click Label using advanced options.
6. Click the Label Field dropdown arrow and click the field you want to use as a label.
7. Click SQL Query. ▸





8. Click the operators and double-click the fields in the Fields list to build an expression to identify the subset of survey objects that you want to label.

   In this example, total station measurements with a slope distance between 200 and 300 will be labeled with their horizontal angles.

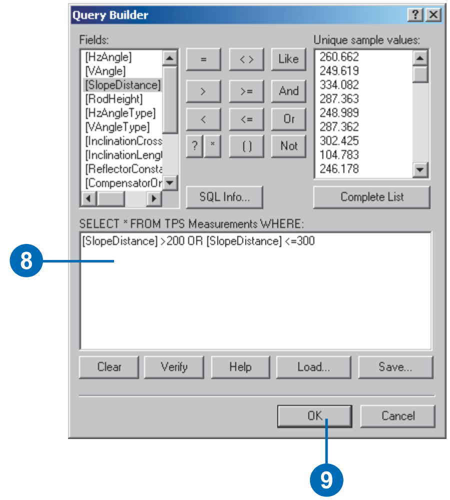
9. Click OK.

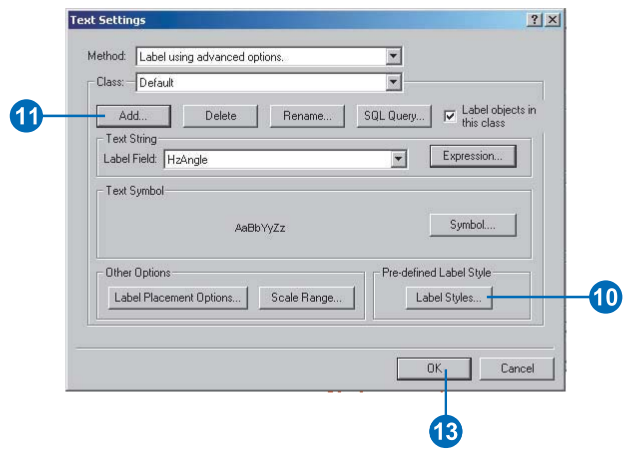
10. Click Label Styles to choose the style—for instance, font and size—of the label you want.

11. If you want to create additional subsets of survey objects to label, click Add and type a new class name.

12. Repeat steps 7–10 to create additional subsets of survey objects that you want to label.

13. Click OK.





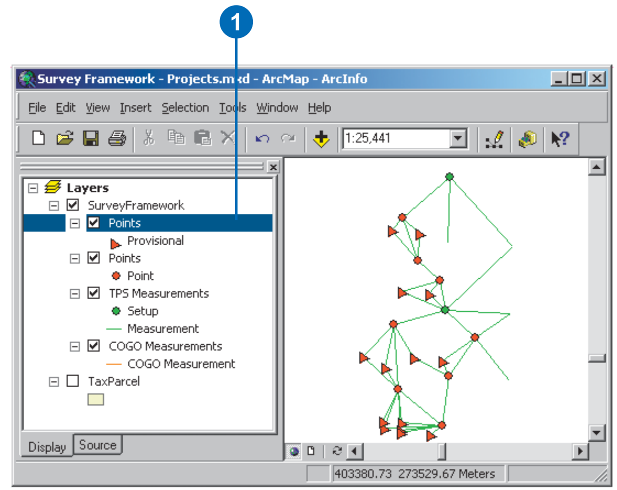
Visualizing error information

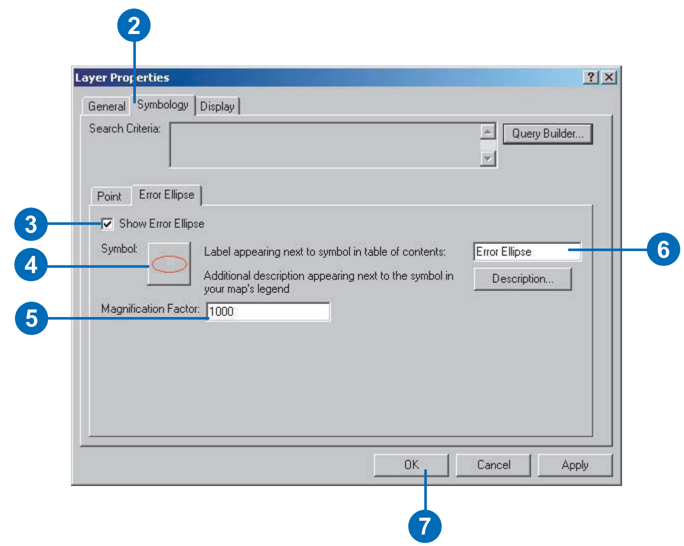
Where error information is available in the covariance matrix of a survey point, it is possible to display this information for a point's GIS coordinate. If you alter the GIS coordinate using the Coordinate Manager tab, the new error information is updated on the map.

Since the error ellipse is only visible at very large scales, you can select a magnification based on the typical map scales that you use. In this way, you can get a relative indication of error in the coordinates based on others.

Drawing error ellipses for survey points

1. Double-click the survey point sublayer name for which you want to display error ellipses.
2. Click the Symbology tab.
3. Check the Show Error Ellipse check box.
4. Click the Symbol Selector button if you want to change the symbol for the error ellipse.
5. Type a value for magnification of the error ellipse for displaying it on the map.
6. Type a text description to be used in the legend for the survey point sublayer.
7. Click OK.





Using survey class fields for symbology

Using an attribute-based query definition on sublayers, you can draw survey points or measurements differently based on the attributes of the survey classes that the sublayers represent. For instance, you can use different symbols for survey points that occur above and below a specific elevation.

You can also select the set of survey projects that should be represented by the survey layer.

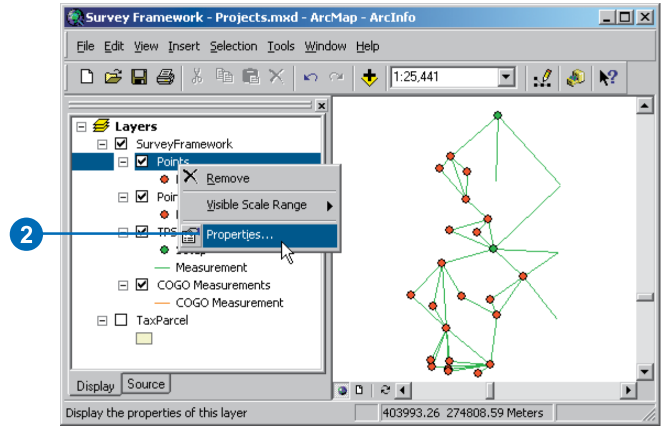
Tip

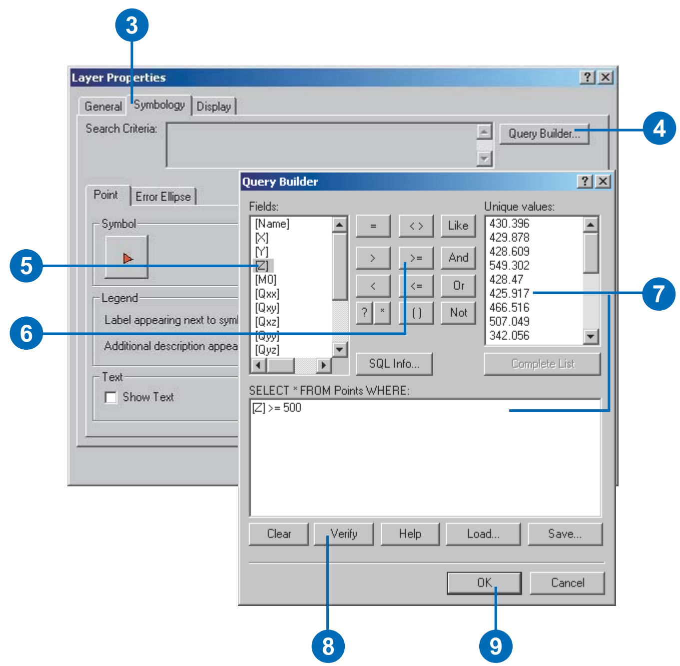
Using the NOT operator

When displaying two sublayers of the same class, it is often necessary to define queries in which one is the inverse of the other. Otherwise, symbols will be drawn on top of each other. You can avoid this by repeating the query and prefixing it with the NOT operator for the appropriate sublayer.

Defining which survey objects to display based on their attribute fields

1. Right-click the survey point sublayer.
2. Click Properties.
3. Click the Symbology tab.
4. Click Query Builder.
5. Double-click the field you want to use in the query.
6. Click the logical operator you want to use.
7. Scroll through the unique values list and click the value you want to use as part of the query, or type the value in the query box.
8. Click Verify to verify the query.
9. Click OK.





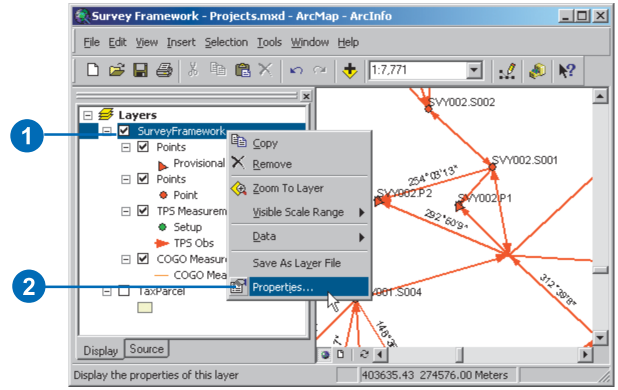
Representing projects in a survey layer

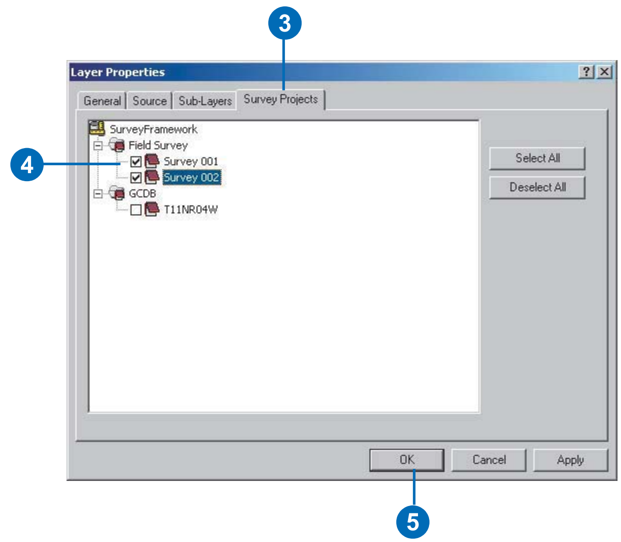
When displaying your survey information on the map, you will often want to view it based on a specific project or set of projects.

The survey layer has a set of survey projects that it represents, and changing which projects are represented by a layer is easily done through the Layer Properties dialog box.

Changing the projects represented in a survey layer

1. Right-click the SurveyFramework layer.
2. Click Properties.
3. Click the Survey Projects tab.
4. Expand the survey folders and check the projects that you want to be visible through the survey layer.
5. Click OK.





Symbolizing feature links

Survey points often represent the location of features. When these features are represented in layers on a map, it is possible to create links with their surveyed location. These links can be displayed on the map.

Additionally, you can have the feature vertices symbolized based on their links with survey points. Feature vertices have three different *states* in relation to survey data:

- Unlinked
- Linked to survey points
- Linked and snapped to survey points

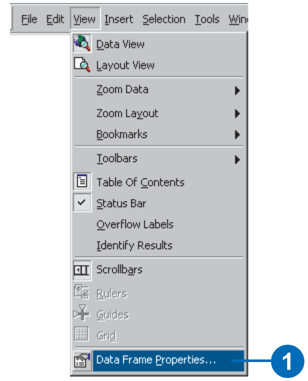
You can choose whether or not to display this information, and you can choose the symbols that should be used to represent the different link states.

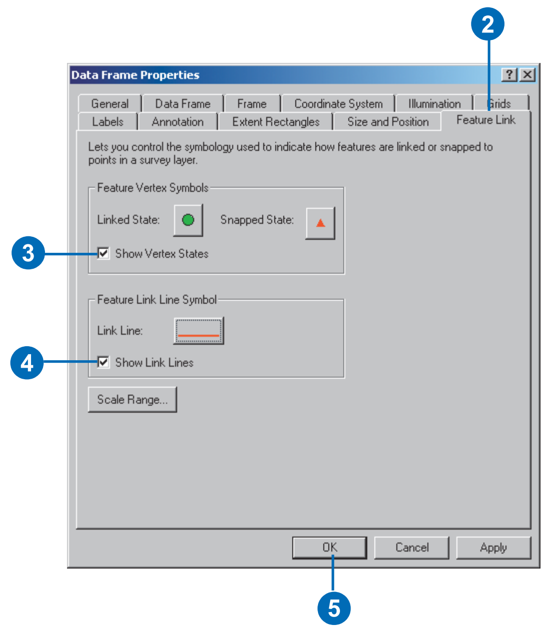
See Also

To learn how to create links and update feature geometry based on links, see Chapter 8, 'Editing feature geometry'.

Switching on symbols for feature links

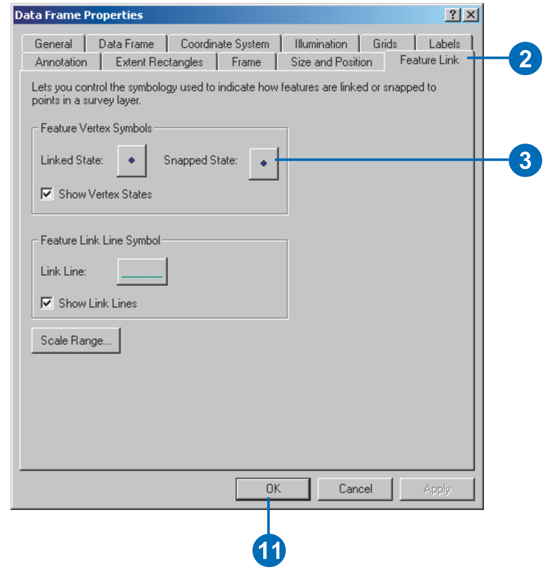
1. Click View in the Main menu and click Data Frame Properties.
2. Click the Feature Link tab.
3. Check Show Vertex States to display a link symbol on feature vertices that are linked and a snap symbol on feature vertices that are snapped.
4. Check Show Link Lines to display link-lines between survey points and feature vertices.
5. Click OK.

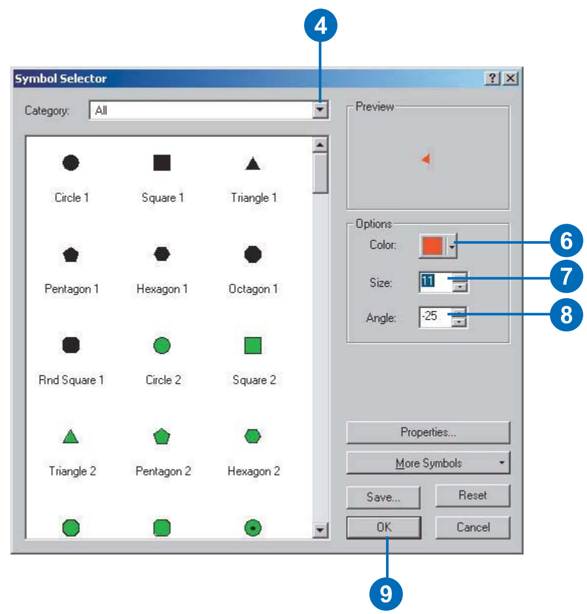




Changing the symbols for feature links

1. Click the View menu and click Data Frame Properties.
2. Click the Feature Link tab.
3. Click the Snapped State Symbol Selector button.
4. Click the Category dropdown arrow and select a symbol category.
5. Scroll through the available symbols and click the symbol you want to use.
6. Click Color to choose a color for the new symbol.
7. Type a symbol size.
8. Type a symbol rotation value if you want the symbol to be rotated.
9. Click OK on the Symbol Selector dialog box.
10. Click the Link Line Symbol Selector button if you want to change the Feature Link Line symbol and repeat steps 4–9.
11. Click OK on the Data Frame Properties dialog box.





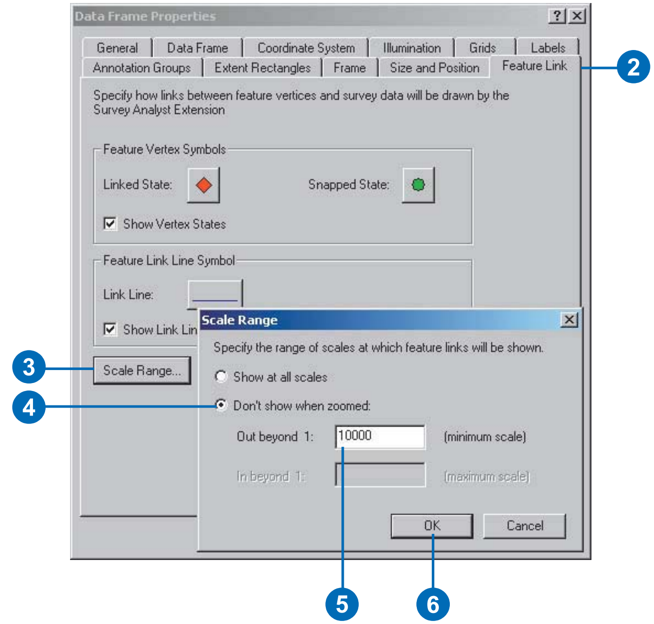
Scale range for feature link symbols

In some cases, you do not want to display the link symbology at very small scales. You can adjust the minimum scale at which the symbology will appear in the Data Frame Properties dialog box.

Changing the scale range for feature link symbols

1. Click the View menu, and click Data Frame Properties.
2. Click the Feature Link tab.
3. Click the Scale Range button.
4. Click Don't show when zoomed.
5. Type the minimum scale in the Out beyond 1 text box.
6. Click OK on the Scale Range dialog box.
7. Click OK on the Data Frame Properties dialog box.

   In this example, the link lines and feature vertex symbols will not be displayed at a scale lower than 1:10000.



Using the Survey Explorer

6

IN THIS CHAPTER

- **An overview of exploring survey data**
- **The Survey Editor toolbar**
- **Working with the Survey Explorer**
- **Creating list pages**
- **Selecting survey objects**
- **Navigating dependencies**
- **Navigating to details**
- **Map highlighting options**
- **Using the Active object context menu**

You can explore and edit your survey data in the *Survey Explorer*. It is important to be able to visualize *survey points* and *measurements* as described in the previous chapter. You also need to view and analyze numerical values of measurements and *coordinates* created in your *survey dataset*. To obtain this information, tools and commands are used to add lists of coordinates, measurements, and *computations* to the Survey Explorer.

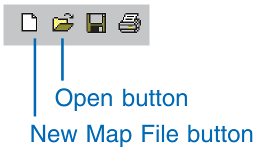
In this chapter, you will interact with the Survey Explorer by:

- Selecting rows of survey objects from a list
- Applying operations to selected rows of survey objects
- Navigating from selected *survey objects* to dependent objects in a computation network
- Moving back and forth between pages stored in a stack
- Viewing the details of a stored survey object

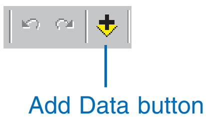
This chapter covers the important tools and commands for exploring and navigating the survey dataset, as well as the details of working with the Survey Explorer.

The following is a general overview of how to explore your survey data using the Survey Explorer.

1. Start ArcMap.
2. Open a map document or create a new one.



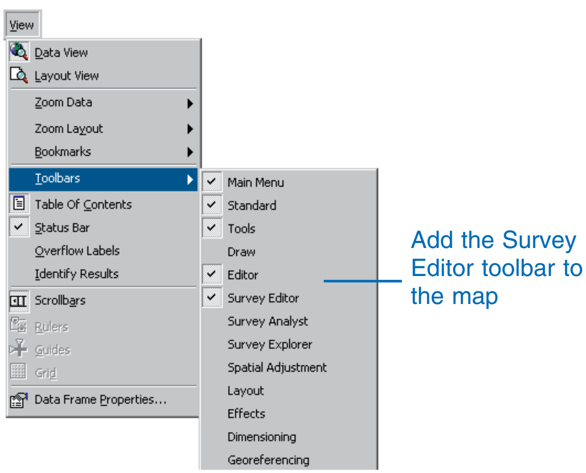
3. Add a survey dataset or survey project that you want to edit to the map.



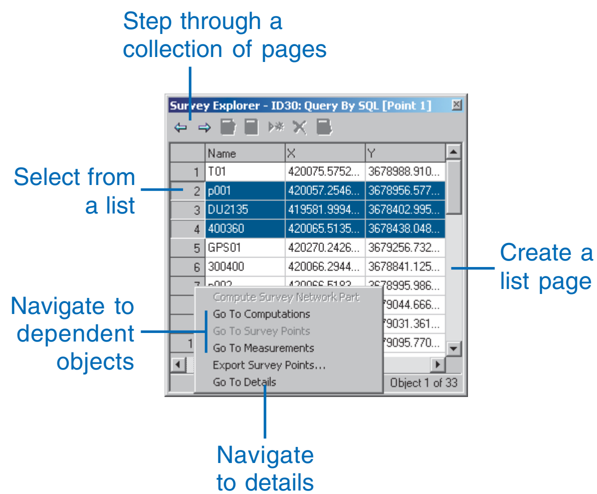
4. Add to the map the survey projects that you want to explore.

   Survey layers are created in the map document.

5. Add the Survey Editor toolbar to the map.



6. Open the Survey Explorer and collect list pages of survey objects.
7. Navigate to the details of listed objects or to new lists of dependent objects.
8. Step through the pages collected in the Survey Explorer.
9. Close the Survey Explorer.

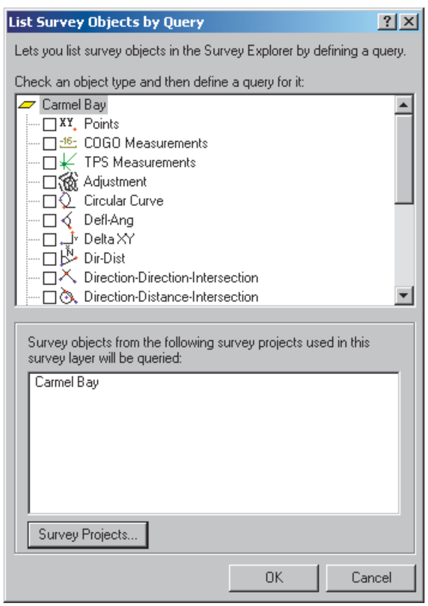


The Survey Editor toolbar

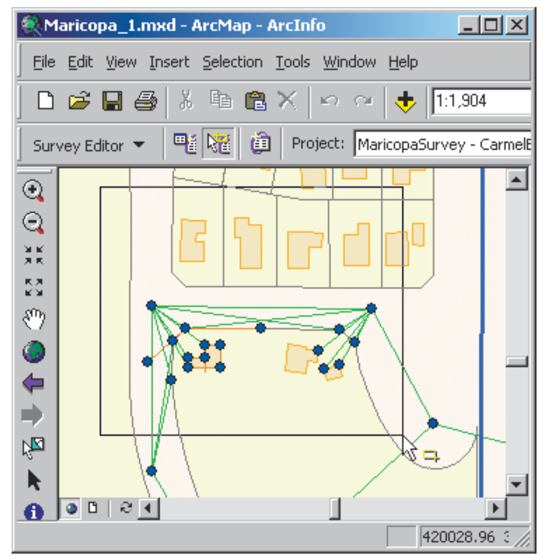
List Survey Objects By Query command: allows you to add lists of survey objects to the Survey Explorer by defining a query.

List Survey Objects tool: allows you to add lists of points and measurements to the Survey Explorer by dragging a box.

Survey Explorer button: opens the Survey Explorer.



Using the List Survey Objects by Query dialog box



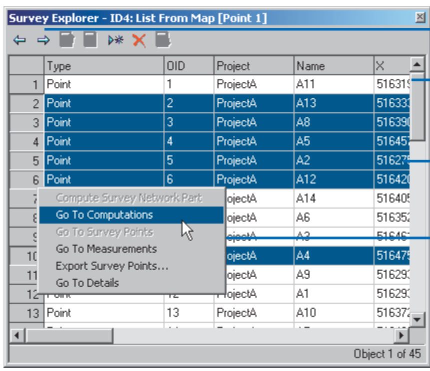
Using the List Survey Objects tool

Working with the Survey Explorer

Explore and edit survey objects in the Survey Explorer. The Survey Explorer is a container for pages of survey information. You create these pages as you work. There are two types of pages: the first, called the *List page*, lists multiple survey objects, and the second, called the *Detail page*, displays a detail view of individual survey objects.

There are different phases to working with the Survey Explorer. First, use tools or commands to collect survey objects from the survey dataset; a List page is created to represent this collection. Next, make a selection from this list of survey objects. Then you can either navigate from the selection to a list of the dependent survey objects in the *computation network*, or you can create a Detail page of a stored survey object.

Using the Backward and Forward buttons, you can step through the Survey Explorer.

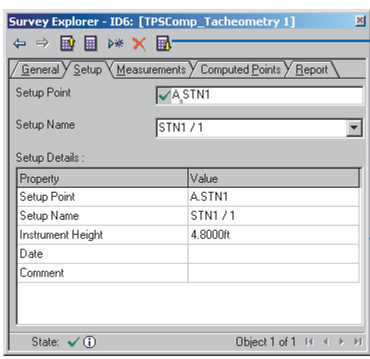


Backward and Forward buttons let you move between Survey Explorer pages.

Survey points can be displayed as attributed list pages.

Selected survey objects are used to start navigation and to do other activities.

A navigation menu lets you explore related survey objects in the survey dataset.



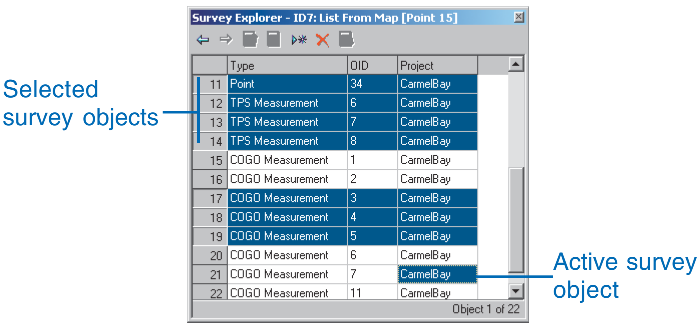
The active and dependent computations can be processed from the Survey Explorer toolbar.

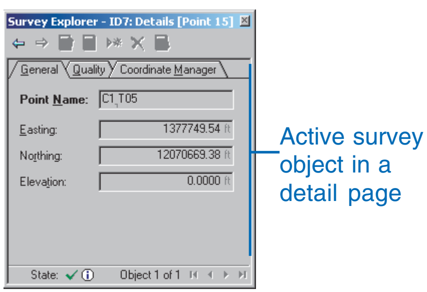
Computation details are displayed in detail pages.

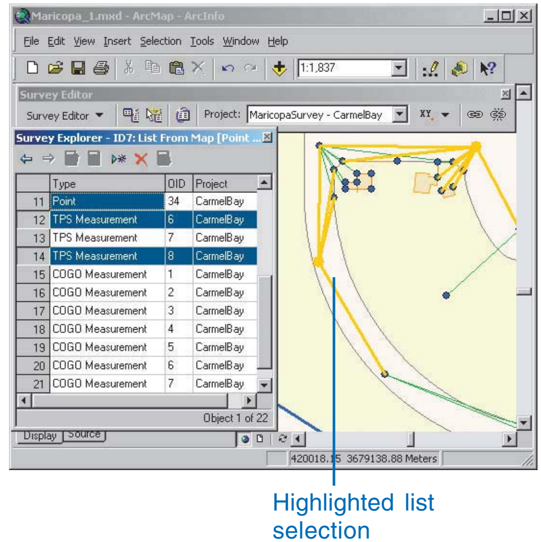
What are selected, active, and highlighted survey objects?

A survey object selection is represented in a list page as one or more selected rows.

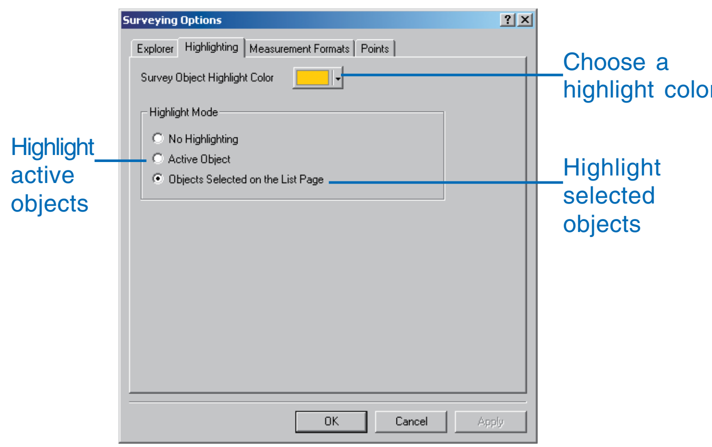
A survey object is active either when its detail view is the visible page in the Survey Explorer or if it is the last row clicked in the list. Only one survey object can be active at a time.







If the selected or active objects are points or measurements, you can choose to highlight them on the map. Different options are available for you to choose how you want the survey points and measurements to be highlighted.



Creating list pages

There are different ways to add pages to the Survey Explorer. A page is added when you:

- Draw a box around objects on the map using the List Survey Objects tool.
- Use the Survey Explorer query command.
- Open the detail view for a survey object.
- Navigate from a set of survey objects to another related set, from features to computations, or to a detail view from an object selected in the Survey Explorer list. ▸

Tip

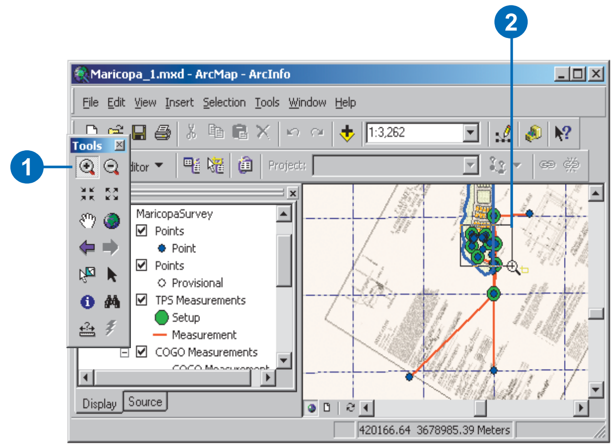
Opening the Survey Explorer automatically

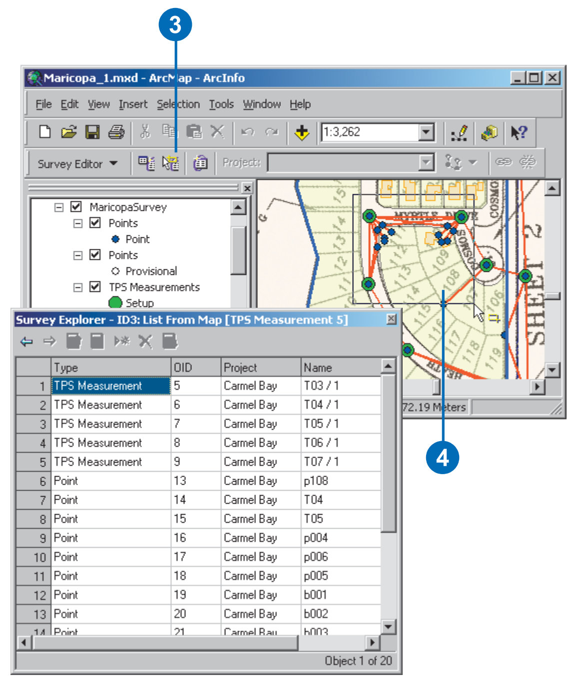
The Survey Explorer will open automatically when you use the List Survey Objects tool or the List Survey Objects By Query command.

Using the List Survey Objects tool

1. Click the Zoom In tool.
2. Click and drag a box to zoom to the area of interest on your map for the measurements and points you want to explore.
3. Click the List Survey Objects tool.
4. Click and drag a box around the survey points and measurements you want to list.

   The Survey Explorer opens, and a new list page is added that contains the measurements and points you listed from the map.





Two types of lists can be displayed. The first type has a mixed set of rows that might have, for instance, survey points, coordinate geometry measurements, and a mix of different computations. This type of list is called a *mixed list*.

The other type of list is the *uniform list*. It has rows that represent survey objects of the same type.

You can determine which survey layers are used with the List Survey Objects tool by interacting with the Set Selectable Survey Layers dialog box.

Computations are survey objects that are not directly visible in the map. You can add computation objects to Survey Explorer lists by using the List Survey Objects By Query command. ►

Tip

How can you resize columns in the list page?

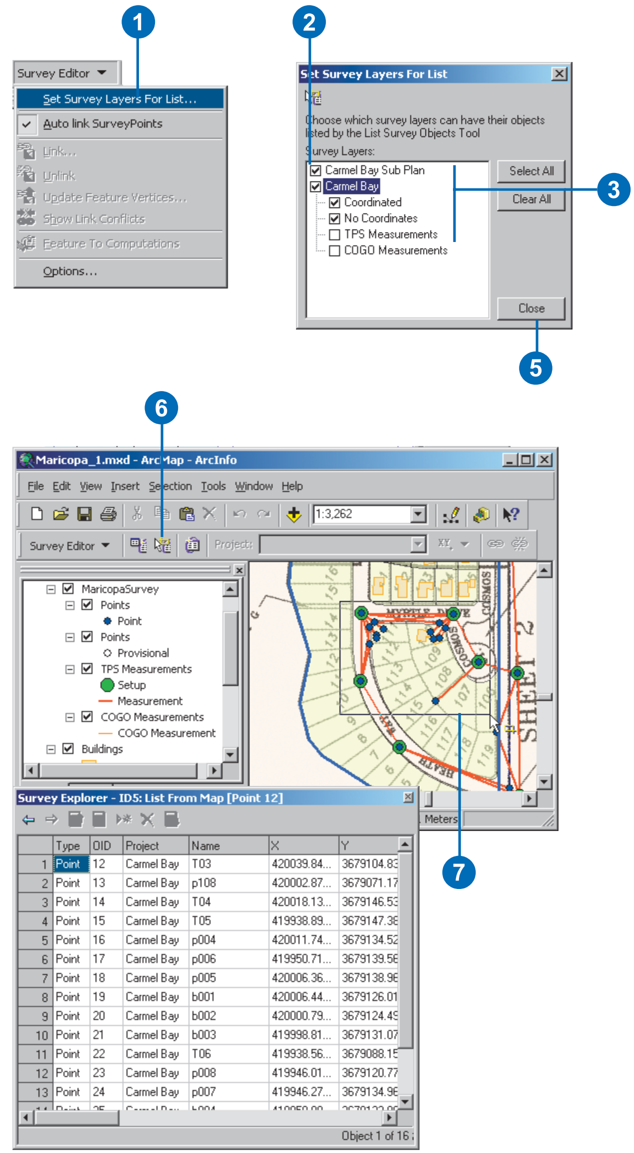
Click and drag a column separator left or right to change its width.

Filtering the type of objects used by the List Survey Objects tool

1. Click Survey Editor in the Survey Editor toolbar and click Set Survey Layers For List.
2. Check the survey layers from which you want to list survey objects.
3. Check the sublayers in a checked survey layer from which you want to list survey objects.
4. Uncheck the sublayers in a checked survey layer from which you do not want to list survey objects.
5. Click Close.
6. Click the List Survey Objects tool.
7. Click and drag a box around the survey points and measurements you want to list.

   The Survey Explorer displays a new filtered list page containing the measurements and points within the box you defined and stored in the sublayers that are checked in the Set Survey Layers For List dialog box.

   This example shows a uniform list of survey points.



Use this dialog box to select the classes of survey objects that you want to add to the list, select the projects that you want these objects to belong to, and for each class, define a specific definition query based on its attributes.

The List Survey Objects by Query dialog box operates from the survey datasets represented on the map as survey layers. When you define a query, you do it for each survey layer. This allows you to further refine the search criteria based on the survey layer properties, such as survey projects and *sublayers*.

Tip

Resizing the Survey Explorer

Move your mouse cursor to the edge or corner of the dialog box, then click and drag the edge or corner until the Survey Explorer is displayed at the size that you want.

Tip

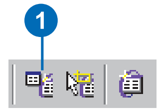
What attributes are displayed in a mixed list?

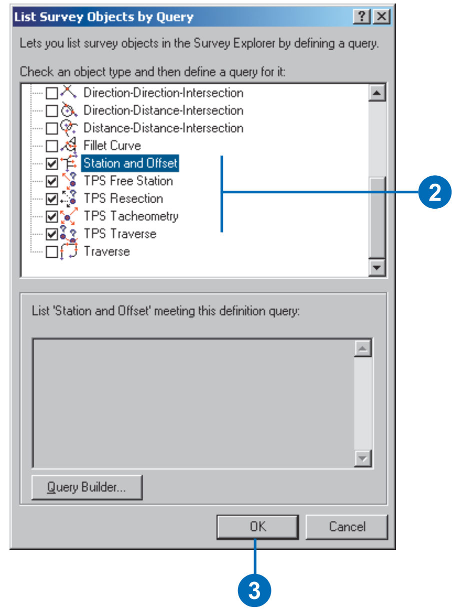
The Survey Explorer will only list the attributes that are common to all of the listed survey objects.

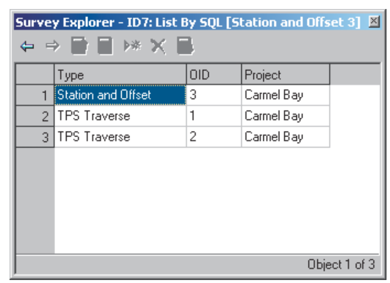
Adding list pages based on specific survey classes

1. Click the List Survey Objects By Query button in the Survey Editor toolbar.
2. Check the survey classes from which you want to list survey objects.
3. Click OK.

   The Survey Explorer displays a new list page containing all the survey objects from the classes you checked in the List Survey Objects By Query dialog box.







This example shows a mixed list of computations.

You can use the query dialog box to create a refined list by selecting a subset of the projects represented on the map.

Tip

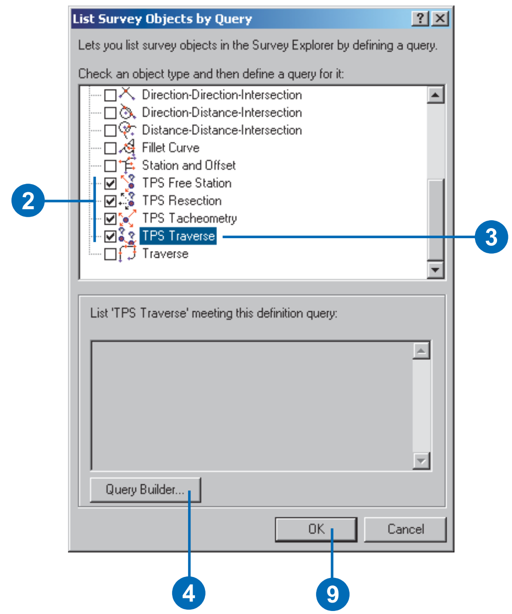
Verifying a query

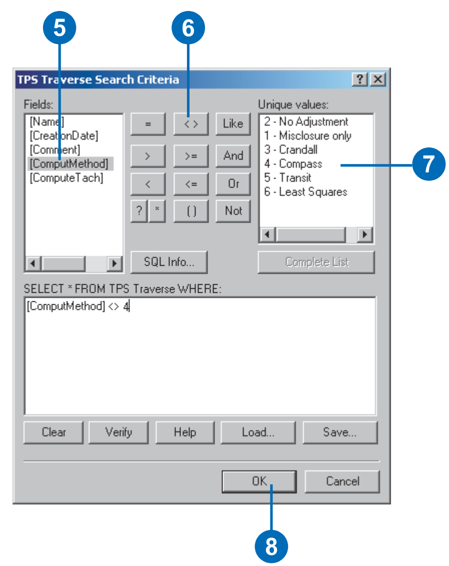
After you have defined your query, click the Verify button to get information back about whether the query is valid or not.

Adding list pages based on survey class attributes

1. Click the List Survey Objects By Query button in the Survey Editor toolbar.
2. Check the survey classes from which you want to list survey objects.
3. Click the survey class for which you want to refine the list based on the class attributes.
4. Click the Query Builder button.
5. Double-click the field you want to use in the query.
6. Click the logical operator you want to use.
7. Double-click the value in the Unique values list that you want to use as part of the query or type the value in the query box.
8. Click OK on the Search Criteria dialog box.
9. Click OK on the List Survey Objects By Query dialog box.

   The list page that is added in this example is the set of total station computations but excludes traverse computations that have been adjusted by the compass method.

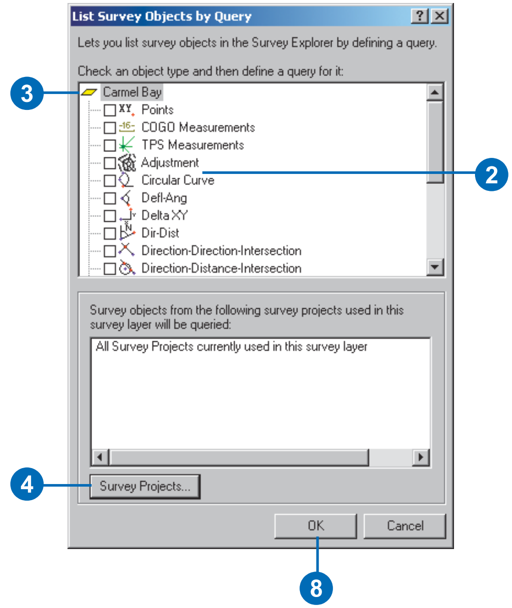


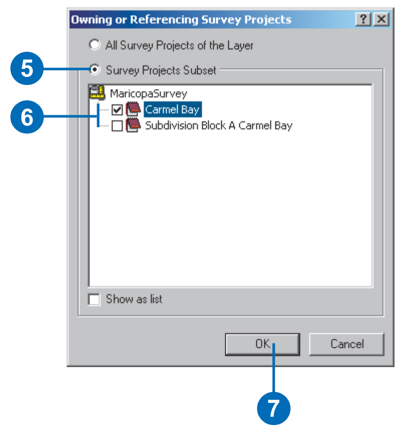


Adding list pages based on projects

1. Click the List Survey Objects By Query button in the Survey Editor toolbar.
2. Check the survey classes from which you want to list survey objects.
3. Click the survey layer name.
4. Click the Survey Projects button.
5. Click the Survey Projects Subset option.
6. Check the projects from which you want to list survey objects.
7. Click OK in the Owning or Referencing Survey Projects dialog box.
8. Click OK in the List Survey Objects by Query dialog box.

   In this example, all survey points belonging to or referenced from the Carmel Bay project will be displayed in a uniform list.





Selecting survey objects

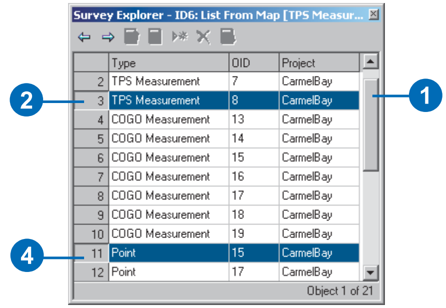
Select survey objects in the Survey Explorer list pages by clicking the objects' row numbers. You can tell when a survey object is selected when all cells in its row are colored and its number field is depressed. You can add to the existing selection of survey objects by holding down the Ctrl key and clicking the additional row numbers of the objects you want to add to the selection. You can also select multiple survey objects by holding down the Shift key while clicking two row numbers that define a block of rows.

Tip

Removing survey objects from the selection

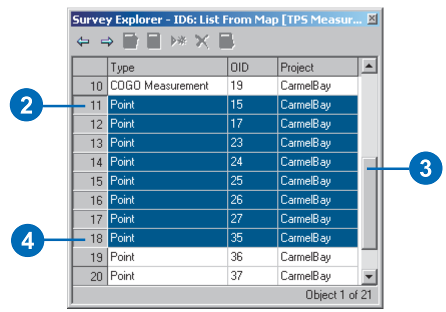
To remove survey objects from the selection, hold down the Ctrl key while you click the row number in the far left column of the Survey Explorer list.

Selecting one or more survey objects



1. Scroll through the list page to find the row of the survey object you want to select.
2. Click the row number in the leftmost column of the list.
3. Scroll through the list to find other objects to add to the selection.
4. Add to the selection by holding down the Ctrl key while repeating step 2.

Selecting multiple survey objects in a block of rows



1. Scroll through the list page to find the first row in the block of rows you want to select.
2. Click the row number in the leftmost column of the list.
3. Scroll through the list to find the last row in the block of rows you want to select.
4. Hold down the Shift key and click the leftmost column of the list.

Navigating dependencies

Chapter 3, 'Survey Analyst concepts,' describes how computations depend on the stored measurements and survey points that they use.

These dependencies can be navigated through the Survey Explorer, allowing you to find stored computations using a navigation menu.

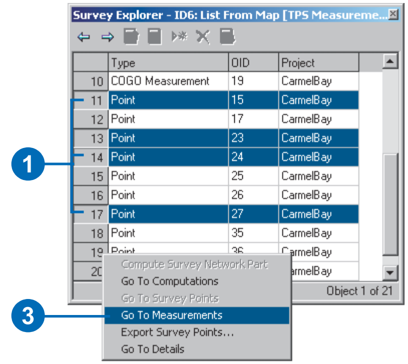
This is useful because, although computations are not directly visible on the map, you can easily identify specific computations from the mapped location of the measurements they use and the survey points they define.

The easiest way to get to computations is to use the List Survey Objects tool, select the points or measurements in the list, then navigate to the list, then navigate to the computations using the navigation menu.

Navigating from selected survey points to a list of measurements

1. Select survey points in the Survey Explorer.
2. Right-click the leftmost column in the Survey Explorer.
3. Click Go To Measurements.

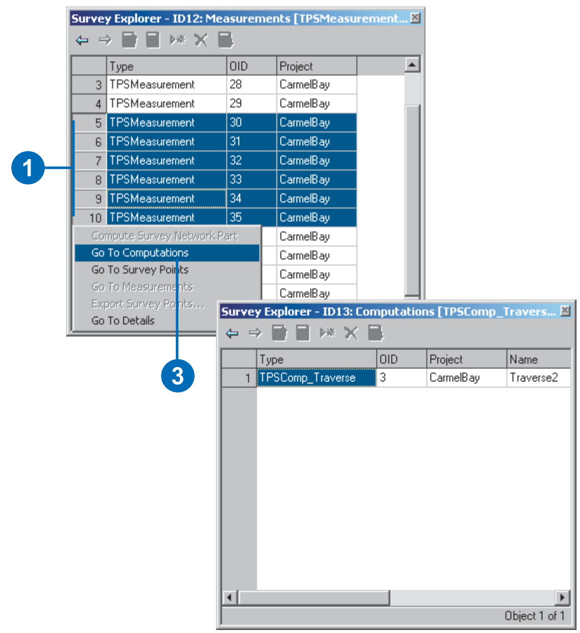
   A new list page of computations is added to the Survey Explorer.



