Congratulations on your purchase of Ashtech Solutions!

Please register your software!

Extend your 90 day software support to 12 months for **FREE**! Detach the postage-paid Registration Card below and mail it in.

Ashtech Customer Support -
Friendly, professional, knowledgable support staff ranked top in the GPS industry year after year.

Customer Registration Card

Registration entitles you to FREE customer support (extended to 1 year), upgrade notices and much more!

Name ______________________ Title ______________________

Company ______________________

Address ______________________

City, State, Country, Postal Code ______________________

Telephone ______________________ Fax ______________________

Email ______________________

Date Purchased ______________________ Dealer ______________________

Model ______________________ Serial # ______________________

Model ______________________ Serial # ______________________

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST-CLASS MAIL PERMIT NO. 1758 SANTA CLARA, CA

POSTAGE WILL BE PAID BY THE ADDRESSEE

Magellan Corporation
Ashtech Precision Products - Customer Support
471 El Camino Real
Santa Clara, CA 95050-9974

Ashtech Solutions™

User's Guide

Magellan Corporation
Ashtech Precision Products
471 El Camino Real
Santa Clara, CA USA 95050-4300

Phone and Fax Numbers

- Main
  - Voice: +1 408-615-5100
  - Fax: +1 408-615-5200
- Sales
  - US: 1-800-922-2401
  - International: +1 408-615-3970
  - Fax: +1 408-615-5200
- Europe
  - Voice: +44-118-931-9600
  - Fax: +44-118-931-9601
- Support
  - US: 1 800-229-2400
  - International: +1 408-615-3980
  - Fax: +1 408-615-5200

Internet

- support@ashtech.com
- http://www.ashtech.com
- http://www.magellangps.com

Ashtech

Printed in the United States of America.
Part Number: 630821, Revision B
February, 2001

SOFTWARE LICENSE AGREEMENT

IMPORTANT: BY OPENING THE SEALED DISK PACKAGE CONTAINING THE SOFTWARE MEDIA OR INSTALLING THE SOFTWARE, YOU ARE AGREEING TO BE BOUND BY THE TERMS AND CONDITIONS OF THE LICENSE AGREEMENT ("AGREEMENT"). THIS AGREEMENT CONSTITUTES THE COMPLETE AGREEMENT BETWEEN YOU ("LICENSEE") AND MAGELLAN. ("LICENSOR"). CAREFULLY READ THE AGREEMENT AND IF YOU DO NOT AGREE WITH THE TERMS, RETURN THIS UNOPENED DISK PACKAGE AND THE ACCOMPANYING ITEMS TO THE PLACE WHERE YOU OBTAINED THEM FOR A FULL REFUND.

LICENSE. LICENSOR grants to you a limited, non-exclusive, non-transferable, personal license ("License") to (i) install and operate the copy of the computer program contained in this package ("Program") in machine acceptable form only on a single computer (one central processing unit and associated monitor and keyboard) and (ii) make one archival copy of the Program for use with the same computer. LICENSOR and its third-party suppliers retain all rights to the Program not expressly granted in this Agreement.

OWNERSHIP OF PROGRAMS AND COPIES. This License is not a sale of the original Program or any copies. LICENSOR and its third-party suppliers retain the ownership of the Program and all copyrights and other proprietary rights therein, and all subsequent copies of the Program made by you, regardless of the form in which the copies may exist. The Program and the accompanying manuals ("Documentation") are copyrighted works of authorship and contain valuable trade secret and confidential information proprietary to LICENSOR and its third-party suppliers. You agree to exercise reasonable efforts to protect the proprietary interests of LICENSOR and its third-party suppliers in the Program and Documentation and maintain them in strict confidence.

USER RESTRICTIONS. The Program is provided for use in your internal commercial business operations and must remain at all times upon a single computer owned or leased by you. You may physically transfer the Program from one computer to another provided that the Program is operated only on one computer at a time. You may not operate the Program in a time-sharing or service bureau operation or rent, lease, sublease, sell, assign, pledge, transfer, transmit electronically or otherwise dispose of the Program or Documentation, on a temporary or permanent basis, without the prior written consent of LICENSOR. You agree not to translate, modify, adapt, disassemble, decompile, or reverse engineer the Program, or create derivative works of the Program or Documentation or any portion thereof.

TERMINATION. The License is effective until terminated. The License will terminate without notice from LICENSOR if you fail to comply with any provisions of this Agreement. Upon termination, you must cease all use of the Program and Documentation and return tem, and any copies thereof, to LICENSOR.

GENERAL. This Agreement shall be governed by and construed in accordance with the Laws of the State of California and the United States without regard to conflict of laws provisions thereof and without regard to the United Nations Convention on Contracts for the International Sale of Goods.

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITY

LICENSOR AND ITS THIRD-PARTY SUPPLIERS MAKE NO WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING THE PROGRAM, MEDIA, DOCUMENTATION, RESULTS OR ACCURACY OF DATA AND HEREBY EXPRESSLY DISCLAIM ANY WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE AND NONFRINGEMENT. LICENSOR AND ITS THIRD-PARTY SUPPLIERS DO NOT WARRANT THE PROGRAM WILL MEET YOUR REQUIREMENTS OR THAT ITS OPERATION WILL BE UNINTERRUPTED OR ERROR-FREE.

LICENSOR, its third-party suppliers, or anyone involved in the creation or deliver of the Program or Documentation to you shall have no liability to you or any third-party for special, incidental, indirect or consequential damages (including, but not limited to, loss of profits or savings, downtime, damage to or replacement of equipment or property, or recover or replacement of programs or data) arising from claims based in warranty, contract, tort (including negligence), strict liability, or otherwise even if LICENSOR or its third-party suppliers have been advised of the possibility of such claim or damages. The liability of LICENSOR and its third-party suppliers for direct damages shall not exceed the actual amount paid for this Program License.

Some states do not allow the exclusion of limitation of implied warranties or liability for incidental or consequential damages, so the above limitations or exclusions may not apply to you.

U.S. GOVERNMENT RESTRICTED RIGHTS

The Program and Documentation are provided with RESTRICTIVE RIGHTS. Use, duplication, or disclosure by the Government is subject to restrictions as set forth in subdivision (c)(1)(ii) of the Rights in Technical Data and Computer Software clause at DFARS 252.227-7013 or subdivision 9(C)(1) and (2) of the Commercial Computer Software - Restricted Rights 48 CFR 52.227.19, as applicable.

Should you have any questions concerning the Limited Warranties and Limitation of Liability, please contact in writing: Magellan Corporation, 471 El Camino Real, Santa Clara, CA 95050, USA.

Table of Contents

List of Figures

List of Tables

1

Introduction

What is Ashtech Solutions?

Ashtech Solutions is a state-of-the-art automatic post-processing software package. It is extremely user-friendly, simplifying many of the office tasks, a feature which will be appreciated by novice and experienced users alike. Ashtech Solutions runs on Windows 95, 98, 2000, and NT 4.0 operating systems.

This powerful package includes components designed to assist you in all stages of planning and post-processing a GPS survey:

- Mission planning
- Receiver setup
- Data transfer
- Vector processing
- Network adjustment
- Quality analysis
- Coordinate transformation
- Report generation
- Exporting

Ashtech Solutions integrates one of the fastest post-processing engines available, as well as superior blunder detection to ensure proper processing the first time. As the processing takes place, Ashtech Solutions continuously updates a graphical display to provide a a true representation of your fieldwork.

Data presentation is optimized by use of a modified file system recently added to Ashtech GPS receivers and data collection software. The new file system allows entry of site ID, antenna height, and site descriptor for each point. The following products use this modified file system:

- **Receivers**
  - Z-Xtreme, firmware version ZA00 or later
  - Z-Surveyor, firmware version UG00 or later
  - Z-12 Receiver, firmware version 1M00 or later
  - Real-Time Z, firmware version 6J00
  - Locus, firmware version LA00 or later
- **Handheld Software**
  - Pocket Survey Control v. 1.0 or later
  - GPS FieldMate v. 3.0
  - Mine Surveyor II, v. 3.0
  - SeisMark II v. 3.0
  - TDS Survey Pro with GPS v. 4.5.02 or later

Role of Ashtech Solutions in a GPS Survey

Once you have conducted your survey, Ashtech Solutions provides the ability to accurately determine site locations within the parameters you establish. With the post-processing completed, Ashtech Solutions allows you to perform blunder detection, adjust your network, and review quality metrics.

Once the automatic processing is complete, Ashtech Solutions transforms your raw data into a polished final report that can be produced in a variety of formats to suit the client's needs.

Where to Find Information

You can find information about Ashtech Solutions as follows:

- Ashtech Solutions - this manual
- Tutorial
- Help System - the Help system has additional information not found in this manual including a comprehensive glossary.

System Requirements

Ashtech Solutions has the following system requirements for your office personal computer (PC).

- Pentium 90 MHz or faster. Ashtech Solutions runs on a slower Pentium or an older 486, but productivity will be impaired.
- Windows 95, 98, 2000 or NT 4.0
- Minimum 35 MB hard drive space
- Minimum 2 MB RAM
- CD ROM
- Serial port to transfer data between PC and receiver/handheld

Installing Ashtech Solutions

To install Ashtech Solutions:

1. Start Windows or, if Windows is already running, close all applications.
2. Insert the CD in the CD ROM drive.
3. On most computers, the autorun utility starts automatically.

   The Setup utility allows you to install Ashtech Solutions, install Adobe Acrobat™, or explore the CD without installing. To install the software, click on **Install** Ashtech Solutions. This starts the installation wizard which guides you through the rest of the process.
4. If the Setup does not start automatically when inserting the CD-ROM, select **Run** from the **Start** menu.
5. Type **x:\setup** and press **Enter**, where x is the letter designation for the CD ROM drive. Ashtech Solutions installs itself after you agree to the terms of the software license.

What Do I Do First?

If you are transitioning from standard surveying techniques to GPS, you may find GPS technology baffling or even intimidating. However, once you become familiar with the basic techniques, you will find that GPS is a powerful productivity tool. The following scenario is recommended for users new to GPS.

1. Skim through all the Ashtech Solutions documentation, including the readme.txt file installed with Ashtech Solutions, to familiarize yourself with content and organization.

2. Following the instructions in the receiver manual, use the receiver to do an actual miniature survey, such as a parking lot or park.

   - OR -

   Spend some time working through the examples in the tutorial to understand the reasoning and terminology underlying the Ashtech Solutions.
3. Transfer your data to your PC, and run Ashtech Solutions software as instructed in the Ashtech Solutions User's Guide.
4. Print out your data in the format that you want.

Customer Support

If you have any problems or require further assistance, Ashtech Precision Products Customer Support can be reached through telephone. e-mail or the Internet.

Please refer to the documentation before contacting Customer Support. Many common problems are identified within the documentation and suggestions are offered for solving them.

Ashtech Precision Products Customer Support, Santa Clara, CA, USA

800 number: 800-229-2400

Direct dial: (408) 615-3980

Local voice line: (408) 615-5100

Fax line: (408) 615-5200

e-mail: support@ashtech.com

Ashtech Europe Ltd. Oxfordshire UK

Tel: +44 118 987 3454

Fax: +44 118 987 3427

Ashtech South America

Tel: +56 2 234 56 43

Fax: +56 2 234 56 47

When contacting customer support, please ensure the following information is available:

- Receiver serial number
- Software version number
- Software key serial number
- Firmware version number
- A clear, concise description of the problem.

2

Getting Started

This chapter describes the fundamentals of Ashtech Solutions, including starting the software, navigating through the software, and using the various windows.

Starting Ashtech Solutions

To launch Ashtech Solutions from your Windows 95, 98, 2000, or Windows NT desktop:

From the **Start** menu **Programs** folder, select **Project Manager** from the Ashtech Solutions folder.

After the Ashtech Solutions screen appears momentarily, the **Welcome** dialog box opens (Figure 2.1).

Figure 2.1. Welcome Dialog Box

Use this dialog box to open an existing project, create a new project, open the last project you worked on, or run Ashtech Solutions without a project.

Click the checkbox to disable **Welcome** dialog box when starting Ashtech Solutions.

Quitting Ashtech Solutions

You can quit Ashtech Solutions at any time by selecting **Exit** from the **Project** menu. If the project you are working on requires saving recent changes, a dialog box appears prompting you to save the project.

Navigating Through the Software

The Ashtech Solutions main window has three windows to view and work with your data: the **Time View** window, the **Map View** window, and the **Workbook** window. All tasks necessary to successfully process and adjust your data can be accomplished within these windows.

Using the Time View Window

The **Time View** window, Figure 2.2, displays the observations for each receiver or file loaded into the project. This display provides a quick and easy look at the observation time for each site.

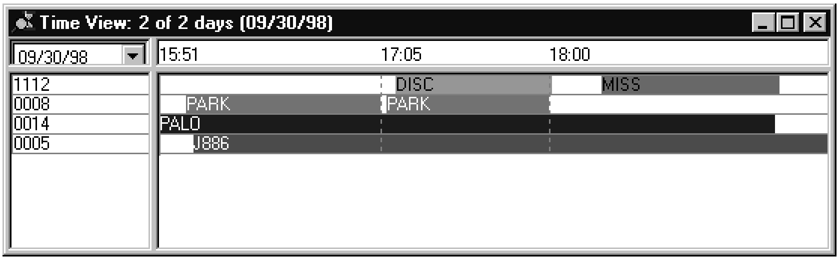


Figure 2.2. Time View Window

The Time View title bar shows the date of data collection and indicates if the data has been filtered. For more information on data filtering, see Chapter 5, **Data Processing**.

When fully zoomed out, the **Time View** window displays one day of data at a time. The Title Bar also shows which sequential day you are viewing.

The left pane of the **Time View** window lists each receiver by serial number, and the right pane displays each observation. Double-click a receiver to view information about the receiver. If you collected data with a Locus receiver, but did not use the handheld, the observations have site names *????*. Before processing data, you need to correct the site name for each observation.

Ashtech Solutions automatically uses different colors for each site in the project, and every observation for a site appears in the same color for easy reference. Above the right pane is the date and time scale.

Zooming

If you need to view a segment of observation data more closely, you can easily zoom in on small segments in the **Time View** window.

To zoom in, click in the **Time View** window near the observation you want to zoom in on, and drag the cursor to define the area to zoom in. When you release the mouse key, the **Time View** window zooms in to the new area.

To zoom out, use the **Esc** key, or the **Zoom Out** button on the Toolbar to zoom out one level. A second click on the **Zoom Out** button expands the view to its maximum.

Tasks in the Time View Window

In the **Time View** window, you can complete the following tasks:

- View receiver information
- View raw data file information
- View and set observation information
- Include or exclude an observation in processing
- Print the time view
- Trim data from an observation

Using the Map View Window

The **Map View** window, Figure 2.3, displays sites and vectors in the project, and has several modes to highlight important attributes.

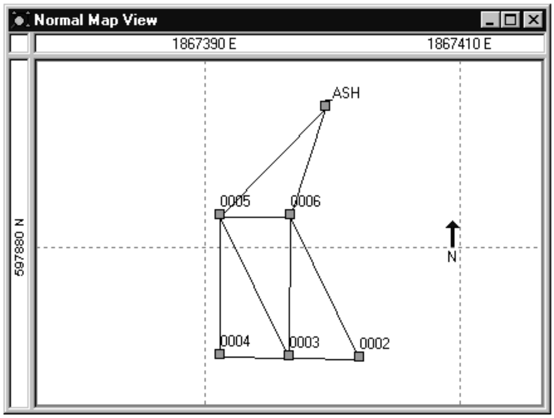


Figure 2.3. Map View Window

- **Normal -** Displays sites for data loaded into the project.
- **Process -** Displays processed sites, vectors between sites, and statistical processing results. Unprocessed vectors are dashed lines, processed vectors that passed the QA test are green, and processed vectors that failed the QA test are red. Site and vector uncertainties are displayed as error ellipses and a vertical error bar.
- **Adjustment -** Displays adjusted sites, vectors between sites, and statistical adjustment results. Un-adjusted vectors are black lines, adjusted vectors that passed the adjustment Tau test are green, and adjusted vectors that failed the adjustment Tau test are red. Site and vector uncertainties are displayed as error ellipses and a vertical error bar.
- **Repeat Vector -** Displays all vectors which have repeat observations and the results of their comparison with each other. Vectors not repeated display in black, repeated vectors whose comparison passes the QA test are green, and repeat vectors whose comparison fails the QA test are red.

Repeat observations of the same site while collecting data in kinematic mode are all averaged into one solution. No repeat vector is generated in these cases.

- **Control Tie -** Displays control points and the results of their comparison between computed and published positions. Control points who comparison pass the QA test are green. Control points whose comparison fails the QA test are red.

- **Loop Closure -** Displays all sites and vectors in the project. You can select a loop of vectors in order to calculate a loop closure. Vectors are selected one at a time until the loop is closed. Results of the loop are displayed. Loops that pass the QA test are green. Loops that fail the QA test are red.
- **Network Relative Accuracy-** Displays adjusted sites, vectors between sites, and the results of site pair relative accuracy computations. Relative accuracy is computed for each site pair between which a vector has been observed. Site pairs which pass the QA test are green. Site pairs that fail the QA test are red.

Use the right-click menu to switch between views and change which elements are displayed. The active tab in the **Workbook** window corresponds to the map view.

Legend, Colors and Symbols

Use the right-click menu to display a Legend (Figure 2.4).

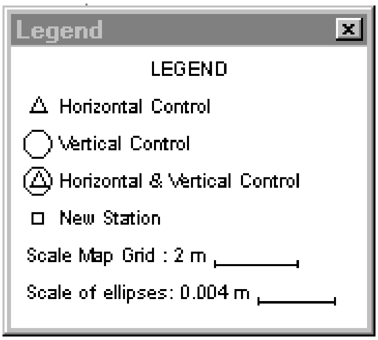


Figure 2.4. Map View Window Legend

General color scheme

The general color scheme for all map views:

- **Green-** Items which pass the QA check
- **Red-** Items which fail the QA check
- **Orange**- Selected Items

Site Symbols and Colors

Table 2.1 lists the symbol colors in all map views:

Table 2.1. Site Symbols

	Unprocessed (Brown; Magenta when selected)	Processed (Blue; Light Blue when selected)	Adjusted (Teal; Bright Green when selected)	Failed (Red; Magenta when selected)
Site				
Horizontal Control Site				
Vertical Control Site				
Horizontal and Vertical Control Site				

Vector Colors

Table 2.2 describes the vector symbols tied to a specific map view.