Navigating from selected measurements to their list of computations

1. Select measurements in the Survey Explorer.
2. Right-click the leftmost column in the Survey Explorer.
3. Click Go To Computations.

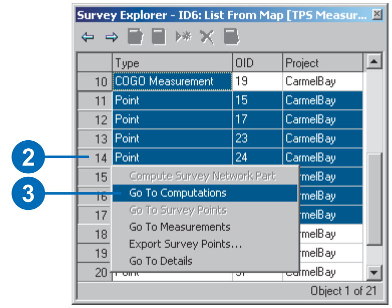
   A new list page of computations is added to the Survey Explorer. In this example, all the measurements are used in a single traverse computation.

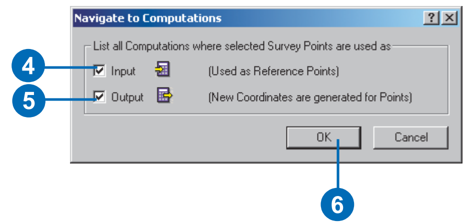


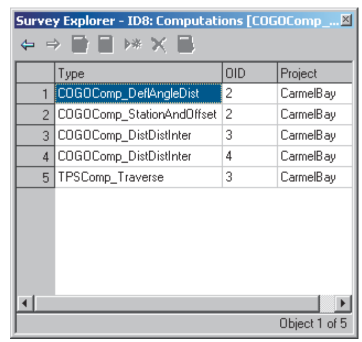
Navigating from selected survey points to a list of dependent computations

1. Select survey points in the Survey Explorer.
2. Right-click the leftmost column in the Survey Explorer.
3. Click Go To Computations.
4. Check using the selected Survey Point(s) if you want a list of computations that use the selected points as input.
5. Check providing coordinates for the selected Survey Point(s) if you want a list of computations that target the selected points.
6. Click OK.

   A new list page of computations is added to the Survey Explorer.







Navigating to details

You will need to edit, view, and work with the numerical values for measurements and coordinates as well as the details of survey points and computations. Adding detail pages to the Survey Explorer is easy—select the computations and click Go To Details in the navigation menu.

If you select more than one survey object, you will be able to step through the detail pages using the Next Object and Previous Object buttons.

Tip

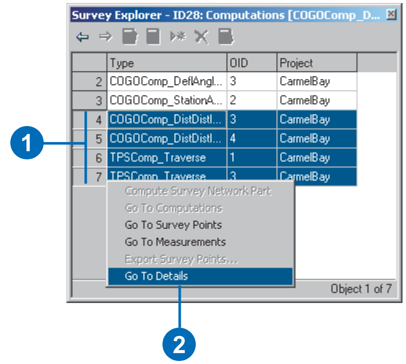
Skipping to the first and last detail pages

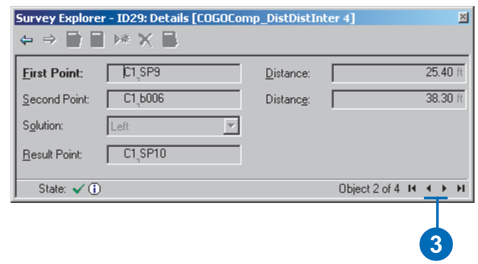
You can skip to the first detail page by clicking the First Object button. Similarly, click the Last Object button to skip to the last detail page.

Navigating to computation details

1. Select the computations in the list for which you want to see detail pages.
2. Right-click the leftmost column in the list and click Go To Details.

   A new set of detail pages for your selected computations is added to the Survey Explorer.
3. Click the Previous Object and Next Object buttons to walk through each of the detail pages.





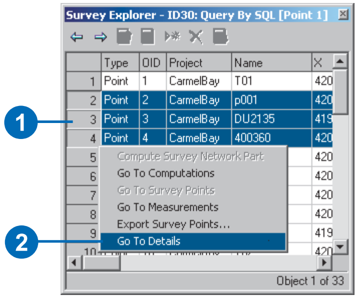
Navigating to survey point details

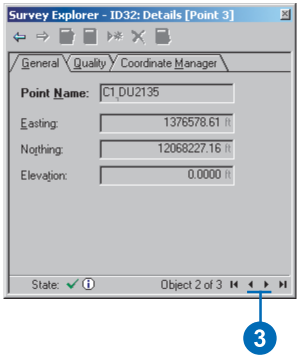
1. Select the survey points in the list for which you want to see detail pages.

2. Right-click the leftmost column in the list and click Go To Details.

   A new set of detail pages for your selected survey points is added to the Survey Explorer.

3. Click the Previous Object and Next Object buttons to move through each of the detail pages.



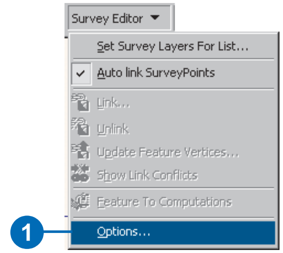


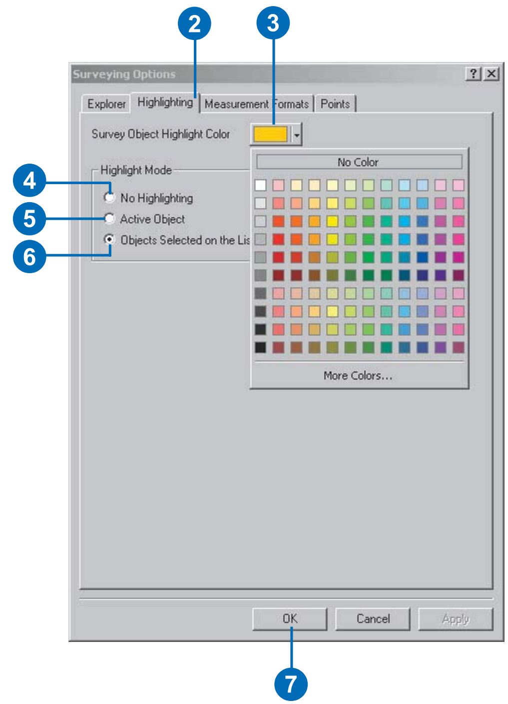
Map highlighting options

Measurements and survey points that are selected in the Survey Explorer are highlighted by default on the map. You can select a highlight color or turn off highlighting. You can also choose to highlight active objects only. This option is useful when, for instance, you are paging through a series of survey point detail pages. Only the survey point for which you are viewing a detail page is highlighted.

Changing highlighting options

1. Click Survey Editor and click Options.
2. Click the Highlighting tab.
3. Click the Color button to choose a different highlight color.
4. Click No Highlighting to turn off all map highlighting.
5. Click Active Object to turn on map highlighting for the active objects only.
6. Click Objects Selected on the List page for all selected objects.
7. Click OK.





Using the Active object context menu

The previous sections show how you can use the map to navigate to survey objects in the Survey Explorer. You can also use the Survey Explorer list pages to manipulate the map extents so you can zoom or pan to specific survey points and measurements using the Active object context menu.

You can also use this context menu to flash measurements or survey points.

Tip

Zooming to an Active object

You can zoom to a point or measurement by right-clicking a cell in its list page row and clicking Zoom To.

Tip

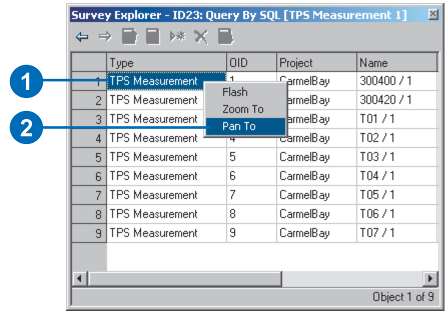
Using the Active object context menu in a detail page

Right-click anywhere on the detail page to open the Active object context menu.

Panning to a survey point or measurement

1. Right-click any cell of a row for the measurement or survey point that you want to bring into view on the map.
2. Click Pan To.

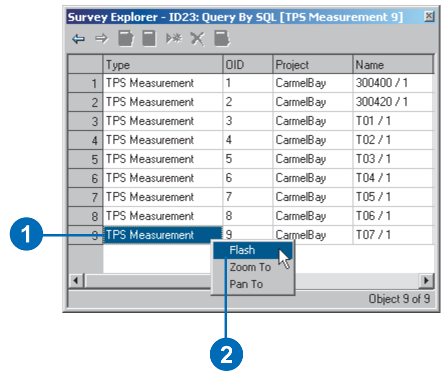
   The map extents shift so that the survey point or measurement is displayed in the center of the map.



Flashing active objects

1. Right-click any cell of a row for the measurement or survey point that you want to flash on the map.
2. Click Flash.

   The active measurement or survey point flashes.



7

Using computations

IN THIS CHAPTER

- **Editing survey data—an overview**
- **The Survey Editor toolbar**
- **Using computation detail pages**
- **The Survey Explorer toolbar**
- **Identifying computation states**
- **Creating a new survey point**
- **Preparing the computation environment**
- **Using Simple COGO computations**
- **Using intersection computations**
- **Using circular curve computations**
- **Using the station and offset**
- **Using the COGO Traverse**
- **Exploring and using TPS computations**
- **Reporting computation results**

Previous chapters illustrate how to import survey data and how to display and explore the *survey points*, *measurements*, and *computations* stored in a survey dataset.

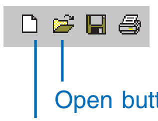
This chapter presents the computations used for coordinate geometry (COGO), and the computations used for processing measurements from the theodolite family of surveying equipment (TPS). You will learn the purpose of each computation and how to apply it to define new coordinates for survey points.

In this chapter, you will also learn how to work with the reporting functionality available for computations.

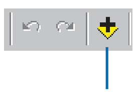
Editing survey data—an overview

The following is a general overview of how to edit your survey data using the Survey Editor and Editor toolbars.

1. Start ArcMap.
2. Open a map document or create a new one.



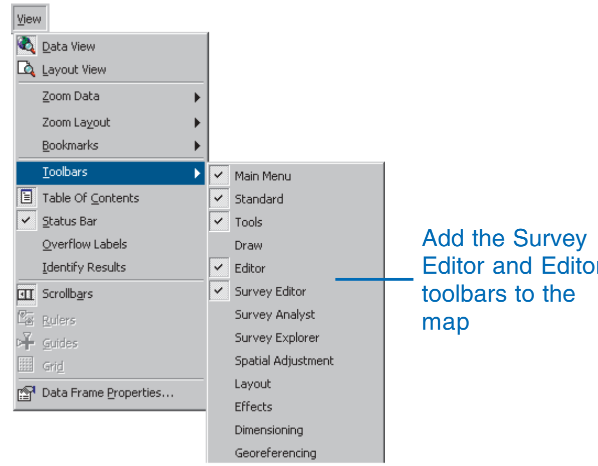
3. Add a survey dataset or survey project that you want to edit to the map.



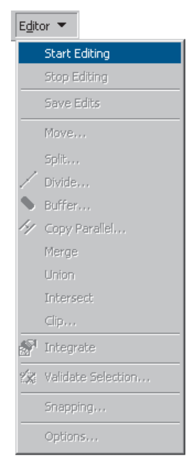
4. Add the survey projects and feature classes you want to edit to the map.

Survey layers and feature layers are created in the map document.

5. Add the Survey Editor and Editor toolbars to the map.



6. Click Start Editing in the Editor menu.

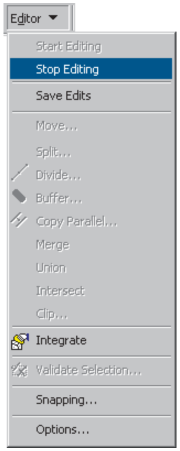


This starts an edit session. In addition to creating and modifying features and feature attributes, you can also create and modify survey objects in the geodatabase during an edit session.

7. Select a target project from those represented on the map that will include all of the new survey objects.

8. Create new survey points and computations; edit existing survey points and computations.

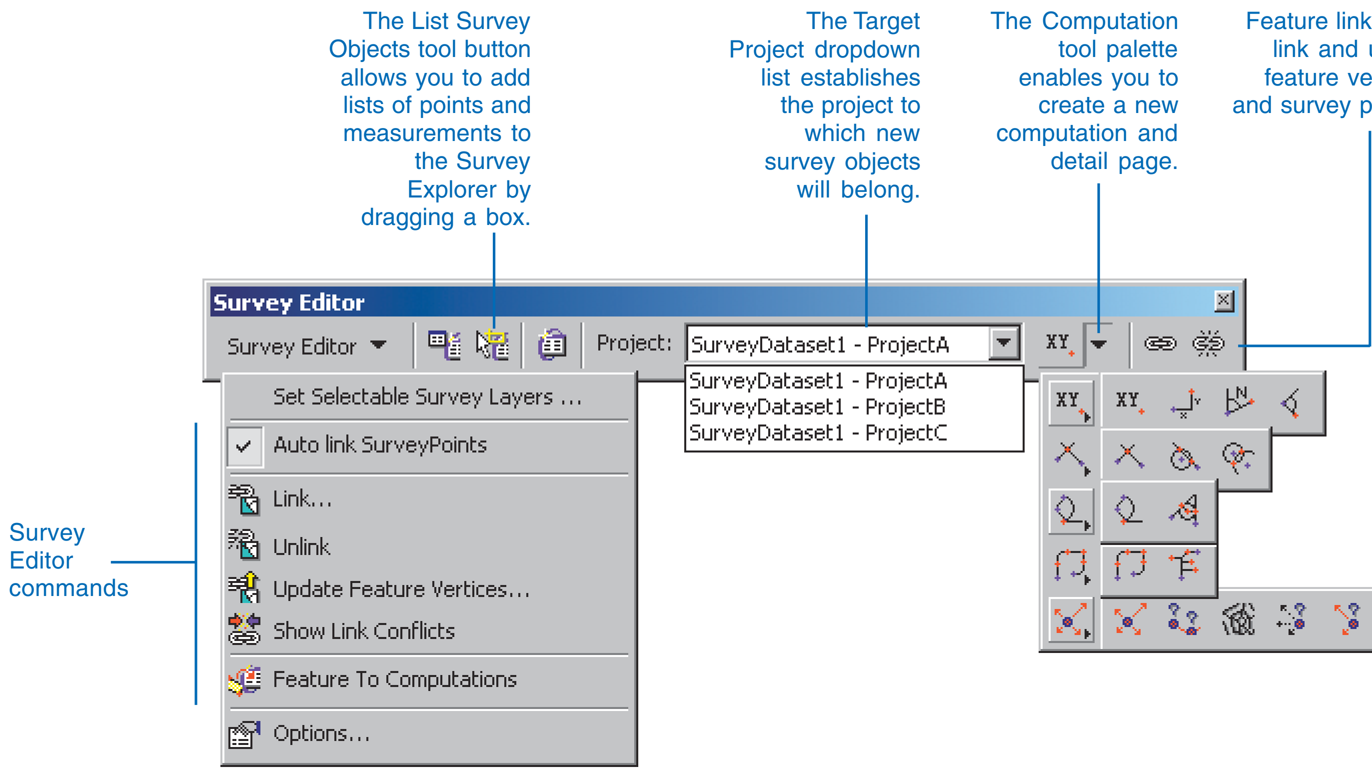
9. Click Stop Editing from the Editor menu and click Yes when prompted to save the edits.



You do not need to save the map document. The edits you have made to the database will be visible when you next view the data.

For more information on general editing in ArcMap, see *Editing in ArcGIS* or refer to Chapter 8, 'Editing feature geometry.'

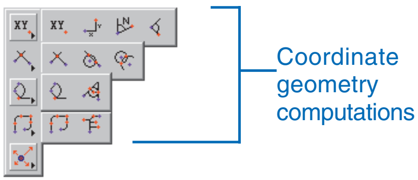
The Survey Editor toolbar

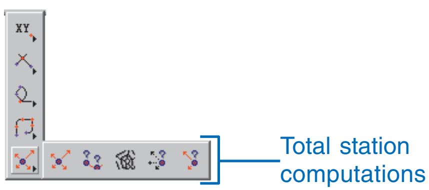


Using computation detail pages

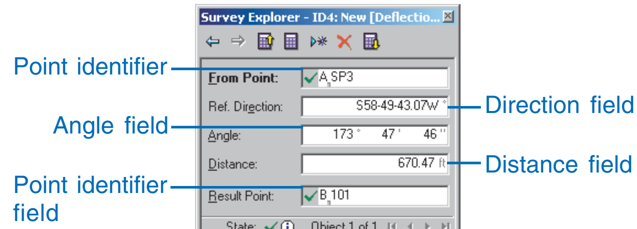
As described in the previous chapter, there are a number of ways to add pages to the Survey Explorer while exploring your data. Empty computation detail pages are also added to the Survey Explorer whenever you click a computation tool on the Computation palette. The detail page for the computation lets you add new parameters to the computation you're creating.

The Computation palette groups together the tools used for working within each computation package.





Though the detail pages for computations can be different, they all have a common environment with standard input fields for specific types of information. For instance, when defining a particular survey point for use in a computation, you need to specify its name—you do this in the *point identifier field*. Additional fields are available for entering values for the different measurement types. You enter angles in the *angle field*, distances in the *distance field*, and directions in the *direction field*.

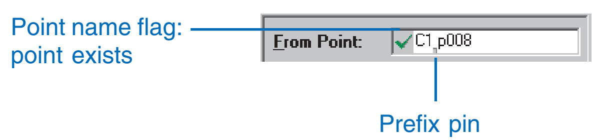


Deflection angle distance computation showing different input fields

Point identifier field

For indentifying points for use in computations, either as a source of coordinates or as a target for coordinates, the point identifier fields are displayed on each computation page. The point identifier field has useful functionality, providing:

- A *prefix pin* separating the prefix and point name strings
- A *point name flag* which gives an immediate visual indication after each keystroke of whether or not a point with the name you type exists in the survey dataset



Angle field

Angles are used as input for several COGO computations, and also for most computations that process TPS measurements. The angle field is used to represent *horizontal angles* and *zenith angles*.

Horizontal angles are formed by the intersection of two lines in a horizontal plane, and are used in both TPS and COGO computations. The horizontal angle is the difference between two readings on the horizontal circle of a TPS intrument.

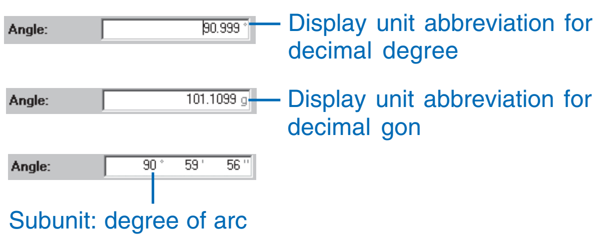
Vertical angles are formed by the intersection of two lines in a vertical plane and are entered for zenith angles observed on the vertical circle of a TPS instrument.

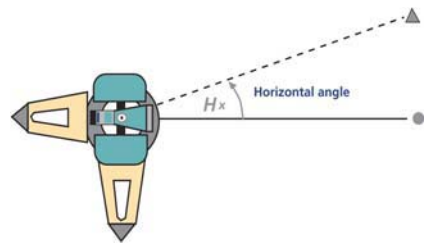
In addition to being used for input, the angle field can be used to report angles between lines. The angle field provides the following functionality:

- Entry fields for each subunit.
- Visual identification of the *display unit*.

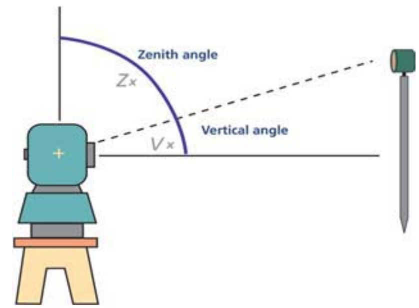
You can use the map options to change the display format and units for angles, and you can also create your own custom angle unit. The units supported for angles are:

- Gradians/gons
- Decimal degrees
- Degrees-minutes-seconds

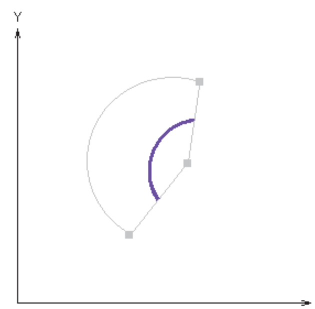




Horizontal angles observed with a total station



Zenith angles observed with a total station



Horizontal angle entered in a COGO computation

Direction field

Directions are used as input for many computations. The direction fields displayed in computation pages are used to enter *bearings* or *azimuths* between an input survey point and a computed survey point. Directions are based on *grid meridian*. In the case of TPS computations, directions are reported in relation to the zero reading on the oriented or unoriented horizontal circle of a TPS instrument.

In addition to being used for input, the direction field can be used to report azimuths or bearings between two existing points.

The direction field provides the following:

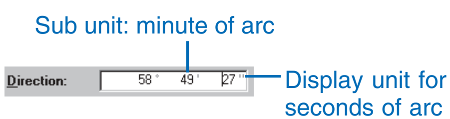
- Ability to switch between bearing or azimuth entry modes by changing the display units
- Entry fields for each sub unit
- Visual identification of the display unit

Use the Survey Editor options to change the display format and units for directions. The direction units supported are:

- North azimuth based on gradians/gons, decimal degrees, and degrees-minutes-seconds

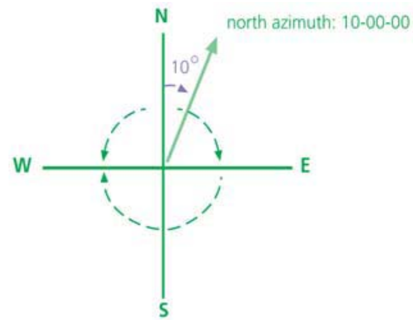
Azimuth format

Azimuth format

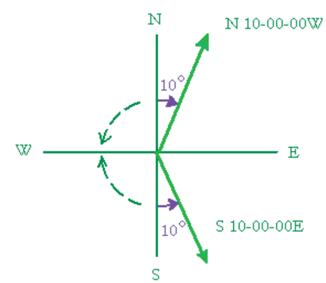


- Quadrant bearing based on degrees minutes seconds

Quadrant bearing format



North azimuth direction



Quadrant bearing direction

Length and Height fields

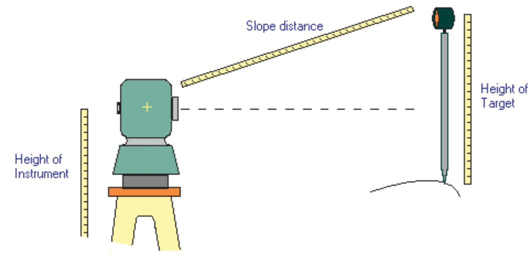
Lengths are used as input for most computations. The length field displayed in computation pages can be used to enter or report distances or lengths, or for the following:

- Horizontal line between an input survey point and a computed survey point
- Circular curve arc length, chord length, or radius
- Values for standard deviations and limits for horizontal and slope distances
- Slope distance between two survey points

Heights are used in total station computations to report or enter the following:

- Height of instrument
- Height of target
- Values for standard deviations and limits for height values

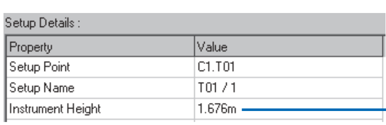
You can use the Survey Editor options to change the display units for lengths and heights, and you can also create your own custom length or height units. The units supported include meters, International feet, and U.S. feet.



Height and length observations for total station measurements

Length field: distance in units of feet

Height field: standard deviation value for elevation in units of meters



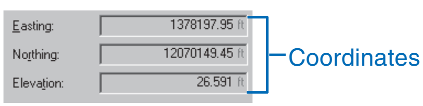
Height field: instrument height in units of meters

Coordinate fields

Coordinates can be easting, northing, and elevation values used to identify a position in space with origins based on a projected or geographic coordinate system and on a vertical datum. In Survey Analyst, this datum is assumed to be mean sea level. Coordinate fields are used to display and enter these values for survey points; they are one of the following:

- X coordinate (easting)
- Y coordinate (northing)
- Z coordinate (elevation)

You can use the Survey Editor options to change the display units for projected coordinate system coordinates or for geographic coordinate system coordinates. Geographic coordinates are supported in units of degrees-minutes-seconds, and projected coordinates are supported in units of meters, International feet, and U.S. feet.



Entering values using the map

The previous sections describe how to enter measurement values and point names into the computation detail pages. Often the points required in a computation are visible on the map. In addition, the values for coordinate geometry computations may be available from the relative geometry of survey points and features represented on the map.

In addition to directly typing point names and computation values, there are other map-based methods for completing the computation fields.

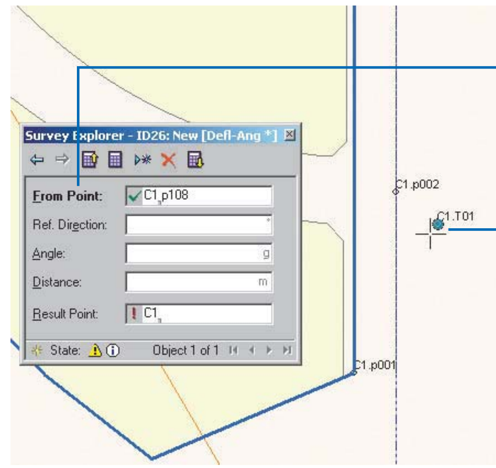
Each computation page works together with a map tool called the *Computation tool*. This tool integrates the computation pages and the map. It honors the snapping environment of the editor.

While working with the detail pages, you can use the Computation tool to retrieve information from the map. The tool lets you make entries into fields by snapping and clicking to feature geometry or by dragging out directions and lengths.

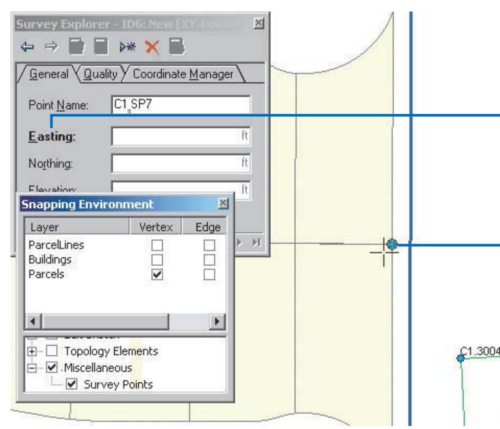
When a particular field is the current target for data entry—the *focus field*—the title of the field is displayed in bold text, giving a visual indication of the target for data entry.

This section illustrates the basic concept for working with the Computation tool and the different focus fields.

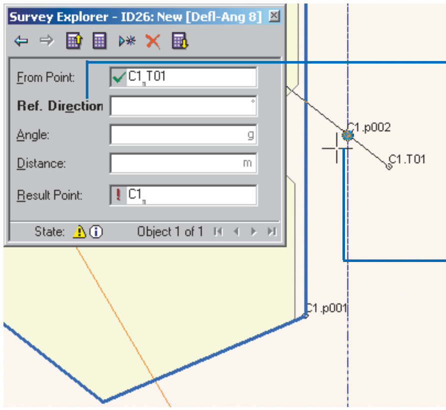
Point field entry



Coordinate field entry

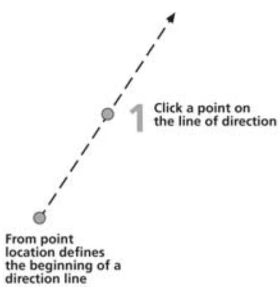


Direction field entry by the single-click method

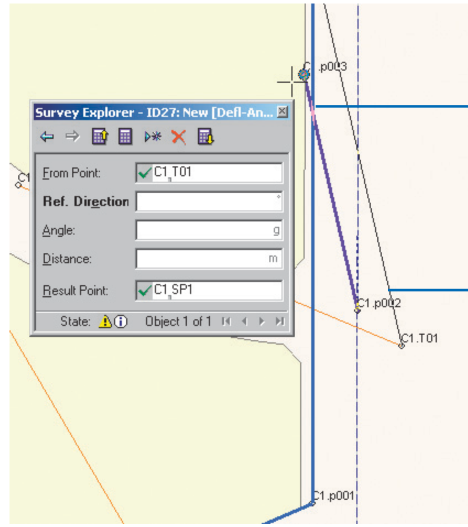


Direction field text is bold and has focus.

The from point location defines the start of the line of direction. Click the location on the map that defines the end of the direction line.

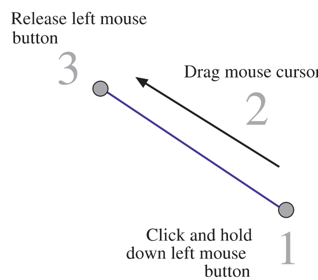


Direction field entry by the drag method

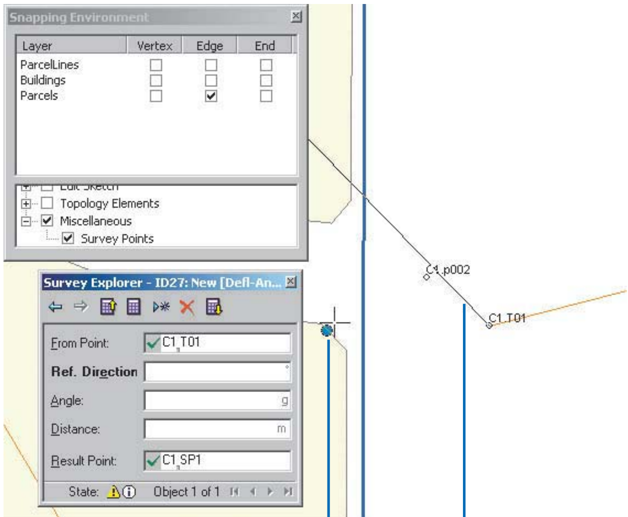


Drag a line that defines the direction you want to enter; release the left mouse button at any map location or after snapping to a known location.

Map feedback indicates the drag direction.



Direction field entry by snapping to edges



Snap to the edge of a feature to capture the direction of the edge. Since there are two possible directions for a segment, the direction used is based on which end of the segment you click closest to.

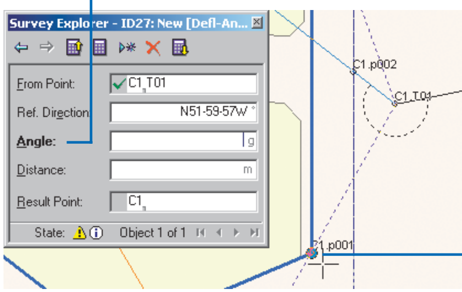
Direction of map feedback shows to which side of the segment the cursor is snapped.

Angle field entry

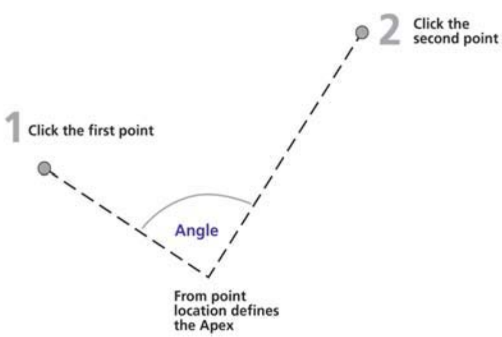
You enter an angle from the map by defining two directions using any combination of the methods described in the previous sections for defining directions. The angle entered is defined by the difference between the two directions.

Angle field entry by the two-click method

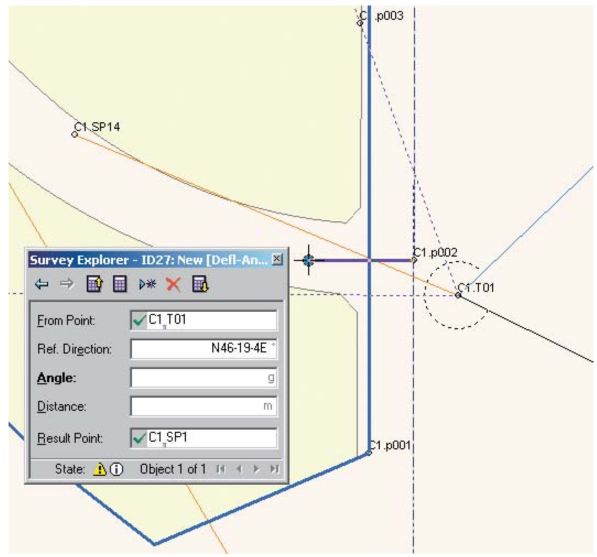
Angle text is bold and Angle field has focus.

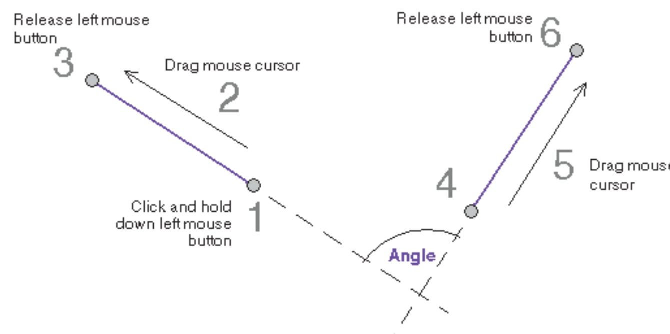


Click two locations on the map, so that the apex at the from point location defines the angle you want to enter.

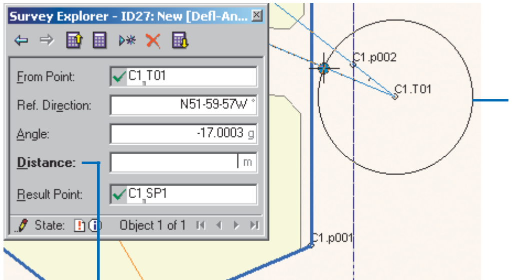


Angle field entry by dragging two directions



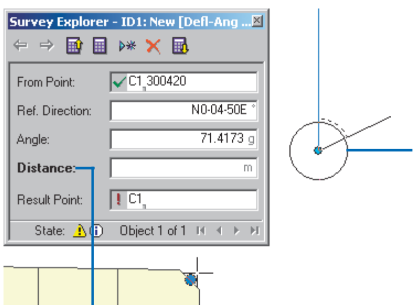


Distance field entry by the click method



Bold text indicates that the Distance field has focus.

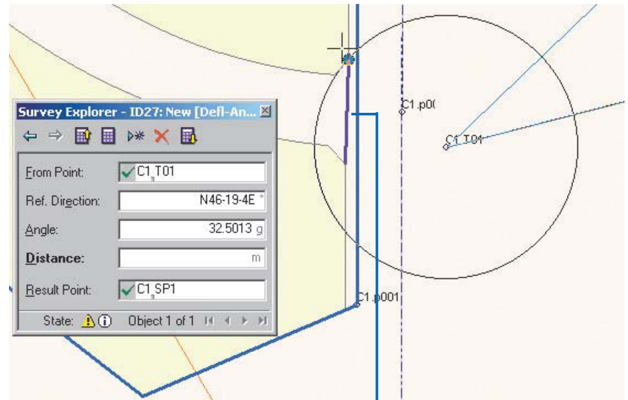
Distance field entry by snapping to edges



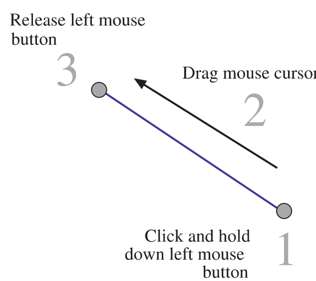
Distance matches the length of the snapped feature segment.

Bold text indicates that the Distance field has focus.

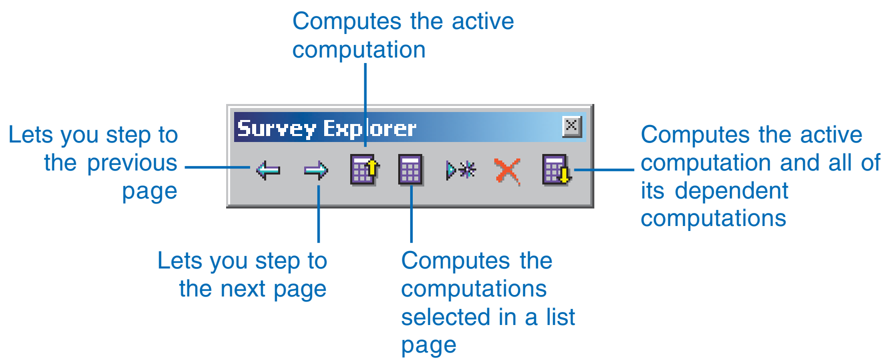
Distance field entry by the drag method

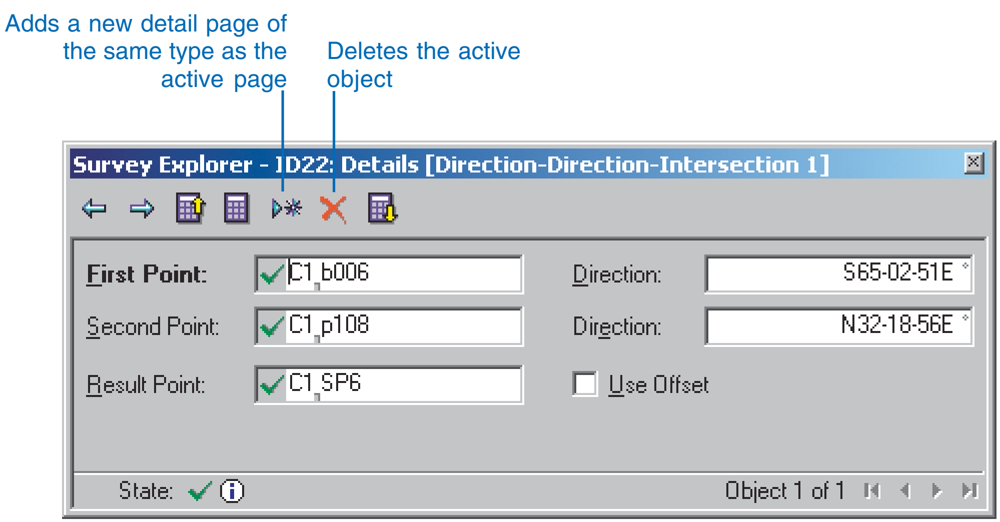


Drag out a distance. You can snap to feature geometry or survey points.



The Survey Explorer toolbar



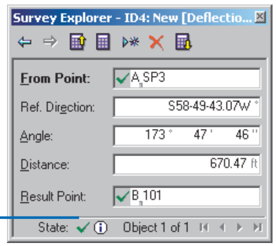


Survey Explorer with its toolbar docked

Identifying computation states

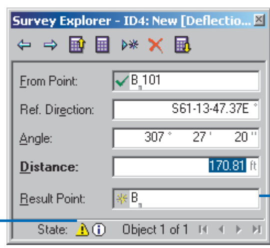
A computation is always in one of four states: *valid*, *incomplete*, *out-of-date*, or *incorrect*. The state of a computation is displayed as an icon in the status bar of the detail page.

A computation is valid when the latest edits to the computation have been stored and it has been successfully computed.



Computation state: valid

A computation is incomplete until all the required parameters of the computation have been defined.

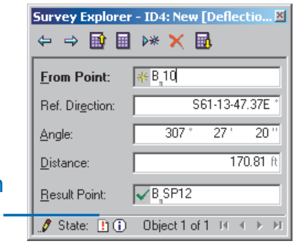


Computation state: incomplete

Point identifier field is not complete

After a stored computation is edited, it is in the out-of-date state until it is recomputed. A computation can also be out-of-date if one or more of the points that it uses as a source of coordinates have been edited. If you make changes to a computation that cause it to be out-of-date, any other computations that depend on this computation also have their states changed to out-of-date.

While working with computations, limits exist that determine when a computation does or does not have a solution. These can be geometric limits or error limits that you define.

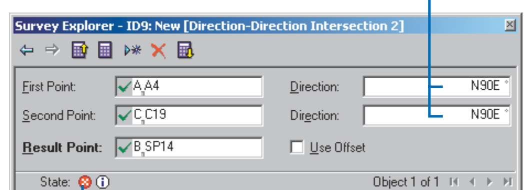


Computation state: out-of-date

For instance, there is a geometric limit in a computation for intersecting directions; there is no solution if the directions are identical since, in this case, they can never intersect at a specific coordinate.

Survey Analyst assigns the incorrect state to computations that are outside the geometric or error limits.

Identical directions do not intersect



Computation state: incorrect

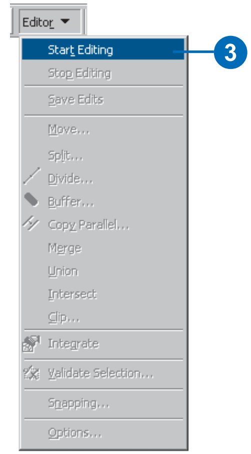
Creating a new survey point

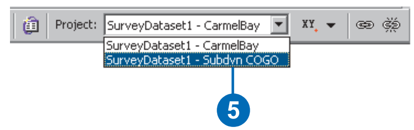
Survey points define the positions of geographic features. They are stored in a survey dataset, are owned by a survey project, and are used for the following purposes:

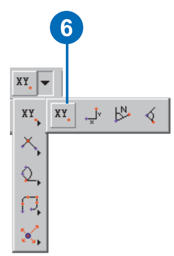
- Defining a discrete physical location on the earth's surface
- Collecting multiple coordinate representations for a physical location. Since surveyors often compute different coordinate values for the same positions, survey points are containers that hold multiple coordinates.
- Providing control for computing new coordinates, or updating existing coordinates
- Collectively defining a framework of control for feature geometry ▸

Typing coordinates for a new survey point

1. Start ArcMap, add the Editor toolbar, and add the Survey Editor toolbar.
2. Add to the map the *survey project* in which you want to create a survey point.
3. Click the Editor menu in the Editor toolbar and click Start Editing.
4. Click Snapping in the Editor menu and click Survey Points in the Snapping Environment dialog box.
5. Click the Project dropdown arrow in the Survey Editor toolbar, then click the survey project that should own the new survey point.
6. Click the Computation tool palette dropdown arrow, move the cursor to the first row of buttons on the palette, and click the XY tool. ▸







You are not able to start defining new coordinates through computations until at least one coordinated survey point is available as a starting location.

The XY tool is used to add new coordinates to existing survey points or to create new survey points. This tool also allows you to define quality information for new points.

Tip

New Object button

The New Object button on the Survey Explorer toolbar lets you add a new detail page for a computation using the active object as a template.

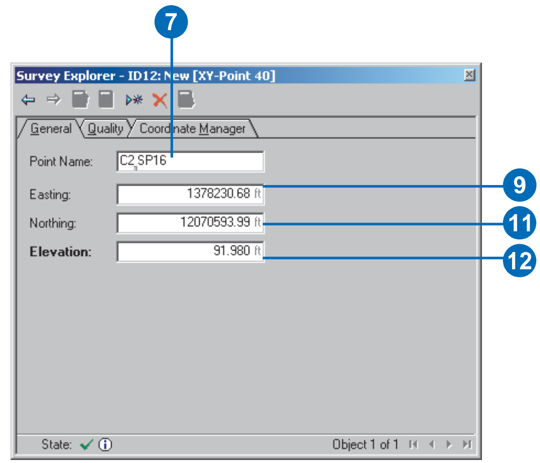
See Also

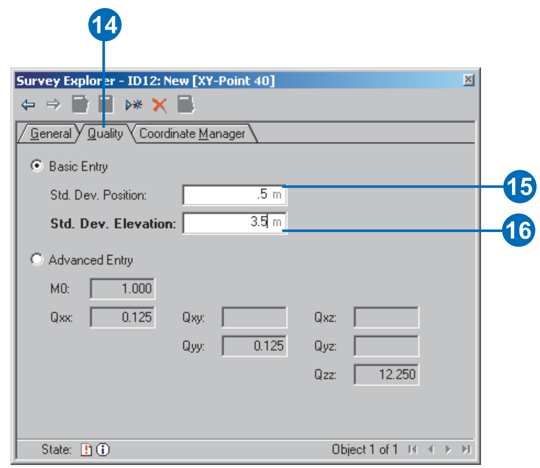
For more information on working with coordinate geometry computations and the edit sketch, refer to Chapter 8, 'Editing feature geometry.'

7. Type a name for the point if you do not want to use the default name.
8. Press Tab.
9. Type the Easting value into the first coordinate field.
10. Press Tab.
11. Type the Northing value into the second coordinate field and press Tab.
12. If an elevation is available, type an Elevation value into the third coordinate field and press Enter.

    The new survey point is added into the survey dataset.
13. Skip steps 13—16 if you do not want to add standard deviations for the survey point coordinates.
14. Click the Quality tab
15. Type a standard deviation value for Position and press Tab.
16. Type a standard deviation value for Elevation.
17. Press Enter.

    The new survey point has standard deviations assigned.





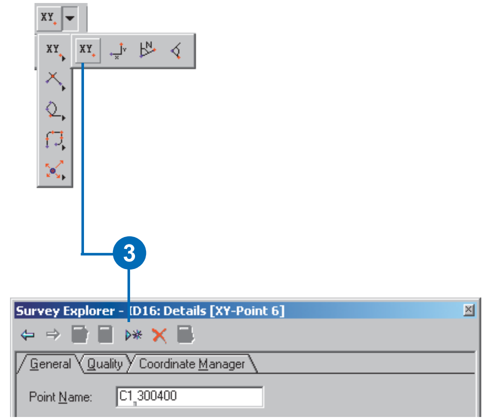
Tip

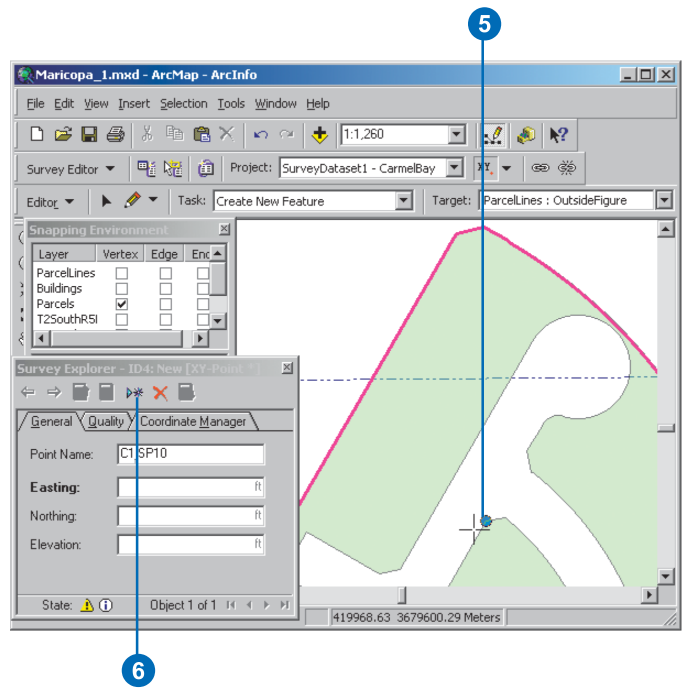
Autocomplete

Instead of clicking the New Object button after creating each survey point, you can check the Autocomplete check box on the active object context menu for any point.

Digitizing a sequence of new survey points

1. Click Snapping in the Editor menu and click Survey Points in the Snapping Environment dialog box.
2. Click the Project dropdown arrow in the Survey Editor toolbar, then click the survey project that should own the digitized survey points.
3. Click the Computation tool palette dropdown arrow, move the cursor to the first row of buttons on the palette, and click the XY tool. If a detail page for the XY tool is open, click the new object button.
4. Type a name for the point if you do not want to use the default name. Press Tab.
5. Click the map at the location where you want to digitize a new survey point.
6. Click the New Object button. Repeat steps 4 and 5 for each new digitized survey point.





Preparing the computation environment

The previous section described how you can enter the coordinates for new survey points.

Usually, most of the coordinates in a survey project are not directly available for entry this way. Instead, you define these coordinates by processing observed measurements in computations.

Consequently, to make the computations as easy to work with as possible, it is important to adapt the computation environment to your needs.

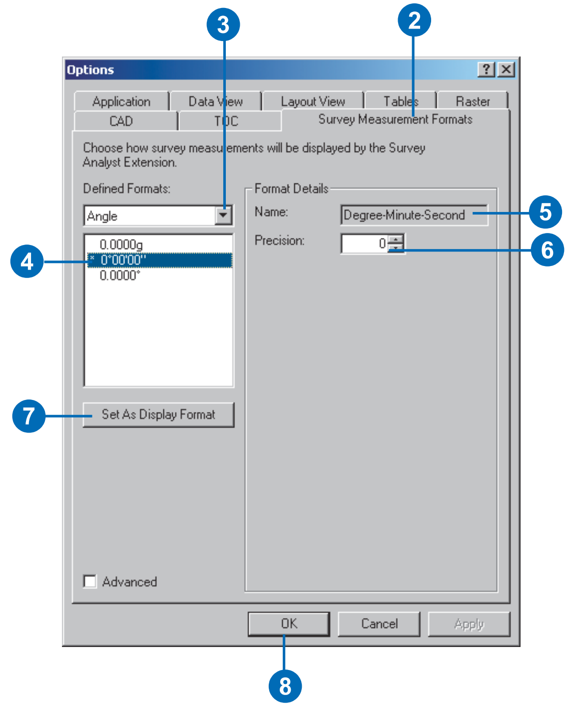
Display units

While working with computations, you will need to enter the measurements in the same units as the data source. You can change the display units for:

- Direction fields
- Angle fields
- Length and Height (distance) fields
- Coordinate fields ►

Setting the display units

1. Click the Tools menu and click Options.
2. Click the Survey Measurement Formats tab.
3. Click the Defined Formats dropdown arrow and click the unit type for which you want to set the display.
4. Click the unit in the units list.
5. Verify the name in the Format Details box to make sure it is the unit that you want to use.
6. Type the Precision for the unit by entering the number of decimal places to display.
7. Click the Set As Display Format button.
8. Click OK.



In addition, you can create your own specific unit based on *scalar reference*. For more information on scalar reference, see Chapter 4, 'Organizing survey data'.

Defining an angle correction and distance scale factor for COGO computations

For planar coordinate geometry, it is sometimes useful to apply correction angles to the entered directions and a scale correction to entered distances.

These corrections are required, for example, when:

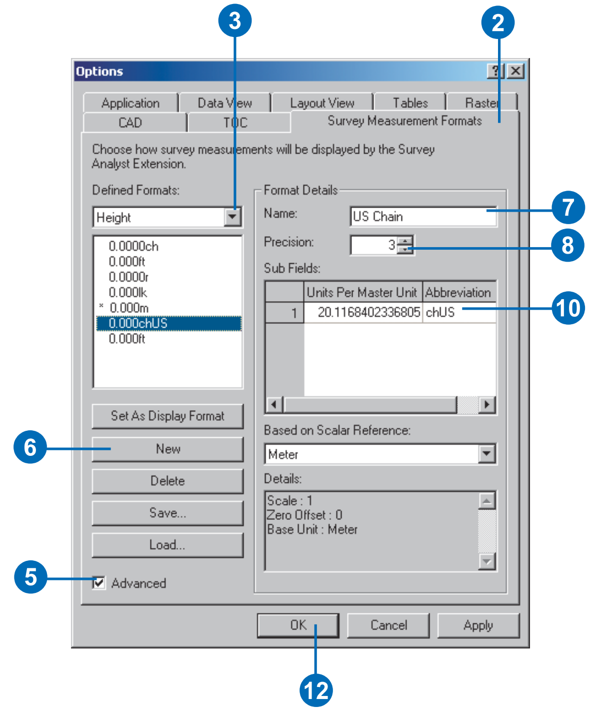
- Directions in your source data are based on an assumed north that is different from the grid north of your project's coordinate system.
- Distances from your source data are based on ground distances that have not been reduced to the ellipsoid of your project's coordinate system.

Each survey project has its own angle correction and scale factor.

The entered direction and distance values are not altered when they are stored in the survey dataset. ►

Creating a custom display unit

1. Click the Tools menu and click Options.
2. Click the Measurement Formats tab.
3. Click the Defined Formats dropdown arrow and click the unit type for which you want to create a custom unit.
4. Click the unit in the units list on which you want to base the custom unit.
5. Check Advanced.
6. Click the New button.
7. Type a name for the new unit in the Name text box and press Tab.
8. Type the Precision for the unit by entering the number of decimal places to display. Press Tab.
9. Type the number of units per master unit. (In this example it is the number of units per meter.)
10. Click Tab and type an abbreviation for the unit.
11. Click the Set As Display Format button.
12. Click OK.



Rather, the corrections are a primitive transformation that is applied directly as part of the computation. The computed coordinates are affected, not the entered values.

Automated point naming

When point identifier fields are used to define new survey points, they automatically provide a default point name.

Often you would like to use a naming convention for particular categories of survey points. For instance, you may prefer all traverse points to start with the character string Tv and be named in sequence Tv10, Tv20, Tv30, and so on.

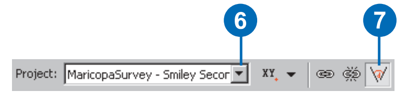
You control this default name by typing the alpha portion of the string and choosing an increment to be added to the numerical portion of the string. This naming format and increment is applied for each new default point name displayed. ▸

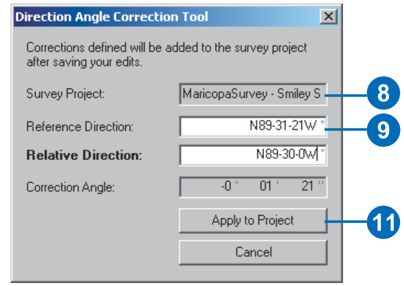
See Also

To learn more about dragging directions and distances, see the section 'Using Computation detail pages' in this chapter.

Defining a correction angle for COGO computations

1. Click the Tools menu and click Customize.
2. Click the Commands tab.
3. Click Survey Editor in the Categories list.
4. Drag and drop the Direction Angle Correction command onto the Survey Editor toolbar. Close the Customize dialog box.
5. Click the Editor menu in the Editor toolbar and click Start Editing.
6. Click the Project dropdown arrow in the Survey Editor toolbar, then click the survey project for which you want to change the correction angle.
7. Click the Direction Angle Correction button. The Direction Angle Correction Tool dialog box appears.
8. Verify that the correction angle will be applied to the correct survey project.
9. Drag a direction on the map. The direction value is added to the Reference Direction field. You can alternatively type a Reference Direction value. ▸



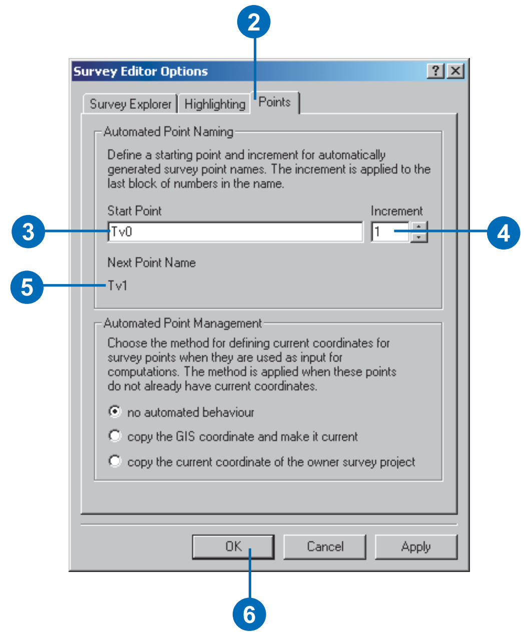


10. Type the value in the Relative Direction field. The Correction Angle field is updated.
11. Click Apply to Project.

    The Direction Angle Correction Tool dialog box is closed automatically.
12. Click Editor in the Editor toolbar, and click Save Edits.

Using a point naming increment

1. Click Survey Editor in the Survey Editor menu and click Options.
2. Click the Points tab.
3. Type the alpha portion of the default point name in the Start Point text box.
4. Type the increment for the numerical portion of the name in the Increment text box.
5. Verify that the Next Point Name is as expected based on your choices.
6. Click OK.



Automated behavior for survey point referencing

Computations can use the survey points created and owned by other projects. When using these survey points, a copy of the coordinate is added to the survey point for exclusive use in your project. This is called *referencing* a survey point. When you reference a survey point, you are required to choose one of the following coordinates:

- GIS coordinate
- Current coordinate of the owning survey project

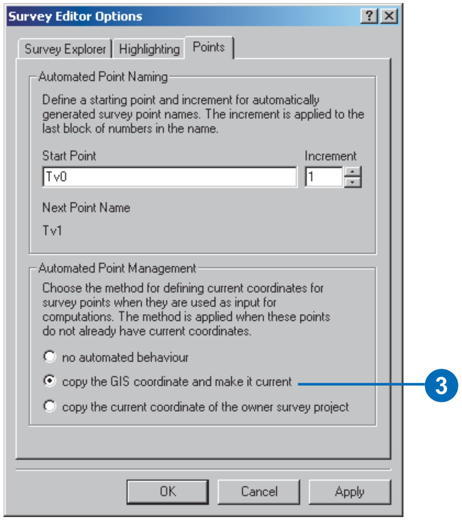
You can automate the choice for this coordinate in the Survey Editor options.

See Also

For more information about current coordinates and GIS coordinates, see Chapter 3, 'Survey analyst concepts'.

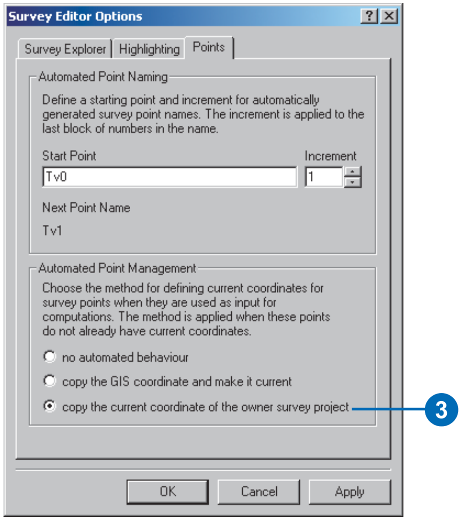
Automate referencing the GIS coordinate in computations

1. Click Survey Editor in the Survey Editor menu and click Options.
2. Click the Points tab.
3. Click copy the GIS coordinate and make it current.
4. Click OK.



Automate referencing the current coordinate of the owning project

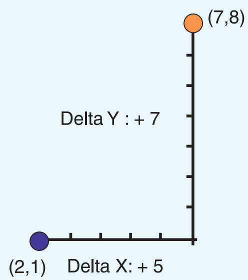
1. Click Survey Editor in the Survey Editor menu and click Options.
2. Click the Points tab.
3. Click copy the current coordinate of the owner survey project.
4. Click OK.



Using simple COGO computations

Delta XY

You can compute coordinates for a survey point based on a known difference in coordinates from a given start point.

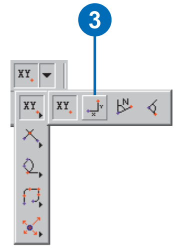


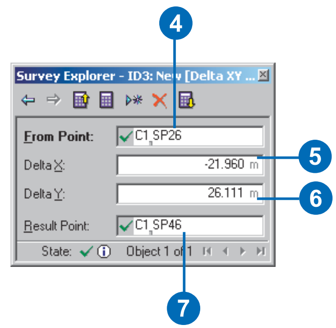
These coordinate differences are termed delta x,y. The direction of the computed coordinates from the start point is defined by the sign of the delta values as shown below:

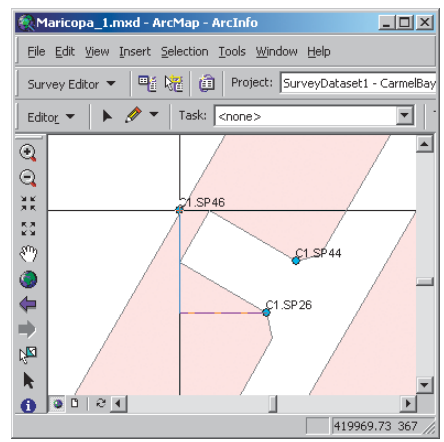
- Northeast: +X, +Y (shown in the above example)
- Northwest: -X, +Y
- Southeast: +X, -Y
- Southwest: -X, -Y

Computing a coordinate using delta x,y values

1. Click Snapping in the Editor menu and click Survey Points in the Snapping Environment dialog box.
2. Click the Project dropdown arrow in the Survey Editor toolbar. Click the survey project that should own the delta values, the survey point coordinate, and the computation.
3. Click the Computation tool palette dropdown arrow, move the mouse to the first row of buttons on the palette, and click the Delta XY button.
4. Snap to and click the from point on the map. The name of the point appears in the From Point field. If the point is not visible on the map, type its name and press Tab.
5. Type the Delta X value and press Tab.
6. Type the Delta Y value and press Tab.
7. Create a name for the point if you do not want to use the default name. Press Enter.





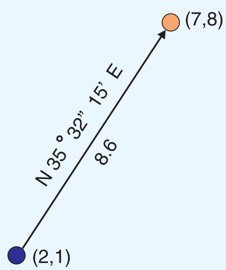


Completed Delta XY computation

Direction Distance

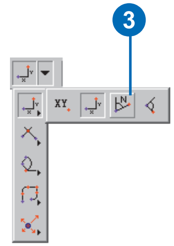
A familiar coordinate geometry computation is the calculation of a coordinate from an existing coordinate using known distance and direction values.

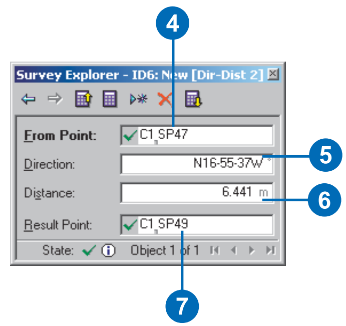
The direction, based on *grid meridian*, is either a bearing or azimuth. The survey project's scale correction and angle correction are applied during the computation but do not change the entered values that are stored in the survey dataset.

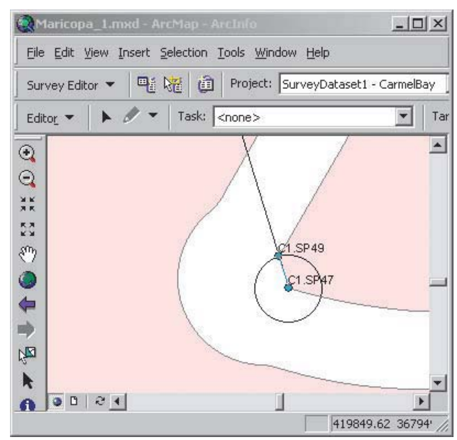


Computing a coordinate using a direction and a distance from a known point

1. Click Snapping in the Editor menu and click Survey Points in the Snapping Environment dialog box.
2. Click the Project dropdown arrow in the Survey Editor toolbar and click the survey project that should own the direction and distance values, the survey point coordinate, and the computation.
3. Click the Computation tool palette dropdown arrow, point the mouse to the first row of buttons on the palette, and click the Direction Distance button.
4. Snap to and click the from point on the map. The name of the point appears in the From Point field. If the point is not visible on the map, type its name and press Tab.
5. Type the Direction value and press Tab.
6. Type the Distance value and press Tab.
7. Type a name for the new point if you do not want to use the default name, then press Enter.



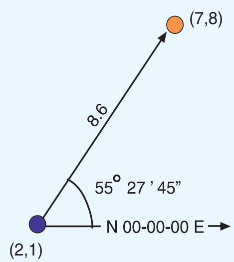




Completed Direction Distance computation

Deflection-Angle-Distance

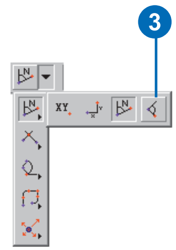
You can compute a new coordinate by defining a deflection angle offset, based on a reference direction, and a distance from a known point.

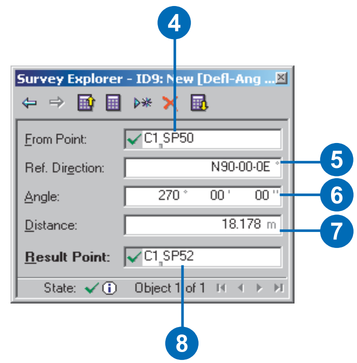


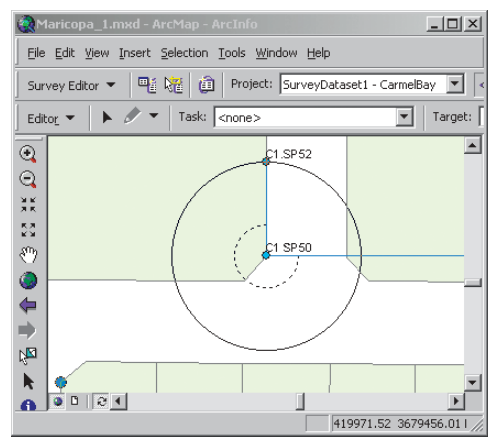
The reference direction is either a bearing or an azimuth, based on grid meridian. The survey project's scale correction is applied during the computation but does not change what gets stored for the entered values.

Computing a coordinate using a reference direction, angle offset, and a distance from a known point

1. Click Snapping in the Editor menu and click Survey Points in the Snapping Environment dialog box.
2. Click the Project dropdown arrow in the Survey Editor toolbar, then click the survey project that should own the measurement, point, and computation survey objects.
3. Click the Computation tool palette dropdown arrow, point the mouse to the first row of buttons on the palette, and click the Deflection-Angle-Distance button.
4. Snap to and click the from point on the map. The name of the point appears in the From Point field. If the point is not visible on the map, type its name and press Tab.
5. Type the Reference Direction and press Tab.
6. Type the Angle value and press Tab.
7. Type the Distance value and press Tab.
8. Type a name for the point if you do not want to use the default name. Press Enter.





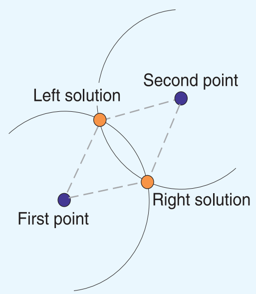


Deflection-Angle-Distance computation

Using intersection computations

Intersecting two distances

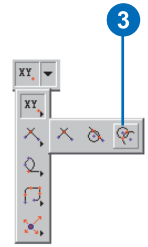
You can compute a new coordinate by defining intersections between two distances, two directions, or a direction and a distance.

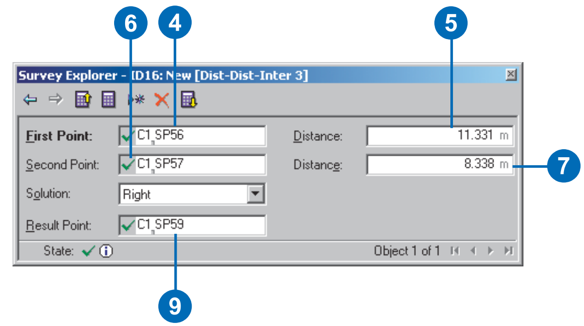


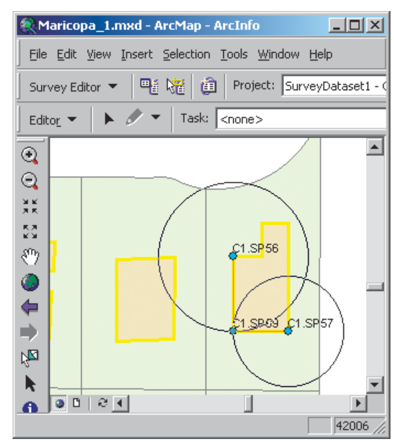
The Distance–Distance computation allows you to choose two known points and two distance values. If either of the distances are too short, they will not intersect and the computation will be flagged as incorrect. To create the computation, select one of two possible solutions. The left solution is defined as the point on the left-hand side as you look along the line from the first point to the second point. The right solution is the point on the right-hand side. ▸

Computing a coordinate using intersection of distances

1. Click Snapping in the Editor menu and click Survey Points in the Snapping Environment dialog box.
2. Click the Project dropdown arrow in the Survey Editor toolbar and click the survey project that should own the measurements, points, and computations.
3. Click the Computation tool palette dropdown arrow, point the mouse to the second row of buttons on the palette, and click the Distance–Distance button.
4. Snap to and click the first point on the map. The name of the point appears in the First Point field. If the point is not visible on the map, type its name in the text box and press Tab.
5. Type the distance from the first point and press Tab.
6. Repeat step 4 for the second point.
7. Type the distance from the second point and press Tab.
8. Press L if you want the left solution or press R for the right solution, then press Tab.
9. Type a name for the point if you do not want to use the default name. Press Enter.



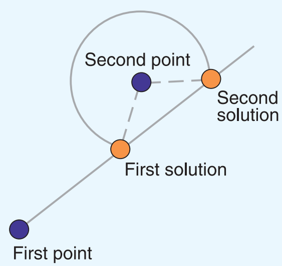




Completed Distance-Distance intersection computation

The survey project's scale correction is applied to the distances during the computation but it does not affect what gets stored for the values entered in the survey dataset.

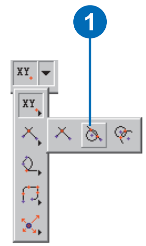
Intersecting a direction and distance

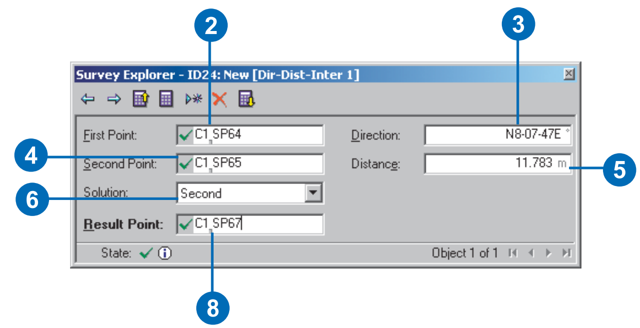


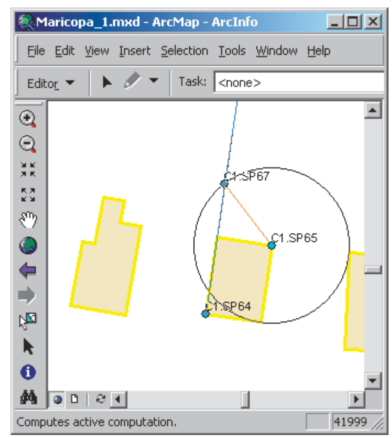
The Direction-Distance-Intersection computation lets you choose two known points and define a direction from the first and a distance from the second. When the direction and the distance do not have a solution for their intersection, the computation is flagged as incorrect. Since, in most cases, two solutions are possible, you need to specify the first or second solution. Looking along the line from the first point toward the second, the first solution is the first computed coordinate location, while the second solution is the second coordinate location. ▶

Computing a coordinate using an intersection of a distance and a direction

1. Click the Computation tool palette dropdown arrow, point the mouse to the second row of buttons on the palette, and click the Direction-Distance-Intersection button.
2. Snap to and click the first point on the map. The name of the point appears in the First Point field. If the point is not visible on the map, type its name in the text box and press Tab.
3. Type the direction value and press Tab.
4. Repeat step 2 for the second point.
5. Type the distance value and press Tab.
6. Using the keyboard, press the F key to select the first solution or the S key to select the second solution.
7. Press Tab.
8. Type a name for the Result Point if you do not want to use the default name and press Enter.







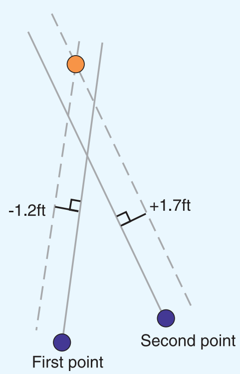
Direction-Distance-Intersection computation

The project's scale correction and angle correction are applied to the direction and distance values, respectively, affecting the location of the computed coordinate. The original values entered in the computation are stored in the survey dataset.

Intersecting two directions

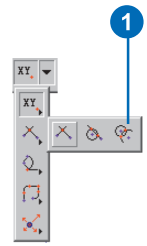
When intersecting lines using direction values, you can also define offsets. The offset distances are entered as left or right of the direction lines from the first and second points. A left offset is a negative value and a right offset is positive.

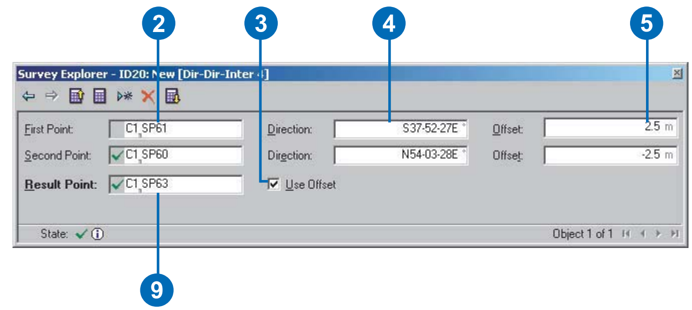
The intersection point is computed as depicted below.

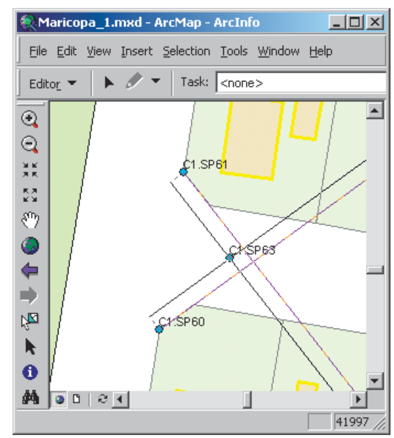


Computing a coordinate using intersection of directions with offsets

1. Click the Computation tool palette dropdown arrow, point the mouse to the second row of buttons on the palette, and click the Direction-Direction-Intersection button.
2. Snap to and click the first point on the map. The name of the point appears in the First Point field. If the point is not visible on the map, type its name in the text box, and press Tab.
3. Check Use Offset.
4. Type the direction in the Direction field and press Tab.
5. Type the Offset distance from the first direction.
6. Repeat step 2 for the second point.
7. Repeat step 4 for the second direction.
8. Repeat step 5 for the offset distance from the second direction.
9. Type a name for the point if you do not want to use the default name, and press Enter.







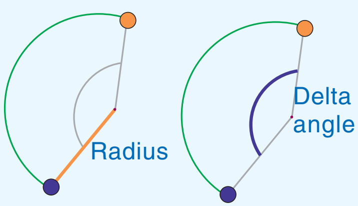
Completed Direction-Direction-Intersection computation

Using circular curve computations

Circular curve

A circular curve computation is available for computing the coordinates at the end of a circular curve. The computation optionally lets you calculate coordinates for the center of the curve. There are a variety of methods to define a circular curve using different combinations of the curve's geometric elements and orientation.

The curve's *geometric elements* define the size and shape of the



circular arc, and comprise any two of the following: radius, central angle, chord length, arc length, and tangent length. ▸

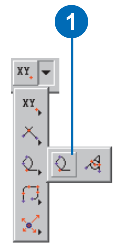
Tip

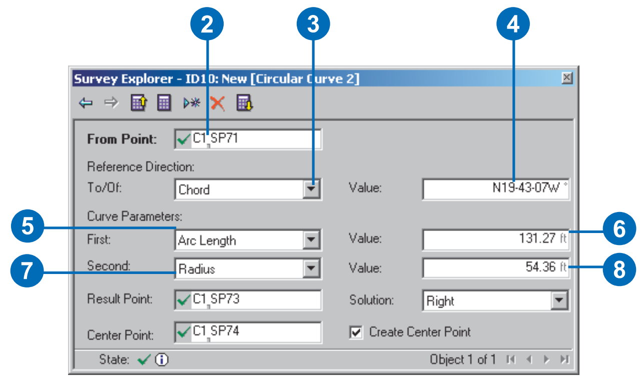
Keyboard shortcut

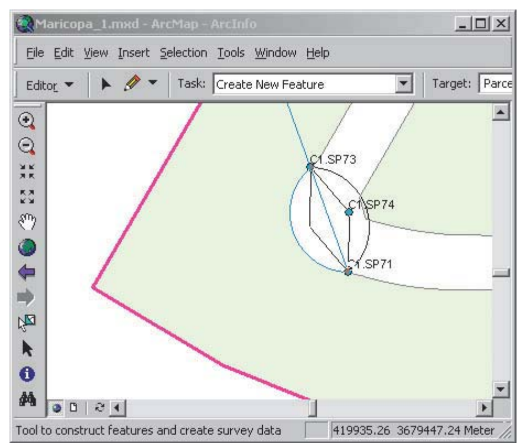
To select a curve parameter from a dropdown field, press the first letter of the parameter's name.

Computing coordinates from a circular curve's chord direction, arc length, and radius

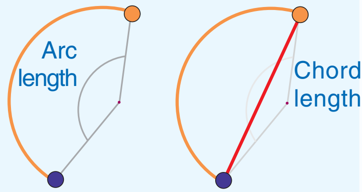
1. Click the Computation tool palette dropdown arrow, point the mouse to the third row of buttons on the palette, and click the Circular Curve button.
2. Snap to and click the from point on the map. The name of the point appears in the From Point field. If the point is not visible on the map, type its name and press Tab.
3. Click the Reference Direction dropdown arrow, click Chord and press Tab.
4. Type the direction value and press Tab.
5. Click the First parameter dropdown arrow, click Arc Length, and press Tab.
6. Type the arc length value and press Tab.
7. Click the Second parameter dropdown arrow, click Radius, and press Tab.
8. Type a length for the radius of the circular arc and press Tab. ▸

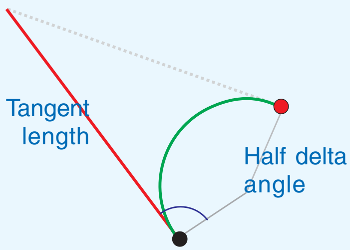




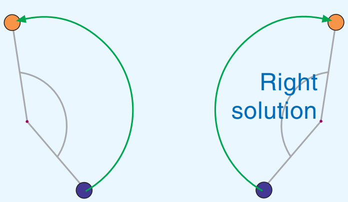


Circular curve computation





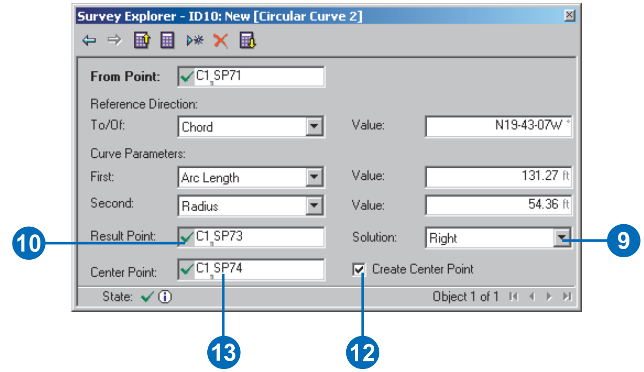
You must also specify whether the computed coordinates lie toward the left or right. This is defined as the side of the circular curve on which the



central point of the circle is located when traversing the curved line from the startpoint to the endpoint.

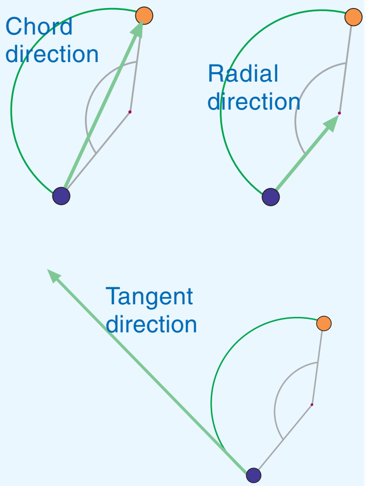
In addition to defining the curve's geometric elements, a direction is required to define the curve's *orientation*. ▶

9. Click the Solution dropdown arrow and click Left to choose the left solution, or click Right to choose the right solution.
10. Accept the default name, or type a new name, and press Tab.
11. Follow steps 12 and 13 if you want to compute coordinates and create a center point for the circular curve.
12. Click the Create Center Point check box.
13. Accept the default center point name, or type a new point name and press Enter.



An orientation for a curve can be any of the following three direction types:

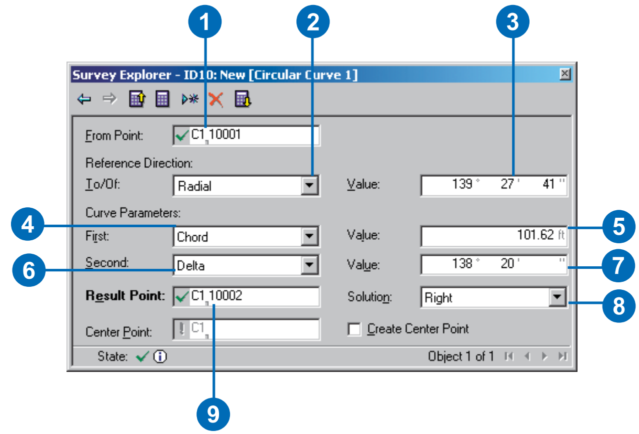
- Radial
- Chord
- Tangent

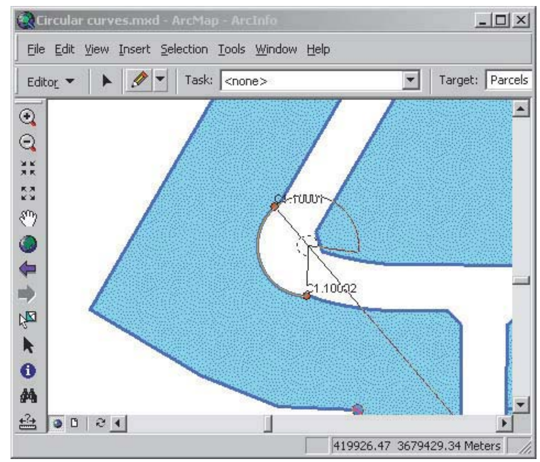


These directions are subject to having an angle correction applied to them when computing new coordinates. The values of the directions as entered are stored in the survey dataset. ►

Computing coordinates from a circular curve's radial direction, chord length, and delta angle

1. Snap to and click the from point on the map. The name of the point appears in the From Point field. If the point is not visible on the map, type its name in the text box, then press Tab.
2. Click the Reference Direction To/Of dropdown arrow, click Radial, then press Tab.
3. Type the direction value and press Tab.
4. Click the First parameter dropdown arrow, click Chord, and press Tab.
5. Type the chord length value and press Tab.
6. Click the Second parameter dropdown arrow, click Delta, and press Tab.
7. Type an angle value for the central angle of the circular arc and press Tab.
8. Click the Solution dropdown arrow and click Left to choose the left solution, or click Right to choose the right solution.
9. Accept the default name or type a new name and press Tab.

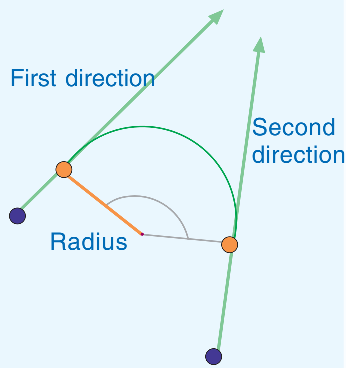




Circular curve computation

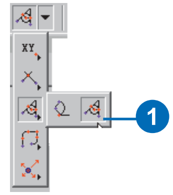
Fillet curve

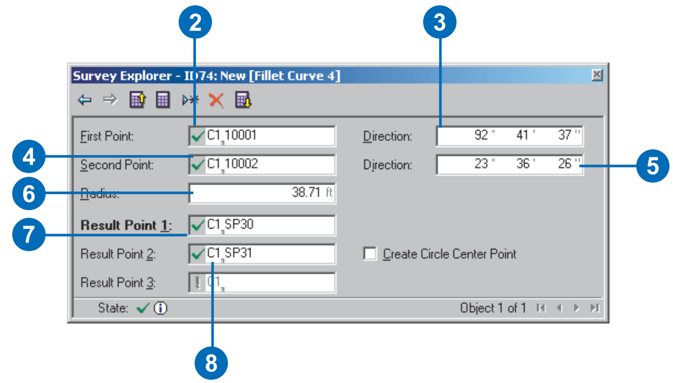
The fillet curve computation allows you to calculate coordinates for points based on two known starting points, two directions, and a radius. The two coordinated locations are computed so they fall along the lines of direction. The circular arc is created such that the radius defines an arc that lies tangent to both lines.

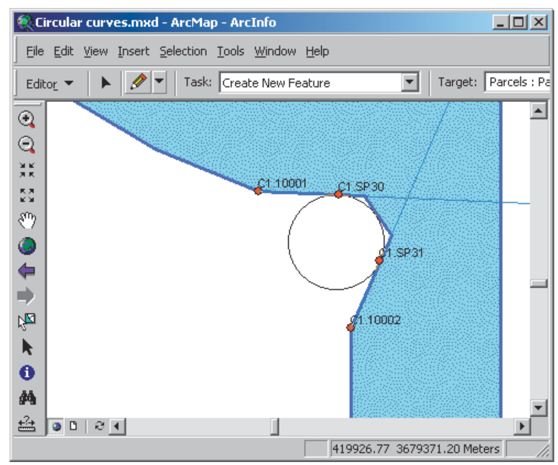


Computing coordinates using a Fillet curve

1. Click the Computation tool palette dropdown arrow, point the mouse to the third row of buttons on the palette, and click the Fillet Curve button.
2. Snap to and click the from point on the map. The name of the point appears in the First Point field. If the point is not visible on the map, type its name in the text box and press Tab.
3. Type the first direction and press Tab.
4. Repeat step 2 for the second point.
5. Type the second direction and press Tab.
6. Type the radius for the fillet and press Tab.
7. Accept the default name for the first result point or type a new name, then press Tab.
8. Repeat step 7 for the second result point.





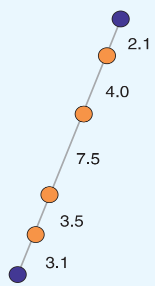


Fillet curve computation

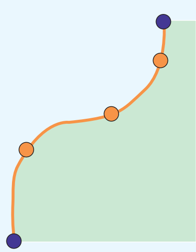
Using the station and offset computation

The station and offset computation can be used for calculating the coordinates along a path. A path is defined as:

- A straight line between two existing survey points.

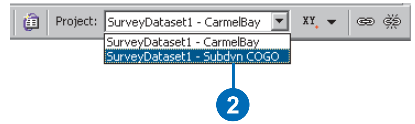


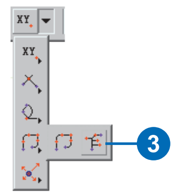
- A sequence of connected feature segments starting and ending at survey points. ▸

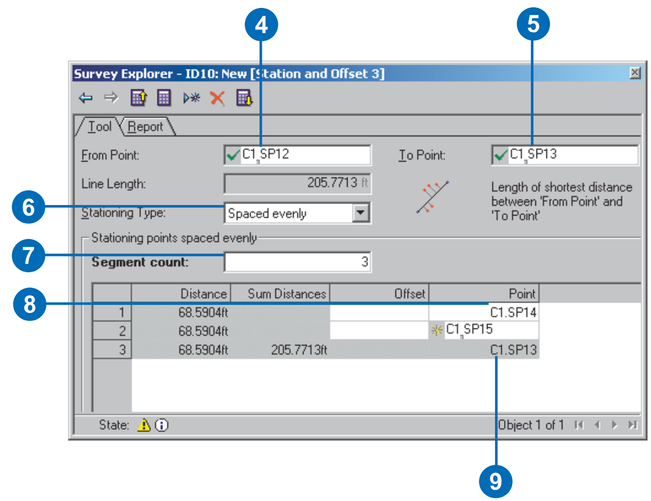


Computing coordinates evenly spaced on a line between two existing points

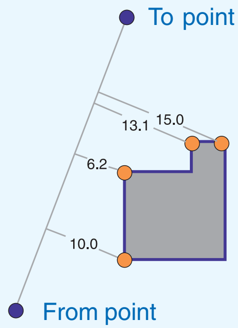
1. Click Snapping in the Editor menu and click Survey Points in the Snapping Environment dialog box.
2. Click the Project dropdown arrow in the Survey Editor toolbar, then click the survey project that should own the measurement, point, and computation survey objects.
3. Click the Computation tool palette dropdown arrow, move the cursor to the fourth row of buttons on the palette, and click the Station and Offset button.
4. Snap to and click the from point on the map. The name of the point appears in the From Point field. If the point is not visible on the map, type its name, and press Tab.
5. Repeat step 4 to define the To Point and press Tab.
6. Click the Stationing Type dropdown arrow, click Spaced evenly, then press Tab.
7. Type the number of equal segments you want to use to divide the line and press Tab. The grid updates with a new row for each of the new points. ▸



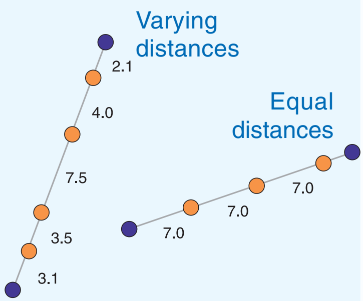




Coordinates can optionally be calculated perpendicular, at a specific offset distance left or

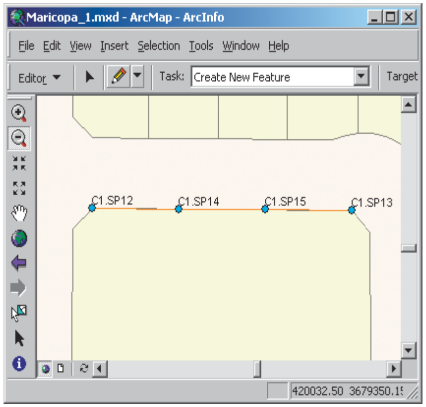


right of the path you've specified. Offsets to the left must be entered as negative values, and offsets to the right must be entered as positive values.



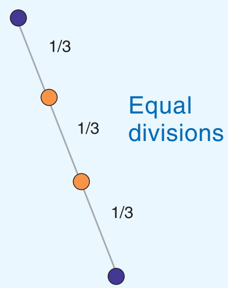
Different methods for computing these coordinates are available. ▶

8. Press Tab to ignore offset distances, press Tab to accept the default name, or type a new name and press Tab.
9. Repeat step 8 for each of the new points in each row.



Computing points on line between points SP12 and SP13

They can be computed at equal distances along the path, at



varying distances, or so that they divide the given path into a specific number of equal lengths. ►

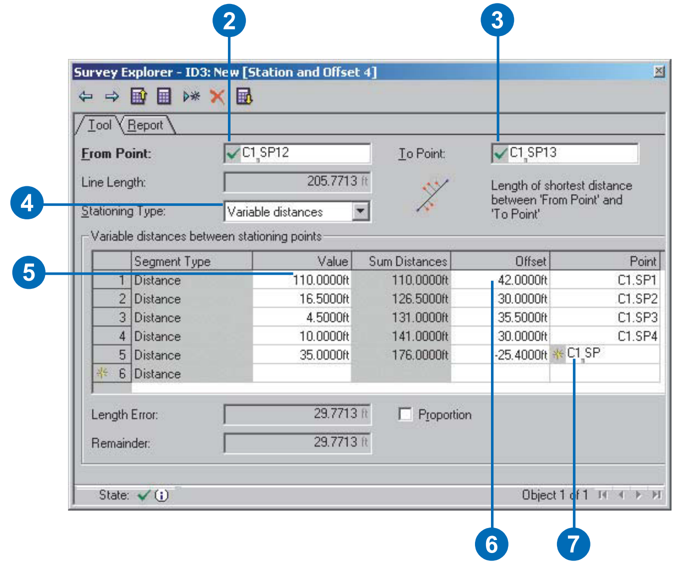
Tip

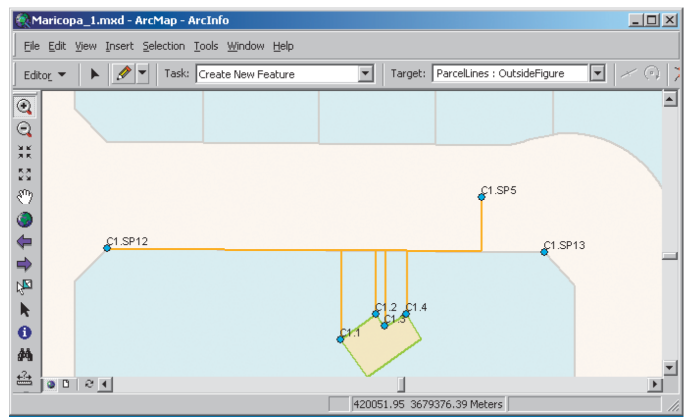
Computing line offsets

When computing coordinates offset from a line, use negative values for coordinates to the left of the line, and positive values for coordinates to the right.

Computing coordinates offset left and right from a line between two points

1. Click the Computation tool palette dropdown arrow, point the mouse to the fourth row on the palette, and click the Station and Offset button.
2. Snap to and click the from point on the map. The point name appears in the From Point field. If the point is not visible on the map, type its name in the text box. Press Tab.
3. Repeat step 2 to define the To Point and press Tab.
4. Click the Stationing Type dropdown arrow and click Variable distances. Press Tab.
5. Type the distance along the line measured from the previous point and press Tab (the first distance starts at the from point).
6. Type the first perpendicular offset distance in the Offset field. Press Tab.
7. Accept the default name in the point identifier field or type in the new name. Press Enter.
8. Repeat steps 5–7 for each distance and offset along the line that you want to enter.

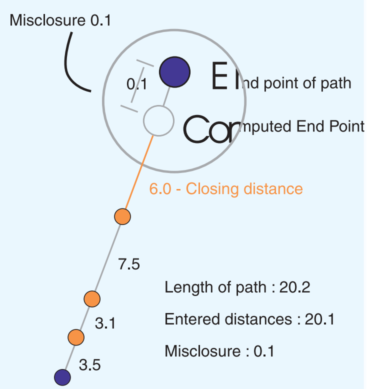




Computing coordinates offset from a line

When using the variable distances method, you can choose to enter a closing distance. This is the distance from the last point computed to the endpoint of the path.