Table 2.2. Vector Colors

Map View	Vector Colors
Unprocessed	Black dashed lines
Processed	Green- Processing QA pass Red- Processing QA fail
Processed and Selected	Bright Green- Processing QA pass Magenta- Processing QA fail
Adjusted	Green- Adjustment QA pass Red- Adjustment QA fail Black- Not adjusted
Control Tie	Black
Repeat vector	Red- Repeat vector analysis QA fail Green- Repeat vector analysis QA pass Black- Not a repeated vector
Loop closure	Red- Loop closed and loop closure QA fail Green- Loop closed and loop closure QA pass Black- Vector not included in loop
Selected in any map	Orange
Excluded	Gray

Error Displays

After you adjust the network, the vertical and horizontal error is displayed for each point (Figure 2.5). Horizontal error is represented as an elliptical region around the site, and estimates real error on the ground. Vertical error is represented as a bold black line; the longer the line, the greater the error. When the Map View legend is displayed, the sizes of these errors can be readily estimated.

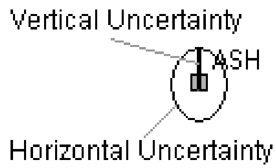


Figure 2.5. Error in the Map View Window

Zooming

The Zoom feature allows you to view the map area in greater detail.

To zoom-in - Click and drag the cursor to define the area to zoom in. When you release the mouse key, the **Map View** window zooms in to the new area.

To zoom-out - Use the **Esc** key or the **Zoom Out** button on the toolbar to zoom out one level.

Tasks in the Map View Window

Use the **Map View** right mouse click to complete the following tasks:

- View a vector's properties
- Include/exclude a vector in adjustment
- View a site's properties
- Enter or edit a site name
- Set a control site to hold fixed for processing or adjustment, and edit its coordinates
- Perform a loop closure test
- Print a map view
- View QA test results

Using the Workbook Window

The **Workbook** window, Figure 2.6, has tabs to display different kinds of information, from coordinates to network precision statistics. Several tabs have editable fields.

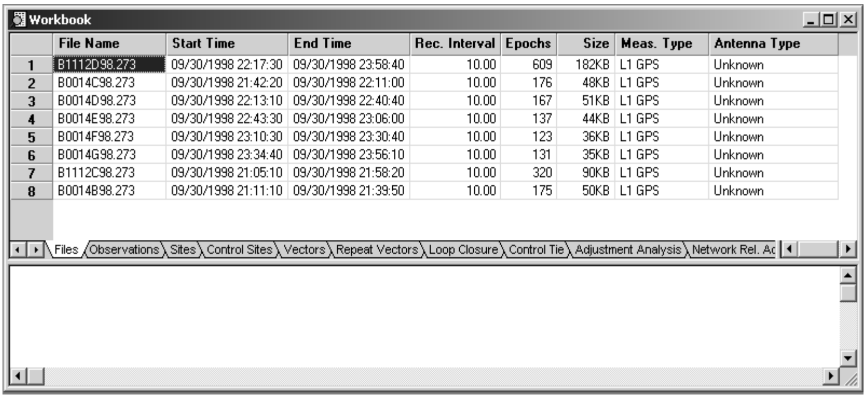


Figure 2.6. Workbook Window - Files Tab

Switch between displays by clicking a different tab.

Click on any column header to sort the data in ascending or descending order.

In many tabs, right-clicking on a value in a column displays the right-click menu with different choices on how to view the information in that column.

Highlighting an item in a **Workbook** tab highlights the same item displayed in the other views. For example, clicking on the Site ID of a particular site in the **Site** tab highlights the site in the **Map View**.

Table 2.3 describes each tab and activities to do in the tab. See the Help system for more information on the fields in the tabs

Table 2.3. Workbook Window Tabs

Tab Name	Description	Activity
Files	Information on the raw data files loaded into the current project.	• Delete file from project • View raw data for the file • Select Antenna Type
Observations	Information on each observation in the current project.	• Edit Site ID • Edit antenna height • Select Antenna Type • Select the antenna height type

Table 2.3. Workbook Window Tabs (continued)

Tab Name	Description	Activity
Sites	Information on all sites including position, uncertainties and whether the point is held fixed.	• View a site's properties • Edit Site ID • Delete a site from the project • Enter or edit a site description
Control Sites	Information on control sites with position, uncertainties and whether the point is held fixed.	• Set a control site • Edit a control site • Enter or edit a site descriptor
Vectors	Information on the most recently computed values for all vectors after vector processing.	• Exclude a vector from adjustment, reports, and export • View raw data for the file • View the residual data for the vector • Set the processing parameters for a vector • View the vector properties
Repeat Vectors	Comparison information on any vector with repeat observations.	• View only
Loop Closure	Results of loop closure tests performed on vectors	• Perform a Loop Closure test
Control Tie	Comparison information on differences between computed coordinates and entered known coordinates for control points not held fixed	• View only
Adjustment Analysis	Analysis of adjusted vectors after network adjustment.	• Exclude a vector from adjustment, reports, and export • View raw data for the file • View the residual data for the vector • Set the processing parameters for a vector • View the vector properties
Network Rel. Accuracy	Analysis of adjusted network precision.	• View only

Message Window

Below the tabs is the **Message Window**, Figure 2.6, which displays summary information, activity log information, and warnings. Although the text is not editable, you can select text and copy to the clipboard or other applications by right-clicking.

The Ashtech Solutions Toolbar

The **Toolbar** provides easy access to frequently used commands. Table 2.4 describes each button on the **Toolbar**.

To display the **Toolbar**, select **Toolbar** from the **View** menu.

To choose a command from the **Toolbar**, click the button.

Table 2.4. Toolbar Buttons

Button	Description
	**New Button** - Click this button to create a new project file.
	**Open Button** - Click this button to open an existing project file.
	**Save Button** - Click this button to save the project.
	**Files from Receiver Button** - Click this button to add data files to the project directly from a receiver.
	**Files from Disk Button** - Click this button to add data files to the project from a hard or network drive.
	**Process New Button** - Click this button to process only those sites and vectors which have not been processed.
	**Adjustment Button** - Click this button to adjust the network.
	**Workbook Button** - Click this button to open or switch to the **Files** tab of the **Workbook** window.
	**Time View Button** - Click this button to open or switch to the **Time View** window.
	**Map View Button** - Click this button to open or switch to the **Map View** window.
	**Zoom Out Button** - Click this button to zoom out to the most recent zoom in the active window.
	**Filter Button** - Click this button to open the **Filter dialog** box and select the days of data you wish to view in the project.

Table 2.4. Toolbar Buttons (continued)

Button	Description
	**Project Settings Button** - Click this button to open the **Project Settings** dialog box.
	**Report Button-** Click this button to generate a report of project data.
	**Export Button** - Click this button to export project data to a file.

The Ashtech Solutions Help System

Ashtech Solutions has an extensive Help system to assist you containing additional information not found in this manual including:

- Context sensitive information for every dialog box
- Additional reference material, including some GPS background information
- Comprehensive glossary of most GPS terms used by Ashtech Solutions and Ashtech receivers

You can access the Help system by pressing **F1** from any window or dialog box in Ashtech Solutions or by selecting **Help Topics** from the **Help** menu.

3

Projects

Ashtech Solutions uses a **Project** to manipulate data files and for processing site locations. This chapter describes the creation, modification, and manipulation of a project once you have collected survey data with a GPS receiver.

A project typically contains raw data files (received from GPS receivers) and site information (site IDs, site names, and antenna heights) recorded in the handheld or manually in a logbook.

Creating a Project

You may create a project anytime while the software is running or at startup.

To create a project with Ashtech Solutions running:

- Type **Ctrl+N**, or
- Click the **New** button on the toolbar, or
- Select **New** from the **Project** menu

This closes the current project and opens a new project. See Step 4 to continue with the project setup.

To create a project at startup:

1. Start Ashtech Solutions.

   A momentary screen opens, followed by the **Welcome** dialog box, Figure 3.1.

2. Check the checkbox if you do not want this dialog box displayed during startup in the future.

Figure 3.1. Welcome Dialog Box

3. Click on **Create a new project**. The **New Project** dialog box opens, Figure 3.2.

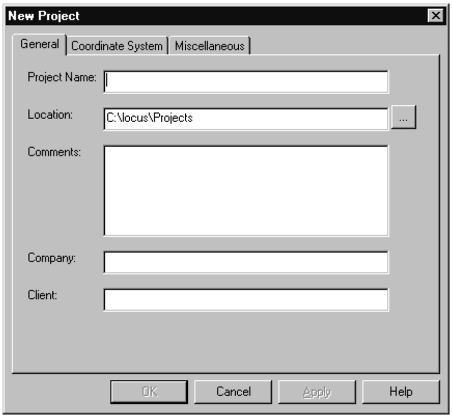


Figure 3.2. New Project Dialog Box

4. The **General** tab allows you to enter project settings and administrative data. Make the following entries:
    - **Project Name**—Type a name for the new project, e.g. Smith Survey.

You must enter the project name in this field prior to entering a location because Ashtech Solutions automatically creates a directory based on the project name.

   - **Location**—This is the directory where the new project file is stored. If the default directory is not the directory you want to use, enter the directory you wish to use, or use the **Browse** button to select a directory, after entering the project name.
5. Type in applicable administrative data in the remaining fields.
6. Click on **Coordinate System** to switch to the **Coordinate System** tab, Figure 3.3.

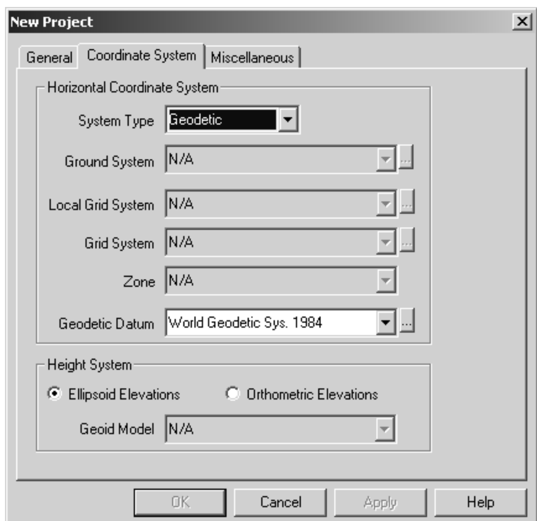


Figure 3.3. New Project Dialog Box — Coordinate System Tab

Use the **Coordinate System** tab to define the coordinate system. The defaults, WGS-84, geodetic system, and ellipsoidal elevation appear the first time you use the software. You can change these parameters to your preferred settings, after which your preferred settings become the new defaults. Refer to Chapter 9, **Coordinate Transformations** for more information about coordinate system settings.

7. Click **Miscellaneous** to switch to the **Miscellaneous** tab, Figure 3.4.

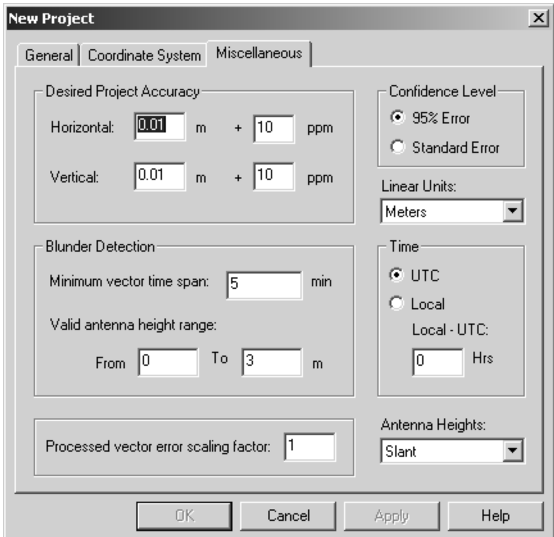


Figure 3.4. New Project Dialog Box — Miscellaneous Tab

8. Set project parameters to the values you want to use. Table 3.1 describes the components of this tab.

Table 3.1. Miscellaneous Dialog Box Description

Component	Description
Horizontal	Enter your desired horizontal project accuracy for this project in this field. Computed uncertainties of adjusted data will be compared to this threshold value. Any data not meeting this accuracy will be flagged in the QA field as Failed. Default horizontal is 0.01m + 10 ppm
Vertical	Enter your desired vertical project accuracy for this project in this field. Computed uncertainties of adjusted data will be compared to this threshold value. Any data not meeting this accuracy will be flagged in the QA field as Failed. Default vertical is 0.01m + 10 ppm
Confidence level	Select the confidence level at which all point and vector uncertainties will be calculated in the project. Your choices are either 95% or Standard Error (68%).

Table 3.1. Miscellaneous Dialog Box Description (continued)

Component	Description
Linear units	Click the arrow to the right of the field and select the linear units for all input, displayed, and output of linear information for the project. Available units systems: US feet, International feet, or Meters.
Minimum vector time span	The threshold value set in the **Minimum Vector Time Span** field defines the minimum amount of overlap time between observations before a vector is processed. If two observations overlap by less than the threshold value, a vector will not be generated. The suggested threshold value is 5 minutes since any lesser amount of data almost always results in a poor vector.
Valid antenna height range	Enter the antenna height range, in the selected project units, for any observation. Any antenna value outside this range is considered a blunder and displays with a warning.
Time	Select whether you wish time displays in the project to display in UTC time or a Local Time. If you select Local Time you must enter the offset in hours between the two systems.
Processed vector error scaling factor	A factor by which the uncertainties of the processed vectors are scaled prior to adjustment. This is described in more detail in Appendix C, **Post-Adjustment Analysis**.
Antenna Heights	Click the arrow to the right of the field to select Slant or Vertical as the default antenna height type. Any observations read into the project that do not have a defined antenna height type will be assigned the type selected here. You can manually change the antenna height type for each observation as necessary.

9. In the **Time** block, select the time system you are using, **UTC** or **Local**. If you selected a Local time, type in the offset. This offset is the difference in hours

between your local time and UTC. Use Figure 3.5 as a reference. For daylight savings time, move one time zone to the east.

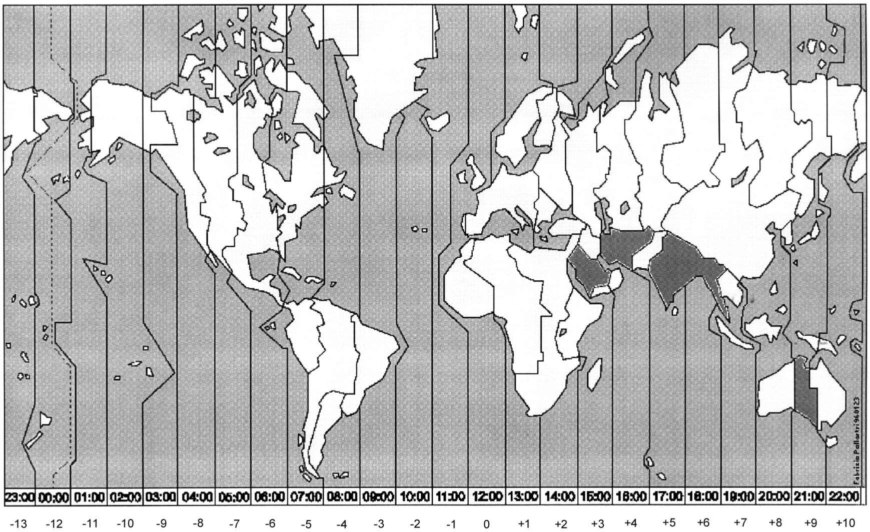


Figure 3.5. Offset from UTC

10. When you have finished setting up the project, click **OK**.

    The **Add Files** dialog box opens, Figure 3.6. For information on adding files to your project, refer to **Chapter 4, Adding Data Files**.

Figure 3.6. Add Files Dialog Box

Opening an Existing Project

To open a previously created project:

1. In the **Welcome** dialog box, Figure 3.7, click on **Open an Existing Project**.

Figure 3.7. Welcome Dialog Box

   -OR-

   - Type **Ctrl+O**
   - Click the **Open** button on the tool bar
   - Select **Open** from the **Project** menu

2. In the **Open** dialog box, Figure 3.8, navigate to the filename of the project you wish to open. A project file has the extension `.spr`.

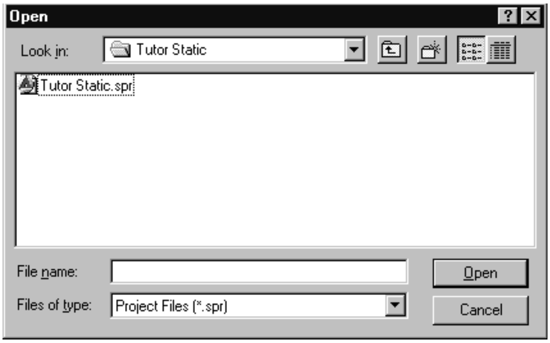


Figure 3.8. Open Dialog Box

3. Double-click the filename, or highlight the filename and click **Open**.

4. The project opens with the **Time View**, **Map View**, and **Workbook** windows. Ashtech Solutions displays the project name in the title bar (Figure 3.9).

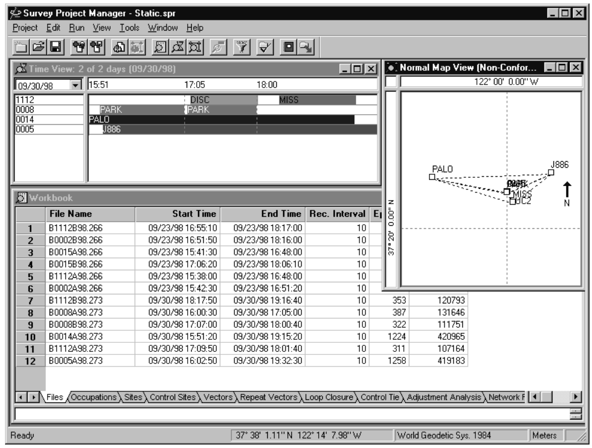


Figure 3.9. Typical Project

After opening a project, you may need to add data files. To add files, refer to Chapter 4, **Adding Data Files**.