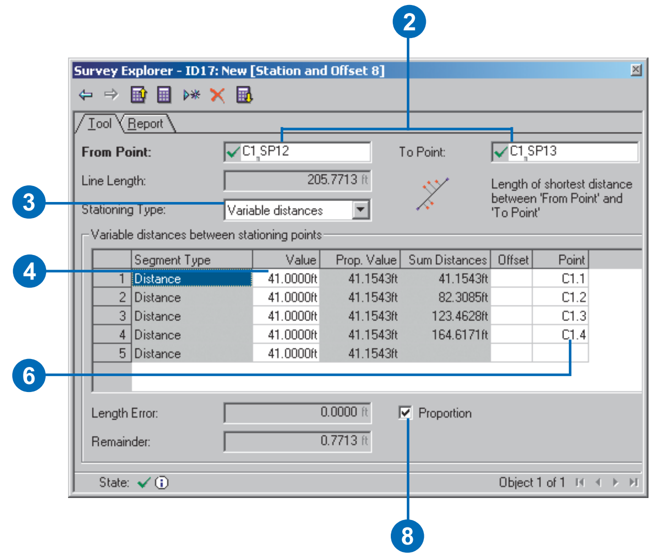
The difference between the sum of all the distances that you enter and the path length is called the distance misclosure or remainder. You can choose to proportion this remainder for each distance and compute new coordinate locations for the points.

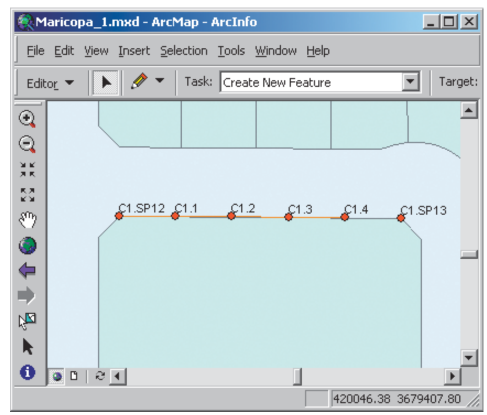


Proportioning the remainder when computing points on line

1. Start a new station and offset computation.
2. Choose the From Point and To Point.
3. Click the Stationing Type dropdown arrow. Click Variable distances and press Tab.
4. Type the distance along the line measured from the previous point in the Value field and press Tab (the first distance starts at the from point).
5. Type an offset value, if required, and press Tab.
6. In the Point identifier field, accept the default name or type in the new name and press Enter.
7. Repeat steps 4–6 for each distance and offset along the line that you want to enter.
8. Check Proportion after you have entered the closing distance.

   The points are recomputed; the remainder is distributed equally in each of the original distance measurements.

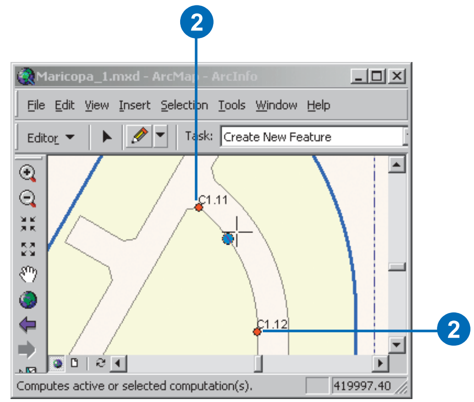


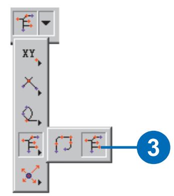


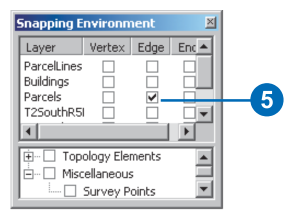
Proportioning the remainder for points on line

Computing coordinate locations along a feature segment path

1. Identify the connected feature segments along which you want to create new survey points.
2. Unless they already exist, digitize two new survey points, snapping to the first and last feature vertices that define the segment path.
3. Start a new station and offset computation.
4. Click Editor in the Editor toolbar and click Snapping.
5. Check Edge for the feature class that represents the feature that holds the feature segment path. ▸







See Also

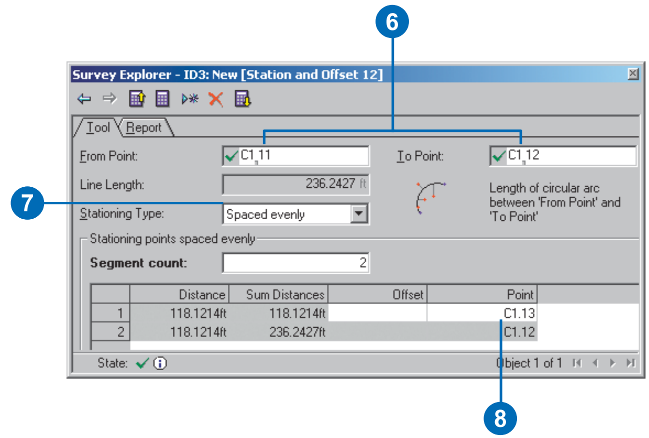
For more information about entering point names, distances, and offsets in the station offset computation, see the section 'Computing coordinates offset left and right from a line between two points' in this chapter.

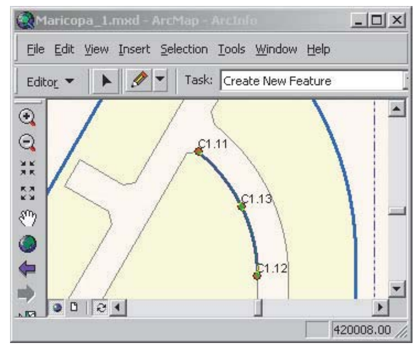
6. Make sure the From Point or To Point field has focus, snap to, and click a segment on the path.

   The points at the beginning and end of the path are added to the point fields.

7. Click the Stationing Type dropdown arrow, click the method you want to use, then press Tab.

8. Enter point names, distances, and offsets, if required.





Point computed along a feature segment

Using the COGO Traverse

The coordinate geometry traverse is used to compute a sequence of survey point locations starting from an initial known point. Each new survey point is defined by a *traverse course* and is used as the take-off point for the next course in the sequence. Two methods are used:

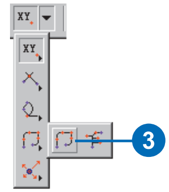
- The *Bearing method* uses directions for the orientation of each course.
- The *Angle Right method* uses an angle measured clockwise from the line of the previous course.

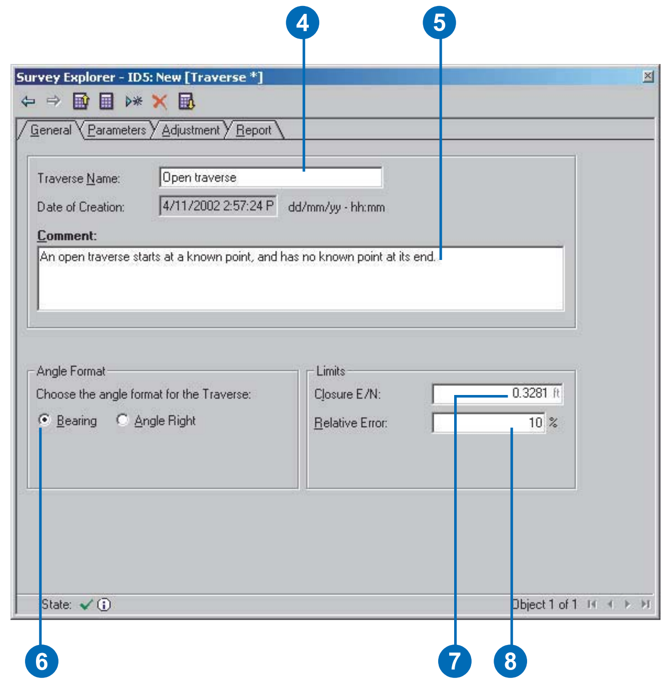
A traverse course can be defined using various combinations of directions, distances, angles, and circular arc parameters.

The COGO traverse is primarily used for defining coordinates based on values taken from subdivision plans. ▸

Computing coordinate locations using a Bearing COGO traverse

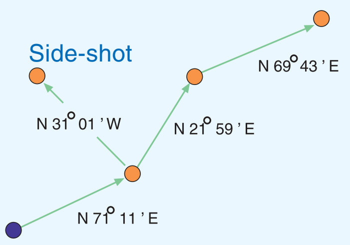
1. Click Snapping in the Editor menu and click Survey Points in the Snapping Environment dialog box.
2. Click the Project dropdown arrow in the Survey Editor toolbar and click the target survey project.
3. Click the Computation tool palette dropdown arrow, point the mouse to the fourth row on the palette, and click the COGO Traverse button.
4. Type a name for the computation and press Tab.
5. Type a comment for the COGO traverse computation and press Tab.
6. Click Bearing.
7. Type the maximum allowable limit for the misclosure in easting and northing.
8. Type the maximum allowable Relative Error as a percentage. ▸





The TPS Traverse computation, described later in this chapter, should be used for processing field traverse data.

A *side-shot course* is used to compute a coordinate that is not a part of the main traverse course sequence.



Open traverse

There are two primary categories for traverses: open or closed.

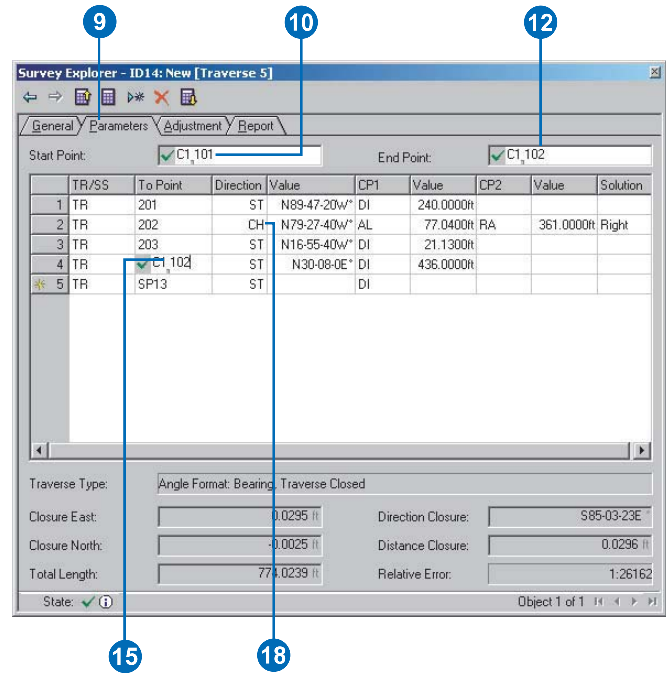
An *open traverse* ends its sequence with a new survey point, whereas in a *closed traverse*, the final course ends at an existing survey point. ►

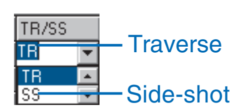
Tip

Keyboard shortcut for curve parameters

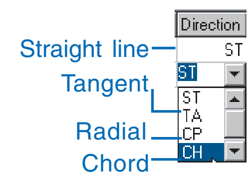
To select a curve parameter from a dropdown field, press the first letter of the parameter's name.

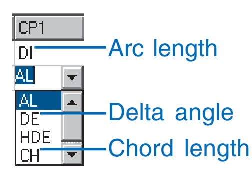
9. Click the Parameters tab.
10. Snap to and click the start point on the map. The point name appears in the Start Point field. If the point is not visible on the map, type its name and press Tab.
11. If you are doing an open traverse, press Tab, and skip to step 13.
12. Repeat step 10 for the endpoint of the traverse.
13. Double-click the TR/SS field, click SS to choose the next course as a side-shot, or choose TR if the next course is part of the main traverse.
14. Press Tab.
15. Press Tab to accept the default To Point name. If you are entering the final course for a closed traverse, double-click the To Point field, and type the endpoint name. Press Tab.
16. If the course you are entering is a circular curve, skip to step 18. Otherwise, continue to step 17.
17. Double-click the Direction field, click ST, press Tab, then skip to step 19.
18. Double-click the Direction field and click the type of direction for the circular curve. Press Tab. ►



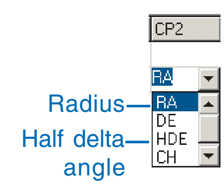


Side-shot or traverse course





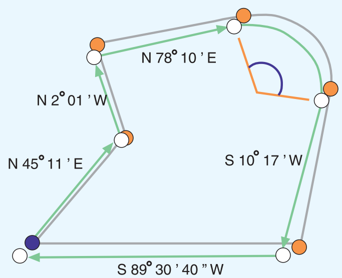
First curve parameter



Second curve parameter

When a closed traverse starts and ends with the same survey point, it is called a *loop traverse* or a *closed loop traverse*.

Since the final point of a closed traverse has known coordinates and the final course of the traverse computes coordinates for the same survey point, there is often a discrepancy between the existing coordinates and the computed coordinates—this discrepancy is called a misclosure or a closure error. ▸

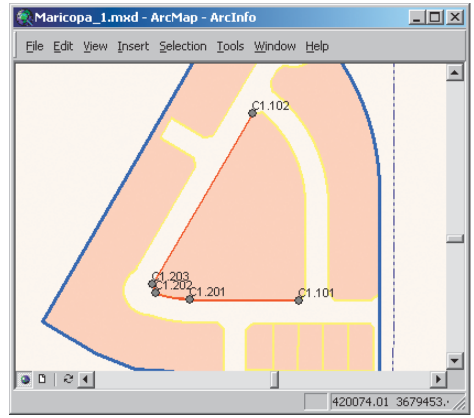


Closed loop traverse

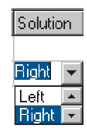
See Also

For more information about defining circular curves, see the section 'Using circular curve computations' in this chapter.

19. Type the direction value and press Tab.
20. Skip to step 23 if the course you are entering is a circular curve. Otherwise, continue with steps 21 and 22.
21. Accept the distance parameter type (DI) and press Tab.
22. Type the distance value for the course and skip to step 28.
23. Double-click the Curve Parameter 1 (CP1) field and click the first parameter type. Press Tab.
24. Type the value of the first parameter. Press Tab.
25. Double-click the Curve Parameter 2 (CP2) field and click the first parameter type. Press Tab.
26. Type the value of the second parameter. Press Tab.
27. Double-click the solution field and click the direction in which the circular curve bends.
28. Press Enter.
29. Repeat steps 13 through 28 for each of the courses in the traverse.



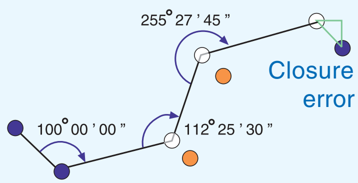
Closed traverse from point C1.101 to point C1.102



Curve direction

The closure error in a COGO traverse may be the result of any of the following:

- Numerical precision
- Mistyped values
- Incorrect values in the source
- Measurement error



A closure error that is identified as being caused by incorrect source values indicates a potential problem in the original survey data.

Closure error caused by a typing error can be handled by reentering the value. ►

Tip

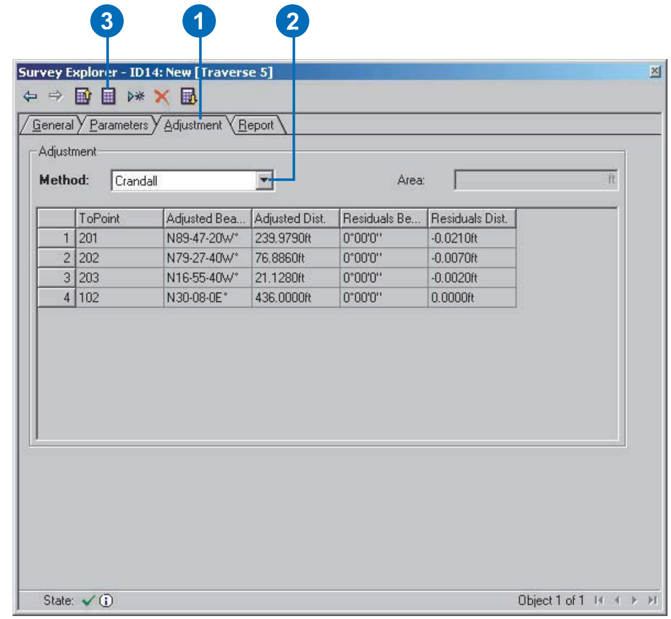
Computing an area with a COGO traverse

When you compute a traverse that is a closed loop, an area is reported on the Adjustment tab.

Adjusting the closure error in a closed COGO traverse

1. Click the Adjustment tab.
2. Click the Method dropdown arrow and click the method you want to use to adjust the error.
3. Click the Compute button.

   The adjusted values and their residuals are displayed.



Misclosure caused by numerical precision, or measurement error can be solved by applying an adjustment to distribute the error through each of the courses.

You can define the allowable limits of closure error on the General tab of the COGO traverse computation.

There are three adjustment methods available:

- Compass rule
- Transit rule
- Crandall rule

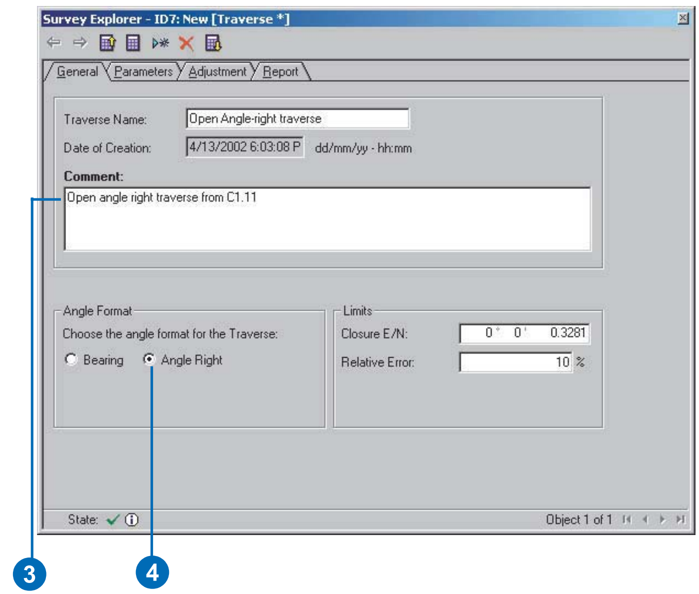
The *Compass rule,* also known as the *Bowditch rule,* distributes the misclosure in the northings and eastings in proportion to the distance along all the courses from the first point to each of the unadjusted coordinate locations.

The *Transit rule* assumes distances have no measurement error and distributes the error only through the directions and angles.

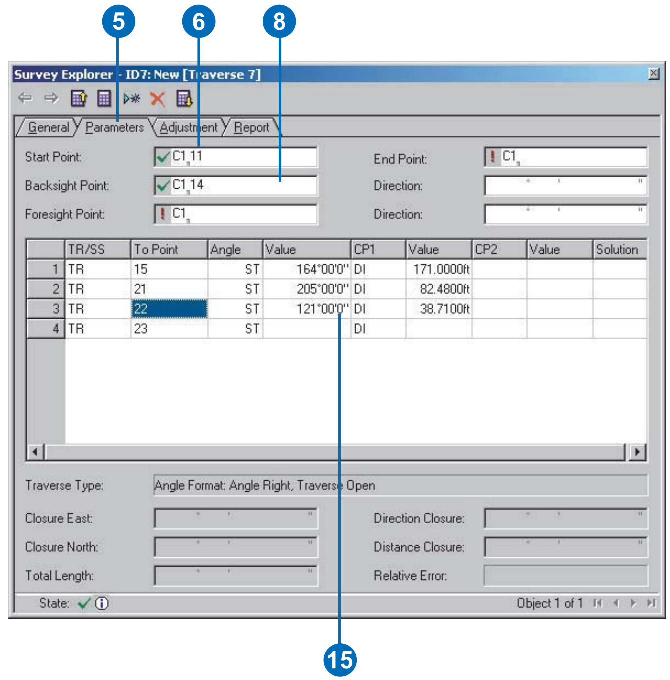
The *Crandall* method distributes the error in the distances only, assuming directions and angles have no measurement error.

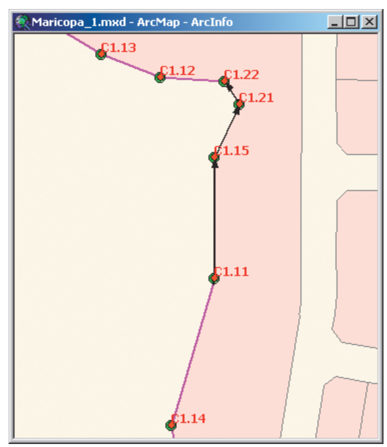
Computing coordinates using an open Angle Right COGO traverse with straight line courses

1. Click the Computation tool palette dropdown arrow, move the mouse to the fourth row on the palette, and click the COGO Traverse button.
2. Type a name for the computation and press Tab.
3. Type a comment for the COGO traverse computation and press Tab.
4. Click Angle Right as the Angle Format. ▸



5. Click the Parameters tab.
6. Snap to and click the start point on the map. If the point is not visible on the map, type its name in the text box, and press Tab.
7. Press Enter to ignore the endpoint.
8. Repeat step 6 to choose the Backsight Point.
9. Press Enter to accept the default backsight Direction value.
10. Press Enter to ignore the Foresight Point.
11. Press Enter to ignore the foresight direction value.
12. Press Enter to accept the TR parameter.
13. Press Enter to accept the default To Point name, or else double-click in the field to type a different point name and press Enter.
14. Press Enter to accept the default Angle parameter (ST).
15. Type an angle value and press Enter.
16. Press Enter to accept the CP1 (DI).
17. Type the distance value and press Enter.
18. Repeat steps 12–17 for each traverse course.





Angle Right COGO traverse

Exploring TPS computations

Total Positioning System (TPS) measurements are a collection of observed values that belong with an instrument setup.

They refer to the values observed using any analog or electronic device from the theodolite family that measures zenith and horizontal angles. The slope distances used in TPS measurements may be from an electronic distance measuring (EDM) device, total station, or tape measure. Other observed values that fall into this category include instrument heights and target heights.

These measurements are imported from files that represent electronic field books or are typed directly into new computations from paper field books.

TPS computations process the information from one or more instrument setups. You work with computations by choosing the instrument setups that should be processed.

The different types of computations that support TPS measurements are:

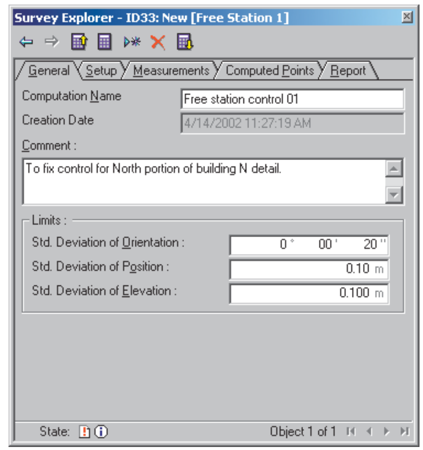
- Tacheometry
- Resection
- Traverse (different from the COGO traverse described in the previous section)
- Free station
- Least squares adjustment

You create and edit TPS computations using a standard methodology for adding measurements, choosing limits, selecting reference points, computing, and viewing the computed points. The detail for a TPS computation has five different pages separated into tabs. This section is an overview of these pages.

The detail for the least squares adjustment computation has additional pages and is described in the section 'Using TPS computations' in this chapter.

The General tab

- Computation name: Since computations are stored as records in the survey dataset, it is useful to give them names. This provides an additonal method to retrieve a specific computation when you know its name. Computation names of a specific type are unique within the survey dataset.

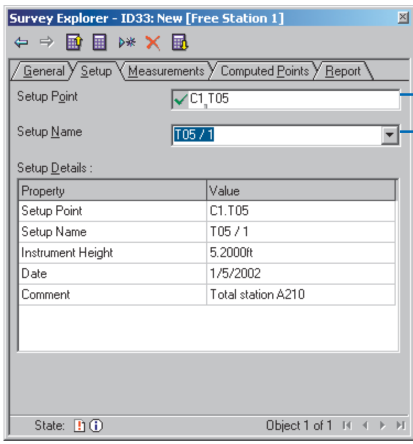


Detail of TPS computation, showing the General tab

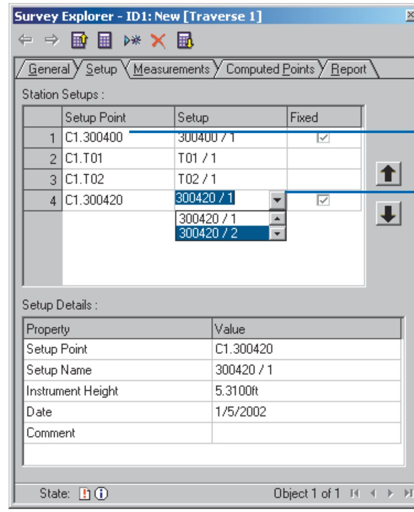
- Creation date: When the computation is created, the date and time are recorded and stored as an attribute of the computation.
- Comment: You can use the comment field to provide some additional information about the computation.
- Limits: Each computation has some allowable limits that define an acceptable level of *measurement error*.

The Setup tab

Since a survey point can have many instrument setups, there are typically two steps for defining the setups for a computation. First, complete a point identifier field that defines where the instrument setup is located, then select the instrument setup or type the name of a new instrument setup in the *Instrument setup field*.



Single setup page



Multiple setup page

The properties of the setup can be viewed and edited. These properties are the instrument height, the date of the instrument setup, and a comment about the setup.

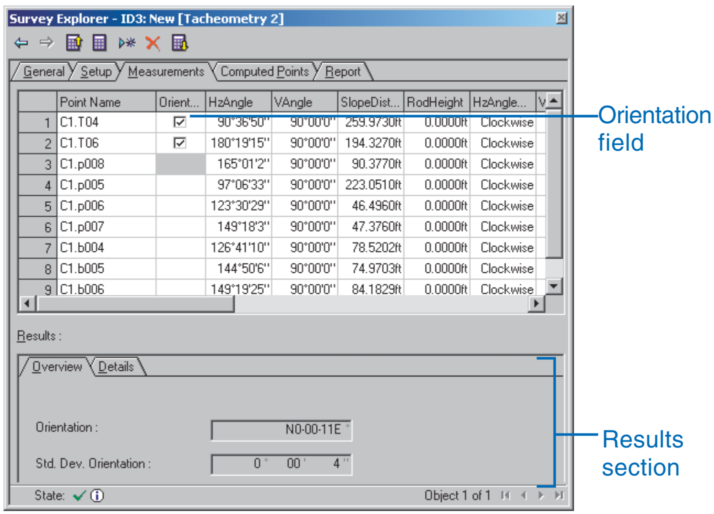
There are two types of setup pages. The first is a *single setup page*, used for computations that process single instrument setups, such as the Free station or Resection computations. The second is a *multiple setup page,* used for computations such as the Traverse or Least Squares adjustment, which process multiple instrument setups.

The Measurements tab

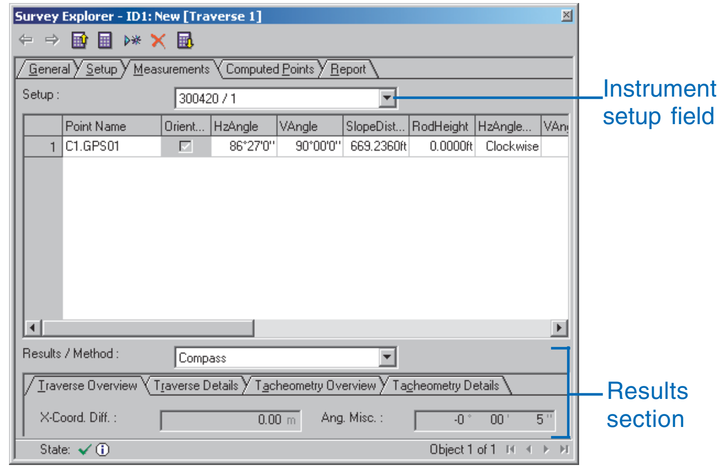
The observed values from the instrument setup are viewed and edited in the Measurements tab. Instrument setups that have been imported from electronic field books are automatically added, and these values appear automatically.

Survey points that have been computed in other computations or that have been imported are recognized on the Measurements tab and displayed with a check box in the Orientation field.

By checking the Orientation field, you indicate that the observed point is to be treated as a *fixed reference point*. Unchecking this field indicates that new coordinates are to be computed for the point.



Single setup measurements page



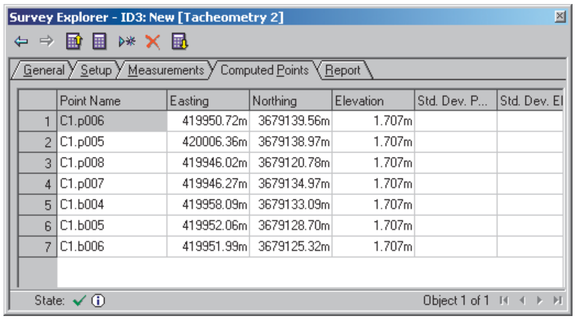
Multiple setup measurements page

If the computation processes multiple instrument setups, the Measurements tab also has an Instrument setup field. As you switch between different instrument setups, the observation list is updated to display the observations for that setup.

Each measurement page also has a Results section, which differs depending on the computation you are working with.

The Computed Points tab

When a computation has been successfully processed, the resulting coordinates are displayed on the Computed Points tab. The computation also displays values for the other point attributes, if they are available.



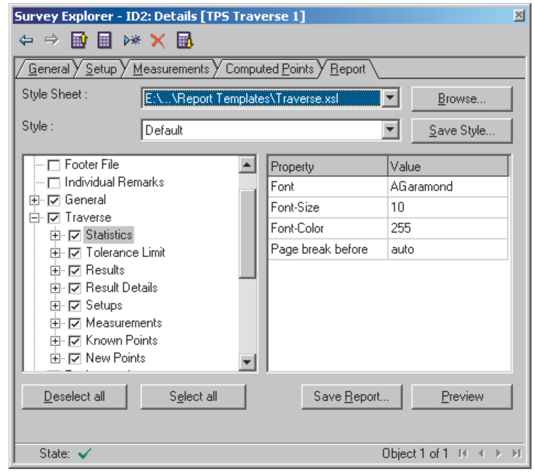
Computed Points tab

Report tab

The Report tab is available for all TPS computations.

Reporting is based on the *Extensible Markup Language* (XML). Once a computation has been processed and has a status of valid, the Report tab allows you to specify a stylesheet and the items from the computation that should be included in your report. You can also choose a font and color for the text.

Define your own header and footer by creating a file using *Hypertext markup language* (HTML) and specifying its path and name. Create a report that includes, for instance, your company logo as a header.



Report tab

Your choices can be saved as a template. Other reports can be generated easily by using the style and selection of items defined in a saved template.

Using the TPS computations

Survey Analyst provides a set of five computations. Four of them are based on the classical survey algorithms for tacheometry, freestation, resection, and traverse. The fifth computation is the least squares adjustment.

Once you have mastered the basics of data entry for the general, setup, measurement, and report tabs, you will have an overall familiarity with all the TPS computations.

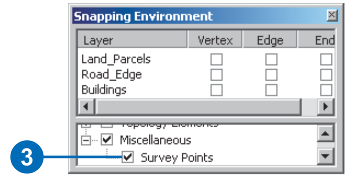
This section covers the general steps required for basic data entry, and also presents additional information about specific TPS computations.

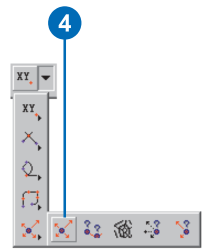
Tacheometry

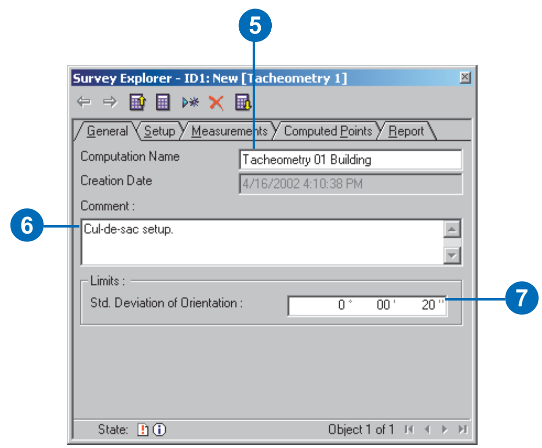
The tacheometry computation uses a single instrument setup at a point with known coordinates—*known points* or *reference points*. It has a set of horizontal circle readings to other known points and is used to process the horizontal angle and distance observations to define coordinates for previously uncoordinated points—*unknown points*, or *measured points*.

Processing a single TPS setup using Tacheometry

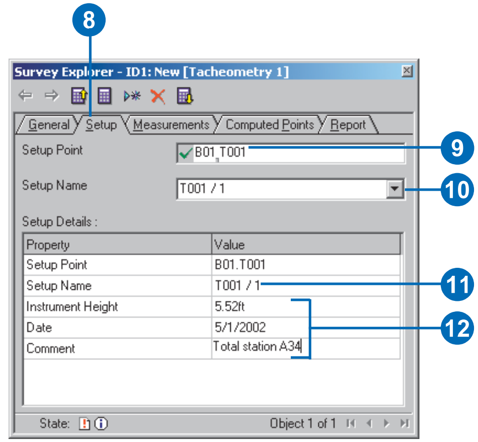
1. Click the Project dropdown arrow in the Survey Editor toolbar and click the survey project that should own the new computation.
2. Click Editor on the Editor toolbar and click Snapping.
3. Check Survey Points.
4. Click the Computation tool palette dropdown arrow, move the mouse to the last row on the palette, and click the Tacheometry button.
5. Type a name for the computation and press Tab.
6. Type a comment for the tacheometry computation and press Tab.
7. Type the limits you will allow for the standard deviation of the orientation. ▸

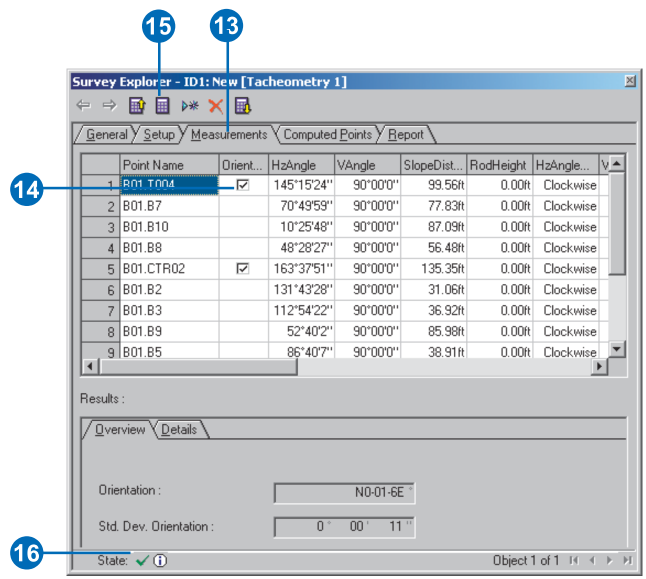






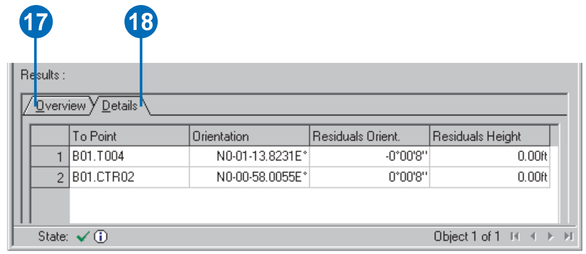
8. Click the Setup tab.
9. Snap to and click the setup point on the map. If the point is not visible on the map, type its name in the text box and press Tab.
10. Click the Setup Name dropdown arrow and click the name of the setup you want to process.
11. Click the Value field for the Setup Name attribute if you want to change the name of the setup and type a new name.
12. Repeat step 11 if you want to change the stored attributes for Instrument Height, Date, or Comment.
13. Click the Measurements tab and resize the Survey Explorer if needed.
14. Check the reference points you want to use for orientation.
15. Click the Compute button.
16. Verify that the computation was processed successfully by ensuring the state is valid. ►



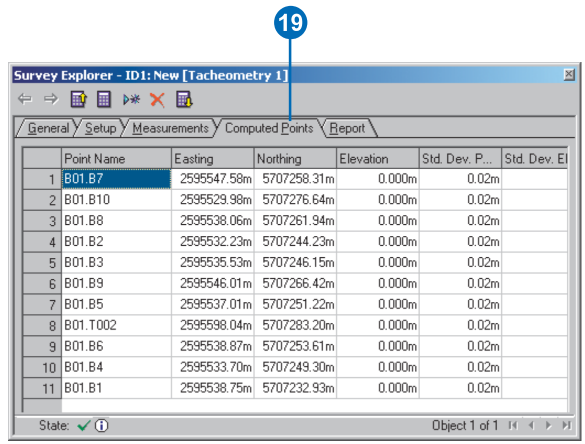


17. Click the Overview tab to see the orientation and its standard deviation.
18. Click the Details tab to see the orientation and residuals for each of the reference points.

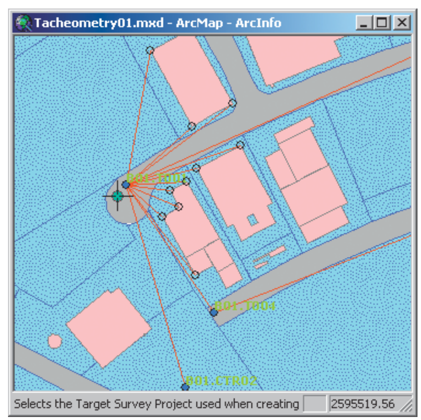
    The Orientation field is the direction of the zero reading on the horizontal circle of the TPS instrument.
19. Click the Computed Points tab to view the coordinates computed.



	To Point	Orientation	Residuals Orient.	Residuals Height
1	B01.T004	N0-01-13.8231E°	-0°00'8"	0.00ft
2	B01.CTR02	N0-00-58.0055E°	0°00'8"	0.00ft



	Point Name	Easting	Northing	Elevation	Std. Dev. P...	Std. Dev. El
1	B01.B7	2595547.58m	5707258.31m	0.000m	0.02m	
2	B01.B10	2595529.98m	5707276.64m	0.000m	0.02m	
3	B01.B8	2595538.06m	5707261.94m	0.000m	0.02m	
4	B01.B2	2595532.23m	5707244.23m	0.000m	0.02m	
5	B01.B3	2595535.53m	5707246.15m	0.000m	0.02m	
6	B01.B9	2595546.01m	5707266.42m	0.000m	0.02m	
7	B01.B5	2595537.01m	5707251.22m	0.000m	0.02m	
8	B01.T002	2595598.04m	5707283.20m	0.000m	0.02m	
9	B01.B6	2595538.87m	5707253.61m	0.000m	0.02m	
10	B01.B4	2595533.70m	5707249.30m	0.000m	0.02m	
11	B01.B1	2595538.75m	5707232.93m	0.000m	0.02m	



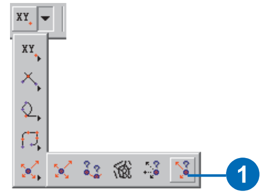
Computing a tacheometry for bulidings

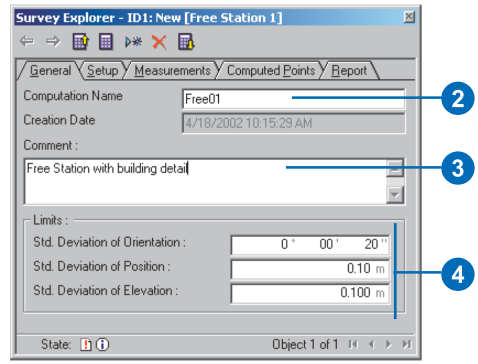
Free Station

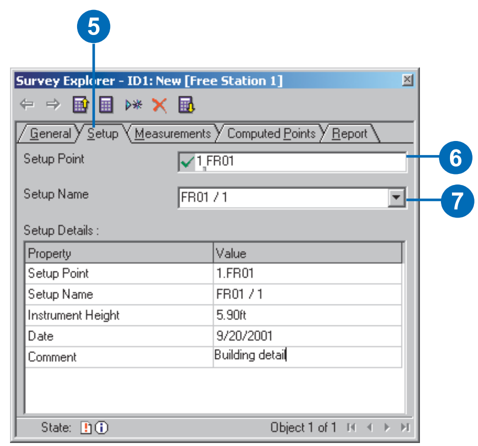
To compute coordinates for an instrument setup at an unknown location, distances and observations on the horizontal circle to at least two reference points need to be observed. The free station computation uses these measurements to define a triangle. The solution of the computation is the set of coordinates at the apex of the triangle that defines the setup location.

Processing a single TPS setup using a Free Station Computation

1. Click the Computation tool palette dropdown arrow, move the cursor to the last row on the palette, and click the Free Station button.
2. Type a name for the computation and press Tab.
3. Type a comment for the computation and press Tab.
4. Type the limits you will allow for the standard deviation of the orientation.
5. Click the Setup tab.
6. Snap to and click the setup point on the map. If the point is not visible on the map, type its name and press Tab.
7. Click the Setup Name dropdown arrow and click the name of the setup you want to process. ▸







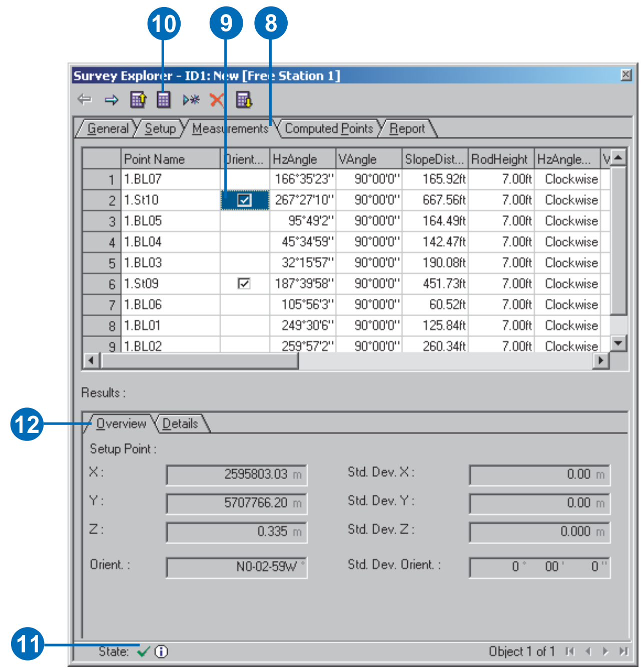
8. Click the Measurements tab and resize the Survey Explorer if needed.

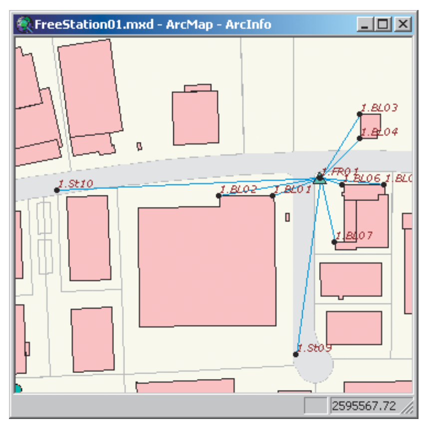
9. Check the reference points you want to use for orientation.

10. Click the Compute button.

11. Verify that the computation was processed successfully by ensuring the state is valid.

12. Click the Overview tab in the results section to see the computed coordinates and their standard deviations. The orientation and its standard deviation is also reported. ►



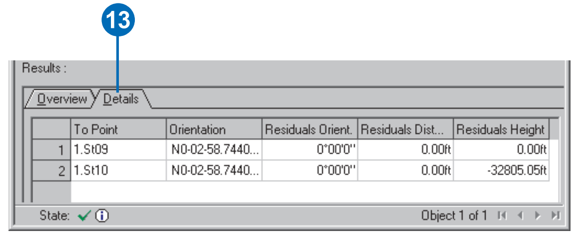


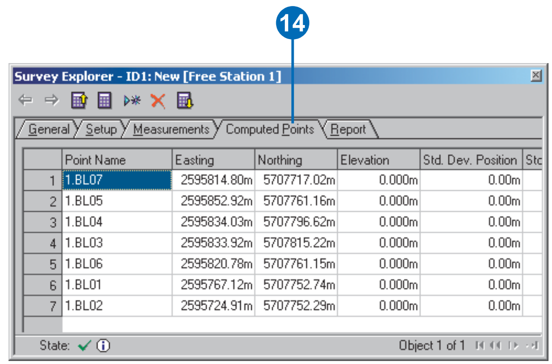
Free station computation. St10 and St09 are used as references to calculate coordinates for FR01.

13. Click the Details tab to see the orientation and residuals for each of the reference points.

    The Orientation field is the direction of the zero reading on the horizontal circle of the TPS instrument.

14. Click the Computed Points tab to view the coordinates computed.





Traverse

The traverse is a sequence of instrument setups that start at a known location and end at another known location, with the intermediate setups being at points with unknown coordinates. Misclosure (or closure error) is the difference between the computed endpoint coordinate and the known endpoint coordinate. The misclosure is distributed through the intermediate points using one of the following methods:

- Compass rule
- Transit rule
- Crandall rule

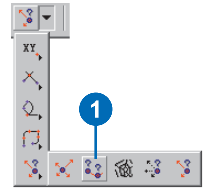
The Compass rule, also known as the Bowditch rule, distributes the closure error in the Northings and Eastings in proportion to the distance along all the courses from the first point to each of the unadjusted coordinate locations.

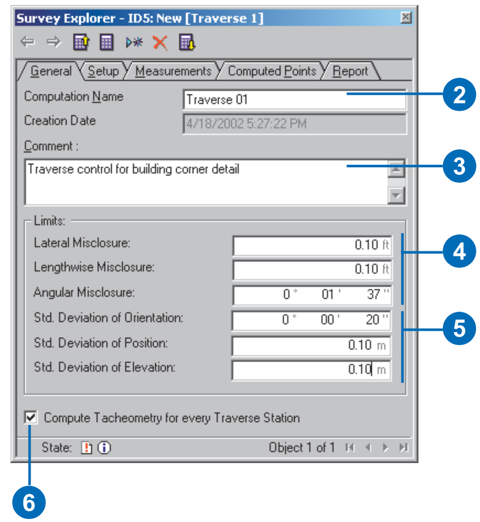
The Transit rule assumes distances have no measurement error, and distributes the error only through the observed angles. ▸

Processing multiple TPS setups using a Traverse Computation

1. Click the Computation tool palette dropdown arrow, move the mouse to the last row on the palette, and click the Traverse button.
2. Type a name for the computation and press Tab.
3. Type a comment for the traverse and press Tab.
4. Type the limits you will allow for lateral and lengthwise misclosure.
5. Type the limits you will allow for the standard deviation in the horizontal position, elevation, and orientation.
6. Check Compute Tacheometry for every Traverse Station if you want to compute all the side-shots.

   This option will automatically process each instrument setup as a tacheometry computation after the initial traverse has been computed. ▸

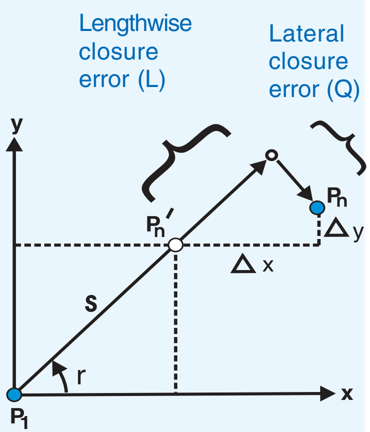




The Crandall method distributes the error in the distances only, assuming observed angles have no measurement error.

You can define the allowable limits for the closure error in the traverse in terms of its *lengthwise misclosure* and *lateral misclosure*.

These elements are depicted in the graphic below.