Saving a Project

You can save an open project at any time with one of the following methods:

- Type **Ctrl+S**
- Click the **Save** button on the toolbar
- Select **Save** from the **Project** menu

You can also save the current project with a different name. To save the project under another name, select **Save As** from the **Project** menu.

If you used GPS Fieldmate, Seismark II, or Mine Surveyor II, a dialog box asks if you wish to update the coordinates in the *.out file. Click **Yes** to overwrite the coordinates in the *.out file. Click **No** if you do not want to update the coordinates in the *.out file.

Project Settings

The project settings are either the default or set when the project was created. To view project settings select **Settings** from the **Project** menu or click the **Project Settings** button on the toolbar.

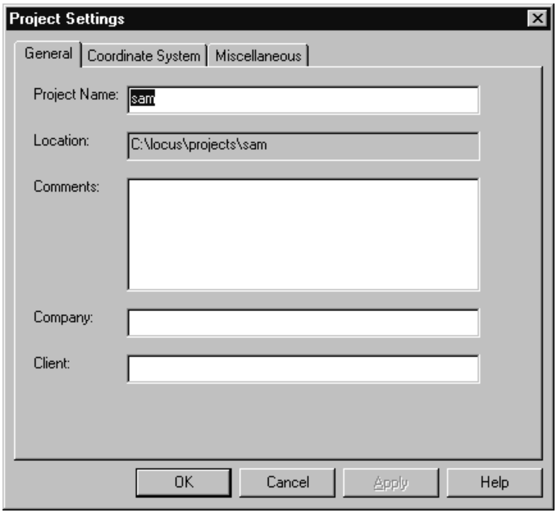


Figure 3.10. Project Settings Dialog Box

The **Project Settings** dialog box (Figure 3.10) is the same as the **New Project** dialog box. You can edit any of the parameters within the **General**, **Coordinate System**, or **Miscellaneous** tabs. Once you have modified the parameters, click **OK** to save the project settings and close the dialog box.

Deleting a Data File From a Project

Any raw GPS data file loaded into a project can later be deleted from the project. All observations and vectors generated by these observations will be automatically removed from the project.

To delete data files:

1. Switch to the **Files** tab in the **Workbook** window.
2. Select the file name of the files you wish to delete.

   -OR-

Press the **Delete** key or right-click and select **Delete** from the menu.

After deleting a data file, you must add the data file to the project again in order to use it.

Deleting a Site from the Project

Deleting a site from the project causes all vectors containing this site to be deleted and the Site ID of all observations for this site to change to **????**.

1. Select the site in the **Sites** tab of the **Workbook** window.
2. Select **Delete** from the right-click menu.

   –OR–

   Press the **Delete** key on your keyboard.

4

Adding Data Files

This chapter describes the process for adding data files to a project. This process uses the Download module of Ashtech Solutions. The following tasks are described:

- Add raw data files from receiver
- Add raw data files from disk
- Add site description data from handheld
- Add processed vectors which have been produced by another processing package
- Remove data from project
- Set receiver parameters

You can add data files to your project when you first create the project, or later as needed. Data files can be located on a hard drive (if previously downloaded from the receiver) or can reside within a receiver.

If a project has already been created and you wish to add data files:

- Click **F3** or select **From Receiver...**from the **Project** menu
- Click **F4** or select **From Disk...**from the **Project** menu

Adding Data From a Receiver

You can add raw data directly from a GPS receiver and handheld by downloading and adding data to a project in one, easy step by selecting **Add raw data files from receiver** in the **Project** menu. Use this option to insert data directly from a handheld, GPS receiver, or PC Card removed from the GPS receiver and inserted in a PC Card reader.

If you have the option of removing the data card from the receiver to download the files using a PC Card drive, you must still use Download to convert the files. If you only copy the files from the PC Card without converting them, Ashtech Solutions will not be able to read and import them.

1. Connect the receiver to the PC as directed in your receiver manual, and verify that the power is on.
2. Select **Add raw data files from receiver** from the **Project** menu. The Ashtech Download main window appears (Figure 4.1).

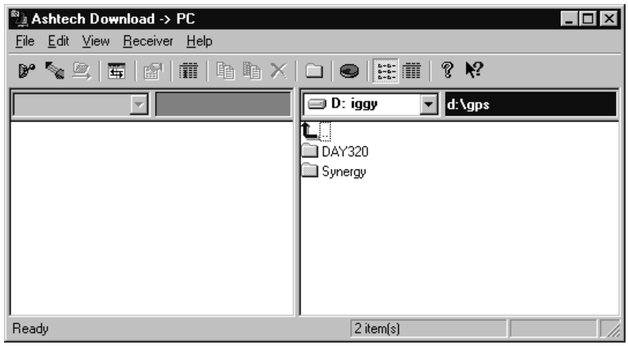


Figure 4.1. Ashtech Download Main Window

The Ashtech Download main window consists of two panes. The right pane (the PC pane) lists the files, if any, in the project directory of the PC. The left pane (the Receiver or Handheld pane) lists the files in the receiver or handheld.

The Receiver pane remains blank until the receiver establishes communication with the receiver or handheld.

Table 4.1 describes the toolbar buttons.

Table 4.1. Ashtech Download Toolbar Button Descriptions

Button	Description
	**Connect via Cable Button** - Click this button to open the **Connect via Cable** dialog box and connect to a receiver through a serial cable.
	**Connect via IR Button** - Click this button to open the **Connect via IR** dialog box and connect to a receiver through an IR device.
	**Switch Data Source Button** - Click this button to open the **Switch Data Source** dialog box and connect to another receiver or handheld.
	**Switch Pane Button** - Click this button to change the active pane.
	**Session Info Button** - Click this button to Open the **Session Information** dialog box and set session parameters for the data file.

Table 4.1. Ashtech Download Toolbar Button Descriptions (continued)

Button	Description
	**Select Files Button** - Click this button to select files based on a file mask. The **Select Files** dialog box opens to enter a file mask for file selection.
	**Copy To Button** - Click this button to copy the selected file(s) to the current directory on the PC.
	**Move To Button** - Click this button to move the selected file(s) to the current directory on the PC.
	**Delete Button** - Click this button to delete the selected file(s).
	**Create New Directory Button** - Click this button to create a new directory in the current PC directory.
	**Free Space Button** - Click this button to check the available disk space for the current drive or receiver.
	**Brief File Info Button** - Click this button to display only the names of the files.
	**Detailed File Info Button** - Click this button to display the name, size, date, and time of last modification for each file and directory in the current directory.
	**Help Button** - Click this button to access the help system.
	**What's This Help Button** - Click this button and anywhere else in the window or menu system for quick help on the feature.

3. Select **Connect** from the **File** menu.

   If you are downloading data from a PC Card inserted in the PC Card reader of you computer, select **PC Drive** and skip steps 4 to 7.

   If you are downloading data from a receiver, select **Receiver** and then select either **Connect via Cable** or **Connect via IR** depending on how the GPS receiver is connected to your PC. Locus receivers are currently the only receivers that connect via the IR port.

   The **Connect** dialog box that opens depends on whether you connected by the serial cable or IR device. Although the **Select Port** tabs are identical, the **Settings** tabs vary.

4. In the **Select Port** tab, Figure 4.2, select the COM port the receiver or IR device is using.

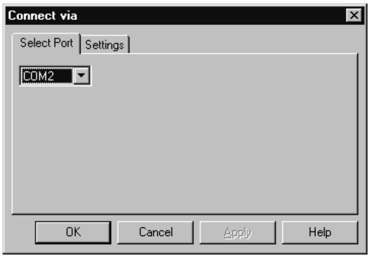


Figure 4.2. Select Port Tab

5. Switch to the **Setting** tab, Figure 4.3 and Figure 4.4.

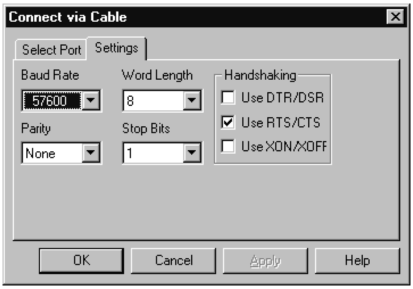


Figure 4.3. Connect via Cable - Setting Tab

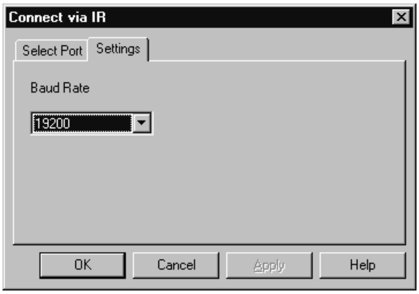


Figure 4.4. Connect via IR - Setting Tab

6. Change the baud rate to the fastest rate the receiver supports to minimize the download time.

7. Verify that the receiver is turned on and the IR ports are aligned, if using an IR device, and click **OK** to connect to the receiver.

Download makes the connection and displays the contents of the receiver memory.

For example, the Receiver pane shown in Figure 4.5 lists:

- **0021a99.162**—raw GPS data file, with “0021” as the site ID for all receivers but Locus, or the Locus receiver serial number, “a” as the session, “99” as the year, and “162” as the day of the year (other data files may be listed)
- **almanac**—GPS satellite information file - use with **Mission Planning** (refer to *Appendix A,* **Mission Planning**)
- **iono corrections**—GPS satellite ionosphere corrections file. The iono corrections file is only created by a Locus receiver.

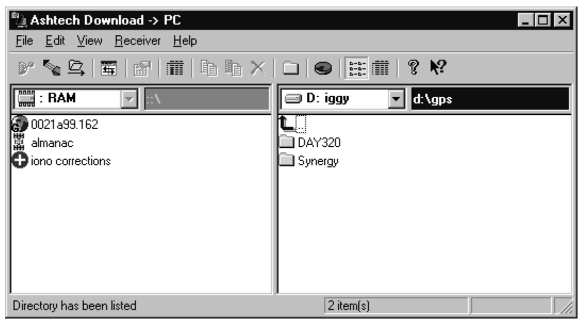


Figure 4.5. Ashtech Download Main Window

The almanac and iono correction files only contain complete information if the receiver has tracked satellites for more than 15 minutes.

8. Verify that the destination directory in the PC pane is the project directory or the directory where you want the data files to be stored.

   If you want to create a new directory, click anywhere on the PC pane, then click the **New Directory** button and type a name for the directory. Be sure to use logical and consistent path and file naming conventions that are easy to remember. Usually it is most convenient to put the data files in the project directory.

9. Select the data file(s) that you want to download and drag them to the PC pane. To select a group of contiguous files, hold the **Shift** key while selecting files. To select particular files in the list, hold down the **Ctrl** key while selecting files.

10. Download copies the files to the PC. A progress dialog box indicates the status of the download.

Although the data files have been downloaded from the receiver, they have not been deleted from the receiver's memory. To delete receiver data files, select the desired files and click the delete button on the toolbar. The **Move** function copies and then deletes the files.

It is good practice to delete the data files in the receiver after verifying that the files have downloaded properly. Otherwise, the memory may fill up during the next data collection session, resulting in the inability to complete the survey.

Downloading Data From a Handheld

The manner in which data is imported from a handheld controller depends upon the handheld software.

If you collected data using a handheld with TDS *SurveyPro w/GPS*, the information is stored in the receiver, and when you download the data files from the receiver, the site information collected using the handheld automatically downloads. You do not need to download anything from the handheld.

If you collected data using a handheld with Seismark II, GPS FieldMate, or Mine Surveyor II, refer to the software manual to download the `*.out` file. Download or copy this file to the project directory. When you import the receiver data corresponding to this `*.out` file into the project, Ashtech Solutions automatically accesses the `*.out` file.

Downloading Data from an HP-48 Handheld

If you used an HP-48 handheld to collect site information download its data after all receivers.

The receiver and handheld must be downloaded in the same download session for the receiver and handheld data to be loaded correctly into the project. If receiver files are downloaded separately from the handheld files, the handheld data will not be associated with the receiver files. If this happens, delete the data files for the project, and load them again using **Add Raw Data Files From Disk**.

1. With Ashtech Download running and connected to a receiver, select **Switch Data Source** from the **File** menu.

   Ashtech Download turns off the current receiver and prompts you to align a different device.
2. Turn on the handheld and start its download program.
3. Align the IR ports within two inches of each other, and click **OK** (Figure 4.6).

It is critical that the handheld be within 2 inches of the IR device for download. Also, take great care to ensure that the IR device and the IR port on the handheld are aligned horizontally and vertically. Since the IR device and the IR port of the handheld must be very close to each other, the horizontal and vertical alignment are critical.

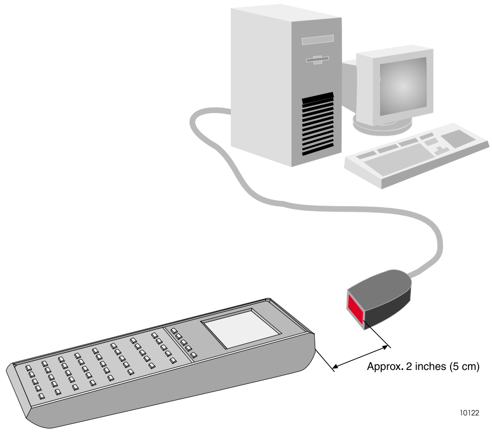


Figure 4.6. Setup for Transferring HP-48 Handheld D-Files

Ashtech Download automatically switches the baud rate to 2400 (the only baud rate supported by the handheld), connects to the handheld, and lists the one file in the handheld pane (D-file).

4. Select the D-file and drag it to the PC pane to copy the file to the PC.

Always transfer the D-file to the same directory as the raw GPS data files for a project.

5. Upon completion, the PC pane lists the D-file, and the handheld automatically disconnects from the PC.

After download, it is good practice to delete the D-file from the handheld.

Downloading Data from Multiple Sources

If you have more than one receiver or handheld to download, use the **Switch Data Source** function:

1. With Download running and connected to a receiver, select **Switch Data Source** from the **File** menu.

Download disconnects from the current receiver and opens the **Switch Data Source** dialog box, Figure 4.7.

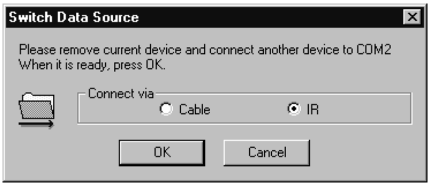


Figure 4.7. Switch Data Source Dialog Box

2. Connect the next receiver or handheld to the PC as specified in the receiver or handheld manual, and verify that the power is on.
3. Click the button that corresponds to the manner in which the receiver or handheld is connected, and click **OK**.

   Download connects to the new receiver or handheld.

Ending the Download Process

Upon completing the download of all data files from the receiver(s) and handheld(s), exit Ashtech Download by selecting **Exit** in the **File** menu.

If you entered Ashtech Download from Ashtech Solutions, verify that the Workbook window lists all the data files you added to the project.

If a handheld was used during data collection and not downloaded with the receiver data, the receiver data load into the project without attribute information. To recover from this:

1. Delete the receiver data from the project file.
2. Download the handheld data into the same directory as the receiver data files.
3. Load the data back into the project using selecting **Add raw data from disk** from in the **File** menu.

Adding Data from Disk

Data files residing on your hard drive can easily be added to a project.

If your data files are stored on a PCMCIA card, use Ashtech Download to convert the files before importing them into Ashtech Solutions. If you have the option of removing the data card from the receiver to download the files from a PCMCIA drive, you must still use Ashtech Download to convert the files. If you just copy the files from the PCMCIA card without converting them, Ashtech Solutions will not be able to read and import them.

1. Select **Add data from disk** from the **Project** menu. The **Add Files** dialog box opens (Figure 4.8).

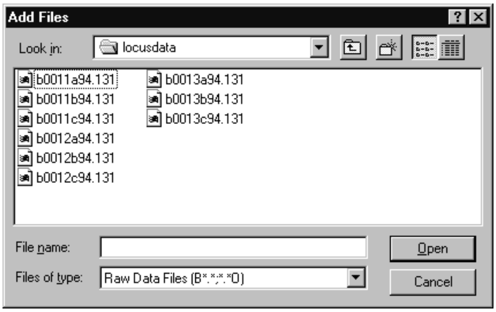


Figure 4.8. Add Files Dialog Box

2. In the **Files of type** combo box select a file type:
   - Raw Data Files—Ashtech and RINEX format
   - Ashtech Raw Files—Receiver-generated files (B*.*)
   - RINEX Observation Files—Standard RINEX formatted files (*.*O)
   - All Files (*.*)
3. Navigate to the data files you wish to add to the project.
4. Select and highlight all the data files you wish to add to the project.

   Each highlighted file name appears in the **File Name** field.
5. Click **Open**.

   Ashtech Solutions adds the files to the project.

   The **Files** tab in the **Workbook** window lists all selected data files added to the project.

Only B-files are shown in the Add Files dialog box. Upon clicking Open, associated D- and E-files also load into the project.

Add Processed Vectors

You can add previously processed vectors (in Ashtech O-files) to your project.

These files may have been created by other Ashtech software packages or may have been exported from other Ashtech Solutions projects.

1. Select **Add Processed Vectors** from the **Project** menu. The **Add Vectors** dialog box opens (Figure 4.9):

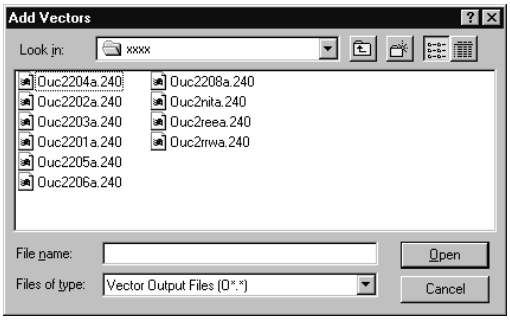


Figure 4.9. Add Vectors Dialog Box

2. Navigate to the directory where the vector files are stored. Ashtech Solutions can import standard Ashtech binary O-files containing vector information.
3. Select the processed vector files you wish to add to your project and click **OK**.