The formulae used for determining the values of L and Q are:

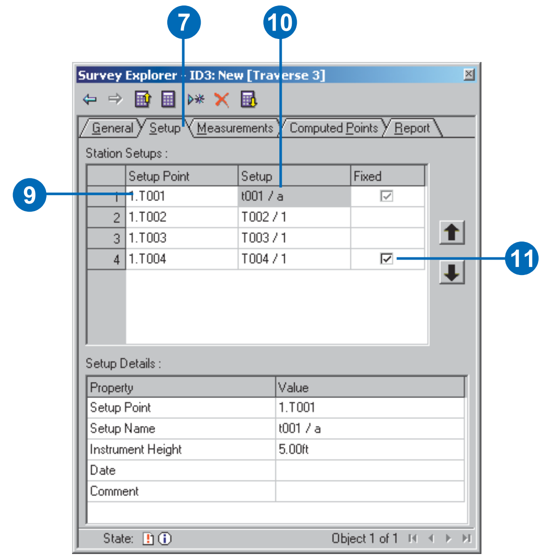
$$L = \frac{\Delta y\,(s.\sin r) + \Delta x\,(s.\cos r)}{\sqrt{(s.\sin r)^2 + (s.\cos r)^2}}$$

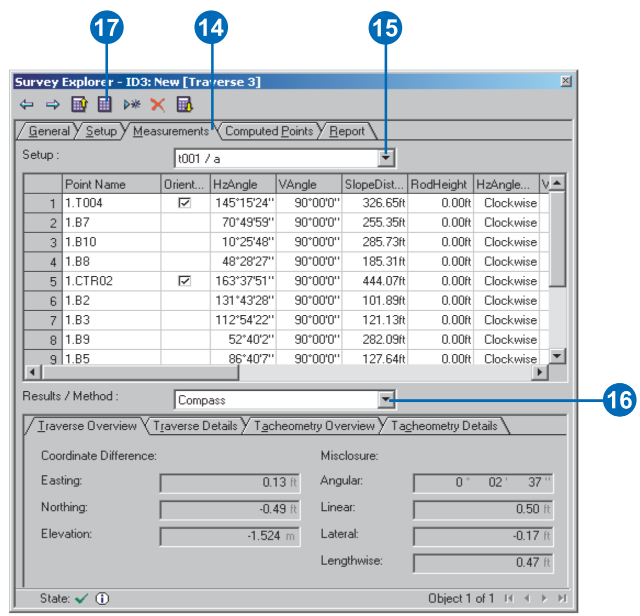
$$Q = \frac{\Delta y\,(s.\cos r) - \Delta x\,(s.\sin r)}{\sqrt{(s.\sin r)^2 + (s.\cos r)^2}}$$

7. Click the Setup tab.
8. Click the Point identity field in the Setup Point field.
9. Snap to and click the setup point on the map. If the point is not visible on the map, type its name and press Tab.
10. Double-click the Setup field dropdown arrow in the text box and click the name of the setup you want to use for the traverse. Press Tab.
11. Check the box in the fixed field (if available) if you want to use the setup point as a reference point.

    Checking this field will not compute new coordinates for this point.
12. Press Enter.
13. Repeat steps 9–12 for each instrument setup that you want to process in the traverse.
14. Click the Measurements tab.
15. Click the Setup dropdown arrow and click the name of the setup with which you want to work.

    The measurements detail for the selected setup is displayed.
16. Click the Results / Method dropdown arrow and select the adjustment method.
17. Click the Compute button. u





See Also

For more information about viewing the results of the Tacheometry computation, see the section 'Processing a single TPS setup using Tacheometry' in this chapter.

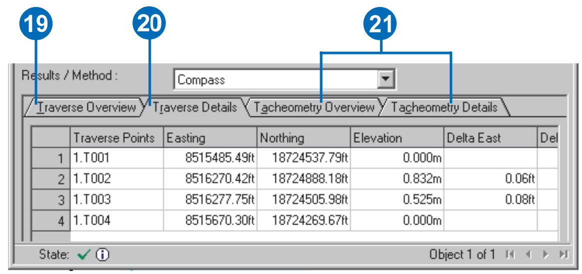
18. Verify that the computation was processed successfully by ensuring the state is valid.

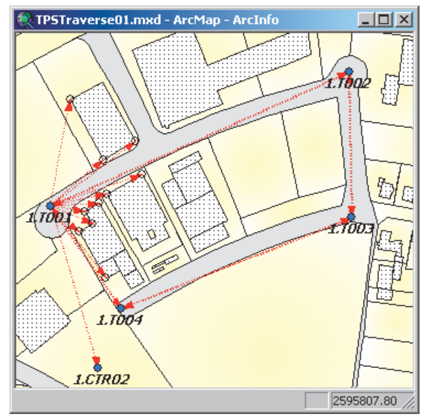
19. Click the Traverse Overview tab to see the coordinate misclosures. In the overview you can also see the angular, linear, latitude, and departure misclosures.

20. Click the Traverse Details tab to see the coordinated locations defined by the traverse.

    The changes from the initially computed coordinates and the coordinates after the adjustment are shown in the the Delta East and Delta North fields.

21. Click the Tacheometry Overview tab and the Tacheometry Details tab to view the results of the tacheometry computation for this setup.





TPS field traverse computation

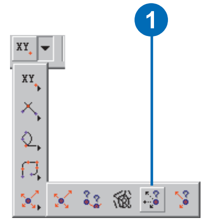
Resection

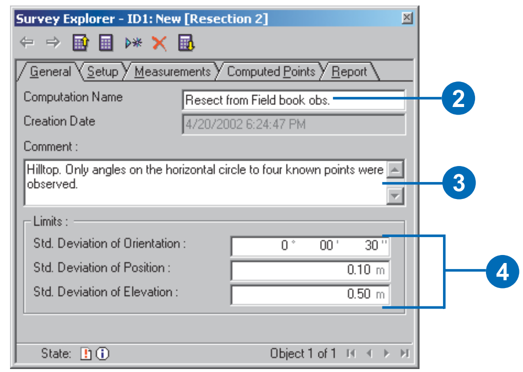
It is possible to compute coordinates for a setup location if you have at least three visible reference points and their horizontal circle readings. The advantage of this method is that distances are not required.

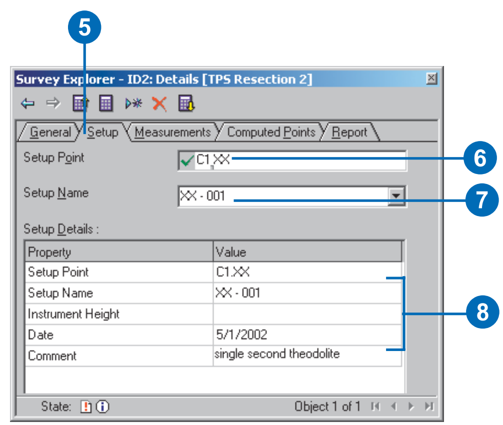
It is important, when using this computation, to be sure you have an approximate coordinate for the point to be computed in order to avoid the resection circle problem. If your known and unknown points all lie approximately on the same circle, then your solution will likely be unreliable. The computation algorithm is unable to determine this without additional measurements to known points that do not lie on the circle.

Typing measurements from a field book—an example based on the Resection

1. Click the Computation tool palette dropdown arrow, move the mouse to the last row on the palette, and click the Resection button.
2. Type a name for the computation, and press Tab.
3. Type a comment for the traverse and press Tab.
4. Type the limits you will allow for the standard deviation in the horizontal position, elevation, and orientation.
5. Click the Setup tab.
6. Click the Point identity field for the Setup Point, type a name for a new survey point, and press Tab.
7. Type a name for the setup and press Tab.
8. Complete the properties for the Setup Details. ▸

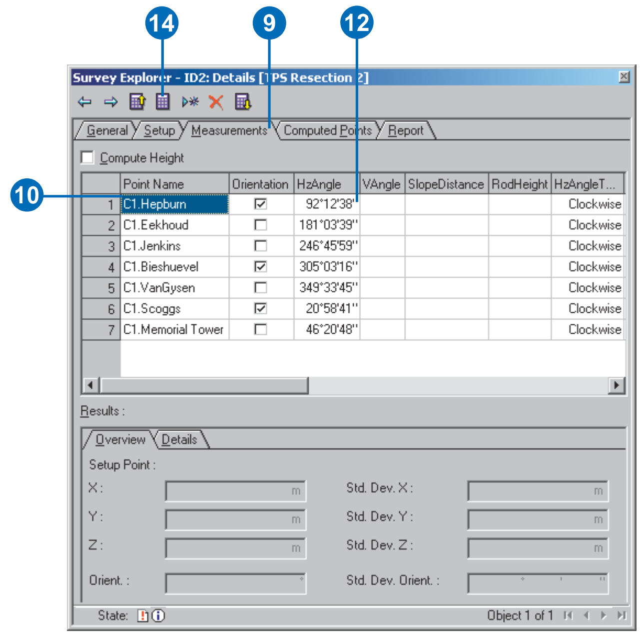


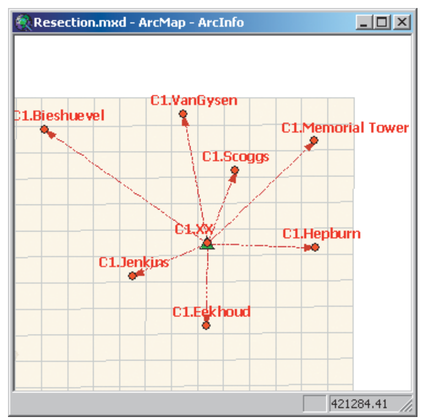




9. Click the Measurements tab.
10. Snap to and click the observed point name on the map. If the point is not visible on the map, type its name in the text box and press Tab.
11. Check the Orientation box if the observed point is a reference point. Press Tab.
12. Type an angle value in the HzAngle field. Hold down Ctrl and press Enter.

    The focus goes to the last field. Press Enter.
13. Repeat steps 10–12 to add new rows for each entry from the field book.
14. Click the Compute button.





Resection computation

Least squares adjustment

The techniques and algorithms supported by the *least squares adjustment* computation make it the best method available for processing multiple instrument setups in a network of measurements.

With a least squares adjustment computation, you strive to remove mistakes in measurements and to improve the quality of your survey points.

For an introduction to the concepts underlying least squares adjustments, refer to Chapter 3, ‘Survey Analyst concepts’.

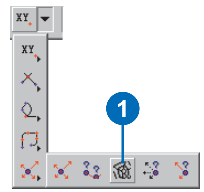
In essence, the least squares adjustment allows many measurements to participate simultaneously in a single computation. This process provides a best fit for survey point locations and allows detection of defective measurements, called *blunders* or *outliers*. These outliers are detected based on statistical tests. ►

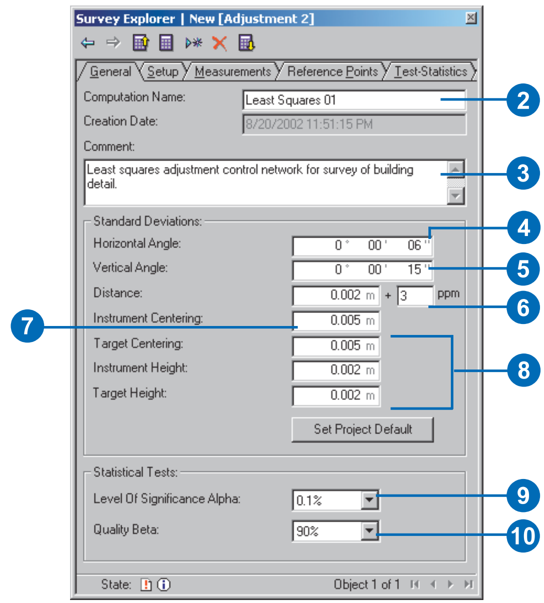
See Also

For more information about the least squares adjustment computation, refer to the literature listed in References of this book.

Processing multiple TPS setups using a Least squares adjustment

1. Click the Computation tool palette dropdown arrow, move the mouse to the last row on the palette, and click the Adjustment button.
2. Type a name for the computation and press Tab.
3. Type a comment for the adjustment and press Tab.
4. Type the a priori standard deviation for the horizontal angle observations and press Enter.
5. Repeat step 4 for the vertical angle observation.
6. Type the standard deviation for the distance, press Tab, and enter the parts per million ratio. Press Enter.
7. Type the a priori standard deviation for centering the setup. Press Enter.
8. Repeat step 7 for the standard deviations of Target Centering, Instrument Height, and Target Height.
9. Click the Level Of Significance Alpha dropdown arrow and click the alpha percentage you want to use.
10. Click the Quality Beta dropdown arrow and click the beta value you want to use. ►





Surveyors typically perform extra measurements in the field to improve the quality of the network, and to guard against loss of information and other blunders.

When the number of observed measurements is greater than the number of computed parameters, *redundancy* exists in the network.

The more redundancy you have in a measurement network, the better your chances are to detect and control problems.

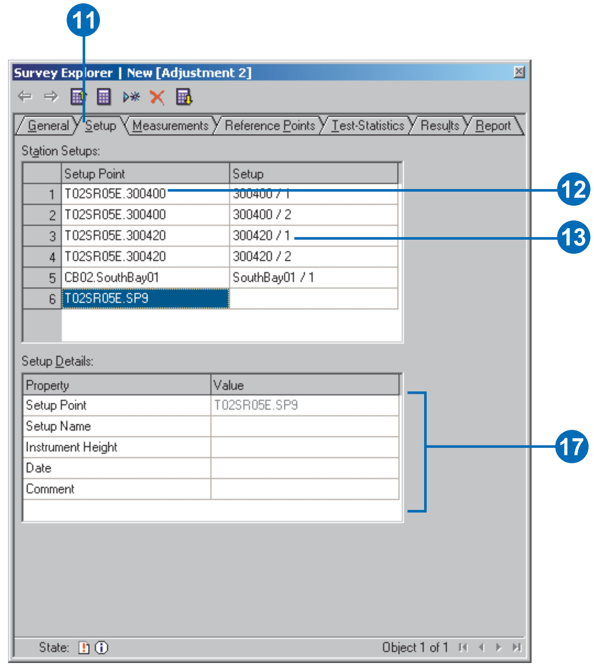
Unlike the other computations, using the least squares adjustment is an iterative process. You remove the measurement or reference point that is detected as the biggest outlier, and recompute. Repeat this until all blunders have been found and the adjustment can be computed successfully. An altenative is to make the testing limits more forgiving by increasing the level of significance. ▸

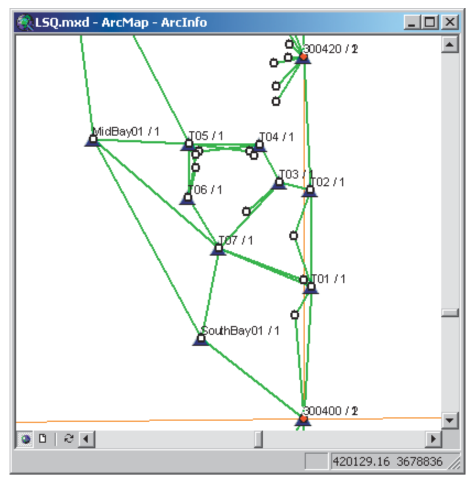
Tip

Setups on the same point

In the least squares adjustment computation, the setup point can be added multiple times, once for each instrument setup.

11. Click the Setup tab.
12. Snap to and click the setup point on the map. If the point is not visible on the map, type its name and press Enter.
13. Press Enter.
14. Skip to step 16 if the correct setup name appears in the Setup field.
15. Double-click the Setup field dropdown arrow and click the name of the setup you want to use for the traverse. Press Enter.
16. Repeat steps 12–15 for each instrument setup that you want to process in the adjustment.
17. Make corrections to the Setup Name, Instrument Height, and Comment, if required. ▸





Least squares adjustment computation

There are two phases involved when performing a least squares adjustment for your measurement network:

- Free network adjustment
- Constrained adjustment

These phases separate the testing of measurements from the testing of the reference points. The *free network adjustment* phase examines the overall geometry of the network by processing the measurements only and using the reference points only for position scale and orientation of the network. In this phase the emphasis is on testing the quality of the measurements rather than computing coordinates. This step is performed to check for outliers in your measurements.

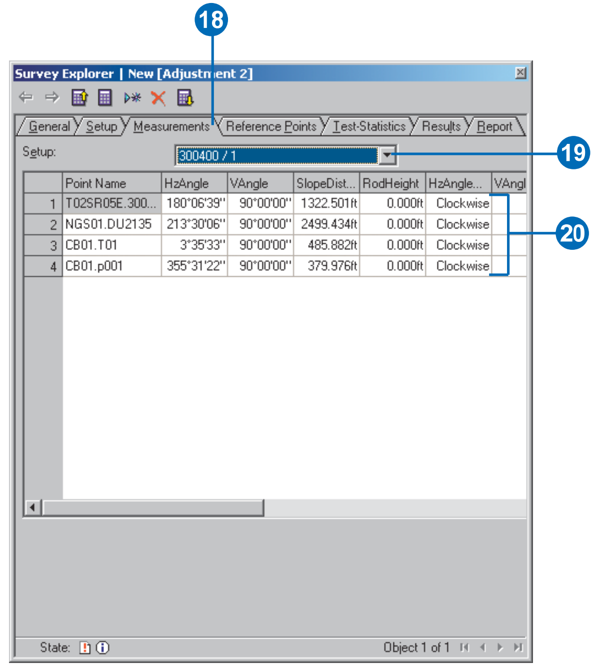
For example, you may have used an incorrect prism offset for a measured distance. If defective measurements are detected, you need to exclude them from the computation to ▸

Tip

Editing measurements

Avoid making edits to measurements from raw data collected in the field unless you are completely conviced that they are incorrect and you are certain of the correct value.

18. Click the Measurements tab.
19. Click the Setup dropdown arrow and click the instrument setup name to view the measurements belonging to the different instrument setups.
20. Make corrections to the measurements, if necessary, by editing their values. Only do this if you know the existing values are mistakes and if you are absolutely certain of the correct value. ▸



prevent them from affecting the overall best fit of the adjustment. Sometimes, you have enough information to correct the mistake by editing the data. However, it is important to be certain that the correction is valid.

After eliminating or correcting the blunders in the measurements, the reference points are used in a *constrained adjustment*. In this second phase, the emphasis is on testing the reference points as well as computing final coordinates.

Including reference points imposes additional constraints on the solution of the adjustment.

There are two possibilties for performing a constrained adjustment.

- Absolutely constrained
- Weighted constrained

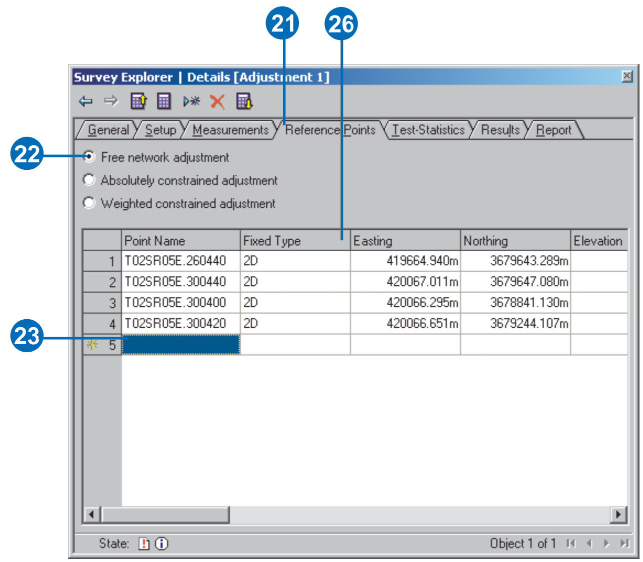
In the *absolutely constrained adjustment*, the coordinates of the reference points keep their ▸

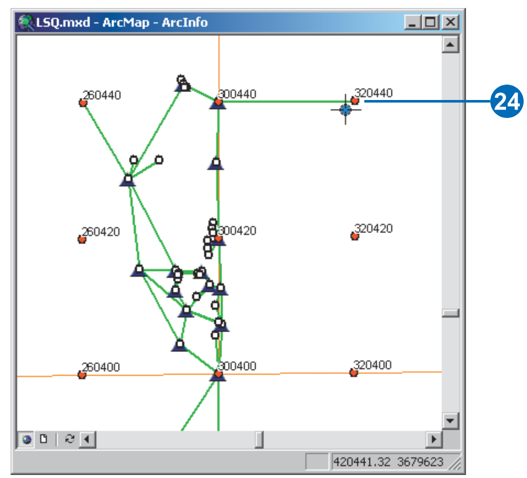
Tip

Choosing a dimension

You can choose the dimension of the reference point in the Reference Points tab of the least squares adjustment by selecting the dimension field and pressing the 1, 2, or 3 keys.

21. Click the Reference Points tab.
22. Click the Free network adjustment option.
23. Highlight the Point Name field in the first row by clicking in the field.
24. Snap to and click the reference point on the map. If the point is not visible on the map, type its name in the text box and press Enter.
25. Skip to step 28 if the reference point should be used as control in three dimensions.
26. Double-click the Fixed Type field to get the Fixed Type dropdown arrow.
27. Click the dropdown arrow and click the dimension to be used for the reference point.
28. Press Enter.
29. Repeat steps 24–28 for each reference point that should be added to the least squares adjustment. ▸





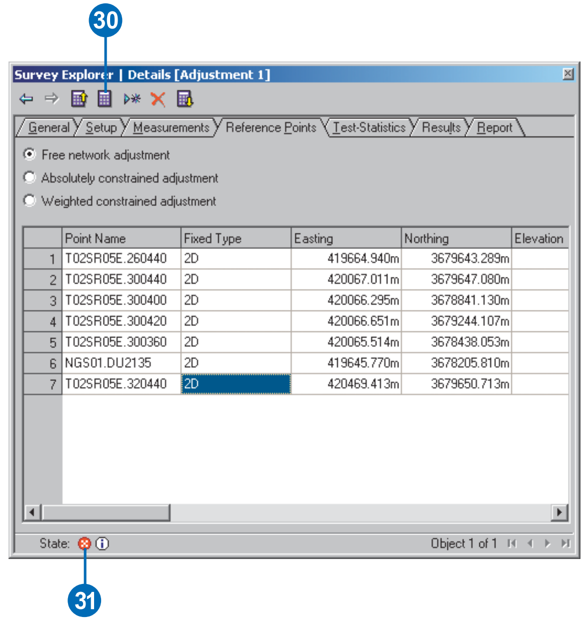
original value. The standard deviations of their coordinates are held at 0 and, therefore, do not shift in response to the adjustment. You would use this method when, for instance, the reference points are coordinates published by a government authority and should, therefore, remain unchanged in the survey dataset.

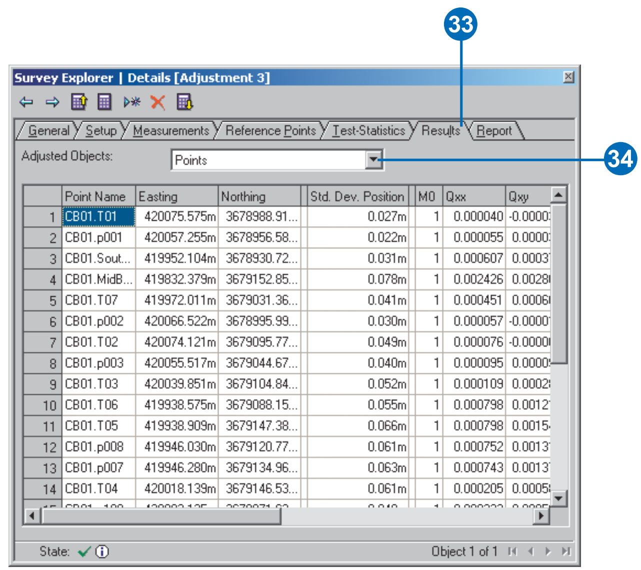
In the *weighted constrained adjustment*, the reference point coordinates are treated as observed values (measurements), and their standard deviations are applied in the adjustment. Unlike the absolutely constrained adjustment, both the reference point coordinates and the measurements receive corrections during the adjustment. This method provides an optimal "best fit" solution and can be used when you are free to define and publish coordinates for your survey control network.

Statistical Testing

The aim of statistical testing is to detect possible outliers (blunders) in the measurements. This provides an imporant component in the process of quality control. The statistical testing is part of the least squares adjustment computation. ▸

30. Click the Compute button.
31. Assess the state of the computation by looking at the State icon.
32. Follow the steps outlined in the next section, 'Detecting and disabling outlier measurements using data snooping', if the icon state indicates that the computation is incorrect. Continue with step 33 once you have completed the datasnooping process.
33. Click the Results tab.
34. Click the Adjusted Objects dropdown arrow and click Points to view the computed coordinates and their quality information. ▸





It is used to verify statistical hypotheses that define a set of assumptions. A special set of assumptions is referred to as the null-hypothesis (H0). This hypothesis implies that:

- There are no blunders (mistakes) in the measurements.
- The relations between the measurements and the coordinates for survey points are correctly defined.
- The chosen a priori standard deviations for the measurements are appropriate.

Level of significance

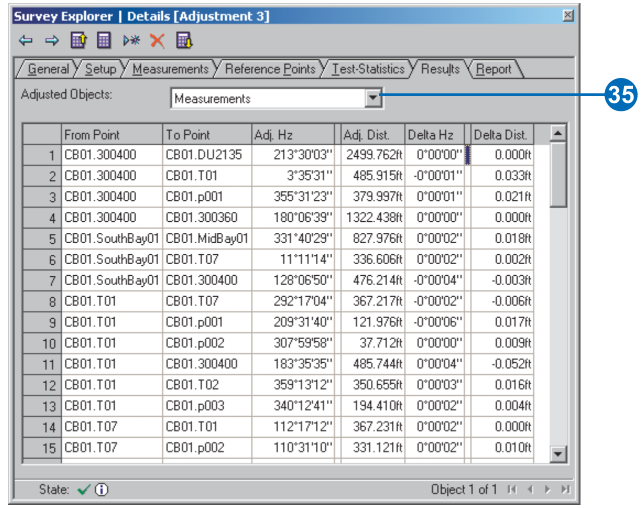
There are two possible outcomes for the testing of a hypothesis: acceptance or rejection. A specific cutoff point, or *critical value,* determines the acceptance or rejection of a hypothesis. ▸

Tip

Original measurement values do not change

In the results of the least squares adjustment, you can view the final adjusted measurement values and their deltas. This information is stored with the computation. The original measurements stored in the survey dataset are not altered.

35. Click the Adjusted Objects dropdown arrow and click Measurements to view the adjusted measurement values. You can also view the deltas, which provide the amount of change from the original unadjusted values.



Critical values are determined by the choice of a *level of significance* (α). The level of significance is the probability of an incorrect rejection. The *level of confidence* 1-α is the complement of the level of significance and is a measure of the confidence one can have in the decision.

Two types of statistical tests are available: the *F-test* and the *W-test*.

The F-test

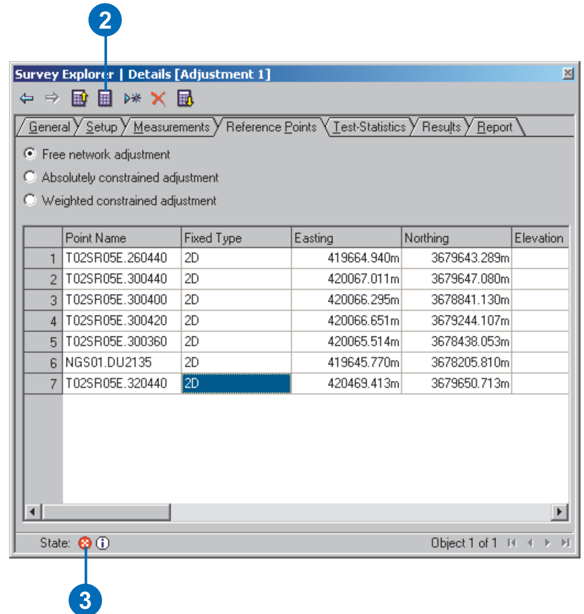
The F-test is a commonly used test that assesses the model in general. The information provided by the F-test, namely acceptance or rejection of the null-hypothesis (H0), is not very specific. This means that if H0 is rejected, it is necessary to find the cause of the rejection by finding problems in measurements. If you suspect that the H0 is rejected due to a gross error present in one of the measurements, you can use the W-test to identify those measurements.

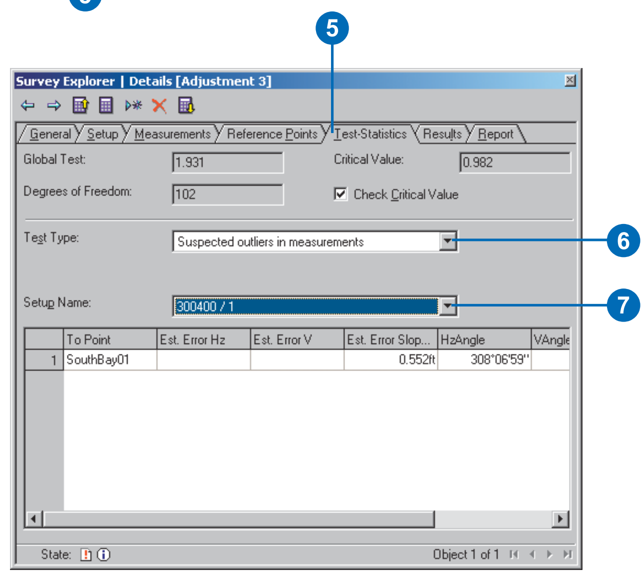
The W-test and datasnooping

A rejection of the F-test does not directly lead to the source of the rejection. In case the null-hypothesis is rejected, other hypotheses must be ▸

Detecting and disabling outlier measurements using datasnooping

1. Complete steps 1–29 defined in the preceding task, 'Processing multiple TPS setups using a least squares adjustment'.
2. Click the Compute button.
3. Assess the state of the computation by looking at the State icon.
4. Continue with the following steps if the icon state indicates that the computation is incorrect; otherwise, you do not need to disable outlier measurements.
5. Click the Test-Statistics tab to start the data snooping process.
6. Click the Test Type dropdown arrow and click Suspected outliers in measurements.
7. Click the Setup Name dropdown arrow and click the different setup names to view their outlier measurements.
8. Identify the measurements that have the largest estimated error for angles and distances and note their setup point and to point names for the next few steps. ▸





formulated that describe possible errors. A simple, but effective hypothesis is the *conventional alternative hypothesis*, based on the assumption that there is an outlier present in a single measurement in the network. The test associated with this hypothesis is called the W-test.

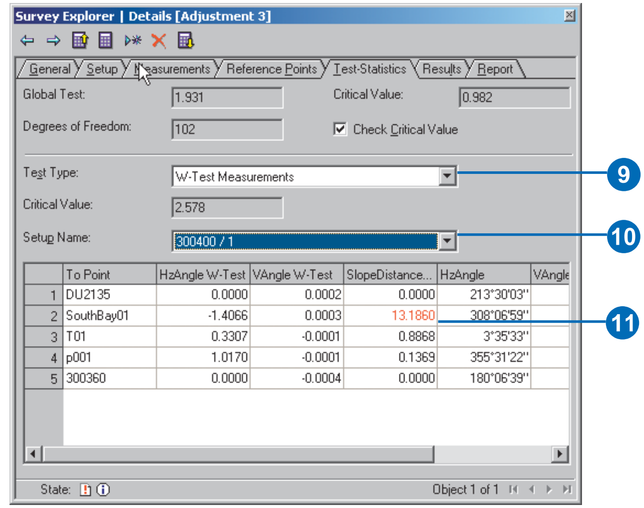
The process of testing each measurement using the W-test is called *datasnooping*.

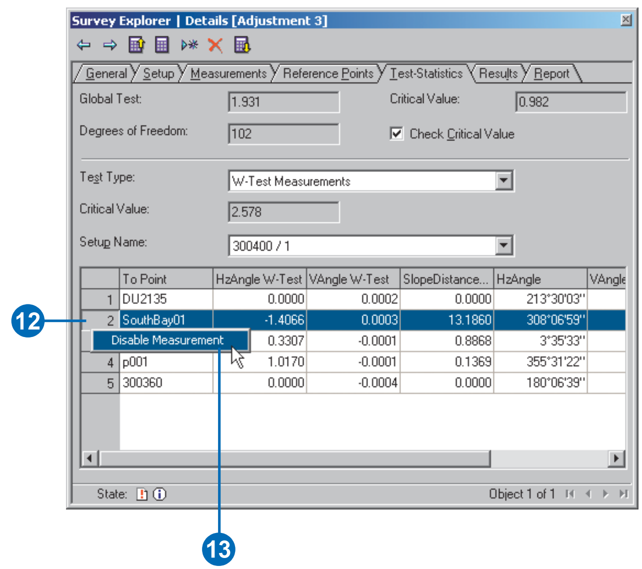
Tip

Disabling measurements

The W-test assumes an outlier in a single measurement. Therefore, outliers should be disabled one at a time and the computation recomputed and tested after each change.

9. Click the Test Type dropdown arrow and click W-Test Measurements.
10. Click the Setup Name dropdown arrow and click the setup points you noted in step 8.
11. Find the outlier measurements highlighted in red, and identify the largest W-Test value.
12. Click the leftmost column of the row with the largest W-Test value. This selects the measurement's row.
13. Right-click the selected row's leftmost column and click Disable Measurement. Do not disable more than one measurement at a time.
14. Return to step 2.





Setting Quality Beta

When used together, the F-test and W-test are referred to as the B-method of testing, for which a power can be defined. The power, or *Quality Beta (β)* of this method is defined as follows: the probability that H_0 is accepted while in fact it is false is equal to 1-β.

The least squares adjustment computation allows you to set the β. The Quality Beta defines a tolerance for a level of accuracy. Setting a lower β will, for example, result in the F-Test and W-Test being more tolerant of systematic error.

Reporting computation results

After succesfully completing a computation, you can present its results in a report. Reports can be created for any of the following computations:

- COGO Traverse
- COGO Station and Offset
- TPS Free Station
- TPS Traverse
- TPS Resection
- TPS Tacheometry
- TPS Least Squares Adjustment

A report can be created if the state of the computation is valid.

Reporting for computations is based on XML. You can select a style for the report by choosing a stylesheet. ▸

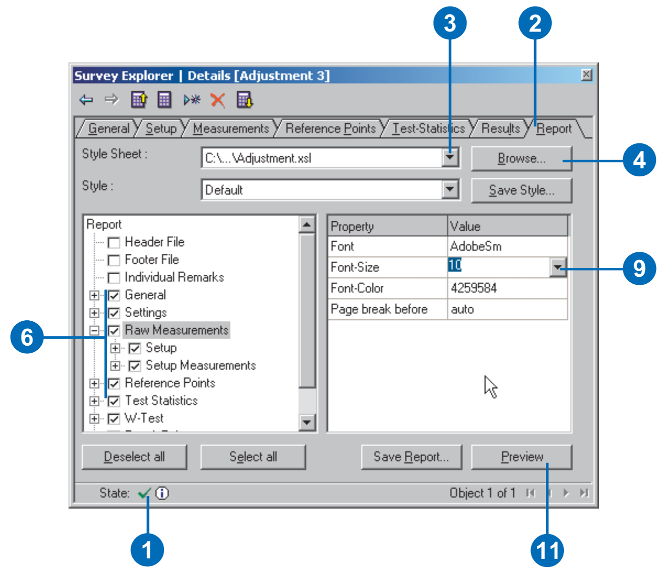
Tip

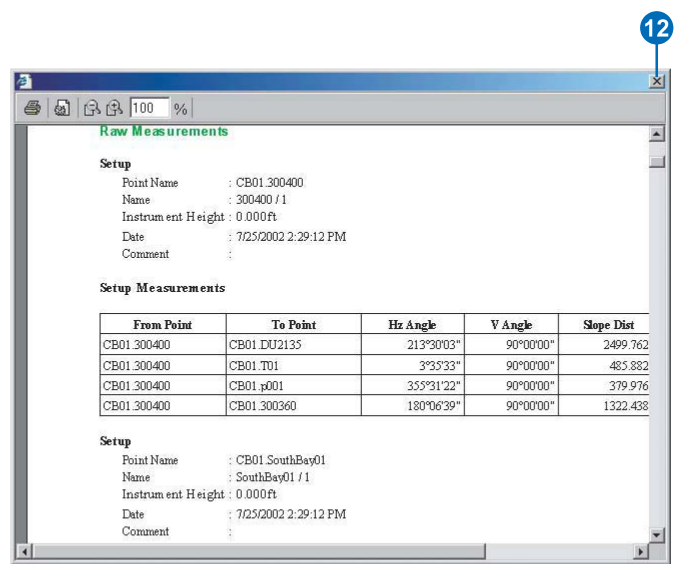
Displaying report headings

Each report item is categorized under a heading. You can choose not to display a heading by unchecking it on the Report tab. Unchecked items in this category will then be displayed in the report without a heading.

Creating a computation report

1. Confirm that the state of the computation is valid.
2. Click the Report tab.
3. Click the Style Sheet dropdown arrow and click the stylesheet that you want to use.
4. Click Browse and navigate to the location of the style sheet if the style sheet you need is not listed.
5. Skip to step 16 if you want to use a predefined style.
6. Check the boxes of the items in the computation you want included in the report.
7. Click the element of the computation for which you want to change the font.
8. Double-click the Value field for the Font property you want to change.
9. Click the font property's dropdown arrow and click the property you want to use.
10. Repeat steps 7–9 for all other elements you want to change.
11. Click Preview to see how the report will appear based on your style changes.
12. Click the Close button. ▸





Survey Analyst provides a stylesheet for each computation (the default path for these is \arcgis\arcexe83\Survey Report Templates on the drive where ArcGIS is installed).

You can also create your own stylesheets for your report.

You can select from a list the elements of the computation that need to be included in the report. For each of these elements, you can choose a font and color for the text.

Using a preview, you can refine the appearance of your report. Once it has been finalized, you can save the style as a template for use when creating reports for other computations.

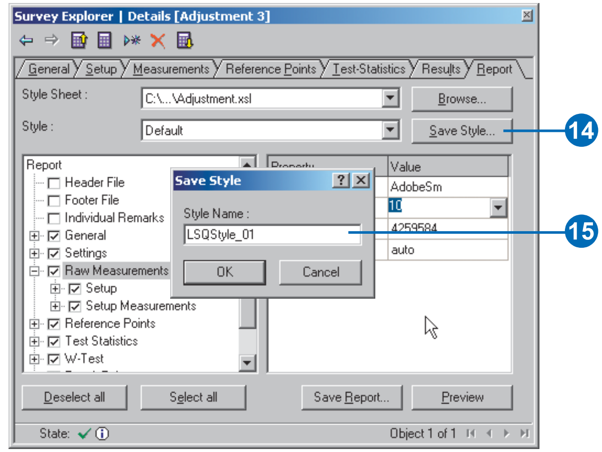
Finally, you can save the report in HTML format, for hard copy printing, or electronic publication.

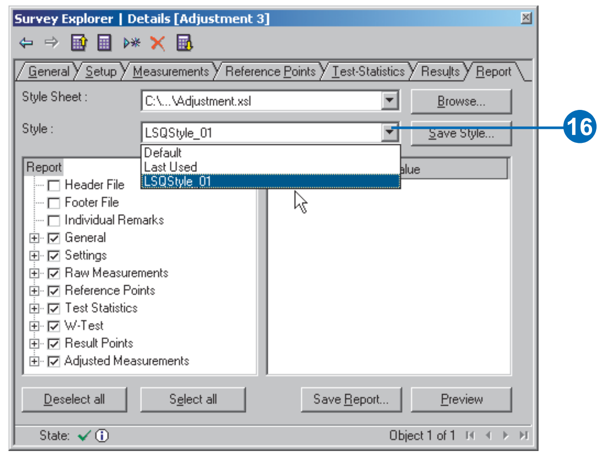
13. Return to step 6 if you want to make changes.

14. Click Save Style.

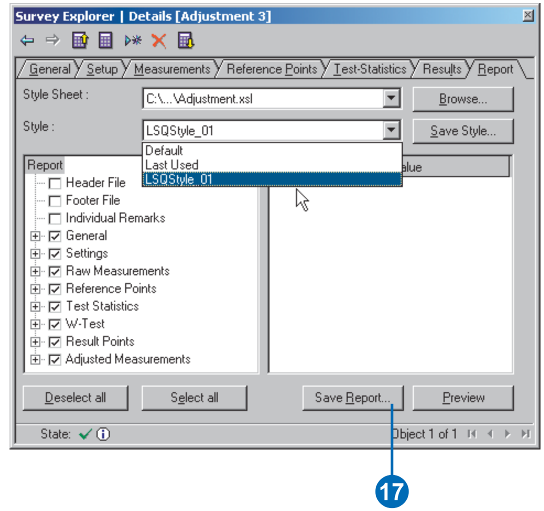
15. Type a name for the new style and click OK.

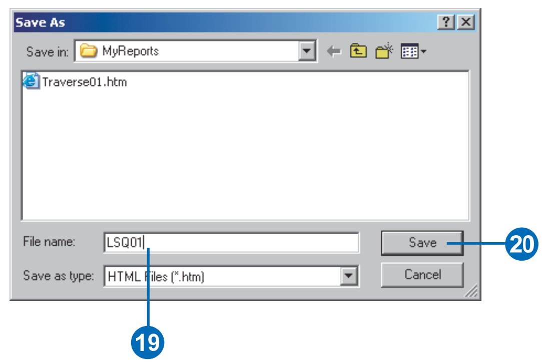
16. Click the Style dropdown arrow and click the style you want to use for the report. ▸





17. Click Save Report.
18. Navigate to the folder in which you want to save the report.
19. Type a name for the report.
20. Click Save.





Editing feature geometry

8

IN THIS CHAPTER

Survey points provide a framework of control for the geometry of features. The focus of this chapter is editing features based on the map location of existing survey points. You can choose to have the geometry of features in *survey-aware feature classes* managed in this control framework.

A survey-aware feature class can be edited in the following ways:

- New features can be digitized by snapping to the geometry of survey points.
- Existing features can be *linked* to survey points. An association between survey points and features is created; feature locations are not updated immediately.
- Existing features that are linked can be *updated* to match the geometry of the survey points.
- Unlinked feature geometry can be updated based on the transformation parameters determined by the existing links.

First, an overview of standard feature digitizing is presented, based on starting and finishing an *edit sketch*. Second, the indirect method of creating an edit sketch using COGO *computations* is introduced. Finally, the tools and commands used for creating and managing links are described.

Using the edit sketch

A standard method for editing feature geometry is to create a temporary sketch—an edit sketch—which is used to perform a variety of different tasks. The edit sketch comprises a set of points, typically connected by segments. Segments can be straight lines or parametric curves. Using the *Sketch tool*, you define the first point by heads-up digitizing, snapping, or entering coordinates. A number of tools and techniques let you add new sketch segments and points to achieve the desired sketch. You finish the sketch and apply the sketch's geometry to complete your chosen task. For instance, the sketch's geometry can be applied to:

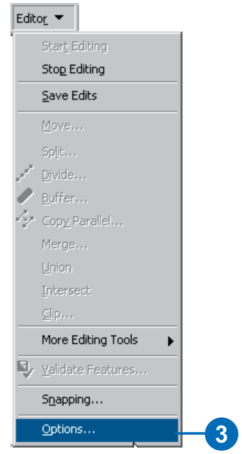
- Select features
- Alter the geometry of selected features
- Work in conjunction with a target feature layer to create new features ▸

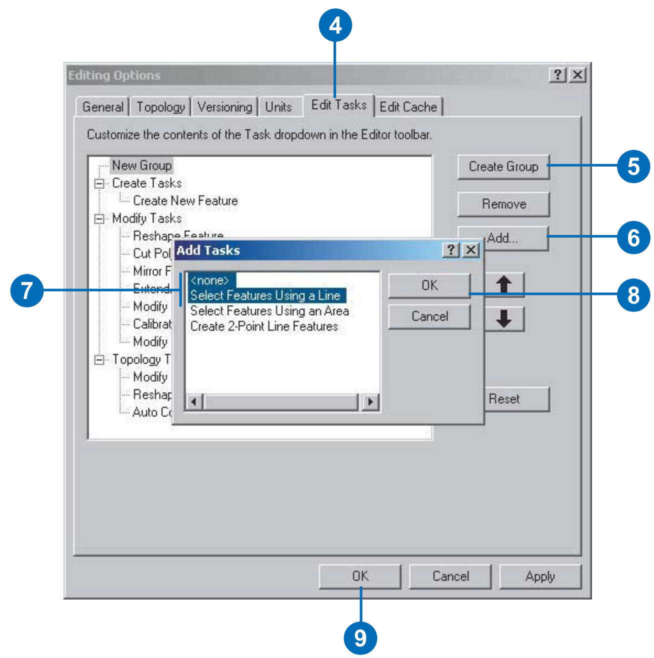
See Also

For more information about using the Editor functionality, see Editing in ArcMap.

Adding tasks to the Editor's task list

1. Start ArcMap and add the Editor toolbar.
2. Click the Editor menu in the Editor toolbar and click Start Editing.
3. Click the Editor menu in the Editor toolbar and click Options.
4. Click the Edit Tasks tab.
5. Click Create Group.
6. Click the New Group in the tasks list and click Add.
7. Click <none> and, while holding down the Shift key, click Select Features Using a Line.
8. Click OK on the Add Tasks dialog box.
9. Click OK on the Editing Options dialog box.





Before working with the edit sketch and using the edit tasks, you need to add the tasks that you will use to the Editor toolbar's task list. In the Editor options you can choose and add tasks that are not part of the default set. The Survey Analyst extension uses a task that needs to be added to the default list. This is the *<none> task*; its purpose is described in the next section, 'Using COGO computations with the edit sketch', in this chapter.

Snapping allows you to precisely digitize sketch points based on the location of existing geometry.

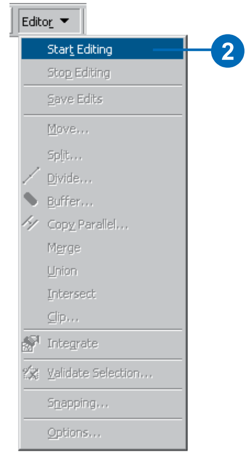
The Editor lets you control how to digitize sketch points by turning on snapping for:

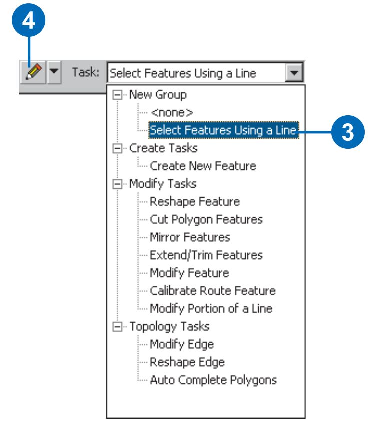
- Selected elements of feature geometry
- The points and segments of the sketch itself
- Survey points

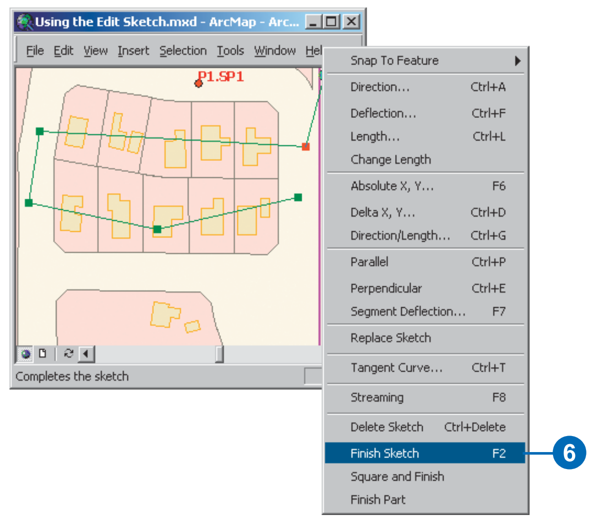
These snapping properties define the *snapping environment*.

Select features using a sketch line

1. Start ArcMap, add the Editor toolbar, and add the Survey Editor toolbar.
2. Click the Editor menu in the Editor toolbar and click Start Editing.
3. Click the Task dropdown arrow in the Editor toolbar and click Select Features Using a Line.
4. Click the Sketch tool.
5. Construct a line by clicking on the map for each vertex, so that the line intersects the features you want to select.
6. Right-click the map and click Finish Sketch to apply the task and select the features.

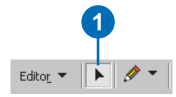


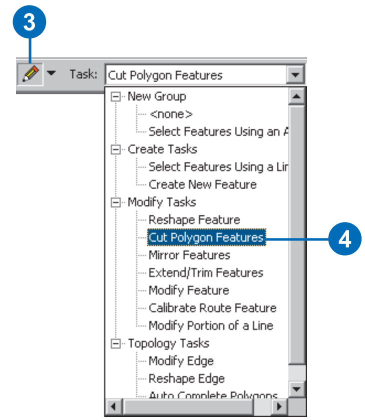


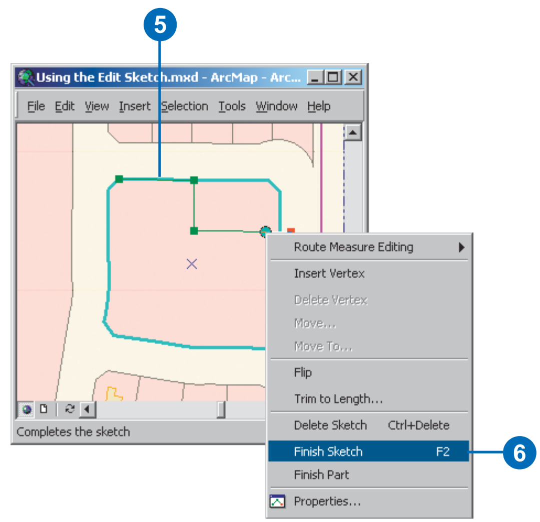


Subdividing a selected feature

1. Click the Edit tool.
2. Click the polygon feature that you want to subdivide.
3. Click the Sketch tool.
4. Click the Task dropdown arrow in the Editor toolbar and click Cut Polygon Features.
5. Construct a sketch line that you want to use to subdivide the selected feature.
6. Right-click the map and click Finish Sketch to apply the task and cut the selected feature.





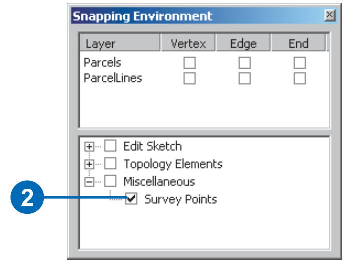


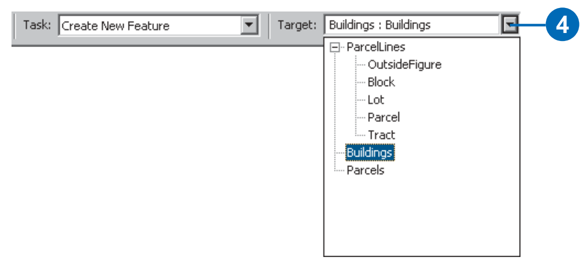
Auto-Linking survey points

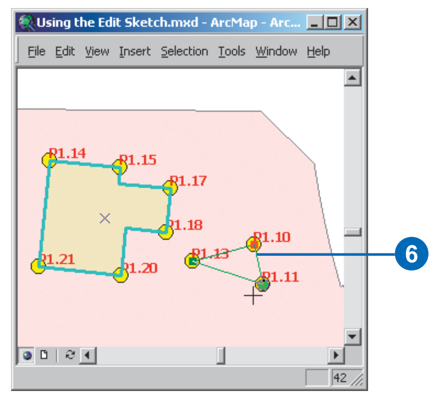
When snapping edit sketch vertices to survey points, links are automatically created. If you do not require these links, turn off the Auto-Linking option in the Survey Editor menu.

Creating a new feature by snapping to survey points

1. Click the Editor menu and click Snapping.
2. Check Survey Points in the Snapping Environment dialog box.
3. Click the Task dropdown arrow in the Editor toolbar and click Create New Feature.
4. Click the Target dropdown arrow and click the feature layer in which you want to create the new feature.
5. Click the Sketch tool.
6. Construct a sketch by snapping the sketch points to the survey points.
7. Right-click the map and click Finish Sketch to apply the task and create the new feature.







Using COGO computations with the edit sketch

You can simultaneously create an edit sketch while adding COGO computations to the *survey project*.

A sketch point is added each time a new survey point is created. It is added at the same location as the new survey point. If you do not want to simultaneously add points to the edit sketch, you can select the *<none> task*.

See Also

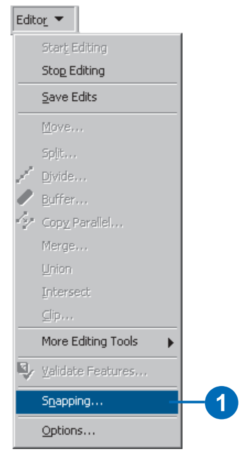
For more detailed information about the Angle format and limits of the COGO Traverse, refer to Chapter 7, 'Using computations'.

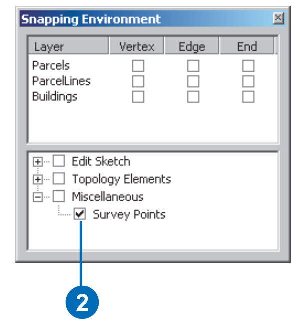
See Also

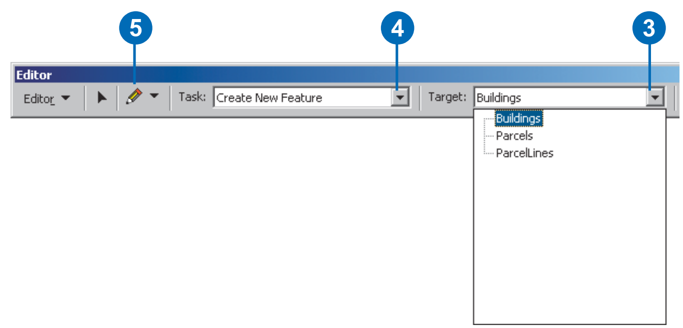
For more detailed information about how to enter traverse courses, refer to Chapter 7, 'Using computations'.

Create a new feature using a COGO traverse

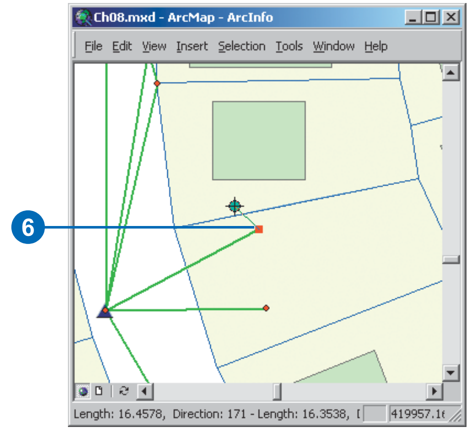
1. Click the Editor menu and click Snapping.
2. Check Survey Points in the Snapping Environment dialog box.
3. Click the Target dropdown arrow and click the feature layer in which you want to create the new feature.
4. Click the Task dropdown arrow in the Editor toolbar and click Create New Feature.
5. Click the Sketch Tool. ▸

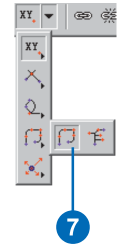


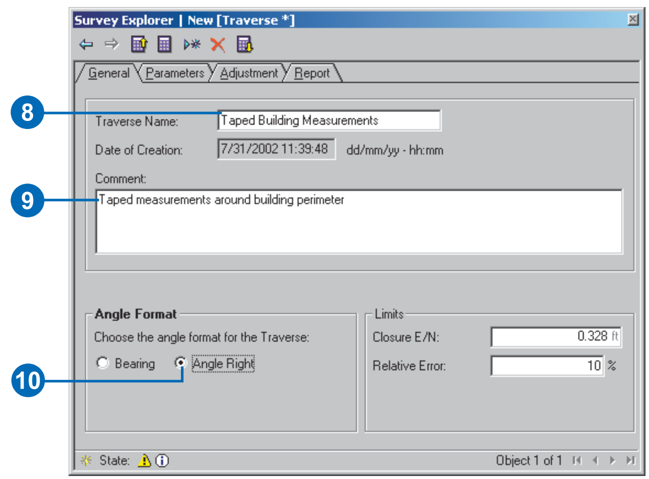




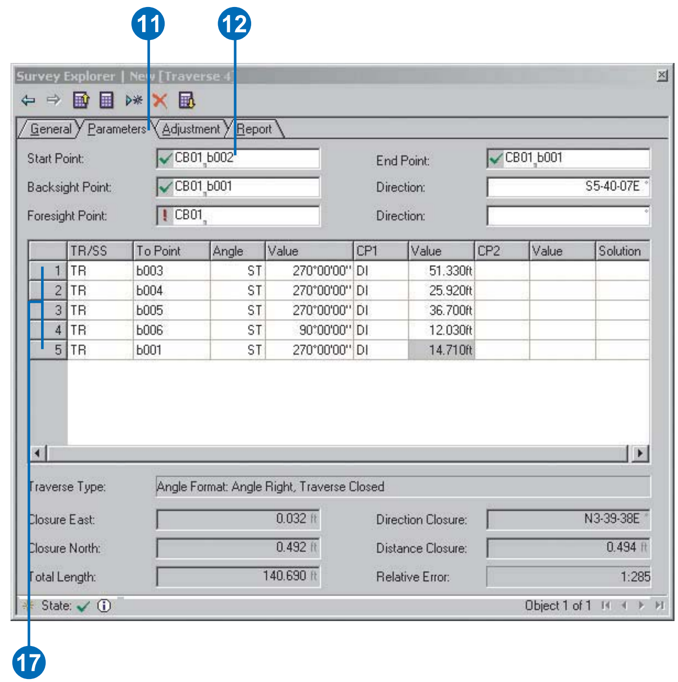
6. Snap and click the first sketch point to the start point of the traverse.
7. Click the Computation tool palette dropdown arrow, point the mouse to the fourth row on the palette, and click the COGO Traverse button.
8. Type a name for the computation and press Tab.
9. Type a comment for the COGO traverse computation and press Tab.
10. Click Angle Right as the Angle Format. ▸

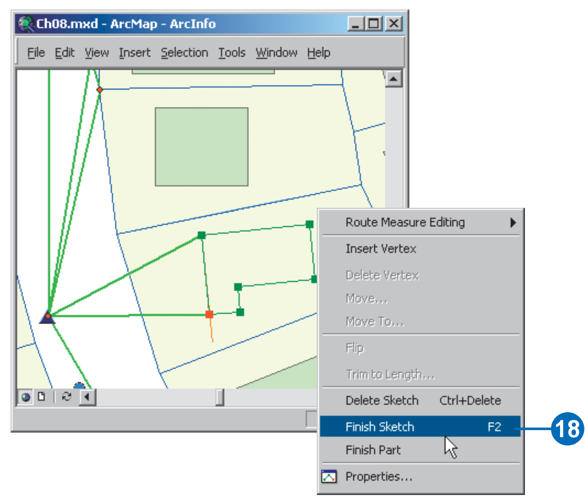






11. Click the Parameters tab.
12. Snap to and click the start point on the map. If the point is not visible on the map, type its name and press Tab.
13. Repeat step 6 and select the traverse endpoint.
14. Repeat step 6 to choose the backsight point.
15. Press Enter to accept the default backsight Direction value.
16. Press Enter to ignore the foresight point.
17. Enter the courses of the traverse.
18. Right-click the edit sketch in the map and click Finish Sketch.





Linking survey points to feature geometry

Frequently, survey points are added to the survey dataset after the features they represent have already become a part of the established map fabric. In most circumstances, the computed locations of survey points will not exactly match the locations of the existing feature vertices.

You can make a link between a survey point and a feature vertex using the *Link tool* or the *Link command*.

The Link tool lets you snap and click on a feature vertex and then snap to and click the related survey point. This creates a link between the feature vertex and the survey point. ▸

Tip

Multiple feature links to a single survey point

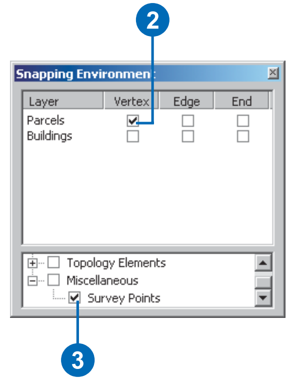
A single survey point may have links to multiple feature vertices.

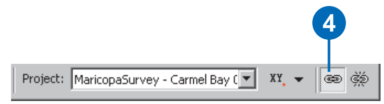
See Also

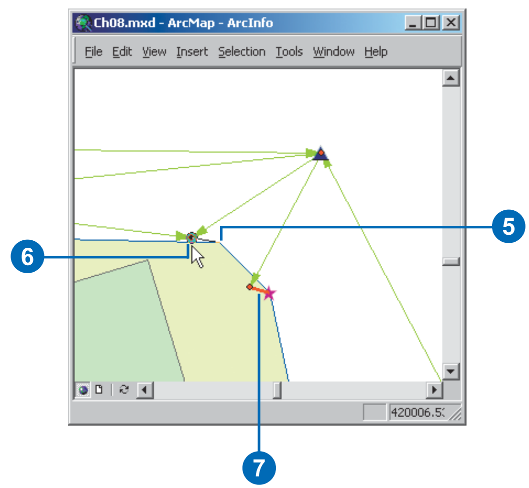
To learn how to work with the symbols for links, see Chapter 5, 'Visualizing survey data'.

Using the Link tool

1. Click the Editor menu and click Snapping.
2. Check Vertex for the feature layer to which you want to create links.
3. Check Survey Points in the Snapping Environment dialog box.
4. Click the Link tool in the Survey Editor toolbar.
5. Snap to and click the vertex of the feature you want to link.
6. Snap to and click the survey point you want to link the vertex with.
7. Verify that the link line is displayed and that the link symbol is displayed on the feature vertex.
8. Repeat steps 5–7 for each link you want to create.







If there are many unlinked features that need to be associated with nearby survey points, you can use the Link command instead of the Link tool.

The Link command operates on the selected features. For each feature vertex, the command finds nearby survey points and automatically creates links. Before processing, the command lets you specify the search tolerance for finding the survey points.

While the Link command is running, more than one survey point may be found within the specified tolerance of any of the feature vertices. In these cases, a Link Conflicts dialog box appears that contains the set of locations for all places where conflicts were found.

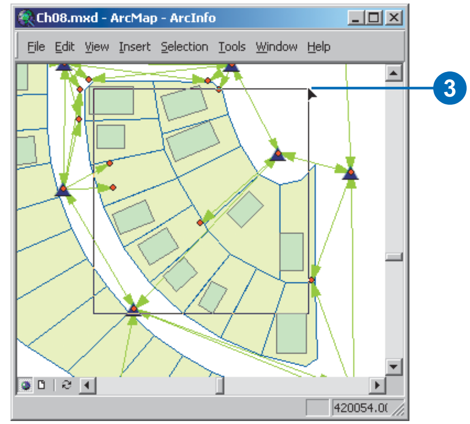
The Link Conflicts dialog box lets you view each of the conflicts individually, and allows you to directly create the appropriate links. When a conflict has been fixed, click the Solved button to remove it from the set.

If necessary, you can close the Link Conflicts dialog box to continue with a different task, and then return to solve the remaining conflicts later in the edit session. You can do this by clicking Show Link Conflicts in the Survey Editor menu. ▸

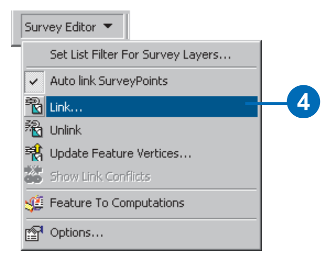
Using the Link command and solving link conflicts

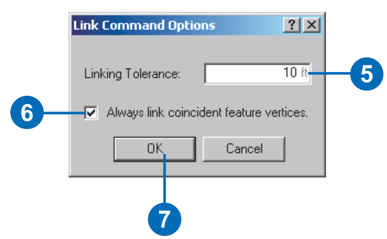
1. Zoom and pan the map to the scale and location of the features that you want to link to survey points.
2. Click the Edit tool in the Editor toolbar.
3. Click and drag a box around the features on the map to create a feature selection.
4. Click the Survey Editor menu in the Survey Editor toolbar and click Link.
5. In the Link Options dialog box, type a value for the Linking Tolerance.
6. Check Always link coincident feature vertices.

   This ensures that vertices sharing the same location will automatically be linked. If this box is not checked, coincident vertices are treated as conflicts.
7. Click OK. ▸



Selecting features





After making the link between a survey point and a feature vertex, *link-lines* are displayed on the map.

Each feature is aware of the survey points to which it is linked. The links are stored with the survey-aware features in the database.

The survey point location can change as additional measurements and computations are added to the survey dataset. Similarly, the position or shape of the feature can be edited. In either situation, the link-lines are updated after changes to survey points or features are made.

Tip

Always link coincident vertices

When using the Link command, you can ensure that feature vertices that share the same location are automatically linked and not detected as a conflict by checking the Always link coincident vertices box.

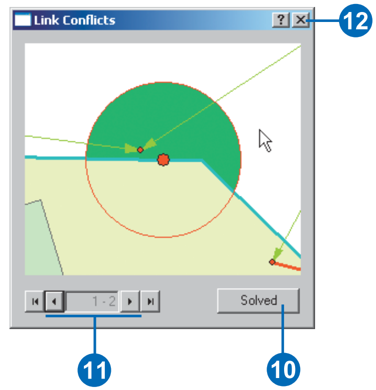
See Also

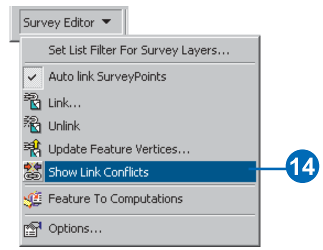
To learn more about how links between survey points and feature vertices are stored, see Chapter 3, 'Survey Analyst concepts'.

8. Continue with steps 9–14 if the Link Conflicts dialog box appears.

   Otherwise, this task is complete; no conflicts occurred, and all points within your specified tolerance are linked to feature vertices.

9. Use the Link tool to create the correct links.
10. Click Solved once you have created the correct link.
11. Click the forward and back buttons to navigate to the next conflict that you want to view or solve.
12. Click Close if you have completed solving all conflicts or if you want to continue with a different task.
13. Repeat steps 9–12 for each conflict as required.
14. Return to the stored conflicts by clicking the Survey Editor menu in the Survey Editor toolbar and clicking Show Link Conflicts.





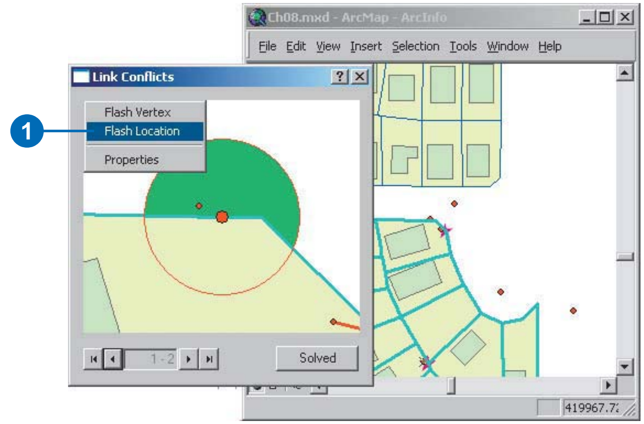
Tip

Flashing the location of the conflict vertex

To flash the location of a vertex displayed in the Link Conflicts window, right-click in the window and click Flash Vertex.

Flashing the location of the Link Conflicts window on the map

1. Right-click inside the Link Conflicts window and click Flash Location.
2. Note that the area on the map covered by the current view in the Link Conflicts window flashes on the map.



Changing the display scale for the Link Conflicts window

You can change the scale at which the Link Conflicts window displays conflict locations. There are three methods for doing this:

- Zoom percentage
- Absolute scale
- Scale relative to tolerance circle

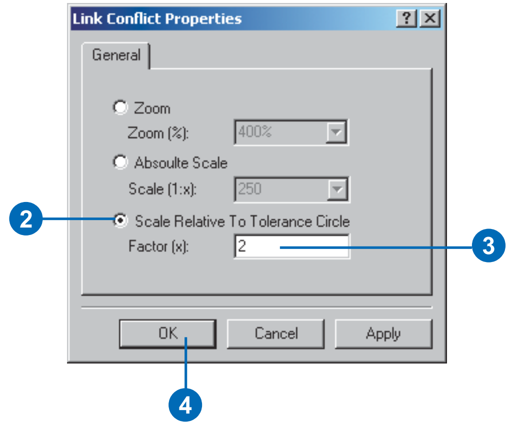
Zoom percentage lets you define a magnification based on the current map scale.

Absolute scale lets you define the scale directly.

You can also specify a display scale based on the tolerance that you specified for the link command. For instance, to have the view cover a region that extends to double the size of the tolerance distance, enter a factor of two.

Displaying the scale of the Link Conflicts window as a factor of the link tolerance

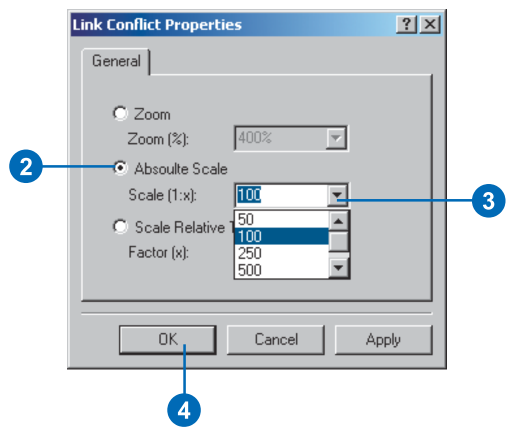
1. Right-click the Link Conflicts window and click Properties.
2. Click Scale Relative To Tolerance Circle.
3. Type a value for the factor.
4. Click OK.



Displaying the scale of the Link Conflicts window using an absolute scale

1. Right-click the Link Conflicts window and click Properties.
2. Click Absolute Scale.
3. Click the Scale dropdown arrow and click the scale you want to use.

   You can also type the scale directly.
4. Click OK.



Breaking links between survey points and features

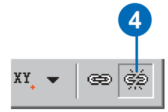
You must explicitly break links using either the Unlink tool or the Unlink command. The Unlink tool works by letting you click the survey point or vertex that you want to unlink.

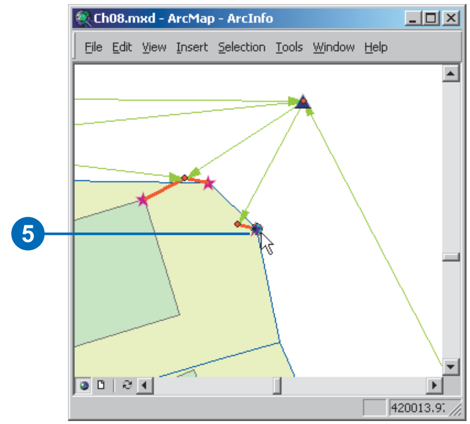
To unlink a single feature vertex, use the Unlink tool to snap to and click the vertex that must be unlinked. To unlink all the feature vertices linked to a survey point, use the Unlink tool and click the survey point.

You can remove all the links for selected features using the Unlink command.

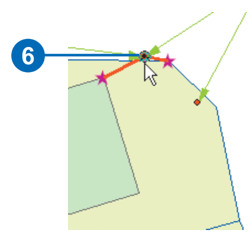
Using the Unlink tool

1. Click the Editor menu and click Snapping.
2. Check Vertex for the feature layer for which you want to remove links.
3. Check Survey Points in the Snapping Environment dialog box.
4. Click the Unlink tool in the Survey Editor toolbar.
5. Snap to and click the vertex of the feature you want to unlink.
6. If there are multiple links to a survey point that need to be removed, snap to and click the survey point.
7. Verify that the link lines and link symbols are no longer displayed.
8. Repeat steps 5–7 for each link that you want to break.



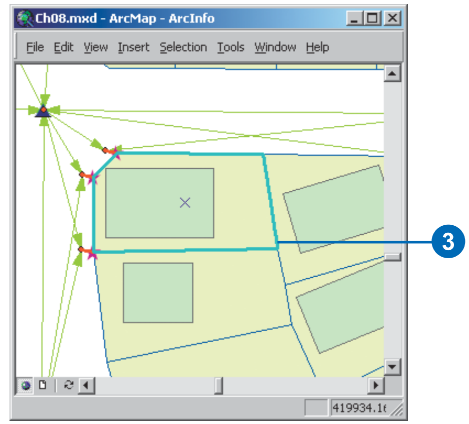


Unlinking survey points from feature vertices

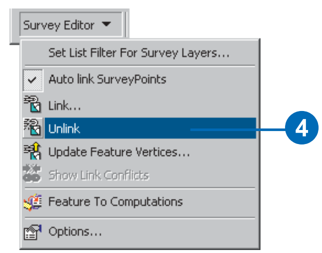


Using the Unlink Command

1. Zoom and pan the map to the scale and location of the features that you want to unlink.
2. Click the Edit tool in the Editor toolbar.
3. Click and drag a box around the features on the map to create a feature selection.
4. Click the Survey Editor menu in the Survey Editor toolbar and click Unlink.



Features selected for unlinking



Updating features

Survey points and the feature vertices they are linked to do not need to share the same location.

However, links can be used to update the geometry of the features to coincide with the survey points.

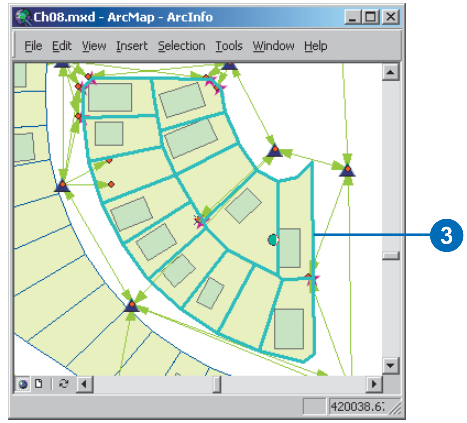
It is usually not feasible to update features immediately after creating links. The update can be postponed until a sufficient number of survey points exist across the extents of the survey-aware feature classes.

The Update Feature Vertices command takes a selected set of features and updates their geometry based on links with survey points. There are three different ways in which this update can be applied:

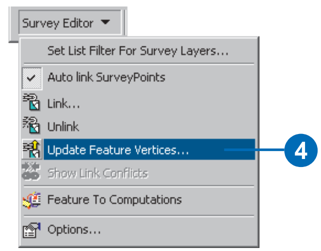
- Linked vertices of the selected features are shifted to exactly match the location of survey points. Unlinked vertices remain unaltered.
- Linked and unlinked feature vertices are all shifted in response to a transformation. The *transformation parameters* are defined based on the existing links. The final locations of the linked ▸

Using the Update Feature Vertices command

1. Zoom and pan the map to the scale and location of the features that you want to update.
2. Click the Edit tool in the Editor toolbar.
3. Click and drag a box around the features on the map to create a selection of the features that you want to update.
4. Click the Survey Editor menu in the Survey Editor toolbar and click Update Feature Vertices. ▸



Features selected for updating



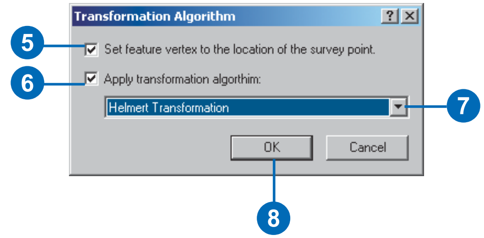
vertices may not coincide with their associated survey points.

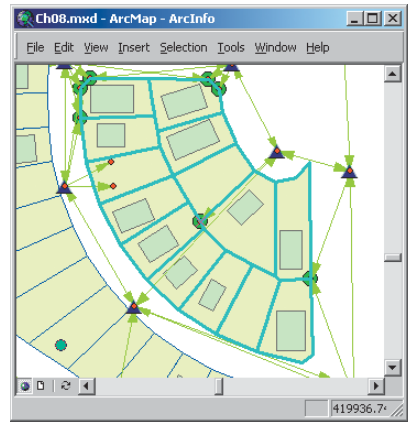
- A combination of both the above methods. The transformation is applied first, then the linked vertices are shifted to exactly match the location of survey points.

Different types of transformations are available. These types include *Simple*, *Affine*, and *Helmert* transformations. The type that can be used depends on the number of links:

- For one link, a translation is applied to all selected features (*Simple transformation*).
- With two links, a rotation, translation, and scale are applied to all selected features (*Simple transformation*).
- For more than two links, you can choose either a *Helmert* or an *Affine* transformation.

5. Check Set feature vertex to the location of the survey point if you want the linked feature vertices to exactly match their survey point locations.
6. Check Apply transformation algorithm if you want to transform the unlinked feature vertices based on the existing links.
7. Click the transformation dropdown arrow and click the transformation method you want to apply.
8. Click OK.
9. Confirm that the update occurred as expected by verifying the features' new locations and their link symbology.





Updated features—link symbols reflect the changes made to the feature geometry.

Analyzing and editing survey data

9

IN THIS CHAPTER

- **The Survey Analyst toolbar**
- **Computation network concept**
- **Analyzing and computing the active network**
- **Survey points and coordinates concept**
- **Survey point and coordinate analysis**
- **Scenarios for point and coordinate analysis**
- **Editing survey objects**

A *computation network* defines a sequence of dependent processes that calculate a series of coordinates. The *survey dataset* manages one computation network for each *survey project*. Since there are often many survey projects in a survey dataset, there can be many computation networks.

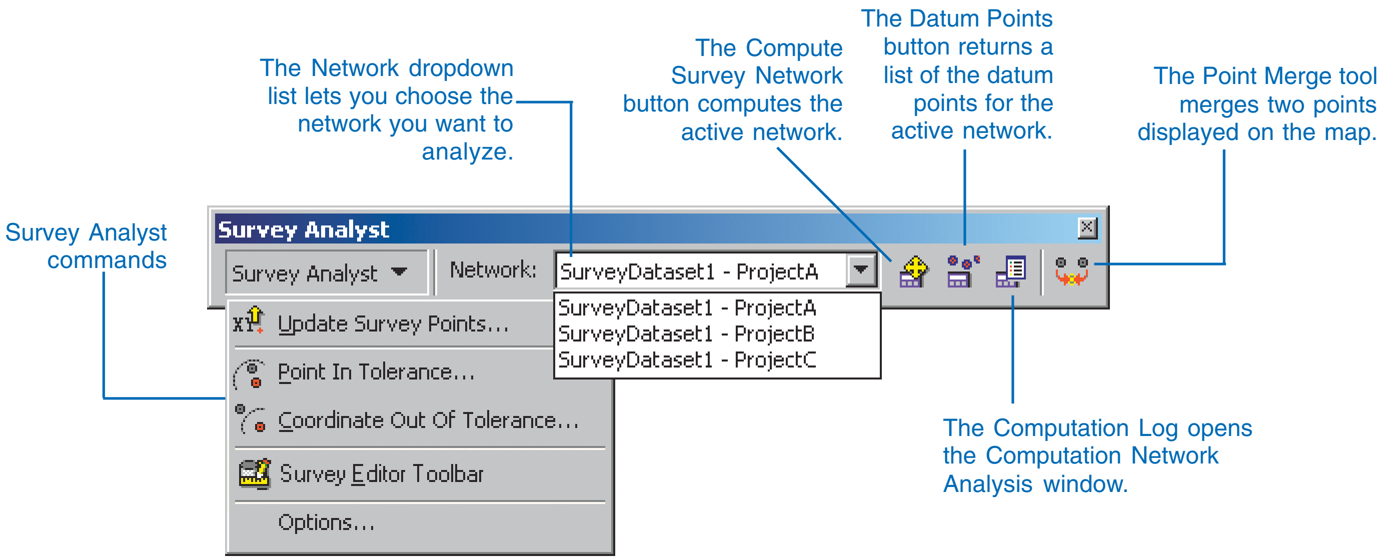
The process of analyzing computation networks involves detecting breaks in the sequence of processes and identifying cycles in the sequences. This chapter describes how Survey Analyst can be used to validate a computation network by detecting and repairing these sequence breaks and cycles. In Chapter 3, it expands on the description of computation states and describes *datum points*.

Equally important to the validation of survey data is the process of *Point* and *Coordinate analysis*. This type of analysis is used to authenticate the relationships between survey points, coordinates, and the physical locations they represent. Survey point and coordinate analysis requires searching for, and correcting, inconsistencies in these relationships.

The Survey Analyst toolbar has commands that allow you to find instances of these discrepancies in the computation networks and *survey points*. The functionality available for editing survey data through the Survey Explorer facilitates the repair of these problems.

This chapter describes how to use the Survey Analyst toolbar to work within this environment.

The Survey Analyst toolbar



Computation network concept

Chapter 3, 'Survey Analyst concepts', introduces *computations* and the computation network. This section expands on these concepts, providing background for the tasks presented in the pages that follow.

A computation stored in the survey dataset represents a process that calculates and updates coordinates for survey points. Computations use the current coordinates of survey points to calculate new coordinates.

Most survey point coordinates are calculated in a sequence—the output coordinates of computations are used as input to one or more others. A computation network models this sequence of calculations. Survey Analyst maintains computation networks by:

- Identifying the datum points of a network
- Managing changes in computation states
- Tracking computation dependencies
- Detecting *computation network cycles*

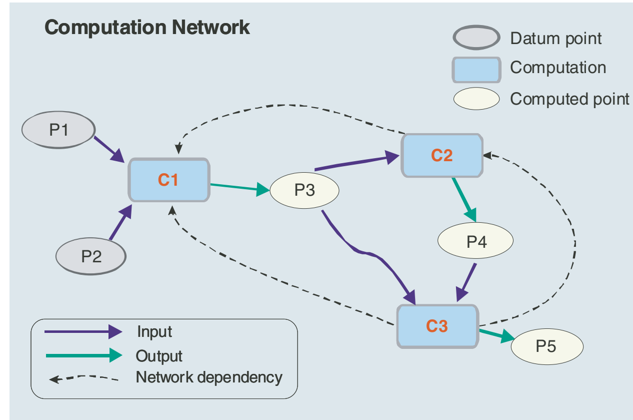
The survey dataset manages one computation network for each survey project. Thus, there can be many computation networks in a survey dataset.

Datum points

Certain computations do not depend on others in the network—the first computation in a survey project, for example. This is because the coordinates used as input are not calculated by other computations. Survey points that contain noncalculated current coordinates for a survey project are the *datum points* for that project.

Datum points are created when coordinates are:

- Imported into a survey project from files
- Directly typed from external sources



Points P1 and P2 do not depend on computations to define their current coordinates. These survey points are, therefore, the datum points in this computation network.

- Imported from other projects

Computation states

There are different *computation states* based on changes introduced into the survey dataset through editing survey points, *measurements*, or other computations. A *state* is a property of a computation categorized into four possible conditions:

- *valid*
- *incomplete*
- *out-of-date*
- *incorrect*

A new computation always starts out as incomplete. It remains incomplete until all the input and output points have been defined and all the required measurements have been entered.

Once it has executed successfully, the computation is valid. If a computation ever loses a reference to one of its input points, or measurements in the computation are removed, it is set back to an incomplete state.

If measurements are altered, or the names of input and output points are changed, the computation is set to out-of-date until it is recomputed. For instance, changing the coordinates of a survey point used as *orientation* in a traverse computation will cause the traverse to become out-of-date.

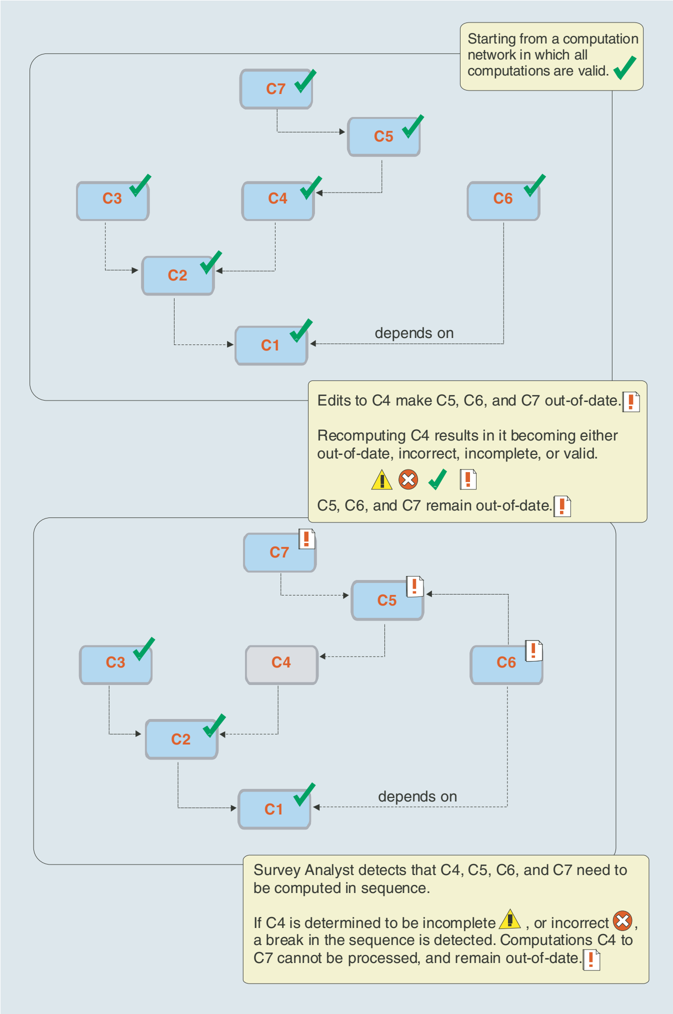
Occasionally, the output points of a computation do not have the expected results, or else coordinates cannot be calculated. In these cases, the computation is incorrect. For example, a traverse closure error exceeds the defined *limits*.

After editing and reprocessing a single computation, all of its dependent computations are out-of-date.

Chapter 7 describes how to process computations individually using the tools in the Survey Editor and Survey Explorer toolbars. The focus of this chapter is the analysis and validation of the entire network using commands in the Survey Analyst toolbar.

When processing a network, the system detects all the source computations that are out-of-date and reprocesses all downstream computations.

During this process, computations may have their states changed to incorrect or incomplete. The resulting break in the sequence is detected and reported in the *Computation Network Analysis window*. The dependent computations cannot be processed and remain out-of-date until the break in the sequence is repaired. This is an iterative process; you compute the network, repair sequence breaks and cycles (see the following section), then recompute the network.

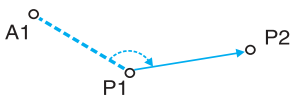


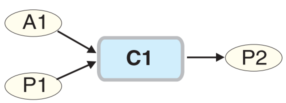
Scenario depicting the effect of computation edits in a network

Network cycles

When processing a computation network, the dependencies described in this section may cause cycles in the network. Cycles need to be fixed before the whole network can be validated and brought to a state where all computations are valid.

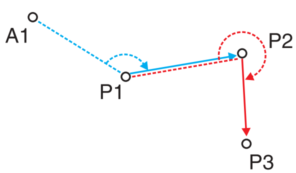
This section provides an example of how cycles are created, and offers examples of how to solve them.

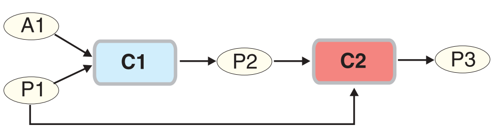




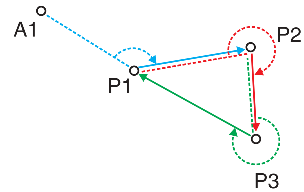
A computation, C1, uses known points P1 and A1 as input, and creates the point P2 as output. This computation uses P1 as the start point and A1 as a reference point for defining an orientation.

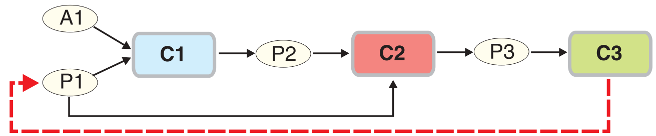
Since these points are the first reference points in the network, they are the network's datum points.





The point P2 is the start point for the next computation, C2. The computation C2 uses the point P1 as a reference point and creates a new point, P3. The points P1 and P2 are input for the computation C2.





The point P3 is the start point of the next computation, C3. This computation uses the point P2 as a reference point and re-measures the point P1. In normal circumstances, this would change P1's current coordinate. However, since P1 is used as input for an earlier computation in the sequence, a cycle has been created. Survey Analyst will automatically detect these cycles, and, in this example, would not permit C3 to change the point P1.

This problem can be solved in a number of different ways. In this example, some typical methods for fixing this cycle are to:

- Deactivate the measurement that targets point P1
- Disallow the new coordinate from participating in defining the current coordinate for the survey point

Analyzing and computing the active network

Survey Analyst allows you to find instances of cycles and breaks in sequences for any computation network in a survey dataset.

To do this, you must first add the necessary survey dataset to a *survey layer* in ArcMap. The survey layer must include the projects for the networks that you want to process and analyze. (Each project in a survey dataset represents a computation network.)

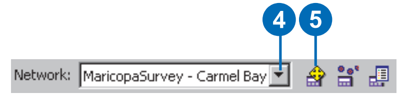
Using the Network dropdown list in the Survey Analyst toolbar, you can specify the active network with which you want to work.

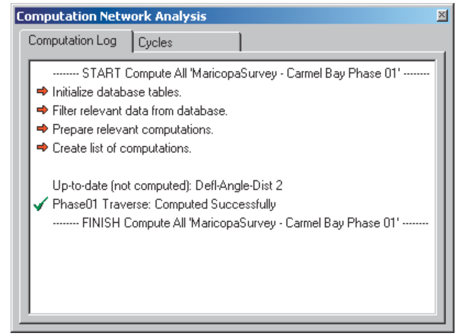
The *active network* is the focus of the analyses you apply. You can list this network's datum points in the Survey Explorer, detect and solve breaks in the network's computation sequences, and find and repair cycles in the network.

Computing and analyzing the active network to remove cycles

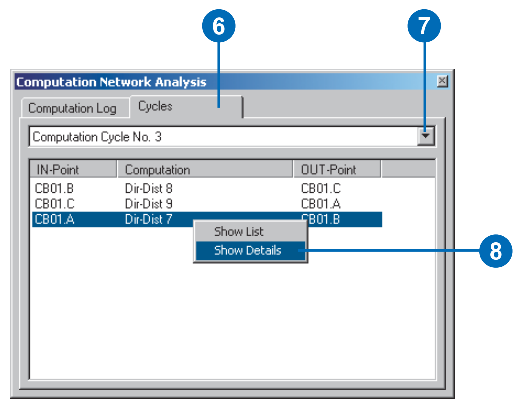
1. Start ArcMap, add the Editor toolbar, and add the Survey Analyst toolbar.
2. Add the survey projects and feature layers that you want to edit to the map.
3. Click the Editor menu in the Editor toolbar and click Start Editing.
4. Click the Network dropdown arrow and click the name of the network that you want to compute.
5. Click the Compute Survey Network button.

   The Computation Network Analysis window appears and lists the sequence of out-of-date computations processed.
6. Click the Cycles tab in the Computation Network Analysis window.
7. Click the Cycles dropdown arrow and click the cycle you want to analyze.
8. Right-click the row in the cycle list for which you want to see details and click Show Details. ▸





Computation Network Analysis window showing list of processed and valid computations. This network is valid.



The set of detail pages for the points and computations that appear in the row are added to the Survey Explorer.

9. Click the back and forward buttons to view the detail pages for the points and computations that participate in the cycle.

10. Identify the problem that is causing the cycle and make the required edits to correct it.

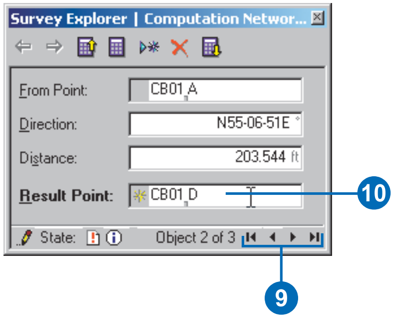
    In this example, the direction distance computation is changed to make a new result point, called D.

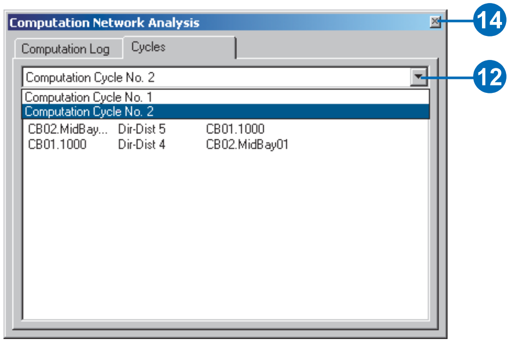
11. Click the Compute Survey Network button again.

12. In the Computation Network Analysis window, click the cycles dropdown arrow to verify that there is one less cycle.

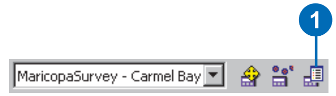
13. Repeat steps 7–12 until you have solved all the cycles.

14. Click the Close button on the Computation Network Analysis window.





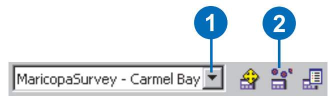
Opening the Computation Network Analysis window



1. Click the Computation log button on the Survey Analyst toolbar.

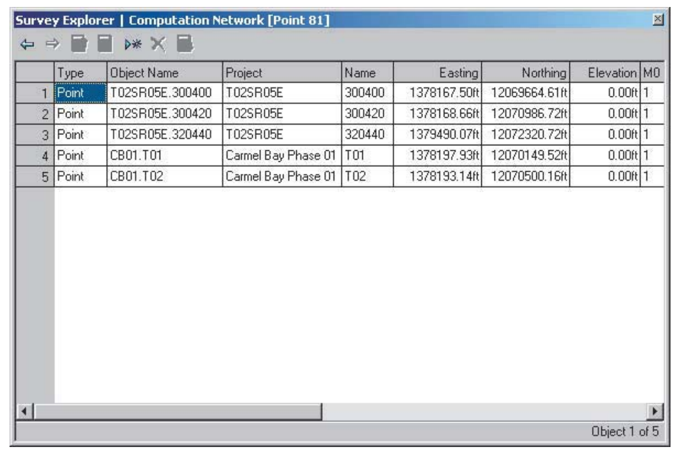
   The results listed from the previous network analysis are displayed.