   Use the Vectors tab in the **Workbook** window to verify that the vectors have been added to the project.

Removing Data From a Project

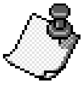
Any raw GPS data file loaded into a project can later be deleted from the project. All observations and vectors generated by these observations will be automatically removed from the project.

To remove data files:

1. Switch to the **Files** tab in the **Workbook** window.
2. Select the file name of the files you wish to delete.
3. Press the **Delete** key

   -OR-

   or select **Delete** from the right-click menu.



Once you delete a data file, you must add the data file to the project again in order to use it.

Recording Interval and Kinematic Warning Alarm

Use Ashtech Download to set the receiver recording interval and turn on or off the kinematic warning flag on the Locus receiver.

1. Verify Ashtech Download is connected to a receiver.
2. Select **Receiver Parameters** from the **Receiver** menu. The Receiver Setup dialog box opens.
3. Ashtech Download queries the receiver recording interval and displays it in the **Receiver Setup** dialog box (Figure 4.10).

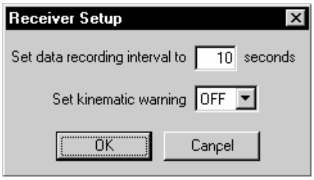


Figure 4.10. Receiver Setup Dialog Box

4. Enter the recording interval in seconds; the range of values is 0.5 to 999.

   The recording interval is the time interval between recording data to memory.

   Select **ON** to activate the kinematic warning flag, or **OFF** to deactivate this flag. This option is only available for Locus receivers.

   When the kinematic warning is set to ON, the kinematic warning alarm alerts the Locus receiver operator, with a beeping sequence, when the Locus receiver is not logging data from enough satellites to maintain the kinematic initialization.
5. **Click OK** to send the parameters to the receiver and close the **Receiver Setup** dialog box.

5

Data Processing

Raw data collected by a receiver must be processed to determine the differential relationship between the sites occupied during data collection. The result of processing GPS raw data is a vector defining this relationship. Computation of these vectors is the role of the data processing module within Ashtech Solutions.

The data processing module automatically analyzes the quality of the raw data files and adjusts processing parameters to produce the best vector possible, transferring most of the processing effort from the user to the processing software. In Ashtech Solutions, the actual processing of your data is limited to a simple press of the **Process** button, safe in the knowledge that you will get the best answer.

GPS data is processed in three steps:

- **Pre-process data analysis—**Site and observation properties, such as Site IDs, antenna height parameters, and control site information are verified and/or entered.
- **Processing—**A push of a button invokes the processing engine to produce GPS vectors from raw data.
- **Post-process data analysis—**Processed GPS vectors are analyzed using supplied analysis tools, to determine the quality of processed data.

This chapter outlines the steps for processing your raw GPS data.

Pre-processing Data Analysis

The processing of GPS vectors relies on two sources of data, raw GPS data collected by the receiver, and observation and site-specific data provided by the user. When using a handheld or a GPS receiver with an integrated user interface, much of the user-supplied data can be entered in the field during data collection.

In this case, verify the data before processing. If a handheld was not used, this data may be entered manually.

Verification and editing of user-supplied observation and site data can be performed in more than one location within Ashtech Solutions. Primarily, the **Observation Property** dialog box is used for this task. Table 5.1 outlines the user-supplied data that can be viewed and edited in this dialog box.

You should analyze your data before processing. Pre-processing data helps you through the preparation of data for baseline processing. You will also be able to identify and correct common problems.

To begin the pre-process analysis:

1. If you have not done so already, load all the data files into your project. See Chapter 4, **Adding Data Files** for more information.
2. Verify that the **Time View** window and the **Workbook** window with the **Observations** tab are open (Figure 5.1).

   In the **Time View** window, each horizontal band of color associates with a different Site ID. All observations of a site are in the same color, e.g., each observation of site PARK is green.

   The **Observations** tab lists the associated antenna heights, start and stop times, and file name for each observation.

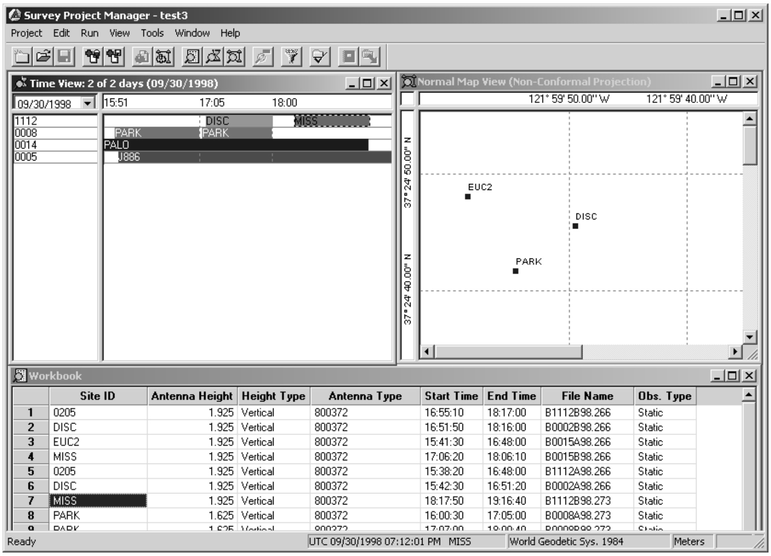


Figure 5.1. Project Manager Main Window

Filtering Data

Occasionally during data processing and adjustment it is beneficial to isolate a segment of data for individual attention. Use the **Filter** function to isolate a segment.

Data can be filtered by the day of collection. After filtering data, all subsequent actions, including processing and adjustment, are performed only on the data selected in the **Filter** dialog box. Data that have been filtered out are not visible and no actions are taken on them.

For example, if three days of raw data were imported into a project and you wish to work with only the data from one of these days, the other two days of data can be filtered out.

To filter data:

1. Select **Filter** from the **Edit** menu
2. In the **Filter** dialog box, Figure 5.2, select the date(s) for the data you wish to view.

   Other days of data which you have not selected remain in the project but are not visible.

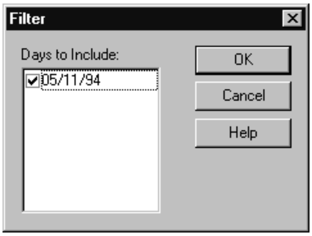


Figure 5.2. Filter Dialog Box

3. Click **OK** to close the **Filter** dialog box and filter the data to the selected date(s).

Time View provides another way to selectively view data. **Time View** shows one day of data at any one time. You can easily switch to a different day by clicking on the drop-down list in the top left of the window, and selecting a date. The **Time View** changes to indicate the date. This only affects what is visible in the **Time View** and does not affect any other views or actions such as processing or adjustment.

Data Processing

Editing Data

If you logged site information in the field using a handheld or integrated user-interface on the receiver and have confirmed that Site IDs, observation time, and antenna heights are correct, then you may not need to edit your data.

However, when viewing the data during the preprocess analysis, you may find that you need to change some values. For example, if you conducted a static survey without entering site information, you need to set the Site IDs and antenna heights for every observation, or a site name entered incorrectly on the handheld.

Observation Properties

User-supplied observation data consists of the observation Site ID and antenna height parameters. If this information was entered in the field using a handheld or integrated user-interface to the receiver, verify the information is correct. If this site information was not entered in the field, it needs to be entered manually prior to processing.

Occasionally, observation start and stop times may need to be adjusted. For example, during data collection of a kinematic survey, you may accidentally move from a site while data was still being collected for the site. The end time of the site observation would need to be modified to not include the time when the receiver was moved off the site.

You can view the properties of each observation by double-clicking on the time bar for an observation or by selecting **Properties** from the right-click menu of an observation in the **Time View** window. In the **Observation Properties** dialog box, Figure 5.3, you can change the Site ID and antenna parameters.

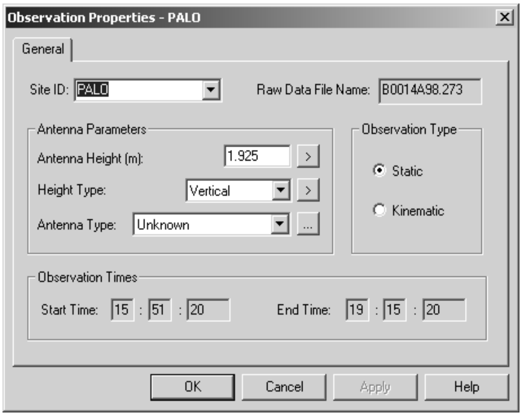


Figure 5.3. Observation Properties Dialog Box

Table 5.1 describes the components of the **Observation Properties** dialog box**.**

Table 5.1. Observation Properties Dialog Box

Parameter	Description
Site ID	A four-character alphanumeric identifier for the survey point. Each survey point must have a unique Site ID. Otherwise, the processor has problems determining which site each observation belongs to, causing inaccurate positions.
Raw Data File Name	Raw data binary file (known as a B-file), generated by the receiver, containing carrier phase, code phase and computed receiver position for every epoch, along with health flags indicating the confidence of the measurements. The name of this file includes the Site ID or receiver serial number, session letter, year, and day of the calendar year (B0014A98.273).
Antenna Height	This field displays the antenna height in the units specified in the **Miscellaneous Tab** of the **Project Settings** dialog box. You can set the slant measurement for this observation, this file, or this receiver.
Height Type	This field displays if the Antenna height is the **Slant** height or **Vertical** height for the Observation.
Antenna Type	This field displays the antenna model used to collect the data.
Observation Type	The selected radio button corresponds to the data type for this observation. • Select **Static** if this observation was collected while stationary over a point. • Select **Kinematic** if this observation was collected while moving. Data collected using the **Continuous Kinematic** mode of data collection and data collected while moving between points using the **Stop&Go Kinematic** mode of data collection are both examples of observations of a **Kinematic** observation type.
Start Time	The time data started recording for the observation in either local time or UTC Time. The Time Frame is specified in the **Miscellaneous Tab** of the **Project Settings** property sheet.
Stop Time	The time data stopped recording for the observation in either Local Time or UTC Time. The Time Frame is specified in the **Miscellaneous Tab** of the **Project Settings** property sheet.
OK Button	Click the button to accept the parameters and close the dialog box.
Cancel Button	Click this button to close the dialog box without saving the parameters.
Apply Button	Not used.
Help Button	Click this button to access the help system

You can edit any of these parameters except for the **Raw Data File Name**. Although you can edit the start and stop times of an observation, there is one exception to this; if the start or stop time of the observation coincides with the beginning or end of a data file, you can not edit that time. Instead, insert a new observation (see “Trimming Data” on page 54 for more information) and then edit the times.

Site Properties

User supplied site data consist of Site ID, site descriptor, and, if available, known site coordinates. If any sites occupied during data collection have known coordinates, these should be entered as control sites for processing, for you should begin processing with known coordinates at a minimum of one site. This is referred to as the seed site for processing.

Ashtech Solutions can process raw data without a seed site. In such a case, Ashtech Solutions selects one site to use as the control for processing. The raw data coordinates for this site are used as the seed coordinates. In some cases this may introduce error in the processed vectors in the amount of approximately 2-4 ppm of vector length. If this level of error is significant to your survey, a control site must be used to process the data.

Kinematic data needs special attention when preparing the data for processing. If the kinematic survey was initialized on a known vector, i.e. two known sites, the coordinates for the sites on each end of this vector must be entered as control sites. If initialization was performed using a Kinematic Initialization bar, the base site should be identified as a control site. If this site does not have known coordinates, use the raw data coordinates.

The **Site Properties** dialog box has three tabs to view and set site data. To open the **Site Properties** dialog box for a site,

- Double-clicking on site in the **Map View**

  -OR-

- Highlight a sight, and then select **Properties** from the right-click menu in the **Sites** tab or **Map View**.

General Tab

The **General** tab Figure 5.4, lists the site name, Site ID, solution type, and whether the site is a control site and held fixed. You can edit the Site ID or Site Descriptor by typing over the existing text.

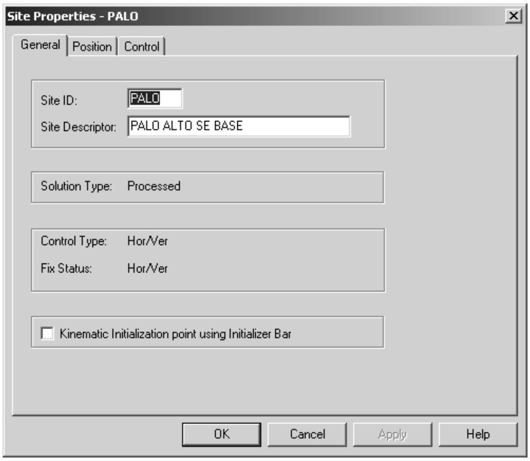


Figure 5.4. Observation Parameters Dialog Box - General Tab

Table 5.2 describes the components of the **Site Properties** dialog box, **General** Tab.

Table 5.2. Site Properties Dialog Box - General Tab Parameters

Parameter	Description
Site ID	A four-character alphanumeric identifier for a survey point. Each survey point must have a unique Site ID. Otherwise, the processing will have problems determining which point certain observations belong to. Site name changes will modify any associated observation’s site name.
Site Descriptor	20-character alphanumeric name or description for the Site ID to identify the site.
Solution Type	• Raw—the position derived from a raw GPS data file collected at the site • Processed—the position derived from the processing of the vector(s) including this site • Adjusted— the position derived from the adjustment of vectors including this site
Control Type	Indicates if the site is a control site for the project in either the horizontal or vertical directions or both.

Table 5.2. Site Properties Dialog Box - General Tab Parameters (continued)

Parameter	Description
Fix Status	Indicates if the position is fixed vertically or horizontally.
Kinematic Initialization point using Initialization Bar	Flag indicating this site is the Rover-initialized site on a kinematic initialization bar.

Position Tab

The **Position** tab (Figure 5.5) lists the position coordinates and position uncertainty for the site.

To view the site coordinates in a different coordinate system, click the arrow to the right of the **System** field, and select a coordinate system from the list presented.

Only the system type selected in the Coordinate System tab, and the types below it, are available.

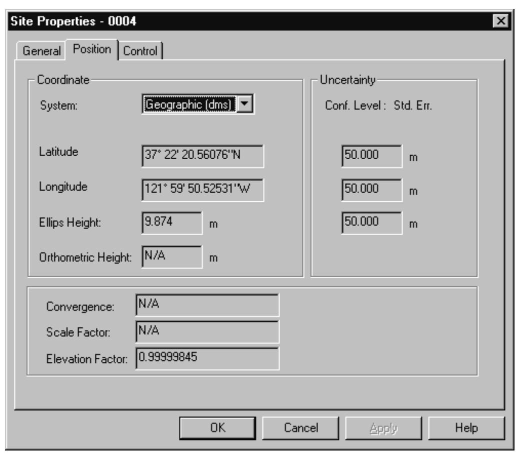


Figure 5.5. Site Properties Dialog Box - Position Tab

Table 5.3 describes the components of the **Position** tab.

Table 5.3. Site Properties Dialog Box - Position Tab Parameters

Parameter	Description
System	Geodetic/Grid/Local Grid - Selection available depends on the system type chosen in the **Coordinate System** tab of the **Project Settings** dialog box.
Latitude/Easting	The latitude or the easting (x) of the point

Table 5.3. Site Properties Dialog Box - Position Tab Parameters (continued)

Parameter	Description
Longitude/Northing	The longitude or the northing (y) of the point
Ellips Height	The ellipsoidal height of the point, if available.
Orthometric Height	The orthometric height of the point, if available.
Conf. Level	The statisically derived confidence level of each component of the position.
Convergence	The grid convergence angle for the site. A convergence angle displays only when a Grid or Local system is selected.
Scale Factor	If using a grid system, this is the factor used to convert ellipsoidal distances to grid distances. It varies from point to point over the projection area.
Elevation Factor	Elevation factor is a scale adjustment applied to distance measurements in order to reduce the distances to the ellipsoid surface. This is the first step to converting measured distances to grid distances. After the measured distance is reduced to an ellipsoidal distance, it is scaled again by the scale factor to produce a grid distance.

Control Tab

The **Control** tab (Figure 5.6) is used to set the site as a control point, hold the site fixed, and enter the control site coordinates.

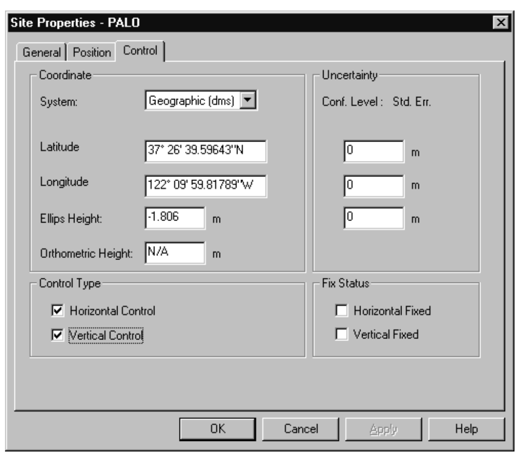


Figure 5.6. Site Properties Dialog Box - Control Tab

Table 5.4 describes the components of the **Control** tab.

Table 5.4. Site Properties Dialog Box - Control Tab Parameters

Parameter	Description
System	Geodetic/Grid/Local Grid - Selection available depends on the system type chosen in the Coordinate System Tab of project settings.
Latitude/Easting	The latitude or the easting (x) for the point
Longitude/Northing	The longitude or the northing (y) for the point.
Ellips Height	The ellipsoidal height of the point, if available
Orthometric Height	The orthometric height of the point, if available.
Conf. Level	This is the statistically derived confidence level of each component.
Control Type	Check the box corresponding to the type of control: horizontal and/or vertical. If neither box is checked, none of the fields in **Coordinate, Uncertainty,** or **Fix Status** are accessible. After selecting a control type, enter the control coordinates for the site.
Fix Status	Check these boxes to indicate that the position is fixed vertically and/or horizontally.

Using Sites in Processing

Including

All sites are automatically included when you process the data.

Removing

To remove a site from processing you must delete it. Select the site in the **Map View** window and select **Delete** from the right-click menu to completely remove the site from the project file.