Listing the datum points of a computation network in the Survey Explorer



1. Click the Network dropdown arrow and click the name of the network for which you want to list datum points.
2. Click the Datum Points button on the Survey Analyst toolbar.

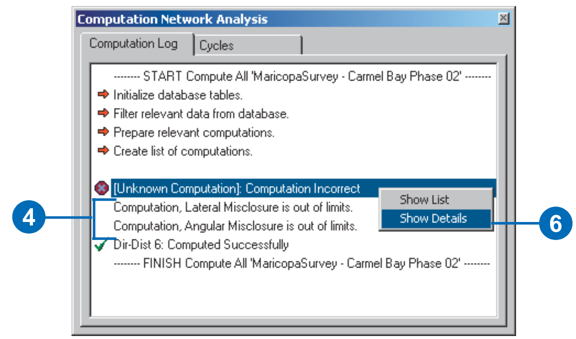
   The datum points appear in a list page in the Survey Explorer.



	Type	Object Name	Project	Name	Easting	Northing	Elevation	M0
1	Point	T02SR05E.300400	T02SR05E	300400	1378167.50ft	12069664.61ft	0.00ft	1
2	Point	T02SR05E.300420	T02SR05E	300420	1378168.66ft	12070986.72ft	0.00ft	1
3	Point	T02SR05E.320440	T02SR05E	320440	1379490.07ft	12072320.72ft	0.00ft	1
4	Point	CB01.T01	Carmel Bay Phase 01	T01	1378197.93ft	12070149.52ft	0.00ft	1
5	Point	CB01.T02	Carmel Bay Phase 01	T02	1378193.14ft	12070500.16ft	0.00ft	1

The Survey Explorer displays a list page of datum points as a result of running the Datum Points command.

Computing and analyzing the active network to detect breaks in computation sequences



1. Click the Editor menu in the Editor toolbar and click Start Editing.
2. Click the Network dropdown arrow and click the name of the network that you want to analyze.
3. Click the Compute Survey Network button.

   The Computation Network Analysis window appears. The computations listed include those that are incorrect or incomplete.
4. Make note of the additional information provided for these computations.
5. Right-click the computation in the list for which you want to make corrections, or that you need to complete.

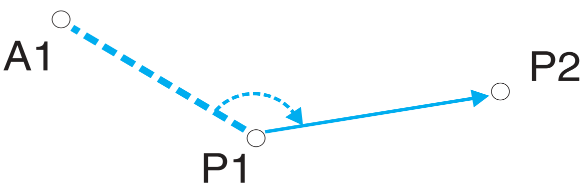
   A navigation context menu appears.
6. Click Show Details.
7. Refer to the information you noted in step 4 and correct or add the required data to the computation.

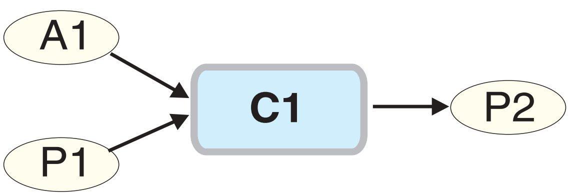
Survey points and coordinates concept

This section expands on the relationship between coordinates and survey points; this relationship was first introduced in Chapter 3, 'Survey Analyst concepts'. This section expands the concept, providing a foundation for the tasks that follow.

A survey point stored in the survey dataset represents a physical surveyed location that has been given a name. The survey project that creates the survey point is the owner of this point.

A physical location can be surveyed many times in different surveys. Each survey is represented in the survey dataset as a survey project. Thus, a survey point may accumulate a set of coordinates in the survey dataset through one or more survey projects. Coordinates contained in a survey point can be defined by different survey projects.





Project 1 and Project 2 contribute to defining P1's GIS coordinate. Each project's current coordinate is weighted according to available quality information and averaged to compute the final GIS coordinate.

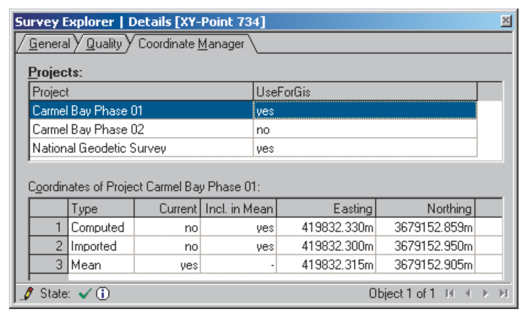
Coordinates are created in different ways and can have different roles. One of the coordinates for a survey point is called the GIS coordinate.

This is the survey dataset's best representation of the survey point's location. The GIS coordinate is used for the map display and creating links to *survey-aware features*.

Only the project that owns the survey point can update the GIS coordinate. When editing a survey point, you can select which projects to use for contributing to the point's final GIS coordinate.

Within each project, there is always a current coordinate for a survey point. This is the coordinate used by computations and for defining the GIS coordinate.

These concepts define how to work with the point analysis functionality available through the Survey Analyst toolbar.



The Coordinate Manager tab in the details page of a survey point lets you specify the projects that should be used for the GIS coordinate. For each project, you also specify coordinates that are included in the mean and the current coordinate.

Survey point and coordinate analysis

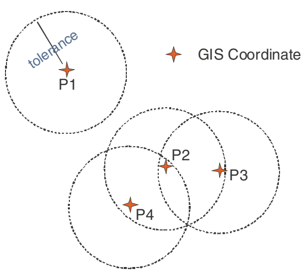
A survey point and its contained coordinates represent a single physical location.

The point analysis tools and commands are used to authenticate the relationship between survey points, coordinates, and the physical locations they represent.

The analysis requires searching for inconsistencies in these relationships. These inconsistencies fall into two categories:

- A single physical location is represented by more than one survey point in the survey dataset.
- Survey points in the survey dataset have wayward coordinates—these coordinates fall outside a theoretical tolerance circle that represents the coordinate spread for each point.

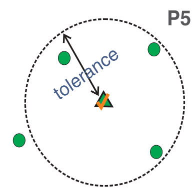
The Survey Analyst toolbar has commands that allow you to find instances of these discrepancies and tools that facilitate the repair of these problems.



Based on the specified tolerance, the points named P2, P3, and P4 represent the same physical location and can be merged.

For the first category described above, a command is available that allows the discovery of survey points that lie close together. This command uses the GIS coordinates of the survey points to search for point clusters based on a tolerance that you specify. From the results, you can elect to merge survey points that represent the same physical location.

For the second category, a command is used to search for survey points that contain one or more coordinates that lie beyond a given distance from a specific location. The criteria for searching for such survey points include a distance limit for the expected spread of coordinates, and a choice for whether the search is project-based (uses the current coordinate as the center) or survey dataset-based (uses the GIS coordinate as the center).



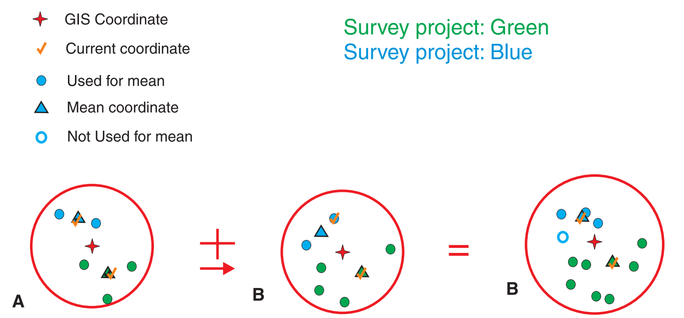
P5 has a coordinate that falls beyond a specified tolerance from the mean. This coordinate may need to either be recomputed, excluded from the mean, or deleted.

Merging survey points

Once you discover two or more survey points in the survey dataset that represent the same physical location, it is likely that you will want to merge them.

When merging two survey points, coordinates from the source point are added to the target point, then the source point is deleted. The new current coordinate is the mean of all coordinates used to define the current coordinates for both survey points. If all the coordinates have quality information, a weighted mean is used for the new current coordinate.

If any of these coordinates do not have quality information, then the arithmetic mean is used for the new coordinate.



GIS coordinate	Name
XYZ	A

Coordinates	Type
xyzA1	imported
xyzA2	computed
xyz	mean
xyzA3	imported
xyzA4	computed
xyzA5	computed
xyz	mean

GIS coordinate	Name
XYZ	B

Coordinates	Type
xyzB1	imported
xyzB2	computed
xyz	mean
xyzB3	imported
xyzB4	computed
xyzB5	computed
xyzB6	computed
xyz	mean

GIS coordinate	Name
XYZ	B

Coordinates	Type
xyzB1	imported
xyzB2	computed
xyzA1	imported
xyzA2	computed
xyz	mean
xyzB3	imported
xyzB4	computed
xyzB5	computed
xyzB6	computed
xyzA3	imported
xyzA4	computed
xyzA5	computed
xyz	mean

Survey points A and B are merged. A is the source point and B is the target point. All coordinates from A are transferred to B and A is deleted. For each project, a new mean coordinate is computed and is set as the current coordinate. Only coordinates that originally contributed to the current coordinate are used in the new mean.

Survey Point Merge tool

To merge the coordinates of two survey points, you can use the Survey Point Merge tool.

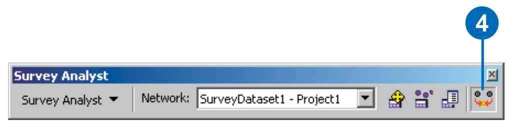
To use this tool, first choose a source point and then a target point on the map.

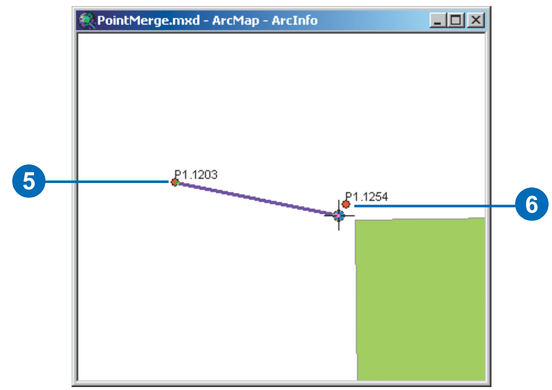
Coordinates from the source point are added to the target point, then the source point is deleted.

The new current coordinate is the mean of all coordinates used to define the current coordinates for both survey points. If all these coordinates have quality information, a weighted mean is used for the new current coordinate.

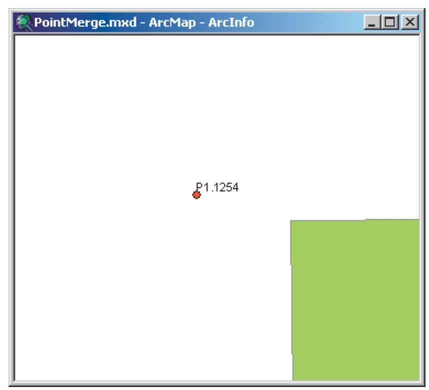
If any of these coordinates do not have quality information, then the arithmetic mean is used for the new coordinate.

1. Start ArcMap, add the Editor toolbar, and add the Survey Analyst toolbar.
2. Add the survey projects and feature layers that you want to edit to the map.
3. Click the Editor menu in the Editor toolbar and click Start Editing.
4. Click the Point Merge tool.
5. Snap to and click the Source survey point.
6. Snap to and click the Target survey point.





Merging survey points



After merging, the source point is deleted and the GIS coordinate of the target point is updated.

Point In Tolerance command

To find clusters of survey points that fall within a specific distance tolerance of each other, use the Point In Tolerance command.

To use the command, you must specify a horizontal search tolerance and, optionally, a vertical search tolerance. The command uses the GIS coordinate of each survey point to find these clusters.

You must also specify the set of survey points in which the command should look for clusters. The choices for this set include:

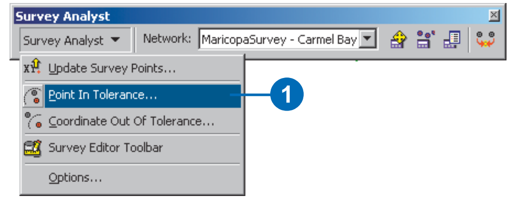
- Survey points selected in the Survey Explorer
- All points in the survey dataset of the active network
- Survey points displayed in the map extents
- Survey points in the active network ►

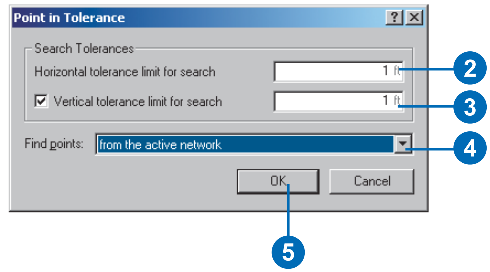
See Also

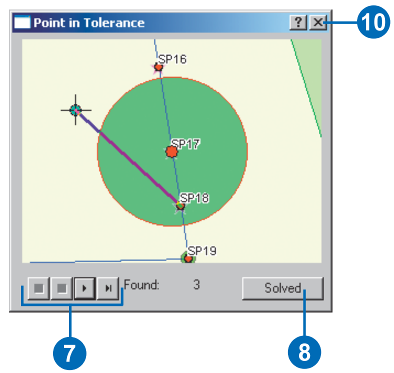
To see more information about how to use the Survey Point Merge tool, refer to the previous task.

1. Click the Survey Analyst menu in the Survey Analyst toolbar and click Point In Tolerance.
2. Type a horizontal search tolerance value.
3. Check Vertical tolerance limit for search and type a vertical search tolerance value, if you also want to define a height range tolerance.
4. Click the Find points dropdown arrow and click your choice for specifying the set of survey points that must be tested.
5. Click OK.

   The Point in Tolerance window is displayed.
6. Use the Survey Point Merge tool to merge pairs of survey points, where required.
7. Click the back and forward arrows to show the different conflicts collected in the window.
8. Click the Solved button to remove conflicts from the set shown in the window.
9. Repeat steps 6–8 for all conflicts with which you want to work.
10. Click the Close button.







After running the command, a window presents a set of locations for all places where survey point clusters are found.

You can then use the Point Merge tool to solve the conflicts that you recognize as data inconsistencies (this tool is automatically activated after the command is run).

Once a pair of points has been merged, you can remove the conflict from the set by clicking the Solved button.

See Also

For more information about setting the properties of conflicts windows, refer to the Link command described in Chapter 8, 'Editing feature geometry'.

Coordinate out of Tolerance command

To find survey points for which coordinates are outside a defined tolerance limit, use the Coordinate out of Tolerance command. To use the command, you must specify a tolerance circle that defines the maximum acceptable spread for the coordinates.

This limit can be defined vertically, horizontally, or in both directions at once.

The command can be applied using one of the following two methods:

- Local check—searches within each survey project
- Global check—searches within the whole survey dataset

You must also specify the set of survey points within which the command should perform the search. The choices for this set of survey points include:

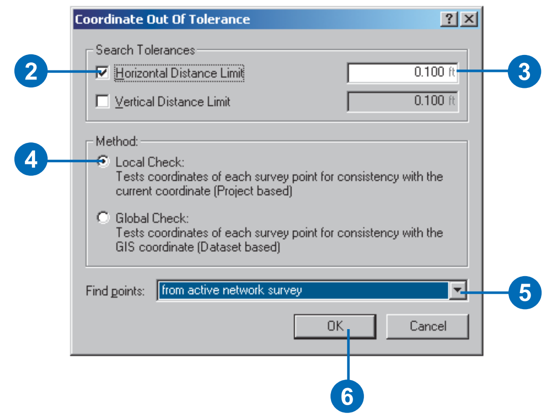
- Points selected in the Survey Explorer
- Points within the active network
- Points within the survey dataset of the active network
- Points in the map extents ▸

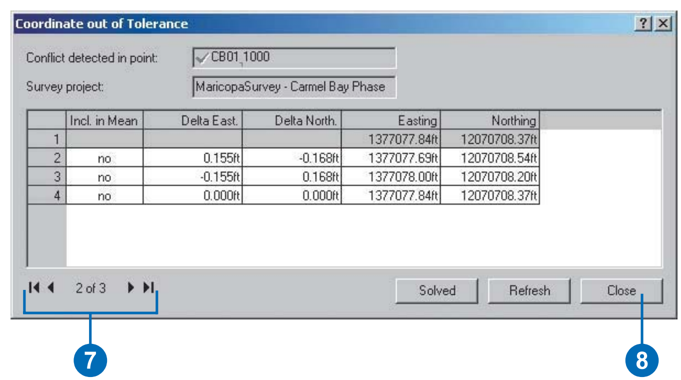
Using the current coordinate of survey points to find coordinates that are out of horizontal tolerance

1. Click the Survey Analyst menu in the Survey Analyst toolbar and click Coordinate out of Tolerance.
2. Check Horizontal Distance Limit for the search tolerance.
3. Type a value for the Horizontal Distance Limit.
4. Click Local Check.
5. Click the Find points dropdown arrow and click points from active network survey.
6. Click OK.

   If survey points are found that fall outside the limits you specify, the Coordinate out of Tolerance dialog box appears.

   Otherwise, a message is displayed indicating that no coordinates are out of tolerance for the criteria you specified.
7. Click the back and forward buttons to view the details of all the points with coordinate displacements that fall outside your tolerance limits.
8. Click Close.



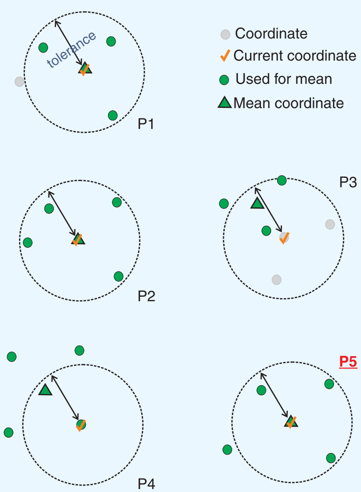


The Local Check method

According to the local check method, a point has coordinates that are out of tolerance if both the following criteria are true:

- The current coordinate is the mean coordinate of the survey point.
- Any coordinate used to define the mean coordinate falls outside the tolerance circle limits. The center of the tolerance circle is the current coordinate.

This method will only return conflicts found in the set of coordinates defined by the project that owns a survey point. ▶



Based on the specified tolerance, P5 is detected as having a coordinate out of tolerance using a local check.

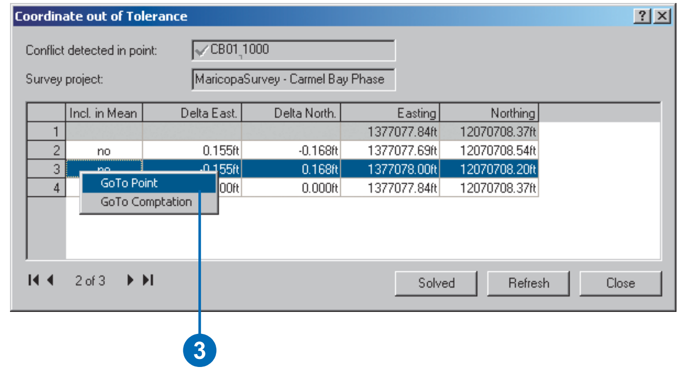
Navigating from the Coordinate out of Tolerance dialog box to delete an incorrect coordinate

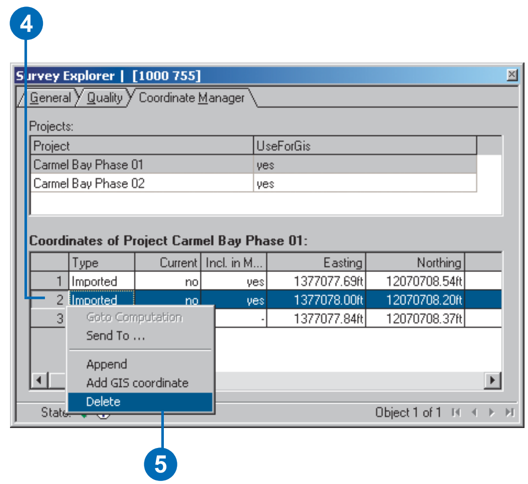
1. Run the Coordinate out of Tolerance command.
2. Click in the table of the coordinate conflicts to select any one of them from the table.
3. Right-click in the table of coordinate conflicts and click Go To Point.

   The Detail page for the survey point appears in the Survey Explorer.
4. Click the leftmost column of the incorrect coordinate to select it.
5. Right-click the leftmost column and click Delete.

   In this example, the second imported coordinate is incorrect and is deleted.

   Note that only imported coordinates can be deleted. ▶





Depending on the cause of the conflicts, the following methods can be used to solve them:

- Exclude the coordinate from defining the mean (if the mean coordinate is used as the currrent coordinate)
- Delete the coordinate
- Correct the coordinate by editing it (only possible if it's an imported coordinate)
- Correct a mistake in measurements of the defining computation

Survey points that are outside your defined tolerance limits are listed in the Coordinate out of Tolerance dialog box.

All coordinates for these points are listed, regardless of whether or not they were used for the current coordinate.

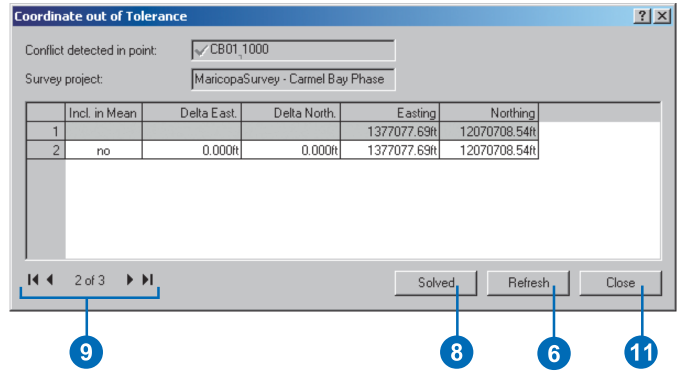
The first row listed is the current coordinate used for the local check.

Different fields are displayed in the list, and these fields depend on your choice of horizontal and vertical options. ►

6. Click Refresh in the Coordinate out of Tolerance dialog box.

   Note that the incorrect coordinate no longer appears and that the Delta Easting and Delta Northing values are updated.

7. Review the details page of the survey point to make other changes, if necessary.
8. Click Solved.
9. View other conflicts by clicking the forward and back arrows.
10. Repeat steps 2–8 to delete other coordinates from points that are out of tolerance.
11. Click Close.



The fields displayed are: Incl. in Mean, Delta Easting, Delta Northing, Delta Height, Easting, Northing, and Elevation.

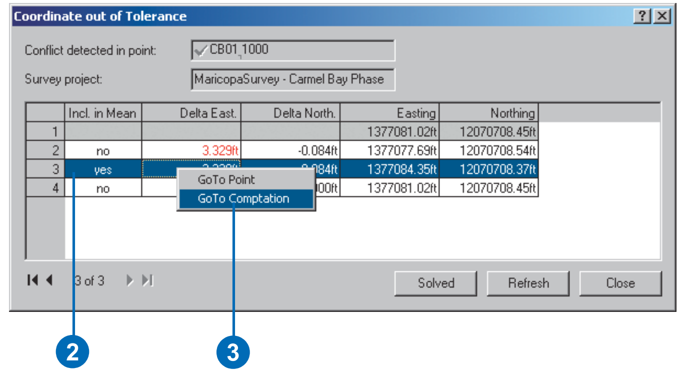
If a vertical check is not defined, then Elevation and Delta Height are not shown. Similarly, if no horizontal check is defined, then Easting, Northing, Delta Easting, and Delta Northing are not shown. ▶

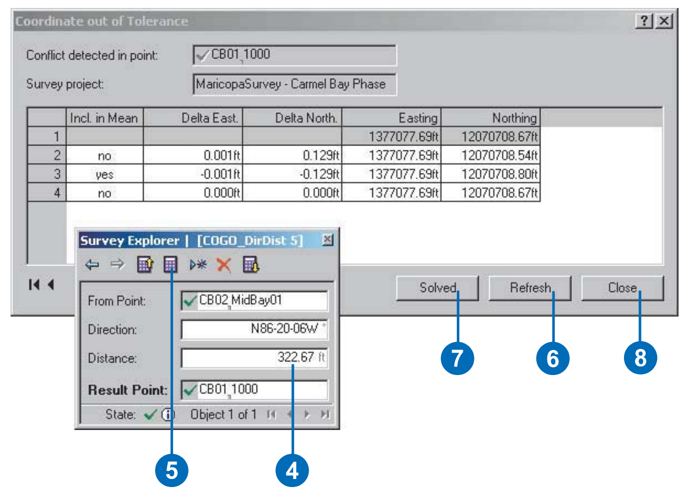
Navigating from the Coordinate Out of Tolerance dialog box to edit an incorrect measurement

1. Run the Coordinate out of Tolerance command.
2. In the Coordinate out of Tolerance dialog box, click the row for the coordinate of the computation to which you want to navigate.
3. Right-click in the selected row and click GoTo Computation.

   The detail page for the computation that defines the coordinate appears in the Survey Explorer.
4. Make the necessary edits to the measurement values in the computation.

   In this example, the distance value in a Direction–Distance computation is corrected.
5. Click the Compute button.
6. Click Refresh and verify that the delta values are within the limits you specified for the Coordinate out of Tolerance command.
7. Click Solved to continue with further analysis of the remaining survey points, if necessary.
8. Click Close.

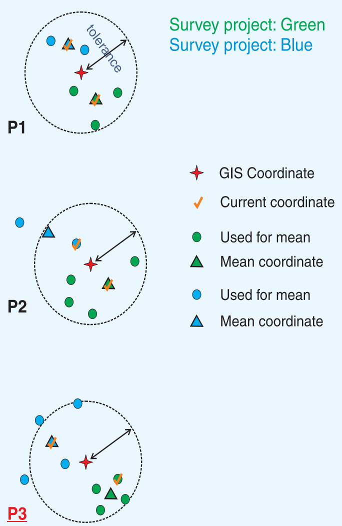




The Global Check method

Using this method, a survey point is out of tolerance if any of the current coordinates used to define its GIS coordinate fall outside the tolerance circle.

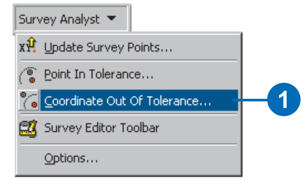
Coordinates that are used for the mean are also tested against the tolerance limit. ▸

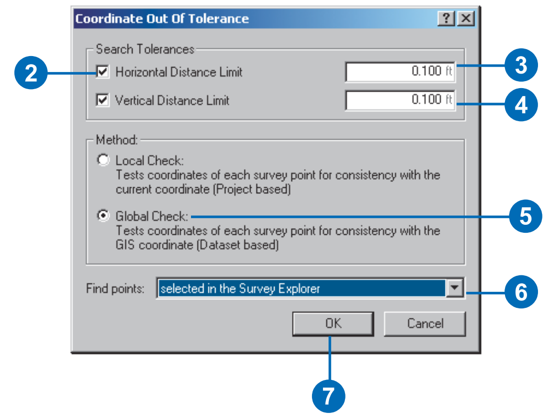


Using a global check, P3 is detected as having a coordinate out of tolerance.

Using the GIS coordinate of points selected in the Survey Explorer to find coordinates that are out of tolerance

1. Click the Survey Analyst menu in the Survey Analyst toolbar and click Coordinate Out of Tolerance.
2. Check Horizontal Distance Limit for the search tolerance.
3. Type a value for the Horizontal Distance Limit.
4. Check Vertical Distance Limit for the search tolerance if you want to use a vertical limit. Type a value for the Vertical Distance Limit.
5. Click Global Check.
6. Click the Find points dropdown arrow and click points selected in the Survey Explorer.
7. Click OK. ▸





Different fields are displayed in the list, and these fields depend on your choice of horizontal and vertical options.

The columns displayed are: UseforGIS, Delta Easting, Delta Northing, Delta Height, Survey, Easting, Northing, Elevation.

If a vertical check is not defined, then Elevation and Delta Height are not shown. Similarly, if no horizontal check is defined, then Easting, Northing, Delta Easting and Delta Northing are not shown.

Pressing the Solved button removes the displayed conflict. The Coordinate out of Tolerance dialog box is not automatically updated when values are changed in the Survey Explorer.

You can update the dialog box view by clicking the Refresh button.

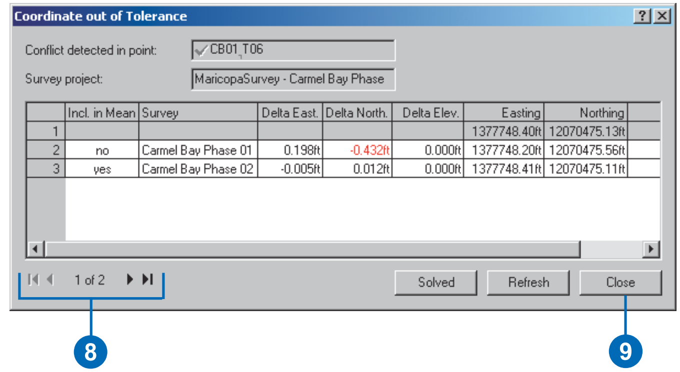
Conflicts in coordinates derived by computation can be solved in the details view of the relevant computation. Conflicts in imported coordinates are fixed by editing the relevant coordinates in the survey point's detail page.

You can navigate to the computations or points from the Coordinate out of Tolerance dialog box. The resulting detail pages are displayed in the Survey Explorer.

If survey points are found that fall outside the limits you specify, the Coordinate out of Tolerance dialog box appears.

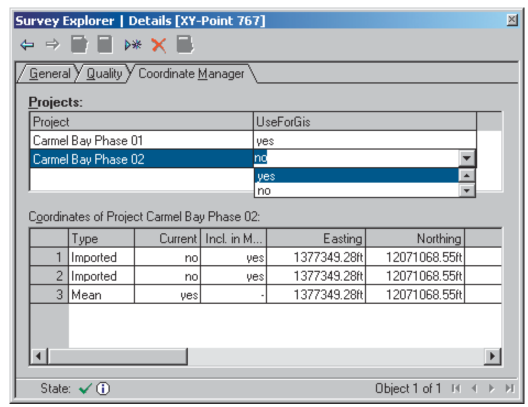
Otherwise, a message is displayed indicating that no coordinates are out of tolerance for the criteria you specified.

8. Click the back and forward buttons to view the details of all the points with coordinate displacements that fall outside your tolerance limits.
9. Click Close.



Choosing the projects that define the GIS coordinate for a survey point

1. Add a detail page to the Survey Explorer for the survey point for which you want to choose projects.
2. Click the Coordinate Manager tab.
3. Click a project to view its list of coordinates for the point.
4. Double-click the row of the project that you want to have participate in defining the GIS coordinate.
5. Click Yes.
6. Press Enter.



Updating Survey Points

Like computations, survey points can have different states. They can be incomplete, incorrect, or valid.

In the multiuser environment, where your survey dataset is part of an enterprise geodatabase, survey points can also be out-of-date.

Consider two projects called A and B. Both projects define coordinates for the same survey point, called P1. P1 is owned by project A.

As the owner of P1, project A has exclusive control over the GIS coordinate for P1. (It is only possible to change which projects contribute to the GIS coordinate through the survey project that owns the survey point.)

P1 becomes out-of-date when the following conditions occur concurrently:

- The current coordinate from project B is used to define the GIS coordinate for P1
- The current coordinate from project B changes

In order to detect and update all cases where the GIS coordinate of survey points is out-of-date, Survey Analyst provides a command called Update Survey Points. ►

Using Update Survey Points

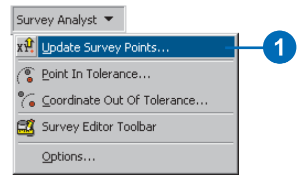
1. Click the Survey Analyst menu in the Survey Analyst toolbar and click Update Survey Points.

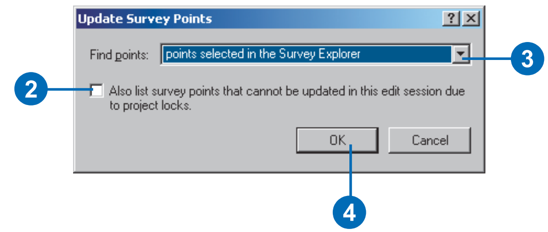
   The Update Survey Points dialog box is displayed, defining which points must be shown in the Point out of Date dialog box.

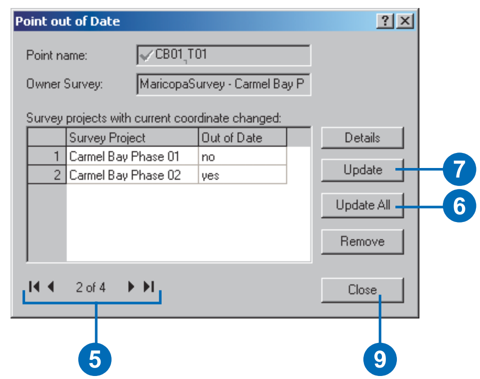
2. Uncheck Also list survey points that cannot be updated in this edit session due to project locks.

   This lets you exclude from the list those survey points that cannot be updated due to project locks.

3. Click the Find points dropdown arrow and click the option that you want to use for finding out-of-date survey points.
4. Click OK.
5. Click the back and forward buttons to view the survey points that are out-of-date.
6. Click Update All, and skip to step 9 if you do not need to analyze and update points individually.
7. Click Update to update the GIS coordinate for the displayed survey point.
8. Repeat steps 5–7 for all survey points that need to be updated.
9. Click Close.







Using the Update Survey Points command, you can display the set of out-of-date survey points in the Point out of Date dialog box.

If the project you are editing owns the point, and you have a lock on the project, you can update the point.

When you do not have a lock on a project, you will not be able to update the points that belong to that project. However, the command still provides the option to list these survey points in a read-only mode.

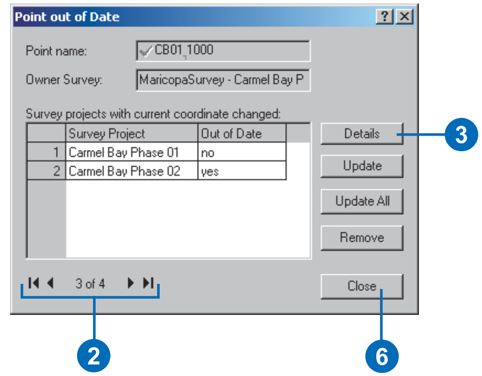
The Point out of Date dialog box has back and forward arrows that let you view all of the points individually.

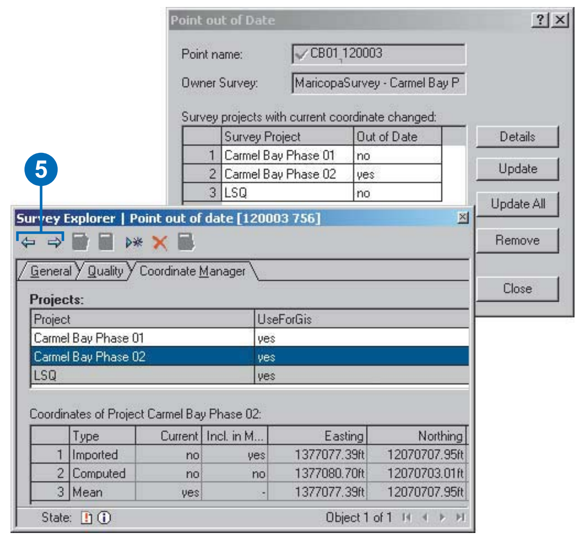
In this dialog box, you can choose to view the detail pages of the out-of-date survey points (these appear in the Survey Explorer). You can also update specific points or all the points in the set at once.

Viewing survey point details from the Point out of Date dialog box

1. Display the set of out-of-date survey points by using the Update Survey Points command.
2. Click the back and forward buttons in the Point out of Date dialog box to find the survey point for which you want to see the details.
3. Click Details.

   The Survey Explorer displays the detail page for the out-of-date survey point.
4. Repeat steps 2 and 3 to add additional survey point detail pages to the Survey Explorer.
5. Click the Previous page and Next page buttons in the Survey Explorer toolbar to view the different detail pages.
6. Click Close on the Point out of Date dialog box.





Scenarios for point and coordinate analysis

Scenario 1

A regional survey office uses published coordinates from the federal office as control points. The survey projects maintained by this regional office are used to provide geometry control for the survey-aware features in the geodatabase for the region.

An operator in this office first runs the Coordinate out of Tolerance command using a local check for a project. After fixing all the problems found by this command, the Point In Tolerance command is executed.

Scenario 2

The survey administrator, working at the federal office, is responsible for maintaining all projects from the regional offices. The operator needs to check the whole survey dataset to ensure consistency. First, the operator runs the Coordinate out of Tolerance command for each network using a local check.

Thereafter, a global check for all coordinates is executed across the whole survey dataset, and lastly, the Point In Tolerance command is executed.

Editing survey objects

Chapter 7 provides details for creating new computations, measurements, points, and coordinates. During the analysis of computation networks, you will need to correct the problems discussed in the preceding sections by editing the attributes of these survey objects. The tasks of this section show you how to:

- Rename survey points and computations
- Change and add coordinate values for points
- Edit measurement and computation values
- Delete survey objects
- Change project properties

Renaming survey points

You can directly edit a survey point's details and change its name in the details page of the point.

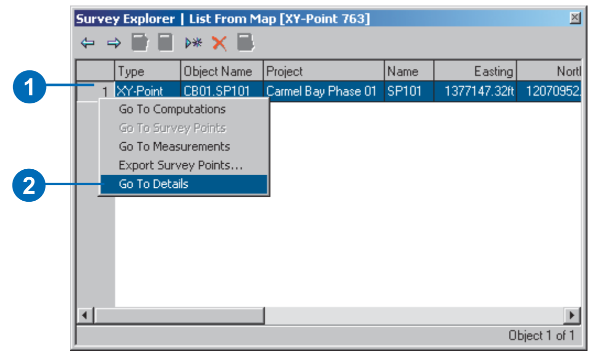
If the new name that you choose already exists in the survey project, a message is displayed and Survey Analyst prevents the name change until an unused name is typed. ▸

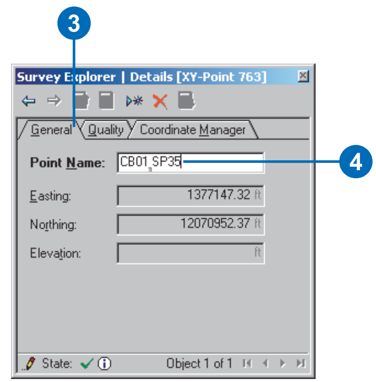
Changing a point's name

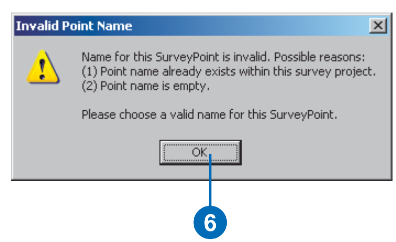
1. Select the point in the list page of the Survey Explorer.
2. Right-click the leftmost column in the list and click Go To Details.
3. Click the General tab in the details page of the survey point.
4. Click in the Point Name field to the right of the prefix pin and change the existing text to the new point name.
5. Press Enter.

   If the Invalid Point Name message appears, you typed a name that is already in use by another point in the project. In this case, go to step 6.

   Otherwise, you have completed the task.
6. Click OK in the Invalid Point Name message.
7. Repeat steps 4 and 5.







You are not able to change the ownership of survey points by renaming point prefixes.

When the survey point is renamed, its relationships to computations and measurements are maintained. Therefore, the new name will appear in all the computation detail pages that use this point.

Renaming computations

Certain types of computations can be named. Unlike survey points, a computation name is optional. However, if a name is used, it must be unique within the survey dataset.

You change a computation's name in the General tab of its detail page.

Survey Analyst prevents you from entering a name that is already used by a different computation.

Editing coordinates

Coordinates can be imported into, or computed for, survey points. Whereas imported coordinates can be directly edited, computed coordinates can be altered only by making changes to the measurements and computations that create them. ▸

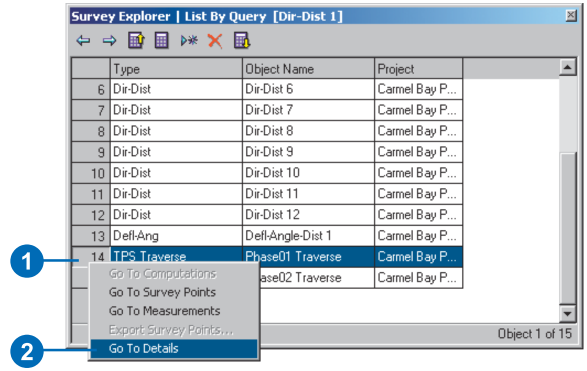
Changing a computation's name

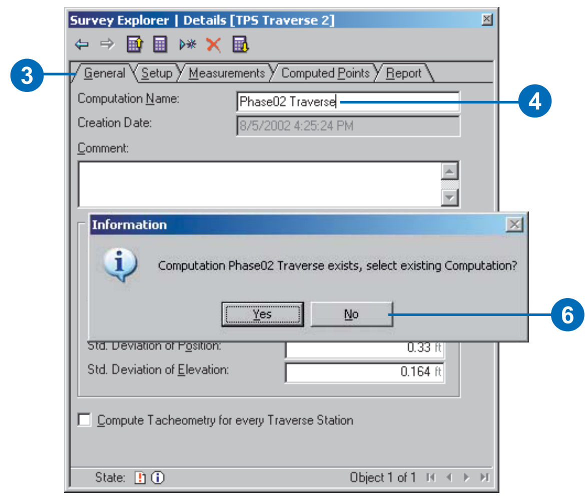
1. Select the computation in the list page of the Survey Explorer.
2. Right-click the leftmost column in the list and click Go To Details.
3. Click the General tab in the details page of the computation.
4. Click in the Computation Name field and change the existing text to the new name.
5. Press the Enter key.

   If the Information message appears, you typed a name that is already used in the dataset. In this case, go to step 6.

   Otherwise, the task is complete.
6. Click No in the Information message box.

   Note: clicking Yes will add a detail page for the existing computation to the Survey Explorer.
7. Repeat steps 4 and 5.





You can also change the role of the coordinate within the survey point. The two types of roles for coordinates that you can change are based on whether the coordinate is:

- Included or excluded from the mean
- The current coordinate or not

If the change in the coordinate affects the current coordinate of the survey point, the state of all computations that use this point are changed to out-of-date.

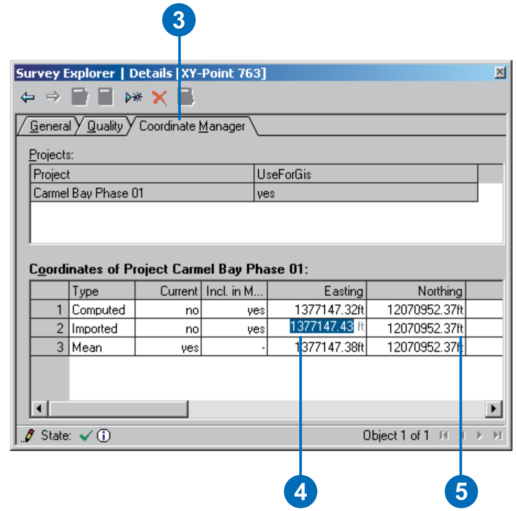
Editing measurement values

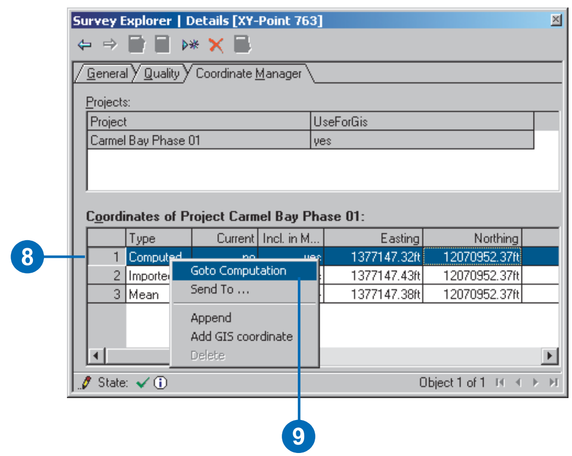
There are circumstances when you recognize obvious mistakes in entered measurement values, for instance, where numbers are transcribed in a distance measurement value—for example, a 12 was entered as a 21—or the value has been entered with the incorrect display unit.

In these cases, you need to edit the measurement values in the computations. When making these changes the computation is out-of-date until it's executed again. After changes are made to measurements, the computed coordinates of the output points are updated.

Changing imported and computed coordinate values

1. Select the survey point in the list page of the Survey Explorer for which you want to change coordinates.
2. Right-click the leftmost column in the list and click Go To Details.
3. Click the Coordinate Manager tab in the details page of the point.
4. Double-click the Easting column of the imported coordinate you want to edit and type a new Easting value.
5. Press Tab and type a new Northing value.
6. Optionally, press Tab and type a new elevation value.
7. Press Enter.
8. Click the leftmost column to select the computed coordinate that you want to change.
9. Right-click the coordinate, then click GoTo Computation. ▸





Editing a computation

In addition to renaming computations, you may also need to change their limits and settings or alter their input and output points.

In these cases, the computation becomes out-of-date.

When reprocessing these computations, the computed coordinates of the output points are updated.

If you changed an output point, the original output point's computed coordinates are deleted and a new computed coordinate is added to the new output point.

Changing survey project properties

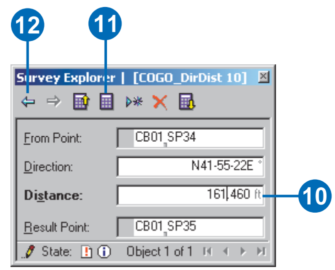
In ArcCatalog, you can alter the properties for a survey project. When making changes that affect computations, such as altering the correction methods, all the computations in the project become out-of-date.

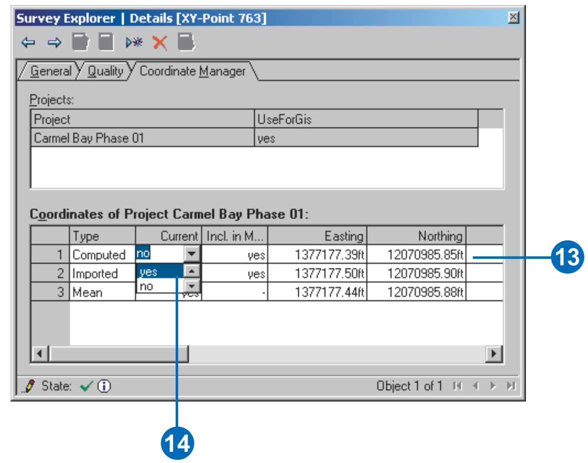
Reprocessing the project's computation network updates all the computed coordinates of the survey points owned by the project.

The detail page of the computation that defines this coordinate is added to the Survey Explorer. In this example, a COGO Direction–Distance computation has an incorrect distance value.

10. Make the necessary changes to correct the mistake in the measurement value.
11. Click the Compute button.
12. Click the Previous Page button in the Survey Explorer toolbar.

    This returns the Survey Explorer to the detail page for the survey point.
13. Verify that the coordinate has changed.
14. To make the updated coordinate current, double-click the Current column for the computed coordinate and click Yes in the dropdown list.
15. Press Enter.