Deleting a site only deletes the point object. The raw data associated with the site remains in the project, and the Site ID is changed to **????.** To reestablish the site, edit the observation Site IDs to the old ID.

Using Observations in Processing

Including

All observations without the Site ID of **????** are automatically included when you process the data.

Removing

You may want to remove an observation from processing because you know the observation was conducted at the wrong survey point, the data was bad, or the receiver lost lock to the satellites. Ashtech Solutions will not process the vectors associated with an excluded observation.

To remove an observation, rename the Site ID to **????**. Refer to “Editing Site ID” on page 50.

Set a Control Site

When processing GPS raw data collected simultaneously within a network, coordinates of one or more points should be held fixed. Normally, these are the known coordinates for one of the points. These coordinates are called seed coordinates and the site a control site. You should always choose a site with known coordinates as your control site. If you are not concerned about the control site, Ashtech Solutions automatically chooses a site and sets it as the control site.

The coordinates for known control points can be entered for use as the seed point in vector processing and as fixed control for the adjustment. Control points can be used as horizontal control only, vertical control only, or both. You have the option of entering a control point but not holding the control values fixed. The advantages of this capability are:

- You can enter all known control points at any time. You may chose to enter all control at the very start of the project. You would select just one point to hold fixed horizontally and one vertically (can be the same point) for processing and the minimally constrained (free) adjustment. When it becomes time to perform the fully constrained adjustment, you simply need to inform the software to hold fixed the other control points.
- You can perform a Control Tie Analysis. You enter all control prior to the minimally constrained adjustment but hold fixed only one horizontally and one vertically. The Control Tie tab of the Workbook will then display the comparisons between the known control values and the adjusted values for those control points you entered values for but did not hold fixed. A large deviation may indicate a problem with the control.

Set a control site from the Workbook window

1. Click on the **Control Sites** tab of the **Workbook** window.

   There may not be any control sites listed yet in this tab.
2. Click on the arrow on the right side of the **Site ID** box and select a control site.
3. Enter the known Easting/Latitude, Northing/Longitude, and Orthometric/ Ellipsoidal Height coordinates for the control site unless you wish to use the raw data coordinates (NAV position).

Ashtech Solutions automatically sets the site as a vertical and horizontal fixed control site.

4. If you wish the point to be held fixed in either the vertical or horizontal direction, click the arrow in the **Fixed** field and select the type of fix for the point.
5. Unless known, set the **Std. Err.** of each value to zero (0).

   After setting a control site, the symbol for that site in the **Map View** window becomes a circle with a triangle inside it.

Set a Control Site in the Site Properties Dialog Box

1. From the **Map View** window, double-click on a site to open the **Site Properties** dialog box.
2. Switch to the **Control Tab**.
3. Check the **Control Type** and **Fix Status** boxes corresponding to the type of control and position fixing for the site.
4. Select the **Coordinate System**, and enter the known position coordinates for the control site.
5. Click **OK** to save any changes and close the **Site Properties** dialog box.

Editing Site ID

The Site ID is a very important property of a site. Each site must have a unique Site ID. A site cannot exist unless there exists an observation associated with it. When an observation is entered into the project with a specific Site ID, a site is created. The Site ID of any existing site can be edited to a different ID. Observations with this Site ID are automatically changed to the new ID. There may be times when you want to change the Site ID—such as when you want to remove observation from being processed, rename a Site ID from ????, or modify an incorrect Site ID.

You can edit a Site ID in a number of different ways:

- Click on the **Sites** tab in the **Workbook** window and double-click (or right-click) on the Site ID and modify the name.
- Double-click (or right-click) on the observation bar of a site in the **Time View** window to open the **Observation Parameters** dialog box and double-click (or right-click) on the Site ID and modify the name.
- Double-click (or right-click) on the site within the **Map View** window to open the **Site Properties** dialog box and then double-click (or right-click) on the **Site ID** and modify the name.

Changing the Site ID in the **Site Properties** sheet has a different effect than changing it in the **Observation Properties** sheet. In the **Site Properties** sheet, a change in the Site ID changes all observations containing this Site ID to the new value. In the **Observation Properties** sheet, a change of the Site ID only affects that particular observation.

Editing Antenna Parameters

Invalid antenna parameters are a major cause of blunders during processing including, but not limited to: transposing numbers when writing down the antenna height, reading the height incorrectly, or occupying the wrong point.

If incorrect data (or no data) were entered into the data files, Ashtech Solutions provides the opportunity to modify these measurements to ensure valid and reliable processing of the data.

To determine if antenna parameters were incorrectly entered via the handheld, review the field notes from the survey(s).

To verify the antenna parameters:

1. Double-click on the observation bar for and observation in the **Time View** window to open the **Observation Parameters** dialog box.
2. If the Antenna Parameters are missing or incorrect, enter the correct antenna parameters, and indicate if the value should be used only for the selected observation, all observations for the file, or all observations for the receiver.

You can also edit antenna parameters in the **Observation** tab of the **Workbook** window.

Antenna Height

The three elements defining the location of the GPS data collection point are Antenna Height, Height Type, and Antenna Type. The Antenna Height and Height Type are inseparably tied together.

The Antenna Height is one of three elements that define the vertical offset between the location of the GPS data collection point and the feature being surveyed (survey mark, topo ground shot, etc). The processing software requires this information to report the elevation of the surveyed feature.

If the selected Height Type is Slant, then the Antenna Height is the measured distance between the feature being surveyed and the Slant Height Measurement Point of the antenna (edge of antenna or ground plane).

If the Height Type is Vertical, then the Antenna Height is the measured distance between the feature being surveyed and the Antenna Reference Point (ARP). The ARP is the very bottom of the antenna.

With this information and a selected Antenna Type, the Ashtech Solutions automatically determines the location of the GPS data collection point and compute elevation values of the surveyed feature.

Antenna Type

The Antenna Type is one of three elements that define the vertical offset between the location of the GPS data collection point and the feature being surveyed (survey mark, topo ground shot, etc). The other two elements are Antenna Height and Height Type. To proper determine the elevation of the feature being surveyed, the correct Antenna Type must be selected for each observation.

With the properly Antenna Type selected, along with the Antenna Height and Height Type, the Ashtech Solutions automatically determines the location of the GPS data collection point and compute elevation values of the surveyed feature.

You can select the antenna used for an observation in the following locations:

- **Files Tab** of the **Workbook** window
- **Observations Tab** of the **Workbook** window
- **Receiver Information** dialog box
- **Observation Properties** dialog box

Creating a New Antenna Type

You can create a new Antenna to add to the list of Antenna Types in either the **Receiver Information dialog box** or the **Observation Properties** dialog box.

To create a new antenna from the **Receiver Information** dialog box:

1. Double-click a receiver in the **Time View** window to open the **Receiver Information** dialog box.
2. Click the arrow to the right of the **Antenna Type** field, and select **Unknown** from the list presented.
3. Click the **Define** button to open the **Antenna Parameters** dialog box (Figure 5.7).

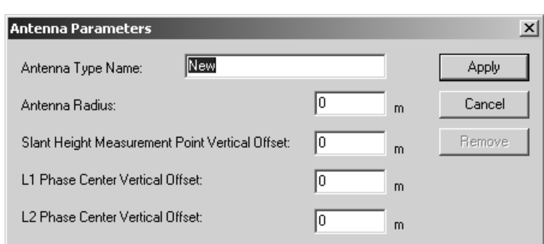


Figure 5.7. Antenna Parameters Dialog Box

4. Enter the name for the new antenna in the **Antenna Name** field.
5. Enter the radius, in meters, in the **Antenna Radius** field.
6. In the **Slant Height Measurement Point Vertical Offset** field, enter the vertical offset from the **Antenna Reference Point** (ARP) to the **Slant Height Measurement Point** (SHMP) of this antenna. The units are in meters. If the SHMP is above the ARP, the offset value is positive. This is the case for most antennae.
7. In the **L1 Phase Center Vertical Offset** field, enter the vertical offset from the **Antenna Reference Point** (ARP) to the L1 Phase Center. The units are in meters. If the L1 Phase Center is above the ARP, the offset value is positive. This is the case for most antennae.
8. If the new antenna is an L1 and L2 antenna, enter the vertical offset from the **Antenna Reference Point** (ARP) to the L2 Phase Center in the **L2 Phase Center Vertical offset** field. If the L2 Phase Center is above the ARP, the offset value is positive. This is the case for most antennae.
9. Click **Apply** to add the antenna to the List of Antenna Types, and close the **Antenna Parameters** dialog box.

   The antenna you just added to the list of Antenna Types is the selected **Antenna Type** in the **Receiver Information** dialog box.

To create a new antenna from the **Observation Properties** dialog box:

1. Select an observation in the **Time View** window or in the **Observation tab** of the **Workbook** window.
2. Select **Properties** from the right-click menu top open the **Observation Properties** dialog box.
3. Click the arrow to the right of the **Antenna Type** field, and select **Unknown** from the list presented.
4. Click the **Define** button to open the **Antenna Parameters** dialog box (Figure 5.7).

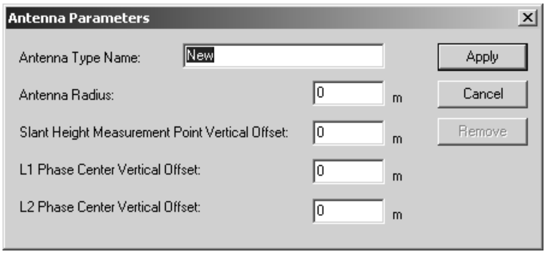


Figure 5.8. Antenna Parameters Dialog Box

5. Enter the name for the new antenna in the **Antenna Name** field.
6. Enter the radius, in meters, in the **Antenna Radius** field.
7. In the **Slant Height Measurement Point Vertical Offset** field, enter the vertical offset from the **Antenna Reference Point** (ARP) to the **Slant Height Measurement Point** (SHMP) of this antenna. The units are in meters. If the SHMP is above the ARP, the offset value is positive. This is the case for most antennae.
8. In the **L1 Phase Center Vertical Offset** field, enter the vertical offset from the Antenna Reference Point (ARP) to the L1 Phase Center. The units are in meters. If the L1 Phase Center is above the ARP, the offset value is positive. This is the case for most antennae.
9. If the new antenna is an L1 and L2 antenna, enter the vertical offset from the Antenna Reference Point (ARP) to the L2 Phase Center in the **L2 Phase Center Vertical offset** field. If the L2 Phase Center is above the ARP, the offset value is positive. This is the case for most antennae.
10. Click **Apply** to add the antenna to the List of Antenna Types, and close the **Antenna Parameters** dialog box.

    The antenna you just added to the list of Antenna Types is the selected **Antenna Type** in the **Observation Properties** dialog box.

Trimming Data

The Trim Data function is useful to cut off and not use the first or last couple of minutes of data in an observation for processing, or rename the beginning or end of an observation to a different Site ID. Trim Data inserts an observation at the start or end of the data file. This observation fills the space left open by the editing of the start or stop time of the observation that previous occupied this time period.

To trim data from the beginning of an observation, select an existing observation, and select **Trim Before** from the right-click menu. Select a new site name, or use **????** to trim the data. Enter the **End Time** for the trimmed data, and click **OK**.

To trim data from the end of an observation, select an existing observation, and select **Insert After** from the right-click menu. Select a new site name, or use **????** to trim the data. Enter the **Trim Time** for the trimmed data, and click **OK**.

Consider an example. Assume you have an observation at the end of a data file which ends at 08:15:00. For some reason, you want to stop this observation at 08:10:00. Since this observation continues to the end of the data file, you can not edit the end time unless you insert a filler observation in its place. Using the Trim Data feature, an observation can be inserted at the end of the file that begins at 08:10:00 and ends at 08:15:00. You can give this observation a Site ID of **????** so that it will be ignored during processing.

Adding Kinematic Data Points to the Data Set

Observations with a Site ID of **????** are normally associated with periods of time when the user is moving. Most commonly, observations with a Site ID of **????** are found between point observation in data collected using the Stop&Go Kinematic mode. Although this data is used in the processing of the Stop&Go Kinematic data, the results from the observation with a Site ID of **????** are not reported anywhere.

It's possible to make use of the observations with a Site ID of **????** by assigning Site IDs to selected data samples with the observation. Each Site ID is assigned to only one data sample. The result is a set of points outlining the trail followed by the user during the time period of the **????** observation.

1. Right-click the observation with the Site ID **????** in either the **Time View** window or the **Observations Tab** of the **Workbook** window.
2. Select **Properties** from the right-click menu to open the **Observation Properties** dialog box.
3. Verify that the **Kinematic** radio button is selected as the **Observation Type**.
4. Enter a valid Site ID in the **Site ID** drop down list box.

   Ashtech Solutions will automatically increment the Site ID to fill the observation; be sure to enter a Site ID that will not overlap existing Site IDs in the project.
5. Click **OK** to open the **Adding Points** dialog box(Figure 5.7).

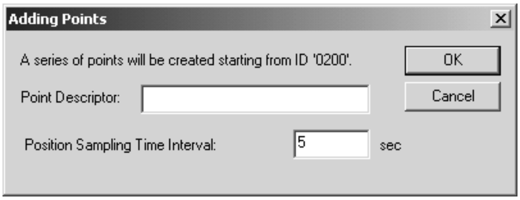


Figure 5.9. Antenna Parameters Dialog Box

6. Enter a description for the series of points.
7. Enter the time in seconds corresponding to the sampling interval you wish.

   For example, if you enter 5, Ashtech Solutions will assign a Site ID to a one second data point (one epoch of data) every five seconds.
8. Click **OK** to create the data points and close the **Adding Points** dialog box.

   If you entered a Site ID which will generate one or more points with Site IDs that will overlap an existing point, the **Point Conflict** dialog box opens asking

Data Processing

you to select a different starting point. Select the suggested Point ID or enter a different Site ID, and click **OK**.

9. Verify the new set of points in the **Observations Tab** of the **Workbook** window or in the **Time View** window.

The **Adding Points** dialog box can also be accessed from the **Observation Tab** in the **Workbook** window by editing the Site ID of an observation whose current ID is **????**. Once the new ID is entered, the **Adding Points** dialog box opens. From this point, follow sets 6 through 9 above.

Processing Data

Processing data is simple. After selecting either **Process All** or **Process Unprocessed**, Ashtech Solutions processes the data and continues until it is done, all the while updating the **Time View**, **Map View**, and **Workbook** windows with processed data information.

Ashtech Solutions requires the hardware key to process L1/L2 and/or GLONASS data. Before processing data, verify that the hardware key is connected to the LPT1 parallel port on your computer.

Processing comprises the following steps:

1. Prior to beginning the actual processing, Ashtech Solutions verifies that you selected a seed site. If not, Ashtech Solutions displays a message similar to Figure 5.10.

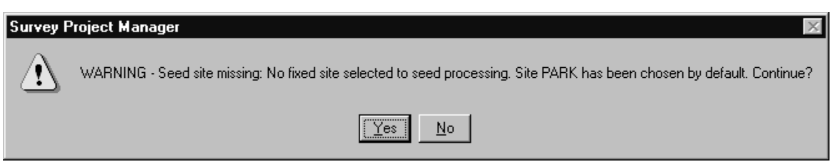


Figure 5.10. Seed Coordinate Message Dialog Box

2. If you wish to select your own seed site, click **No** and select a control site in the **Control Sites** tab.
3. If the specified site is acceptable, click **Yes** and Ashtech Solutions processes the data using the specified seed site.

Process All

To process all data within the project, select **Processing All** from the **Run** menu.

If any vectors already exist, Ashtech Solutions displays a message indicating that they will be overwritten.

Process Unprocessed

To process only data that have not been previously processed or have changed, select **Unprocessed** from the **Run** menu or click on **Process New** button.

Post-Processing Data Analysis

The primary product of processing GPS raw data between two sites is a vector defining the relationship between these sites. Site coordinates are by-products of the processed vector. When a vector is processed, the coordinates of one site are always held fixed. From the processed vector, coordinates are determined for the unknown site. Prior to adjustment, the site coordinates are derived exclusively from the processed vectors to this site. For sites with multiple vectors, the displayed coordinates are derived from the vector with the lowest uncertainties. Adjustment of the data results in more accurate and reliable site coordinates.

Ashtech Solutions has indicators to help determine the quality of processed vectors and computed site coordinates. The quality indicators for processed vectors includes a process QA flag, solution type, and vector uncertainties. Quality indicators for computed site coordinates are site position uncertainties and a position status flag.

The vector uncertainties give an estimate of the quality of the processed vector. Experience helps to determine what level of uncertainties can be expected for varying vector lengths. In general, the uncertainties should be similar to the accuracy specifications of the receiver. Also, vectors of similar lengths should have similar uncertainty values. Notice that the amount of data available for processing a vector has an effect on the vector uncertainty. If too little data is available, the uncertainty values will increase. Refer to your receiver manual to obtain guidelines about the amount of data required for obtaining good results.

The solution type is an indication of the success of determining the integer ambiguities for each satellite in the calculation of a vector. If all integer ambiguities were determined, the vector solution is considered a **Fixed** solution (ambiguities Fixed to integers). A Fixed solution is the best possible solution. If integer ambiguities were determined for only a subset of the satellite (over 50 percent), the solution is considered a **Partial** solution. A vector with a solution type of Partial in many cases is still a quality vector. For instance, on longer vectors (20 km or longer), it is, in many cases, not practical to expect to get a Fixed solution because of the increased noise in the solution due to the length of the vector. Finally, a vector with a solution type **Float** indicates that less than 50 percent of the integer ambiguities were determined. In most cases, a vector with a solution type of Float will be poor in quality. Only very long baselines (80 km or longer) should have a vector with a Float solution type. If you have a float solution on a shorter vector, there is probably a problem with the data used to produce this vector.

The process QA flag examines the magnitude of the vector uncertainties to determine the quality of the processed vector. The magnitude of the vector uncertainties is compared to a threshold value. If the uncertainties are greater than the threshold, the QA test fails and the vector is flagged. The threshold value has been selected based on the expected accuracy for vectors collected and processed in the receiver. It is important to remember that a flagged vector does not indicate conclusively that the vector is bad. The QA test is designed to warn you of potential problems with a vector. Include flagged vectors in the adjustment. The analysis tools in the adjustment provide additional means to determine if the vector is indeed problematic. If so, it can be eliminated.

The site uncertainties estimate the quality of the computed site position. The uncertainties are derived directly from the vector uncertainties for a site. If multiple vectors exist for a site, the site adopts the uncertainties from the last processed vector. An adjustment on the data improves the site coordinates and reduces uncertainties.

The position status flag gives an indication of how the coordinates for the site have been derived. Flag settings are Raw, Processed, and Adjusted. Each represents a different level of reliability and accuracy, with Raw being the least reliable and accurate, and Adjusted being the most reliable.

The quality indicators discussed here are presented in different ways within Ashtech Solutions, depending on the view used for analysis. The remainder of this section shows how to analyze these indicators in graphical and tabular form.

Graphical Review

Once Ashtech Solutions has processed the raw GPS data, the **Map View** window changes from **Normal** to **Process** (Figure 5.11).

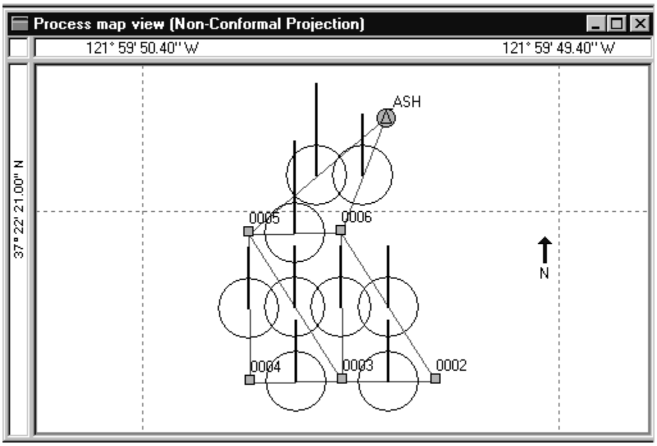


Figure 5.11. Map View - Process

The sites from the raw data have been processed displaying various visual information.

- **Horizontal Control**—a triangle is placed over each site which has horizontal control
- **Vertical Control**—a circle is placed over each vector which has vertical control
- **Horizontal and Vertical Control**—the **ASH** site has a triangle and a circle indicating it has horizontal and vertical control
- **New Sites**—new sites are represented by blue squares
- **Error Regions**—graphical display of the horizontal uncertainties of the vectors.
- **Vertical Error Bar**—graphical display of the vertical uncertainties of the vectors.
- **Vectors**—a solid line represents each processed vector. If the vector passes the QA test and has a solution type of Fixed, the line is green. If the vector fails the test or has a solution type of Partial or Float, the vector is red.

If Ashtech Solutions encounters errors during processing, the **Map View** window displays these errors.

Workbook Review

To review the data in the **Workbook** window:

Vectors

Click the **Vectors** tab in the **Workbook** window.

- Vector uncertainties are presented in tabular form at the confidence level and in the units set in the **Miscellaneous** tab of the **Project Settings** dialog box. An uncertainty is presented for each vector component in addition to an uncertainty for the entire vector.
- A tabular column includes the results of the QA test for each vector. If a tabular cell for a given vector is empty, the vector passed the QA test. This indicates that the computed vector uncertainties fall below the threshold value, the vector fails the test, and **Failed** is displayed.
- A tabular column indicates the solution type for each vector. If the solution type for a specified vector is Fixed, the tabular cell is blank. In the solution type is Partial, the cell displays the word **Partial**. Finally, if the solution type is Float, the cell displays **Float**.

Delta ENU values are always local topocentric values even when a grid or local grid system is current.

Sites

Click the **Sites** tab in the **Workbook** window.

- Site uncertainties are presented in tabular form at the confidence level and in the units set in the **Miscellaneous** tab of the **Project Settings** dialog box. An uncertainty displays for each position component.
- A tabular column displays the position status. If the displayed position is derived from the raw data collected at the site, the position status column displays the word **Raw**. If the displayed position is derived from processing of vectors to this site, the column displays **Processed**. If the displayed position is derived from an adjustment of all vectors to this site, the column displays **Adjusted**.

Message Window

If processing was successful, the following messages are displayed:

```
Processing started.
Processing Summary:
Number of vector processed: 9 of 9.
```

Anticipate that the number of vectors processed is equal to the number you expected to process. In the above example, if only 7 of 9 vectors were processed, you know that a problem exists.

Manually Processing Vectors

When Ashtech Solutions automatically processed GPS vectors, it must make a number of decisions to produce the best possible vector solution from the data it is presented. On occasion, an automatically processed vector will result in a poor quality solution. In some cases, the poor solution is simply due to insufficient or overall poor data. Nothing can be done to improve a solution in this situation. But here are cases where a poor solution is due a segment of poor data, i.e. one satellite or all data below a certain elevation angle. In these cases, it is sometimes possible to eliminate the problem data and reprocess to produce a good quality vector.

Ashtech Solutions includes tools to allow the user to analyze raw data used to produce a vector and analyze the residuals of a processed vector in an effort to isolate the problem data causing the poor vector solution. Once the problem data is identified, Ashtech Solutions allows you to remove this data and reprocess the vector in hopes of producing a good quality solution. This section of the manual explains these tools in detail.

Viewing Residual Data for a Vector

To assist in isolating the cause of a problem with a processed vector, the residuals from the least-squares solution of the vector processing can be viewed and analyzed. If, through analysis of the residuals, a problem is identified with a segment of the data or a specific satellite, the problem data can be removed and the vector re-processed in hopes of a better result.

You can access the **Vector Processing Residual Plot** for a specific vector by right-clicking on the vector name (From – To) in the **Vectors** tab of the **Workbook** window. Select **View Residuals** from the right-click menu.

The **Vector Processing Residual Plot** displays vector processing residuals (double-difference phase residuals) over time. There is one plot for the data from each satellite used in the processing of the vector with the exception of the reference satellite. The following data is plotted for each satellite:

- L1 double-difference phase residuals
- L2 double-difference phase residuals (if available)

Only the data used in vector processing are displayed. Any data eliminated from the processing by certain processing settings are not displayed. For example, if the raw data file contains satellite data down to a 10° elevation but the vector was processed with a 15° elevation mask, the residual plots does not show the data below 15° because it was not used in processing this vector.

When processing a vector using data from raw data files containing multiple observations (such as a data file collected in kinematic mode), all data from the data files are used during in the processing. For this reason, the **Vector Processing Residual Plot** (Figure 5.12), for such a vector, displays residuals for the entire time span covered by the two files used to process this vector, including the data associated with other observations. The segment of the residual plot that pertains specifically to the vector selected is marked by two vertical dashed lines.

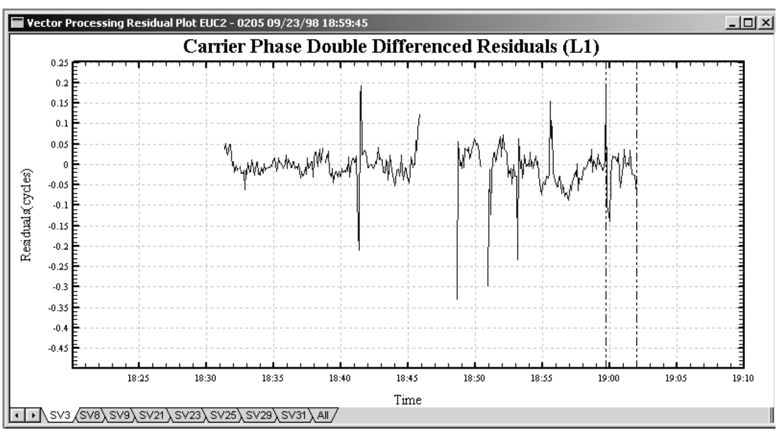


Figure 5.12. Vector Processing Residual Plot

You can right-click anywhere within a plot to access the right-click menu to select which elements to display.

Click on a plotted line to display the satellite pair generating the residuals plotted.

Click each tab to display residuals for available satellites.

The following characteristics of problem satellite data can cause poor results when processed:

- Gaps in the data caused by extended loss of lock of the satellite. This is characteristic of an obstructed satellite. If all satellite plots have gaps during the same time periods, the missing data may be with the reference satellite.

- A satellite with residuals noticeably larger than other satellites. This is a characteristic of a satellite affected by multipath and/or an active ionosphere. If all satellite plots have residuals that seem larger than normal, the problem may be with the reference satellite.
- A segment of a satellite with residuals noticeably larger than the rest of the same satellite. This is characteristic of a segment of satellite data affected by multipath and/or an active ionosphere. If all satellite plots have a segment with residuals that are larger than the rest or the residuals, the problem may be with the reference satellite.
- A satellite with a sloped residual plot. Residual plots should not be sloped and should have a mean value of 0 cycles. A sloped plot usually indicates a problem with the satellite data. If all plots are sloped, this usually indicates that the reference satellite is a problem.
- A satellite contributing a very small amount of data compared to the other satellites in the data set. Sometimes such a satellite causes problems with processing.

You can remove any data exhibiting the above characteristics and reprocess the vector. Refer to “Setting the Processing Parameters for a Vector” on page 65 for more information.

The residual data are stored outside the project file in files named P*.* for each processed vector. If the corresponding file is not located in the project folder, residual information will not display.

Viewing Raw Data for an Observation

Analyzing the raw data used to produce a vector is another good method of isolating a problem with a vector. If, through analysis of the raw observation data, a problem is identified with a segment of the data or a specific satellite, the problem data can be removed and the vector re-processed in hopes of a better result.

A **Raw Measurement Plot** can be accessed by one of the following methods:

1. Right-click a raw data file name in the **Files** Tab of the **Workbook** window, and select **View Raw Data** from the right-click menu.

   -or-

2. Right-click a vector name in the **Vectors** Tab of the **Workbook** window and select **View Raw Data** from the right-click menu. Select the raw data file name containing the observation data used to produce this vector from the second menu.

The **Raw Measurement Plot** (Figure 5.13) displays satellite data collected over time. There is one plot for each satellite observed and a plot compiling all satellites. For each satellite observed, the following data is plotted:

- L1 Carrier Phase
- L1 Signal-to-Noise Ratio
- L2 Carrier Phase (if available)
- L2 Signal-to-Noise Ratio (if available)
- Elevation

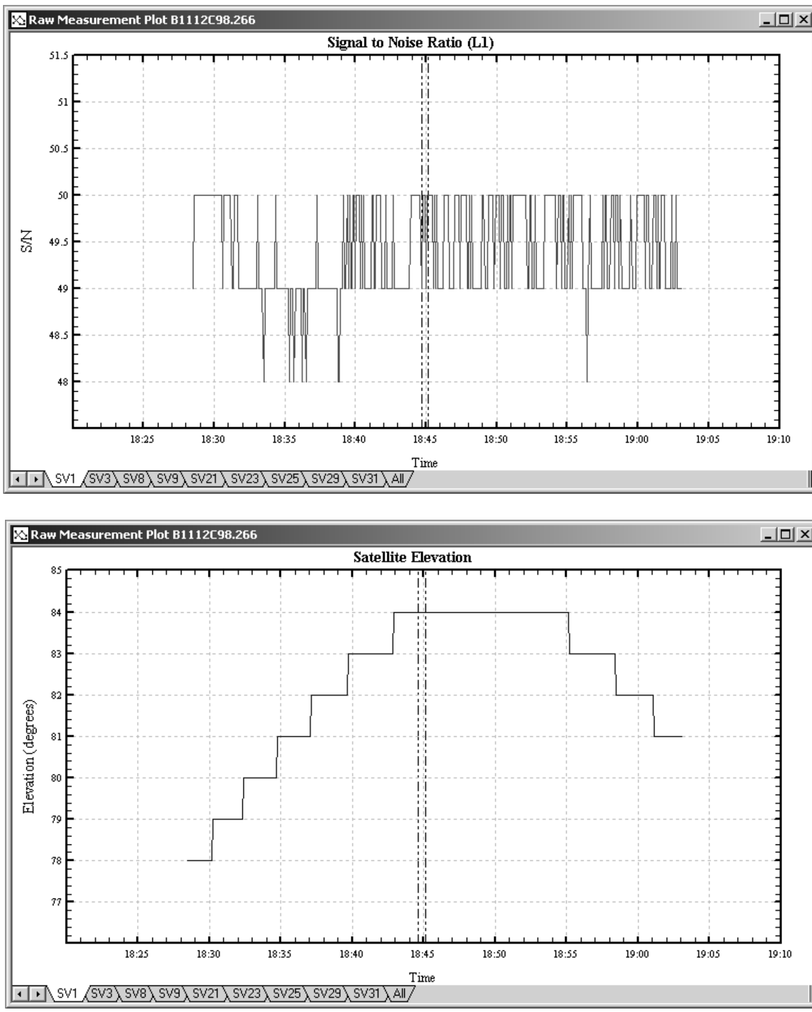


Figure 5.13. Raw Measurement Plots

In addition to the satellite data, the **Carrier Phase Plot** and the **Signal-to-Noise Plo**t displays flags assigned to the data by the GPS receiver during data collection. The following lists the flags along with their symbols:

X – Loss of satellite lock

! – Possible loss of satellite lock

? – Questionable carrier phase

± – Polarity unknown

You can right-click anywhere within a plot to access the right-click menu to select which elements to display.

Click on a plotted line to display the satellite ID for the selected line. This is especially useful when viewing the plot containing all of the satellites.

Click on a flag to display the satellite ID and a description of the type of flag.

Click each tab to display a plot of the data for each satellite observed.

The following characteristics of problem satellite data can cause poor results when processed:

- Segments of satellite data that contain multiple flags. This is characteristic of an obstructed satellite.
- Gaps in the data caused by extended loss of lock of the satellite. This is characteristic of an obstructed satellite.
- A satellite with rapidly varying signal-to-noise ratio compared to other satellites. This is characteristic of a satellite affected by multipath or an active ionosphere.
- A segment of a satellite with rapidly varying signal-to-noise ratio compared to the rest of the same satellite data. This is characteristic of a segment of a satellite affected by multipath or an active ionosphere.
- A satellite contributing a very small amount of data compared to the other satellites in the data set. Sometimes such a satellite causes problems with processing.

You can remove any data exhibiting the above characteristics and reprocess the vector. Refer to “Setting the Processing Parameters for a Vector” on page 65 for more information.

Setting the Processing Parameters for a Vector

On occasion, processing produces vectors that fail the QA test and/or may produce uncertainties that are larger than expected. Through analysis of the V**ector Processing Residual Plot** for a problem vector and **Raw Measurement Plot** for both raw data files used in processing of a problem vector, the specific data segments causing the problem can be identified in many cases. By utilizing the tools found in the **Process Settings** dialog box, this data can be eliminated and the problem vector re-processed in hopes of obtaining better results.

1. Select the vector in the **Vectors** tab of the **Workbook** window by clicking on the vector name (From – To).
2. Select **Process** from the right-click menu to open the **Process Settings** dialog box to the **General** tab (Figure 5.14.

   The **General** tab has many of the most common elements of data you may wish to edit out when processing.

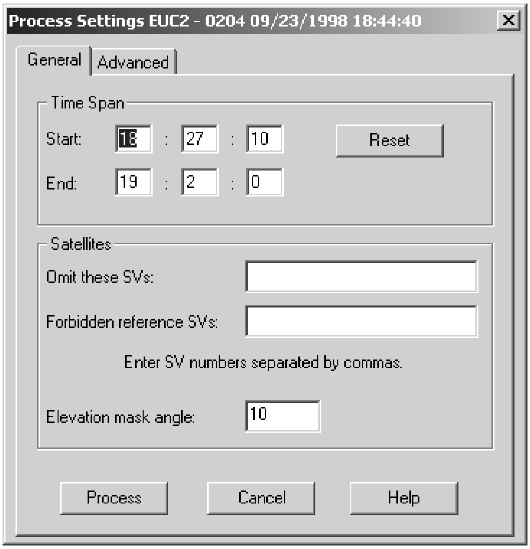


Figure 5.14. Process Settings Dialog Box — General Tab

3. If analysis of the data plots reveals problems at the start or end of the data used in processing the vector, change the start or end time to eliminate this data.
4. To change the start or end time, enter the new time in the time system selected for the project.
5. Click the **Reset** button to reset the observation to the start and end times in the raw data files. The times will reset even after the data has been reprocessed.
6. If analysis of the data plots reveals that all data from one or more satellites is problematic, the data from the problem satellite(s) can be omitted.

To omit one or more satellites from processing, enter the satellite numbers, separated by commas, in the **Omit these SV's:** field. You can retrieve the satellite number from the **Raw Data Plots**.

7. If analysis of the data plots reveals a reference satellite as being problematic, this satellite can be forbidden from use as a reference.

   To specify one or more satellites to not use as a reference satellite, enter the satellite numbers, separated by commas, in the **Forbidden reference SV's:** field. You can retrieve the satellite number from the **Raw Data Plots**.

8. If analysis of the data plots reveals that data below a certain elevation is problematic, this data can be omitted.

   To omit data below a specific elevation, enter this elevation in the **Elevation mask angle:** field.

If analysis of the data plots reveals a segment of data for one or more satellites as being problematic, you can eliminate this data using the **Advanced** tab in the **Process Settings** dialog box.

1. Select the vector in the **Vectors** tab of the **Workbook** window by clicking on the vector name.
2. Select **Process** from the right-click menu to open the **Process Settings** dialog box to the **General** tab.
3. Click on the **Advanced** tab to switch to the **Advanced** tab (Figure 5.15).