Deleting survey objects

Deleting a survey object is contingent on whether or not it is used by other survey objects. For example, it is not possible to delete a measurement if it is used in a computation—this is prevented by Survey Analyst.

Also, deleting a survey point is not permitted until its measurements have been deleted.

To delete survey points or measurements, an ordered approach is required; you need to delete computations first, then the measurements, and finally, the survey points can be deleted.

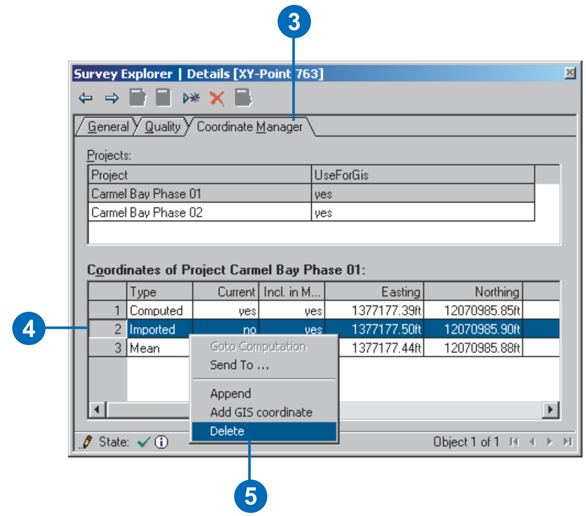
You can remove sets of measurements, points, and computations by selecting them in the list page and clicking the Delete button on the Survey Explorer toolbar. You can also individually delete survey objects by clicking the Delete button when viewing the object's detail page.

Deleting coordinates

To delete a coordinate, you need to be in the details page of a survey point. Instead of using the Delete button, you use the coordinate list's context menu option. ▸

Deleting imported coordinates

1. Select the survey point in the list page of the Survey Explorer for which you want to delete the coordinates.
2. Right-click the leftmost column in the list and click Go to Details.
3. Click the Coordinate Manager tab in the details page of the point.
4. Click the leftmost column to select the imported coordinate that you want to delete.
5. Right-click the coordinate and click Delete.



Only imported coordinates can be deleted. If you delete a current coordinate, the mean coordinate is used as the current coordinate.

If you delete the last coordinate, the survey point is empty and the computations that depend on the point are set to the incomplete state.

If the current coordinate changes after a coordinate is deleted, the computations that use the survey point are out-of-date.

Deleting survey points

If there are any computed coordinates for a survey point, then deleting the point is not permitted. Otherwise, all imported coordinates are deleted along with the survey point.

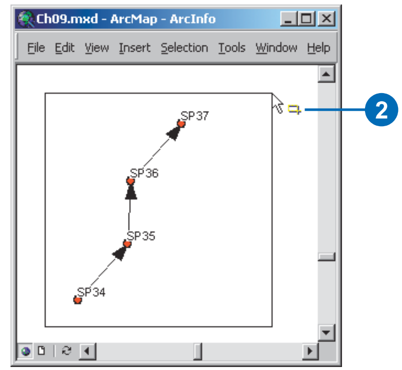
Deleting measurements

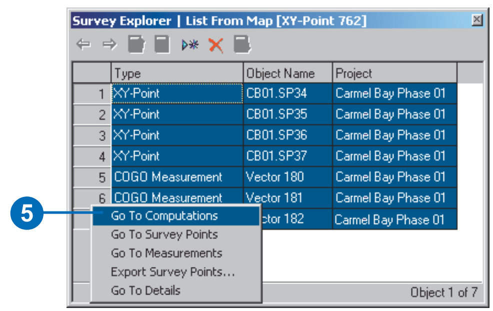
If the system permits you to delete a measurement, this means that there are no computations using it. Deleting measurements has no effect on other survey objects in the survey dataset.

Deleting computation measurements and survey points

1. Click the Survey Objects List from Map tool in the Survey Editor toolbar.
2. Click and drag a box around the measurements and survey points that you want to delete.

   A new list page is added to the Survey Explorer containing the points and measurements.
3. Click the leftmost column of the first row to select it.
4. Hold down the Shift key while clicking the leftmost column of the last row in the list. All measurements and points are selected.
5. Right-click the leftmost column and click Go To Computations. ▸





Deleting computations

Survey Analyst will permit you to delete any computation if you are editing the survey project that created it.

The coordinates computed by this computation are deleted from its output survey points.

Deleting survey projects

In ArcCatalog you can delete an entire survey project. If your survey dataset is a part of an enterprise geodatabase, then you must first have a lock on the project. For more information on project locking, see Chapter 10, 'Managing shared survey data'.

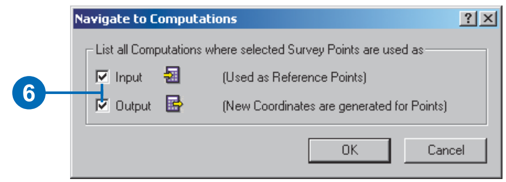
When you delete a survey project, the following survey objects are removed from the survey dataset:

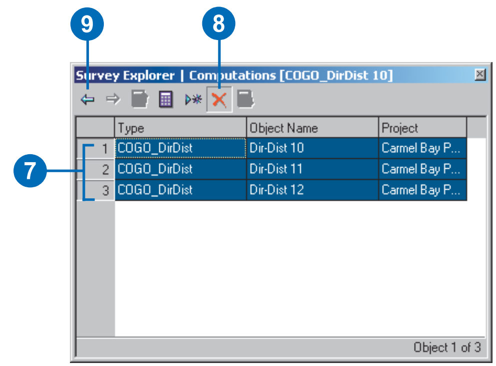
- Computations owned by the project
- Measurements owned by the project
- Coordinates created by the computations of the project
- Survey points that are not used as input or output for computations of another project ►

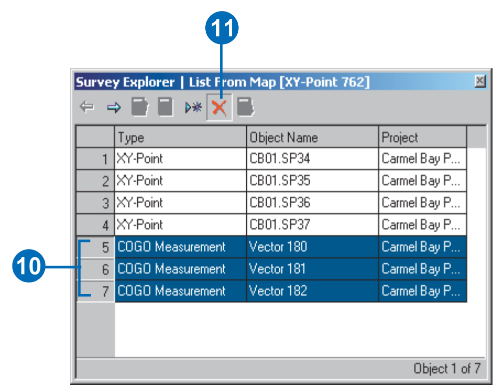
6. Check Input and Output in the Navigate to Computations dialog box, then click OK.

   This adds a new list to the Survey Explorer that has all the computations that use the selected measurements and the selected points.

7. Use the method described in steps 3 and 4 to select all the computations.
8. Click the Delete survey objects button in the Survey Explorer toolbar.
9. Click the Previous Page button to return to the list of measurements and survey points.
10. Select all the measurements; click the first one listed, then, while holding down the Shift key, click the last one listed.
11. Click the Delete survey objects button. ►







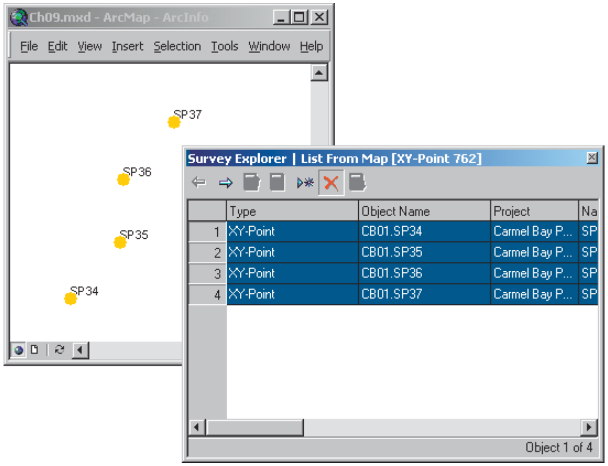
Note that due to dependencies of points across projects, it is not always permitted to completely delete a project. Although the measurements and computations are deleted, the survey points used by the computations of other projects are not deleted. They must be represented by a project, however and, therefore, the project is not deleted.

Tip

Deleting survey points

Delete survey points only after you have deleted all the survey objects that use these points.

12. Select all the survey points using the method described in step 10.
13. Click the Delete survey objects button.



Deleting survey points selected in the Survey Explorer list page

Managing shared survey data

10

IN THIS CHAPTER

- **Survey datasets and versions**
- **Connecting to an ArcSDE geodatabase**
- **Registering a survey dataset for edit sessions**
- **Granting and revoking privileges**
- **Locking survey projects for edit sessions**
- **Changing versions**

In the enterprise geodatabase, ArcGIS offers an environment in which multiple users can simultaneously edit the same set of GIS features by creating named versions of the geodatabase. Conflicts between different versions of the same GIS features are easily detected, reconciled, and posted. For more information about versioning feature data, see *Building a Geodatabase* and *Editing in ArcMap*.

When sharing survey data in your organization, the owner of each survey dataset can grant many database users storing and editing privileges for the data in the survey dataset. Once they have these privileges, each user creates and uses their own survey projects, as described in Chapter 4, 'Organizing survey data'.

Projects also enforce protection from edits by other survey dataset users. Consider, for example, a project that contains the control points published by your organization. The control points in the project can be used by any other project in the survey dataset, but they can only be edited by the person responsible for maintaining control points.

In order to edit survey data in a multiuser survey dataset, you need to acquire a *project lock*. As the creator of a project, you are automatically given this lock, and other users in your organization may access this information but may not alter it.

The other function of the project locking system is to prevent conflicts in survey dataset tables. A project lock ensures that simultaneous edits of a single survey project are not possible.

This chapter presents the multiuser environment for survey datasets.

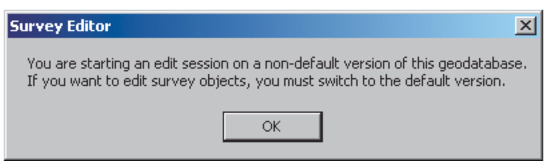
Survey datasets and versions

After reading the preceding chapters, you should be familiar with the organization of survey datasets, the use of survey projects, and the way that features are associated with survey data.

Versions define a variety of representations of data in a geodatabase and are used primarily to design and model GIS features. You can create versions for doing analysis with a series of alternate proposals. The final goal is to update the default version with the most current and best representation of the geodatabase. This process is a quality control mechanism for features in the geodatabase.

Instead of being the subjects of quality control through multiple versions, survey objects are themselves used as agents of quality control for the geometry of the features in the default version of the geodatabase. Survey data is an *orthogonal* approach to quality control that is focused on the geometry of the features represented in the geodatabase.

When database users add records to the tables in the survey dataset, Survey Analyst ensures that they can only edit the default version of the geodatabase.



An error message appears if you start editing a nondefault version of a geodatabase when its survey data is added to the map.

The feature data in the various versions can still be edited using the Editor toolbar, and all versions have the same view of the survey data on default.

Project locking

As described in Chapter 3, 'Survey Analyst concepts', each survey project owns a set of rows in the survey dataset tables. Each project exclusively adds and modifies its own subset of rows in these tables.

Unlike GIS features, measurements are not entities that are expected to be continually edited. Nor do they have multiple representations through time. Similar to the data entered into an accounting database, the survey dataset measurements' core values are not expected to change unless a mistake is made during their entry.

Conditions enforced to prevent conflicts

Survey Analyst enforces a set of conditions that prevents conflicts when multiple database users edit the same survey dataset in the default version of the geodatabase.

These conditions, some of which have been implied in previous chapters, are:

- Only the survey project that owns a survey object can modify it; however, any database user can edit the project by acquiring the lock.
- Many projects can use and reference the same measurements; however, a project cannot modify measurements owned by a different project.
- Computations are only ever managed within the context of the project that creates them and are never shared between projects.
- Coordinates are added to survey points and are owned by the project that computes or imports them.

The conditions differ somewhat for survey points:

- Although a project cannot modify the properties of a point that it does not own, subsets of coordinates can be added to a survey point by different projects. These coordinates may be owned by various survey projects, but only one of them can own the survey point that contains the coordinates.

Connecting to an ArcSDE geodatabase

An ArcSDE® geodatabase is a database management system (DBMS) installed on a server. It provides a central repository for your organization's spatial data, with access for many database users. You create new ArcSDE geodatabase connections using ArcCatalog. For more information about how to create ArcSDE geodatabases, please see the ArcSDE installation guide.

Tip

Testing the connection

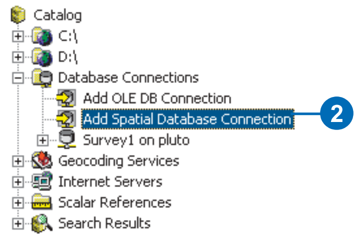
Clicking OK in the SDE Connection dialog box creates a connection file on disk. It does not immediately connect to SDE®. Click Test Connection to make sure that the connection information you entered is correct.

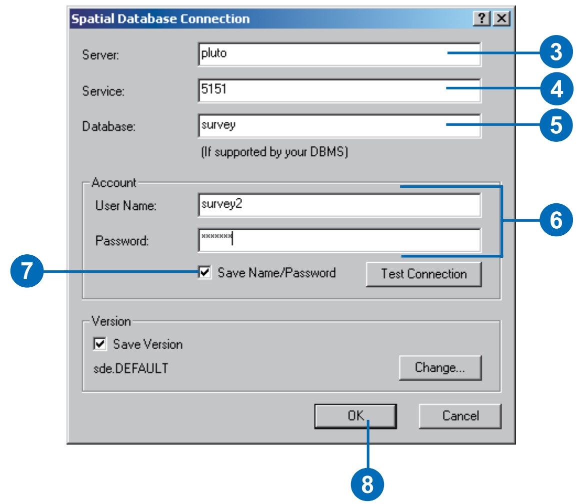
See Also

For more information about connecting to an ArcSDE geodatabase, see Building a Geodatabase *and* Editing in ArcMap.

Creating a new ArcSDE geodatabase connection

1. Click the plus sign next to Database Connections in the Catalog tree.
2. Double-click Add Spatial Database Connection.
3. Type either the name or the IP Address of the server to which you want to connect.
4. Type either the name or the TCP/IP port number of the SDE instance to which you want to connect.
5. If you are connecting to an SDE server that supports more than one database, type the name of the database to which you want to connect. Otherwise, skip to step 6.
6. Type the username and password with which you will connect to the SDE geodatabase.
7. Check the check box if you want to save the username and password. This will let you connect to the database without being prompted to log in.
8. Click OK.
9. Type a new name for the SDE database connection.
10. Press Enter.



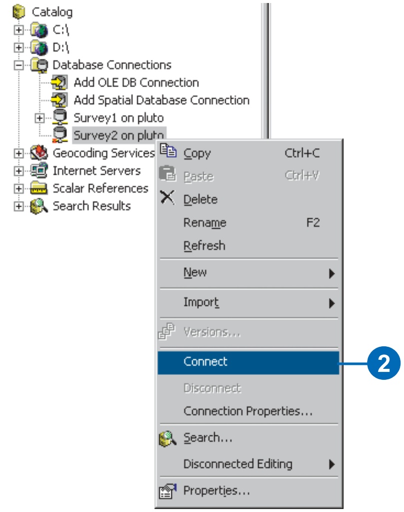


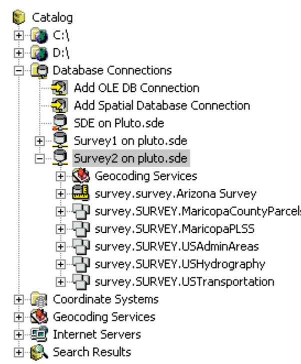
Connecting to a geodatabase

1. Right-click the Database Connection to which you want to connect.

2. Click Connect.

   The Catalog tree updates to display the datasets in the database.





Once it is connected to the database, the Catalog tree updates to display the datasets.

Registering a survey dataset for edit sessions

Before you can edit survey datasets, you need to register the data for edit sessions.

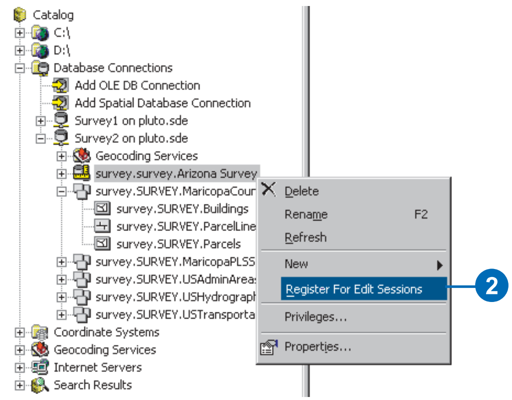
You must be the owner of the survey dataset to perform this registration.

Tip

Registering data for edit sessions

Registering a survey dataset for edit sessions registers all the survey classes in the survey dataset.

1. Right-click the survey dataset that you want to register for edit sessions.
2. Click Register For Edit Sessions.



Granting and revoking privileges

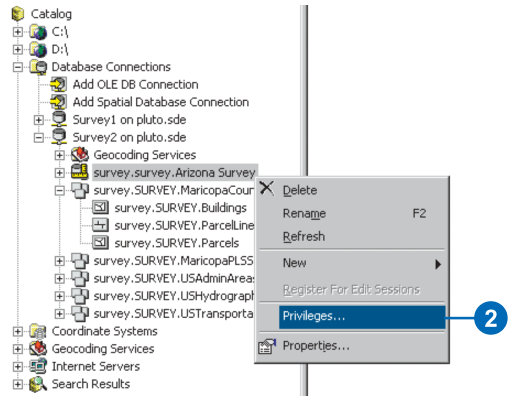
To allow other database users to create, edit, and acquire locks on survey projects, the owner of a survey dataset must grant those users full dataset privileges. Full privileges include SELECT, UPDATE, INSERT, and DELETE privileges for the survey dataset tables.

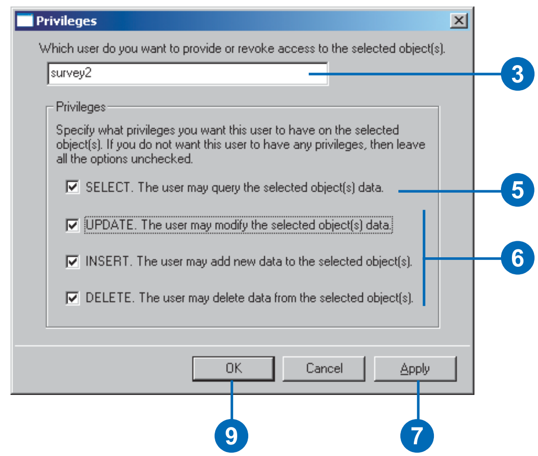
To allow read-only access to the survey projects in the survey dataset, the owner must specify SELECT privileges only.

Once granted, privileges may also be revoked by the owner of the survey dataset. The same command dialog box that is used to grant privileges is also used to revoke privileges.

Granting or revoking privileges on a survey dataset applies the same privilege changes to all the survey dataset tables. If you add a package to the survey dataset to support new measurement or computation types, you need to grant privileges on the survey dataset again.

1. Right-click the survey dataset for which you want to change privileges.
2. Click Privileges.
3. Type the name of the user for whom you want to change privileges.
4. If you want to revoke all the user's privileges, leave SELECT unchecked and skip to step 7. Otherwise, proceed to step 5.
5. Check the SELECT check box to grant the user select privileges.
6. If you want to grant full privileges to the user, then check one of the UPDATE, INSERT, or DELETE check boxes (checking one will make them all checked). Otherwise, proceed to step 7.
7. Click Apply to change the user's privileges.
8. Repeat steps 3–7 to change the privileges of other users.
9. Click OK.





Locking survey projects for edit sessions

To edit data in a survey dataset, you need to acquire a lock on a survey project and have full privileges on the dataset.

When a survey layer has been added to the map, you can define the set of projects that are represented by the layer.

Other users will not be able to start editing and change the survey objects owned by your set of locked projects. This lock remains in place even after you stop editing. You need to explicitly remove the lock before another user can lock the project for their edits.

Additionally, only the locked set of projects are added to the Target Project dropdown list in the Survey Editor toolbar for your edit session.

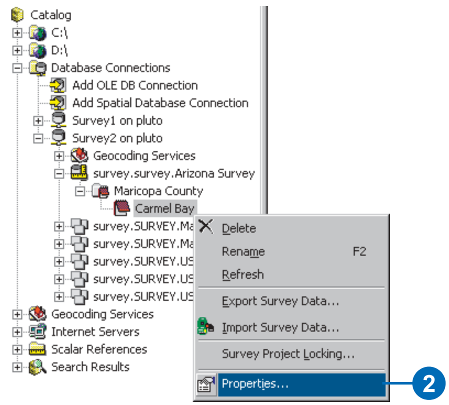
See Also

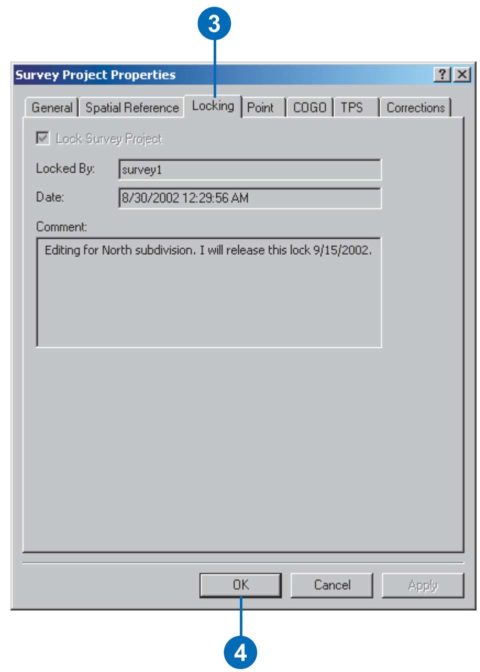
For more information about the Survey Editor toolbar and setting the target project, see Chapter 7, 'Using computations'.

Viewing lock information for a survey project

1. Right-click the survey project for which you want to view lock information.
2. Click Properties.
3. Click the Locking tab.

   The Locking tab displays information about whether the project is locked or not, about which database user has the lock, and the date and time that the lock was acquired. Additional information about the lock may be available in the Comment field.
4. Click OK.

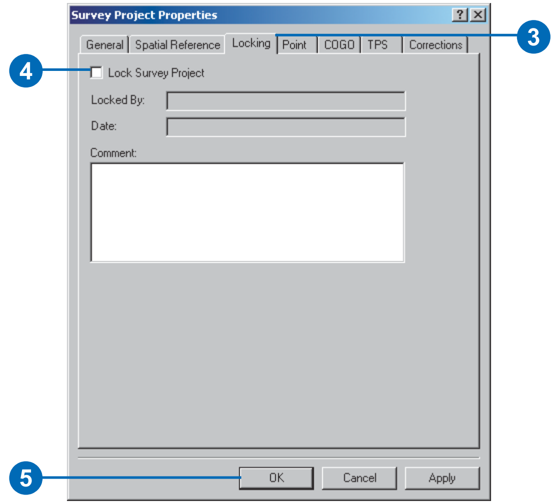




Unlocking a survey project

1. Right-click the survey project that you want to unlock.
2. Click Properties.
3. Click the Locking tab.
4. Click Lock Survey Project to uncheck the check box. The lock information is removed from the Survey Project properties.
5. Click OK.

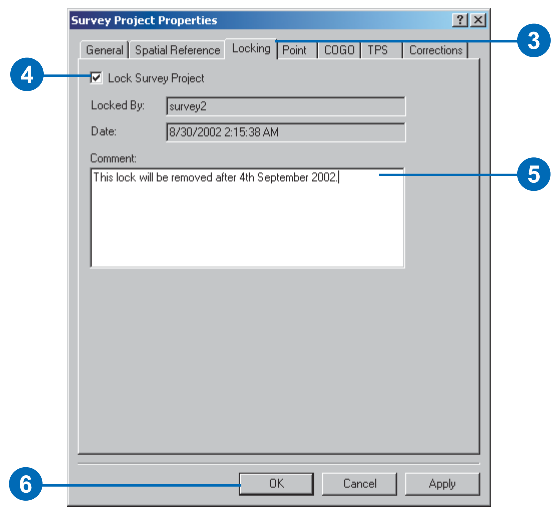
   The project is now unlocked and available for locking by other database users.



Locking a survey project

1. Right-click the survey project that you want to lock.
2. Click Properties.
3. Click the Locking tab.
4. Check the Lock Survey Project check box. Your user name is added to the Locked By text box, and the date and time are added to the Date text box.
5. Optionally, type a comment into the comment field.
6. Click OK.

   The survey project is now locked for your edits.

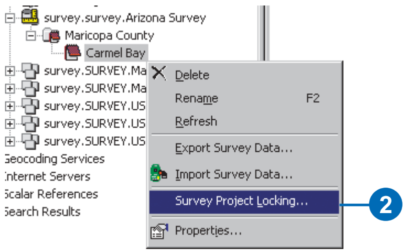


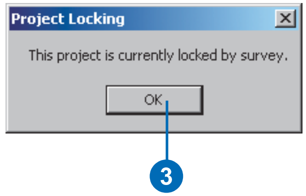
Identifying the user that has locked a project—alternative method

1. Right-click the survey project for which you want to identify the user that has the lock.
2. Click Survey Project Locking.

   If the project is currently locked by another user, the Project Locking message box indicates the user that has the lock.
3. Click OK.

   Otherwise, the Project Locking dialog box provides other choices as described in the next task—'Viewing or changing the lock status of a survey project—alternative method'.





Tip

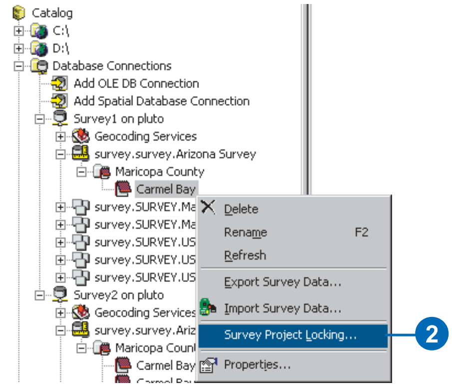
Acquiring a lock while working in ArcMap

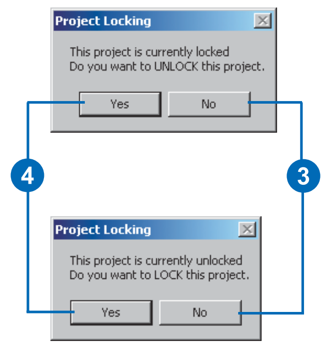
If ArcMap is already running, a lock can be obtained from within ArcCatalog without restarting ArcMap. You will need to stop editing, acquire the lock in ArcCatalog, then start editing in ArcMap.

Viewing or changing the lock status of a survey project—alternative method

1. Right-click the survey project for which you want to view or change the lock status.
2. Click Survey Project Locking.

   The Project Locking message box indicates whether the project is locked or unlocked.
3. Click No if you want to maintain the current lock status for the project; otherwise, skip to step 4.
4. Click Yes to switch the lock status from locked to unlocked or vice versa.





Changing versions

You need to be editing the default version of the geodatabase to modify or create survey objects.

To change versions you must end the edit session. The steps in this task show how to change from a nondefault version of a geodatabase to the default version.

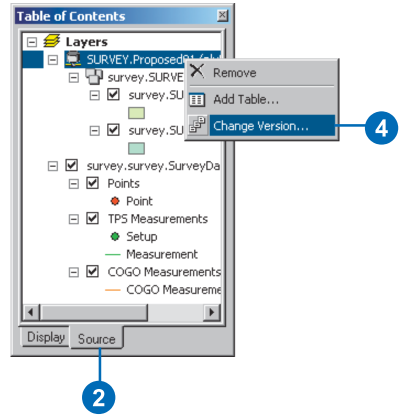
To learn about other methods for changing between different versions, see *Building a Geodatabase* and *Editing in ArcMap*.

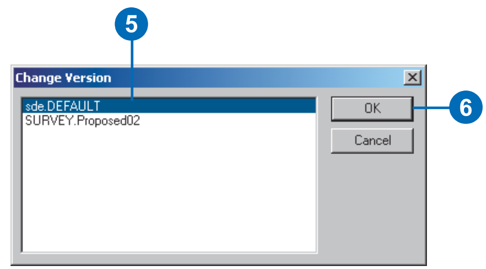
See Also

For more information about editing features and versioning, see Building a Geodatabase *and* Editing in ArcMap.

Changing to the default version of the geodatabase

1. If you are editing the data, click the Editor menu and click Stop Editing. Save your edits if neccessary.
2. Click the Source tab at the bottom of the table of contents to list the workspaces in your map.
3. Right-click the workspace that you want to change to the default version.
4. Click Change Version.
5. Click the default version in the Change Version dialog box.
6. Click OK.





Glossary

<none> task

A task in Survey Analyst that you can use if you don't want to simultaneously add points to the edit sketch while adding COGO computations to the survey project.

absolutely constrained adjustment

One of two possibilities for performing a constrained adjustment. In the absolutely constrained adjustment, the coordinates of the reference points keep their original value. Use this method when reference points should remain unchanged in the survey dataset.

accuracy

Closeness to a theoretical truth. Assessment of the quality of a surveyor's work is based in part on the accuracy of their measured values.

active network

The focus of the analyses you apply. You can list a network's datum points in the Survey Explorer, detect and solve breaks in the network's computation sequence, and find and repair cycles in the network.

Affine transformation

One type of transformation that is available when using the Update Feature Vertices command. You can choose the Affine transformation when you have more than two links.

angle field

Field in Survey Explorer that lets you enter angles for a particular computation. The angle field can represent horizontal or zenith angles. It provides entry fields for each subunit and a visual identification of the display unit.

Angle Right method

One of two methods for the coordinate geometry traverse. The Angle Right method uses an angle measured clockwise from the line of the previous point.

azimuth

The azimuth of a line is its direction as given by the angle between the meridian and the line. It is usually measured clockwise from the north.

Bearing method

One of two methods for the coordinate geometry traverse. The Bearing method uses directions for the orientation of each course.

bearings

The bearing of a line is indicated by the quadrant in which the line falls and the acute angle that the line makes with the meridian in that quadrant. Bearings are called true bearings, magnetic bearings, or assumed bearings, depending on whether the meridian is true, magnetic, or assumed.

blunders

Defective measurements detected by statistical tests.

Bowditch rule

One of three adjustment methods available for adjusting closure error for a traverse computation. The Bowditch rule—also known as the Compass rule—distributes the closure error in the Northings and Eastings in proportion to the distance along all of the courses from the first point to each of the unadjusted coordinate locations.

bust

A discrepancy between the existing coordinates and the computed coordinates that exists because the final point of a closed traverse has known coordinates and the final course of the traverse computes coordinates for the same survey point. See also misclosure and closure error.

closed loop traverse

A closed traverse that starts and ends with the same survey point.

closed traverse

A traverse course whose final course ends at an existing survey point.

closure error

A discrepancy between the existing coordinates and the computed coordinates. It exists because the final point of a closed traverse has known coordinates and the final course of the traverse computes coordinates for the same survey point. See also misclosure.

COGO composite measurement

Measurements that comprise a set of interdependent COGO simple measurements.

COGO simple measurement

These measurements model values that define vectors, directions, lengths, and orthogonal offsets.

comment

The Comment field provides additional information about the computation.

Compass rule

One of three adjustment methods available for adjusting closure error for a traverse computation. The Compass rule—also known as the Bowditch rule—distributes the closure error in the Northings and Eastings in proportion to the distance along all the courses from the first point to each of the unadjusted coordinate locations.

composite measurement

A group of simple measurements that are related and applied as a group.

computation

A process that requires a set of input parameters to apply a set of rules and an algorithm to calculate output parameters. The input parameters are most typically coordinates and measurements. The output parameters are usually coordinates.

computation name

The computation name can be defined on the General tab of the Survey Explorer. It provides an additional method to retrieve a specific computation. Specific types of computations have unique names within the survey dataset.

computation network

A sequence of computation dependencies—the output points of some computations are used as the input for one or more others.

Computation Network Analysis window

Displays information about the computation network. Information includes breaks in the sequence, computation states, and computation network cycles.

computation network cycles

A problem that occurs when a point's coordinates are used as both input and output within the same computation network. Cycles must be fixed before the whole network can be validated and brought to a state where all computations are valid.

computation state

A computation can be in four different states: valid, out-of-date, incorrect, or incomplete.

Computation tool

This tool integrates the computation pages and the map. It provides a means of interacting with the map to add measurement values to computation pages.

constrained adjustment

One of two phases involved when performing a least squares adjustment for your measurement network. In this phase, the emphasis is on testing the reference points as well as computing final coordinates.

conventional alternative hypothesis

A simple but effective hypothesis based on the assumption that there is an outlier present in a single measurement in the network. The test associated with this hypothesis is the W-test.

coordinate system

One component of the spatial reference. The coordinate system is used to project coordinates from a mathematical approximation of the earth's surface to the planar surface of a map.

coordinates

Survey points can have many coordinates associated with their location, especially as new surveys are performed through time. The location of each survey point is improved and becomes more accurate with each new survey. A survey point can have multiple coordinates, but there is always one coordinate that is used for publication to the GIS layers or used in computations. GIS feature geometry can be linked to the location of the survey point. Thus, feature geometry can be improved through time as the survey point's coordinates are updated.

Crandall method

One of three adjustment methods available for defining the allowable limits of closure error for a COGO traverse computation. The Crandall method distributes the error in the distances only, assuming directions and angles have no measurement error.

creation date

An attribute of the computation.

critical value

The specific cutoff point that determines acceptance or rejection of a hypothesis. Critical values are determined by the choice of a level of significance (α).

current coordinate

The single coordinate for a survey point that is the best representation for that survey point's location within each project. A current coordinate is required when the same project computes or imports more than one coordinate for a particular survey point.

datasnooping

The process of testing each measurement using the W-test.

datum points

When used in the context of a computation network, this refers to survey points that are not defined by computations, but that are the input data for the initial computations in the sequence of computations.

Detail page

One of two types of pages in the Survey Explorer. The Detail page displays a detail view of individual survey objects.

direction field

Field in the computation page that lets you enter bearings or azimuths between an input survey point and a computed survey point.

display unit

Although they are stored with consistent units in the survey dataset, you can choose the units in which coordinates and measurements are displayed in the Survey Explorer. These are the display units.

distance field

Field in Survey Explorer that lets you enter the distance for use in a computation.

edit sketch

A temporary sketch that is used to perform a variety of tasks. Creating an edit sketch is a standard way to edit feature geometry.

ellipsoid

The mathematical approximation of the earth's surface.

error propagation

A method of transferring statistical information about the spatial quality of survey points to other survey points.

Extensible Markup Language (XML)

A markup language similar to HTML. With XML you define data using tags that add meaning. For example, <title>California geology</title> declares the text "California geology" to be a title, perhaps for a map. An XML file does not contain information about how to present the data. XML is well formed if an opening, tag, such as <title>, and a closing tag, such as </title>, appear before and after each piece of data.

feature codes

Blocks of text included in data collector file formats that are used to describe the features surveyed in the field.

fixed reference points

Survey points used as an input to a computation. Its coordinates are not updated by the computation.

focus field

The particular field that is the current target for data entry.

free network adjustment

One of two phases involved when performing a least squares adjustment for your measurement network. The free network adjustment phase examines the overall geometry of the network by processing the measurements only and using the reference points only for position scale and orientation of the network. The emphasis is on testing the quality of the measurements rather than computing the coordinates.

F-test

One of two types of statistical tests commonly given to accept or reject a hypothesis. It assesses the model in general and accepts or rejects the null hypothesis.

geometric elements

A curve's geometric elements define the size and shape of the circular arc and comprise any two of the following: radius, central angle, chord length, arc length, and tangent length.

GIS coordinate

The single coordinate for a survey point that is the best overall representation for that survey point's location defined by one or more projects. Feature geometry is always linked to the GIS coordinate.

Global check method

One of two ways to apply the Coordinate Out of Tolerance command. The Global check method searches for coordinates out of tolerance within the whole survey dataset.

gradians

A unit of measurement in a circle. There are 400 gradians in a full arc of a circle.

grid meridian

Used when computing points in planar rectangular coordinate systems of limited extent. It is defined as the meridian that is parallel to the central true meridian.

group layer

A set of survey sublayers in a map document.

Helmert transformation

One type of transformation that is available when using the Update Feature Vertices command. You can choose the Helmert transformation when you have more than two links.

horizontal angles

Angles formed by the intersection of two lines in a horizontal plane. They are used in both TPS and COGO computations. The horizontal angle is the difference between two readings on the horizontal circle of a TPS instrument.

Hypertext markup language (HTML)

An HTML file contains text and tags instructing an Internet browser application how to present the text. For example, <B>24<B> will display the text "24" in bold.

incomplete

One state that a computation can be in. A computation is incomplete when it does not have all the required input.

incorrect

One state that a computation can be in. A computation is incorrect when its predefined limits are exceeded.

Instrument setup field

A field in the Survey Explorer that lets you select the instrument setup or type in the name of a new instrument setup.

known points

A point with known coordinates.

least squares adjustment

Allows many measurements to participate simultaneously in a single computation. This process provides a best fit for survey point locations, and allows detection of defective measurements. The least squares adjustment algorithm minimizes the sum of the squares of measurement residuals.

least squares corrections

The final measurement residuals. The least squares adjustment method defines a best-fit solution by finding a minimum for the sum of the squares of the measurement residuals.

level of confidence (1-α)

The complement of the level of significance. It is a measure of the confidence one can have in the decision to accept or reject a hypothesis.

level of significance (α)

The probability of an incorrect rejection. The level of significance determines the critical value.

limits

Each computation's limits define an acceptable level of measurement error.

link

In Survey Analyst, existing features can be linked to survey points. An association between survey points and feature vertices is created; feature locations are not updated automatically.

Link command

Works on selected features. For each feature vertex, the command finds nearby survey points and automatically creates links. Before processing, the command lets you specify the search tolerance for finding the survey points. This command is useful to use if there are many unlinked features that need to be associated with nearby survey points.

Link tool

Lets you make a link between a survey point and a feature vertex by snapping and clicking on a feature vertex and then snapping to and clicking the related survey point.

link-lines

Lines displayed on the map after making the link between a survey point and a feature vertex.

List page

One of two types of pages in the Survey Explorer. The List page lists multiple survey objects.

Local check method

One of two ways to apply the Coordinate Out of Tolerance command. The Local check method searches for coordinates out of tolerance within each survey project.

loop traverse

A closed traverse that starts and ends with the same survey point.

Mathematical model

A set of relations between the measurements and the unknown coordinates.

measurement error

The noise that is expected in every measurement. It occurs because the observer makes estimates and uses measuring equipment that is unpredictable in an environment that is also unpredictable.

measurement residual

The difference between a measured quantity and its theoretical true value as determined during each iteration of a least squares adjustment computation.

measurements

Observed numerical values that are estimates of the true size of a quantity.

misclosure

A discrepancy between the existing coordinates and the computed coordinates. It exists because the final point of a closed traverse has known coordinates and the final course of the traverse computes coordinates for the same survey point. See also closure error.

mixed list

One of two types of lists in the List page. The mixed list has a mixed set of rows that might have, for instance, survey points, coordinate geometry measurements, and a mix of different computations.

Multiple setup page

One of two types of setup pages in the Survey Explorer. The multiple setup page is used for computations that process multiple instrument setups.

normal probability distribution

Distribution based on the mean m and the standard deviation s of a measured quantity. The mean m is a mathematical representation for the best expected value of the measured quantity. The standard deviation s is a measure of the dispersion or spread of the probability, and characterizes the precision of the measurement.

open traverse

A traverse that ends its sequence with a new survey point, and has no closure error information.

operation codes

Blocks of text included in data collector file formats that are used to describe methodologies used in the field.

orientation

1. A curve's orientation can be any three of the following direction types: radial, chord, or tangent. A direction is required to define the curve's orientation.
2. Orientation defines how horizontal angle readings for TPS measurements are converted into azimuths.

orthogonal

Intersecting at right angles.

orthogonal offset

A distance measured to a point at right angles from a given line.

outliers

Defective measurements. Outliers are detected based on statistical tests.

out-of-date

One state that a computation can be in. If a computation's input measurements or points are altered, the computation and its output coordinates are out-of-date until it is recomputed.

Point and coordinate analysis

Part of the validation of survey data. This type of analysis is used to authenticate the relationships between survey points, coordinates, and the physical locations they represent.

Point identifier field

Field in Survey Explorer dialog box that lets you specify the name of a particular survey point.

point name flag

Gives an immediate visual indication, after each keystroke, of whether or not a point with the name you typed exists in the survey dataset.

point name prefix

A unique part of every survey project. Points have a common namespace across all projects of a survey dataset. However, different points in different projects can have the same name. When making use of these points, you can use the prefix of the survey project before the point's name to uniquely identify it. This ensures that the correct point is used.

precision

The closeness of a repeated set of observations of the same quantity to one another. It is a measure of the control over random error. Assessment of the quality of a surveyor's work is based in part on the precision of their measured values.

prefix pin

Used within the Survey Explorer's Point Identifier field to separate the prefix and point name strings.

project folder

Lets you group projects together.

project lock

The project lock, which is used only in enterprise geodatabases, allows you to lock projects that should not be available for general editing. To edit a project you need to acquire a project lock. You are automatically given a project lock when you create a new project.

projects

Used to define a specific task for capturing survey data. This can include anything from a field control survey to data entry from a subdivision plan.

Quality Beta (β)

When used together, the F-test and W-test are called the B-method of testing, for which a power can be defined. This power is the Quality Beta and can be defined as follows: the probability that the null hypothesis is accepted while in fact it is false is equal to $1-\beta$.

radian

The angle subtended by an arc of a circle that is the same length as the radius of the circle, approximately 57 degrees, 17 minutes, and 44.6 seconds. A circle is 2π radians.

random error

One type of measurement error. Random error is arbitrary; it follows the laws of statistics and probability—the size and sign of the error cannot be predicted.

redundancy

Occurs when the number of observed measurements is greater than the number of computed coordinates in a measurement network.

reference point

A point with known coordinates, used as input to a computation.

referencing

Occurs when a copy of a coordinate from a different project is added to the survey point for exclusive use in your project. When this referencing happens, you must choose one of the following coordinates: the GIS coordinate or the current coordinate of the owning survey project.

scalar reference

Used to define measurement units based on a common standard.

side-shot course

Used to compute a coordinate that is not a part of the main traverse course sequence.

simple measurement

The simplest form in which measurements from COGO sources or TPS sources can be stored. See also COGO simple measurement and TPS measurement.

Simple transformation

One of several types of transformations available when using the Update Feature Vertices command. Use the Simple transformation when you are working with one or two links. For one link, a translation is applied to all selected features. For two links, a rotation, translation, and scale are applied to all selected features.

Single setup page

One of two types of setup pages in the Survey Explorer. The single setup page is used for computations that process single instrument setups.

Sketch tool

Tool that lets you create an edit sketch. You can define the sketch points by heads-up digitizing, snapping, or entering coordinates.

snapping environment

Settings in the Snapping Environment window and Editing Options dialog box in ArcMap that help you establish exact locations in relation to other features. You determine the snapping environment by setting the snapping tolerance, snapping properties, and snapping priority.

spatial domain

The minimum and maximum values for the geometry attributes. The extents of this domain define the precision at which geometry attributes (x,y,z,m,id) can be stored as integers. There is a finite number of integers available in the system, and so the x and y spatial domain is analogous to a square grid that always contains the same number of rows and columns.

spatial reference

Describes both the projection and spatial domain extent for a feature dataset, survey dataset, or feature class in a geodatabase.

states

A computation can be in four different states: valid, out-of-date, incorrect, or incomplete.

Stochastic model

This model describes the expected error distribution of the measurements.

sublayer

A set of sublayers make up a group layer in a map document.

survey class

A collection of survey objects of a particular type. A survey dataset contains a set of survey classes for each of the different types of measurements and computations. There is also a survey class for coordinates and a survey class for survey points.

survey data converters

Interpret operation codes and feature codes when a data collector file is imported. You choose the converter that matches the data collector file format.

survey dataset

Stores survey objects.

Survey Explorer

The main interface for working with stored survey information. You can explore and edit data directly in the Survey Explorer. You can add lists of coordinates, measurements, and computations to the Survey Explorer so that you can view and analyze numerical values of measurements and coordinates created in your survey dataset.

survey layers

In Survey Analyst, layers that are created whenever you add survey datasets or survey projects to the map. Survey layers appear in the table of contents of a map document, and comprise a set of sublayers for survey points and measurements.

survey network

See computation network.

survey objects

Collective term referring to measurements, computations, survey points, and coordinates in the survey dataset.

survey points

Named locations that are observed through various surveys. Survey points can be observed multiple times and by many surveys over time. They represent multiple coordinates, but each identifies discrete physical locations on the earth's surface.

survey project

Represents a unit of work and is used as a logical structure that owns and manages a group of measurements, points, coordinates, and computations that function and belong together.

survey-aware feature classes

The feature classes in the geodatabase that contain survey-aware features.

survey-aware features

Features that are associated with survey data.

survey-awareness

Survey Analyst enhances feature classes with survey-awareness, allowing stored features to be associated with survey data.

systematic error

One type of measurement error. Systematic error follows a mathematical or physical law and it can be corrected to comply with a known standard.

TPS measurement

An entry in an electronic or paper field book that represents observations from a theodolite: a slope distance, vertical angle, horizontal angle, and a height of target define a single TPS measurement.

TPS setup

A group of field book entries that belong together define a single setup of the instrument. Each observation—slope distance, vertical angle, horizontal angle, and a height of target—is recorded as a TPS measurement and is added to the TPS setup. TPS is an acronym for Total Positioning System.

Transit rule

One of three adjustment methods available for defining the allowable limits of closure error for a COGO traverse computation. The Transit rule assumes distances have no measurement error, and distributes the error only through the directions and angles.

traverse course

A group of observed values that define a new coordinate. A traverse course starts from a preexisting coordinate, or a coordinate computed from the previous course.

uniform list

One of two types of lists in the List page. The uniform list has rows that represent survey objects of the same type.

unknown points

Previously uncoordinated points.

Update Feature Vertices command

Takes a selected set of features and updates their geometry based on links with survey points.

valid

One state that a computation can be in. If a computation is out-of-date, it must be recomputed to become valid.

variance

The square of the standard deviation s. The standard deviation s is a measure of the dispersion or spread of the probability, and characterizes the precision of the measurement.

variance–covariance matrix

The symmetric 3 x 3 matrix that mathematically expresses the correlation between errors in coordinates x, y, and z.

versions

In geodatabases, an alternative representation of the database that has an owner, a description, a permission—private, protected, or public—and a parent version. Version are not affected by changes occurring in other versions of the database.

weighted constrained adjustment

One of two possibilities for performing a constrained adjustment. In the weighted constrained adjustment, the reference point coordinates are treated as observed measurements and their standard deviations are applied in the adjustment.

W-test

One of two types of statistical tests commonly given to accept or reject a hypothesis. If you suspect that the null hypothesis is rejected due to a gross error present in one of the measurements, you can use the W-test to identify those measurements.

XML

See Extensible Markup Language.

zenith angles

Vertical angles that are formed by the intersection of two lines in a vertical plane. They are observed on the vertical circle of a TPS instrument.

References

This section contains references for the literature used in writing this book.

1. Anderson, James M. and Edward M. Mikhail. *Surveying Theory and Practice, Seventh Edition*. Boston: McGraw Hill, 1998.

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