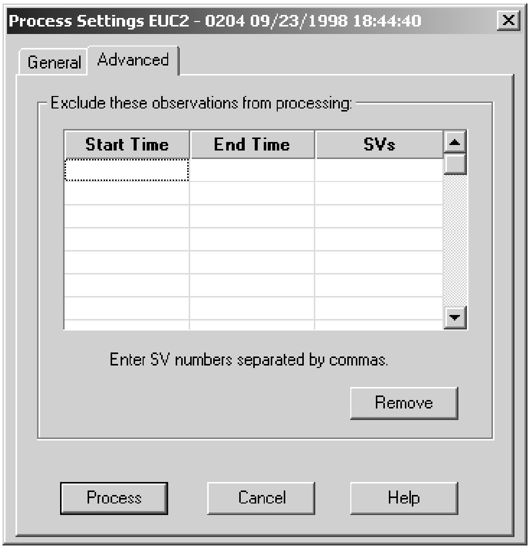


Figure 5.15. Process Settings Dialog Box — General Tab

4. Enter the time in HH:MM:SS you want to start the data exclusion in the first row of the **Start Time** column.
5. Enter the time in HH:MM:SS you want to finish the data exclusion in the first row of **End Time** column.
6. Enter the satellite numbers, separated by commas, in the first row of the **SV's** column. The satellite number can be retrieved from the data plots.
7. Enter the same data in the next row for each additional period of data you wish to exclude from processing.
8. Click **OK** to save the settings and reprocess the vector.

If analysis of the data plots reveals that the same problem data on multiple vectors, it is possible to eliminate this data from all affected vectors at once by selecting multiple vectors prior to entering the **Process Settings** dialog box. Follow the same steps outlined above for eliminating the problem data.

When editing processing settings for a vector generated from data files containing multiple observations, such as a data file collected in Kinematic mode, all vectors computed from the same data files will be affected. Therefore, if multiple problem vectors exist that were computed from the same data files, there is no need to select all the problem vectors to edit the processing settings. Change the settings for just one vector and reprocess. All vectors from the same data files will be automatically reprocessed with the new settings.

When editing Process Settings for multiple vectors, it is not possible to edit the Start and End times.

Special Considerations for Processing Stop&Go and Continuous Kinematic Data

The processing of GPS data collected in Static mode is rather straight forward with the required steps discussed earlier in this chapter. Processing of GPS data collected in stop&go kinematic and continuous kinematic modes require some additional steps that will be outlined here.

Control Points for Kinematic Initialization

The processing of data collected in kinematic mode is successful only if the kinematic survey was properly initialized at the start of the survey and each time initialization is lost due to an insufficient number of satellites. To initialize a kinematic survey, the post-processing software must be able to precisely establish the coordinates of one of the points observed by the rover receiver (initialization point) during kinematic data collection. Alternatively, the precise coordinates of one of the points observed by the rover (initialization point) can be supplied to the processing software. In this case, the coordinates of the initialization point must be precisely known relative to the coordinates of the base point. There are a number of different methods to accomplish this. Each method is handled differently by the processing software. Let's examine each initialization method in detail and discuss the additional steps, with regard to control points, required to prepare the post-processing software to process the data.

- Static Survey Initialization

  One method to determine the precise coordinates of a rover point is to perform a static survey on the first point observed by the rover. By observing this first point in static mode for the required period of time, the processing software will be able to compute the position of this point. This supplies the required point for initialization of the remainder of the kinematic survey.

  Processing of kinematic data with initialized by first performing a static survey requires no special steps compared to static processing. If you know the coordinates of the kinematic base station and want to hold them fixed, enter them in the Control Sites tab. Otherwise, the software will use an approximate position for the base station and hold it fixed for processing automatically. The software will first determine the position of the initialization point and then determine the position of the remaining kinematic points.

- Bar Point Initialization

  The concept of the initializer bar initialization is similar to using a static survey to initialize your kinematic survey. By performing a 5 minute observation on the bar, you are establishing the coordinates of the rover receiver on the other end of the bar. Once the coordinates of the rover location are established, the kinematic survey can be initialized. A 5 minute observation is all that is needed because we have some initial information regarding the short vector between the base and rover receivers. We know that the vector is exactly 0.200 meters long (the length of the bar). We also know that the delta height of the vector is 0.000 (base and rover receivers are at the same HI). Based on this given information, the coordinates of the rover location can be established with a short 5 minute observation.

  Processing of kinematic data initialized by using the bar does require one special step not found in processing static data. The observation on the bar by the rover receiver produces a unique point with it's own unique Site ID. The processing software must be told that this point is the rover initialization point located on the bar. This is the only way that the software knows to constrain the length of the vector and the delta height of the vector for processing. There are two ways to identify a point as the bar initialization point:

- During data collection, the handheld software will automatically tag the bar initialization point. Any point collected with the INI? flag set to Y in Locus Handheld is tagged in the D-file as the bar initialization point. If using Pocket Survey Control handheld software, any point collected while an Initialization Type of Bar Point is selected will be tagged in the D-file. The processing software will read this tag from the D-file and automatically set the point as the bar point for processing.
- If a bar point was inadvertently not identified as such during data collection, it can be set in the **General** tab of the **Site Properties** dialog box.

Once the bar initialization point is identified, the processing of the kinematic data is again similar to that of processing static data. If you know the coordinates of the kinematic base station and want to hold them fixed, enter them in the Control Sites tab. Otherwise, the software will use an approximate position for the base station and hold it fixed for processing automatically. The software will first determine the position of the bar initialization point and then determine the position of the remaining kinematic points.

• Known Point Initialization

If two or more points in your kinematic survey project area have known coordinates, these points can be used to initialize your kinematic survey. The base receiver is set up on one of the known points. The rover observes the second known point for a short period of time (10 seconds for example). This provides a rover point with known coordinates for the processing software to initialize the kinematic survey. If initialization is lost at any time during the kinematic survey, the same or a different known point can be observed for re-initialization. The re-initialization point can even be a point surveyed just moments ago during this kinematic survey.

It's very important to note that the relationship between the base point and the known point to be used to initialize must be very accurately established. For this reason, it is highly recommended that you only initialize on a known point that has been previously established by a GPS survey either with a direct measurement between the base and known point or through a network including both the base and known point.

To process kinematic data where known point initialization was used, the coordinates of the known point(s) must reside in the project file containing the kinematic data to be processed. This can be accomplished in different ways:

- The kinematic data to be processed could be added to an existing project file containing the known coordinates of the base point and initialization points. For example, a project file may exist containing data from a static survey performed earlier that established the coordinates of the known points. The kinematic data to be processed could be added to this project and processed. The processing software will automatically grab the required coordinates for processing of the kinematic data.
- The coordinates of the known points could be added to the project containing the kinematic data to be processed by entering them in the Control Sites tab.

If re-initialization was performed on a point observed earlier in the same kinematic survey, there is nothing special that needs to be done to prepare the software to accept this re-initialization. The software will automatically access the coordinates of this point when needed.

- On-The-Fly Initialization

  On-the-fly initialization requires no special data collection procedures. The kinematic survey is initialized without a special initialization process. The user simply turns on the rover GPS receiver and begins collecting kinematic data. If the user can collect a long enough session of continuous data without loose-of-lock on satellites, the kinematic survey will initialize on it's own.

  The time period of continuous data required to ensure initialization varies depending on a number of factors, the most important of which is GPS receiver type. If using a dual-frequency receiver, such as the Ashtech Z-Xtreme, on-the-fly initialization can occur with just a couple of minutes of continuous data without loss-of-lock. Under some conditions, up to 10 minutes of data may be needed. On the other hand, if the GPS receiver being used is a single-frequency receiver, such as the Locus, you could require 20 minutes of continuous data for initialization.

  Processing of kinematic data with on-the-fly initialization requires no special steps compared to static processing. If you know the coordinates of the kinematic base station and want to hold them fixed, enter them in the Control Sites tab. Otherwise, the software will use an approximate position for the base station and hold it fixed for processing automatically.

Kinematic Surveys using Multiple Base Stations

It is possible to perform a kinematic survey with more than one base station. Multiple base stations provide for redundant observations to the kinematic points being surveyed. There are no special requirements to processing kinematic data with multiple base stations. Follow the procedures outlined above as if there were only one base station in the survey. The processing software will automatically accommodate the other base stations. For example, let's say that a kinematic survey is performed using two base stations and a rover. At one base station, the kinematic survey is initialized using the initializer bar. Data collection proceeds as normal, as if there is only one base station.

During the processing of this data, the processing software will first process the vector between the two base stations. Next, the software will process the vectors between the base station with the initializer bar and all rover points. The software knows which base station has the initializer bar by examining the approximate positions of the base stations and the initialization point. Finally, the software will process the vectors from the second base station to the rover points, using one of the already processed rover points to initialize on.

Adjustment

In most situations, there is no benefit in adjusting vectors that have been collected using the kinematic mode of data collection. This is because there is no redundancy in most kinematic surveys. Only one observation exists between the base and each rover point. This leaves nothing to adjust. The exception to this is the situation were multiple base stations are used during the kinematic survey. In this case, closed loops exist between the base points and each rover point. This survey has redundancy therefore can be adjusted.

Conclusion

Once you have completed the pre-process analysis, processing, and post-process analysis, and are satisfied the processed data have no observable errors, you can adjust the data.

6

Adjustment

Adjusting your survey observations is one of the most important tasks to ensure accurate reliable results. A network adjustment is performed to accomplish two results - to test for blunders and errors in the observations (vectors between points in our case), and to compute final coordinates for your survey points which are consistent with the existing control points that you used.

Only data sets with redundant observations (closed loops) benefit from an adjustment. Performing an adjustment on radial vectors (such as those obtained from a kinematic survey with only one base station) will not identify errors in the observations nor improve the accuracy of the points surveyed.

Adjustment takes place after you have processed the raw data and are satisfied that there are no unaccountable errors in the processed results. There are typically two stages in the adjustment. The first, the minimally constrained adjustment, is used to detect problems in the observations and control coordinates. You may have to iterate several times, using a number of different tools to check for blunders. Once you are confident that no blunders remain, you can proceed to the second stage, the constrained adjustment, where you hold fixed all the control points and readjust to obtain final site positions and accuracies. The final site-pair relative accuracies are compared with the accuracy specification in the **Miscellaneous** tab of the **Project Settings** dialog box.

This chapter takes a step-by-step approach through the adjustment procedure, and highlights what tools you should use and when to use them. Since it is task-oriented, it does not deal with the theory of adjustments in any depth. Instead, refer to *Appendix C,* **Post-Adjustment Analysis**. You will find it helpful to review this appendix before actually performing an adjustment.

Minimally Constrained Adjustment

The first stage of adjusting your data set is to perform a minimally constrained adjustment; the final product of this stage will be a blunder-free adjustment.

1. With an open project containing a processed data set, click on the **Adjustment Analysis** tab of the **Workbook** window.
2. Notice all the fields are blank. No data are available until you perform an adjustment on the data set.

You may choose to hold one site fixed at this point. However, if you do not, the software automatically uses the site with the lowest uncertainty. It is important that you do not hold more than one site fixed.

3. Press **F7** to perform an adjustment or click the **Adjustment** button on the toolbar.

   A progress dialog box opens, indicating the adjustment progress and status; you may cancel the adjustment at any time. Relevant messages are displayed in the message window of the Workbook.
4. Once the adjustment is complete, data appear in the **Adjustment Analysis** tab and the **Network Rel. Accuracy** tab of the **Workbook** window.

   Table 6.1 describes the **Adjustment Analysis** tab.

Table 6.1. Adjustment Analysis Tab Description

Component	Description
From—To	Vector identifier. Format is xxxx – yyyy, where xxxx and yyyy are Site IDs.
Observed	The month, day, and time for the vector.
Tau Test	Displays FAIL if any residual component of the vector does not pass the Tau test (refer to *Appendix C,* **Post-Adjustment Analysis**), otherwise blank.
Delta X/Delta Easting	The adjusted vector component in the x or easting direction.
Std Res.	The residual of the adjusted vector component.
Delta Y/Delta Northing	The vector component in the y or northing direction.
Std Res.	The adjusted residual of the adjusted vector component.
Delta Z/Delta Elevation	The adjusted vector component in the z or vertical direction.
Std Res.	The residual of the adjusted vector component.

Table 6.1. Adjustment Analysis Tab Description (continued)

Component	Description
Length	The 3D spatial distance of the vector in the linear unit system selected in the Project Setup.
Std Res.	The residual of the adjusted vector length.

The first test Ashtech Solutions performs is the Network Connectivity test.

This test ensures that the network does not contain any subnetworks that are not connected. Refer to *Appendix C,* **Post-Adjustment Analysis** for more information. After this test, text similar to the following appears in the message window:

```
Network connectivity test: passed
Number of stations: 6
Number of vectors: 9
```

If this test fails, there are actually two or more unconnected networks in the project. You must either observe more vectors to connect the networks, exclude the vectors for all but one of the networks, or create a new project for each network.

Ashtech Solutions then performs a chi-square test.

For more information about the chi-square test, refer to *Appendix C,* **Post-Adjustment Analysis**. After performing this test, text similar to the following appears in the message window:

```
Chi-square test: passed
Lower limit: 4.403788
Upper limit: 23.336664
Chi-square: 22.083307
```

Actual measurements may differ in the adjustment of your data files.

Refer to *Appendix C,* **Post-Adjustment Analysis** for details on what to do if the chi-square test fails.

After passing the chi-square test, the program performs a tau test for each vector.

A tau test is performed on the residuals of each vector as a test for blunders. The tau test result for each vector is displayed in the **Adjustment Analysis** tab of the **Workbook** window. Only those vectors that fail the test are indicated. For more details on the background of the tau test, refer to *Appendix C,* **Post-Adjustment Analysis**.

It is important to note that even if some vectors are flagged as failing the tau test, if the residuals of the vectors are not significantly larger than those for other vectors, it is probably acceptable to ignore the results of the test.

Other tests that are useful in detecting blunders, especially in larger networks, are the Repeat Vector test and the Loop Closure test. Both tests can be used to identify problem vectors - you can exclude them from further adjustment if necessary. *Appendix C,* **Post-Adjustment Analysis** describes these tests in detail.

5. If no residuals are flagged, you should now have a blunder-free adjustment.

   Once the program determines that it has performed a blunder-free adjustment, it checks to determine if each pair of points meets the relative accuracy specification (known as a Site Pair QA Test). The lowest relative accuracy is the attained accuracy of the survey, while uncertainties present estimated accuracy of adjusted points.

6. If any vectors fail the QA test, you should investigate to determine why this is before proceeding to the next stage of the adjustment. Please refer to *Appendix C,* **Post-Adjustment Analysis** for details.

7. Once you are sure that all problem data has been removed from the minimally constrained adjustment, examine the **Network Rel. Accuracy** tab of the **Workbook**.

Table 6.2 describes the data presented in the **Network Rel. Accuracy** tab.

Table 6.2. Network Relative Accuracy Tab Confirm with Online Help

Component	Description
Site Pair	Vector identifier. Format is *xxxx* – *yyyy*, where *xxxx* and *yyyy* are Site Ids.
QA	A quality indicator for the computed site pair relative error. Displays FAIL if the relative error is greater than the allowable relative error determined from the **Desired Project Accuracy** fields in the **Miscellaneous** Tab of the **Project Settings** dialog box.
Horz. Rel. Error	The horizontal relative error of the vector in the linear units system selected in the Project Setup.
Vert. Rel. Error	The vertical relative error of the vector in the linear units system selected in the Project Setup.
Horz Rel. Accuracy	The precision calculated using the relative error and the vector length. Use the right-click menu to display the accuracies in parts per million (ppm) or as a ratio.
Vert. Rel Accuracy	The precision calculated using the relative error and the vector length. Use the right-click menu to display the accuracies in parts per million (ppm) or as a ratio.
Distance	The distance between the two sites for which the site pair analysis was conducted.

The **Network Rel. Accuracy** tab provides information on the relative accuracy of the survey by examining the relative accuracy of site pairs. The lowest relative accuracy defines the relative accuracy of the survey. The best time to determine the relative accuracy of a survey is after performing the minimal constraint adjustment. Examining network relative accuracy at this point will give you an indication of the internal accuracy of the survey. After performing the constrained adjustment, the adjusted network will be distorted to fit the control points held fixed. This may result in a lowering of the network relative accuracy, which does not reflect the quality of the survey data but reflects the quality of the control being held.

The site pair QA test found on this tab indicates if the associated site pair meets the relative accuracy required to satisfy the desired project accuracy set in the **Miscellaneous** tab of the **Project Settings** dialog box. If the relative accuracy for a given site pair falls below the desired project accuracy, the QA test fails and **Fail** displays in the field. If the QA test passes, the field is blank.

For more details on relative accuracy and the site pair QA test, refer to *Appendix C,* **Post-Adjustment Analysis.**

8. If more than one control point was entered in the Control Sites tab and only one was held fixed (remember that you should hold no more than one fixed at this stage), Ashtech Solutions performs a control tie analysis automatically. To see the results, click on the **Control Tie** tab of the **Workbook** window.

   This test provides an indication of how well your survey agrees with the established control you have entered. If the ties to one of the control points fail and are significantly larger from ties to other control points, then there is good reason to suspect that that control point may be in error. This control point should not be used in the constrained adjustment.
9. Once you have completed the minimally constrained adjustment and have ensured that your network is free of blunders, you can hold fixed all of the control points you have available and perform a constrained adjustment to derive final site positions and network accuracy.

Constrained Adjustment

The purpose of this final stage is to adjust your network, holding all your control sites fixed to obtain final positions that are consistent with the established control.

1. Go to the **Control Sites** tab of the **Workbook** window.
2. Change the fixed status for each control point.

You can have points which are horizontal control only, points that are vertical control only, and points which are both.

3. Click **F7** to perform the adjustment again. You should see text in the **Message** window similar to the following:

```
Adjustment type:    Over constrained
Control stations    Constraints
0002                Latitude Longitude Elevation
_ASH                Latitude Longitude Elevation
```

4. At this stage you can inspect the **Network Rel. Accuracy** tab of the **Workbook** window.

   Examining the network relative accuracy of the constrained adjustment provides details on the relative accuracy of the survey after holding fixed the control points. In most cases, the relative accuracy of the survey decreases from the minimally constrained adjustment to the constrained adjustment since the survey has been distorted to fit the control.

5. Look at the **Map View** window and notice that the display has changed to show the relative accuracies between the site pairs as error regions. This is a good graphical tool to quickly determine if there are obvious problems in your network.

6. If the site pairs pass the QA, the adjustment is constrained.

   Uncertainties present estimated accuracy of adjusted points. The lowest relative accuracy dictates the relative accuracy of the survey. Relative accuracy will be less than that of minimally constrained adjustment due to added constraints. Relative accuracy may fall below the accuracy specification if problem control points are held fixed.

   Figure 6.1 shows the tasks listed in this chapter.

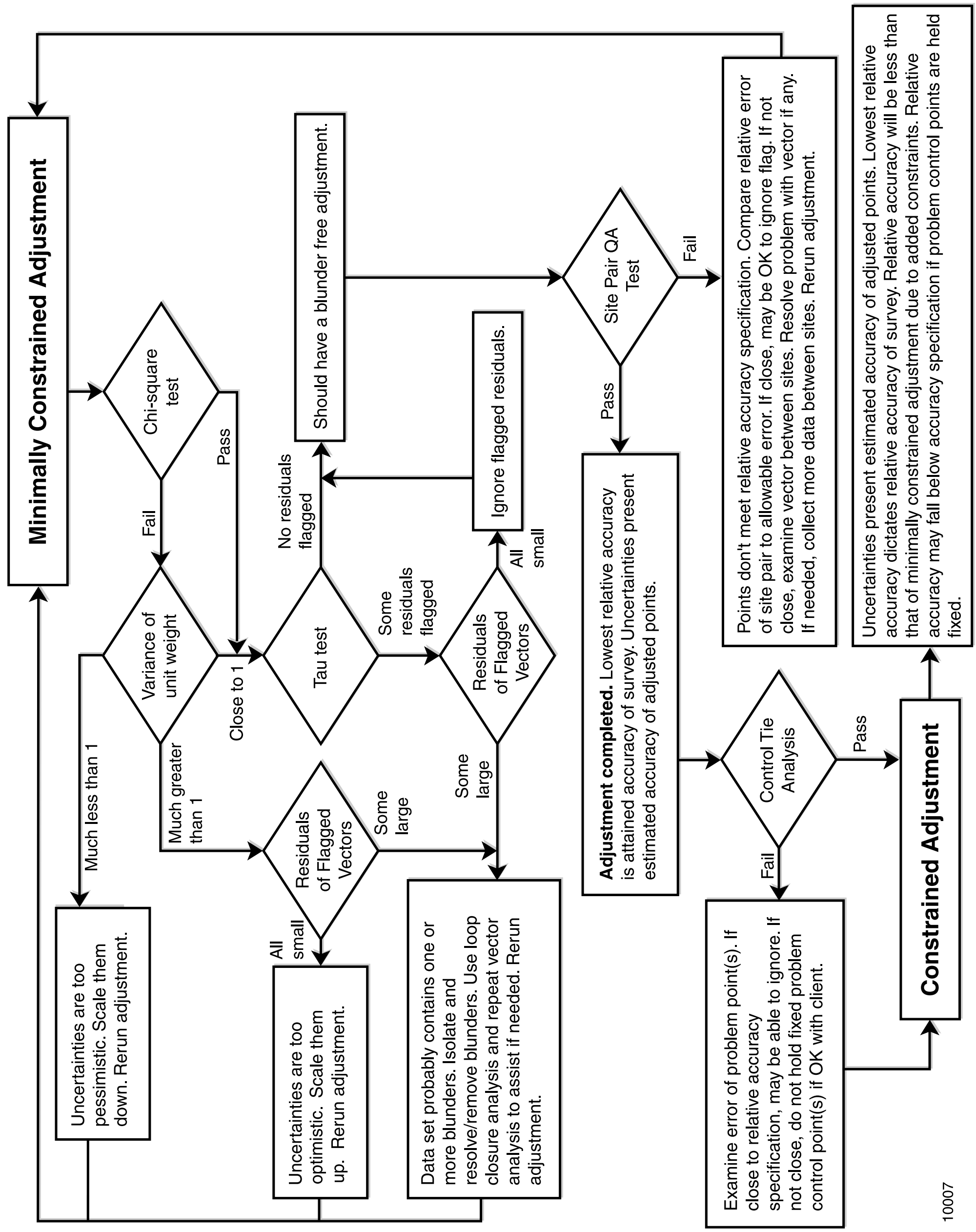


Figure 6.1. Adjustment Flowchart

7

Reports

This chapter covers the procedures for producing a printed copy of your project data. The report software lets you select the information you want to print, and automatically inserts the selected parameters into a standard RTF-formatted report that can be edited and printed by any standard word processing program. It is assumed that you have created a project and completed the processing described in the preceding chapters, and you now want to compile the results.

Setting the Report Viewer Program

Although a report editor program, such as WordPad or MS Word was selected during the installation of Ashtech Solutions, you can change the Report Editor program at any time in the **Program Setup** dialog box.

Ashtech Solutions can use any of the following applications as a report editor:

- MS Word 6.0 through 2000.
- WordPad
- Write

1. Select **Program Setup** from the **Tools** menu to open the **Program Setup** dialog box (Figure 7.1).

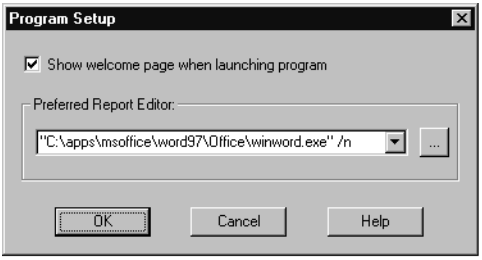


Figure 7.1. Program Setup Dialog Box

The **Preferred Report Editor** field lists the full path for the word processor application.

Any previously specified word processors can be selected by clicking the arrow to the right of the **Preferred Report Editor** field and selecting from the displayed list.

2. To specify and select a new word processor, click the **Browse** button, navigate to and select the application in the **Select Report Editor** dialog box, Figure 7.2, and click **Select**.

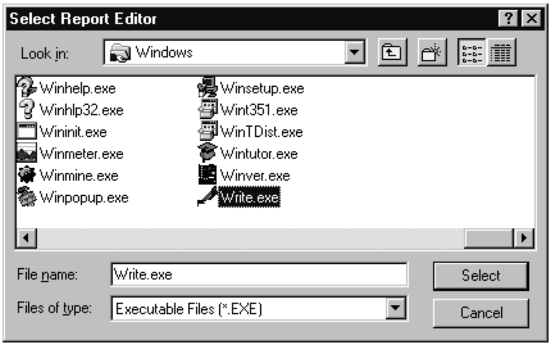


Figure 7.2. Select Report Editor Dialog Box

3. Click **OK** in the **Program Setup** dialog box to accept the changes and close the dialog box.

Generating a Report

The program has pre-specified reports than can easily be generated to view site positions, project summaries, adjusted measurements, processed vectors, control tie analysis, observation information, etc. If you want a specialized format for your report, you can create one using the export functions described in *Chapter 8,* **Exporting Data**.

1. Select **Report** from the **Project** menu to open the **Project Report** dialog box, Figure 7.3.

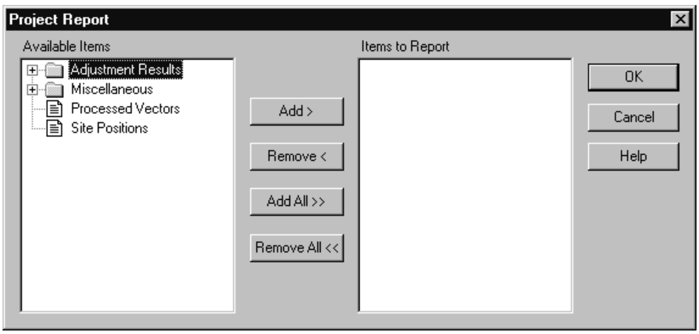


Figure 7.3. Project Report Dialog Box

Use the **Project Report** dialog box to select the content of your report. You can click the **+** sign next to the **Adjustment Results** or **Miscellaneous** folders to expand them with further topics.

2. Select the items in the **Available Items** listbox you wish to include in the report, and click **Add**.

   You must select and add one item at a time; you can not select several items and add simultaneously as a group.

   Use the **Add All** button to add every report topic in the **Available Items** listbox to the report, or use the **Remove All** button to remove every report topic from the report.

3. Click **OK** to close the **Project Report** dialog box and generate the report in the specified word processing application. A separate report and page generates for each selected topic.

4. Use the features of the word processing application to edit, save, and print as needed. Figure 7.4 and Figure 7.5 show typical report formats.

Site Positions

report

Horizontal Coordinate System:	State Plane Coordinate 1983	**Date:**	09/11/98
Height System:	Ortho. Ht. (GEOID96)	**Project file:**	report.spr
Desired Horizontal Accuracy:	0.010m + 1ppm		
Desired Vertical Accuracy:	0.020m + 1ppm		
Confidence Level:	Std. Err.		
Linear Units of Measure:	Meters		

	Site ID	Site Discriptor		Position	Std Error	Fix Status	Position Status
1	**BASE**		East.	1867390.023	17.871		**Raw**
			Nrth.	598010.088	20.787		
			Elev.	2.158	20.628		
2	**0017**		East.	1867393.064	22.449		**Raw**
			Nrth.	598012.407	23.223		
			Elev.	12.310	23.914		

Figure 7.4. Typical Site Positions Report

Network Relative Accuracy

report

Desired Horizontal Accuracy:	0.010m + 1ppm	**Date:**	11/05/98
Desired Vertical Accuracy:	0.020m + 1ppm	**Project file:**	report.spr
Confidence Level:	Std. Err.		
Linear Units of Measure:	Meters		

	Site Pair		Relative Error(m)	Allow. Error(m)	Horizontal Relative Acc	Vertical Relative Acc	Distance	Site Pair QA
1	**0205**	Lat	0.001	0.010	1:259526	1:259526	259.527	
	DISC	Lng	0.001	0.010				
		Elv	0.001	0.020				
2	**0205**	Lat	0.002	0.010	1:28366	1:56733	56.733	
	EUC2	Lng	0.001	0.010				
		Elv	0.001	0.020				
3	**0205**	Lat	0.006	0.010	1:485268	1:1455806	2911.613	
	MISS	Lng	0.002	0.010				
		Elv	0.002	0.020				
4	**EUC2**	Lat	0.002	0.010	1:118826	1:237652	237.652	
	DISC	Lng	0.001	0.010				
		Elv	0.001	0.020				
5	**DISC**	Lat	0.006	0.010	1:464475	1:1393427	2786.855	
	MISS	Lng	0.002	0.010				
		Elv	0.002	0.020				

Figure 7.5. Typical Network Relative Accuracy Report

Printing Views and the Workbook Window

The **Map View** window, **Time Diagram** window, or an individual **Workbook** tab or common information stored in the **Workbook** tab can be printed in report format.

Printing Map View or Time View Windows

1. Verify that the window you wish to print is active.
2. Select **Print** from the **Project** menu to open the **Print Setup** dialog box.
3. Set the printer options as necessary and click **OK**.

   Ashtech Solutions sends an image of the active window to the printer.

Printing the Workbook Window

1. Verify that the tab with information you want to print is active in the **Workbook** window.
2. Select **Print** from the **Project** menu to open the **Print Setup** dialog box.
3. Set the printer options as necessary and click **OK**.

   Ashtech Solutions sends the information from the current tab to the printer.

   You can review the information before sending it to the printer by selecting **Print Preview** in the **Project** menu.

8

Exporting Data

You to create customized ASCII export formats containing a wide range of information from your project. You can save the formats you create for convenient reuse, and use formats others have created on different machines. Additionally, you can export project information in the following predefined formats:

- Ashtech O-file
- TDS coordinate file (*.cr5)
- NGS Bluebook files (B-file and G-file)

Exporting Data

The **Export Data** dialog box, Figure 8.1, is a standard **File Save As** dialog box. Use it to export project information in a selected format to a specified directory.

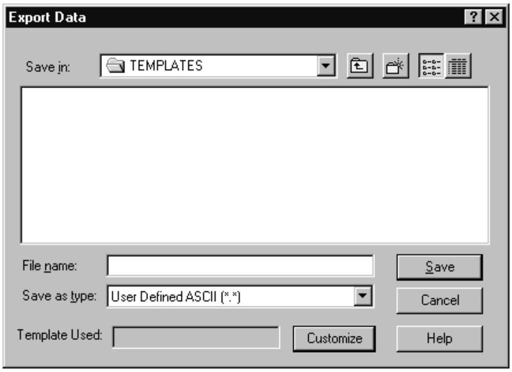


Figure 8.1. Export Data Dialog Box

Table 8.1 describes the components of this dialog box:

Table 8.1. Export Data Dialog Box

Components	Function
Save In	Determines which drive and directory to save the exported file.
File Name	Enter the name of the export file. The program creates file names with certain extensions required by format specification.
Save as type listbox	A list of export formats available.
Save Button	Click this button to retrieve the selected export file name, begin the export process, and close the **Export Data** dialog box. If the selected file already exists, Locus ProcessorAshtech Solutions displays an overwrite message.
Cancel Button	Click this button to cancel the export process, and close the **Export Data** dialog box.
Help Button	Click this button to access the Help system
Customize Button	Click this button to open the **User ASCII Template** dialog box to customize the export template. This button is only available if **User Defined ASCII** is selected in the **Save as type** list.

Exporting Processed Versus Unprocessed Data

Ashtech Solutions does not require processing prior to exporting. You can create an export template which contains vector data with “From Site ID”, “To Site ID”, and “Date and Time” fields, although no processed or adjusted vector information is included.

Effects of Filtering

Filtered data will not export (refer to “Filtering Data” on page 41).

Export File Format Descriptions

Ashtech Solutions supports the following export formats. Select the format in the **Save As Type** list:

- User-defined ASCII— The file extension is user-defined, but the default is `.uda`.
- Ashtech O-file— This file is the standard Ashtech binary O-file. You can create one file containing all vectors, or one file for each vector in the project.
- TDS Coordinate file— This is the standard TDS `.cr5` file format.
- Bluebook files— These files export vectors and site positions to NGS Bluebook B-file and G-file formats.

User-Defined ASCII Files

The program lets you customize ASCII export files.This ASCII file allows you to export data in a format that can be used by other software packages. These files assemble project data into an ASCII file configured to your preferences. Create an export template that specifies extension, delimiter, and type/arrangement of data within the file.

The following procedure describes how to customize an ASCII export file.

Customizing an ASCII Export File

1. Once the project file is open, click the **Export** button or **F8**.

   The **Export Data** dialog box opens, as shown in Figure 8.1.
2. Select **User defined ASCII** in the **Save as Type** drop down listbox.
3. Click **Customize** to open the **User ASCII Template** dialog box, Figure 8.2.

   Table 8.2 describes the component in the **User ASCII Template** dialog box.

4. Create a new or modify an existing ASCII template.

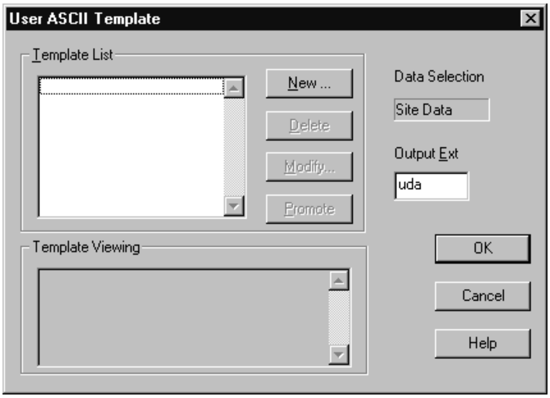


Figure 8.2. User ASCII Template Dialog Box

Table 8.2 describes the components of this dialog box.

Table 8.2. User ASCII Template Dialog Box

Component	Description
Template Listbox	Provides a list of all default and previously saved ASCII export file templates
New Button	Click this button to create a new template. The **New Template Name** dialog box opens; enter a unique name and select either Site or Vector Data output.
Delete Button	Click this button to delete the selected template.
Modify Button	Click this button to edit the selected template.
Promote Button	Click this button to specify a file extension and file type description and include the selected export template in the list of defined export file types in the **Save As Type** list in the **Export Data** dialog box. Click **Demote** to remove the selected export template from the list of export file types in the **Save As Type** list in the **Export Data** dialog box.
Data Selection • Site Data • Vector Data	 • Export of Project site information • Export of Project baseline information
Output Ext	Lets you define extension of output file (default is `.uda`).
Template Viewing	Lists fields in the selected template in **Template** list.
OK Button	Click this button to use the selected template and close the dialog box.

Table 8.2. User ASCII Template Dialog Box (continued)

Component	Description
Cancel Button	Click this button to close the dialog box without using a user-defined template.
Help Button	Click this button to access the help system.

Creating a User-Defined Format

1. If you click **New** or **Modify** in the **User ASCII Template** dialog box, the **New Template Name** dialog box opens, Figure 8.3.

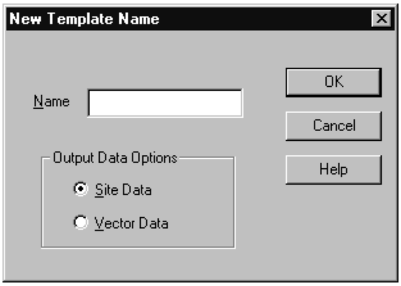


Figure 8.3. New Template Name Dialog Box

Use this dialog box to assign a name and select either **Site** or **Vector** as the output data. You may not export both site and vector data in the same template.

2. Once you enter a name and click **OK**, the **User Defined Format** dialog box opens, Figure 8.4 and Figure 8.5, showing Site Data or Vector Data in the **Field**

Exporting Data

Selection list, depending upon whether you select **Site** or **Vector** output data in the **New Template Name** dialog box.

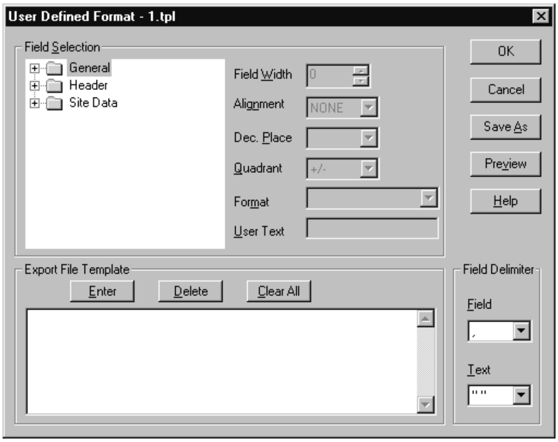


Figure 8.4. User-Defined Format Dialog Box with Site Data

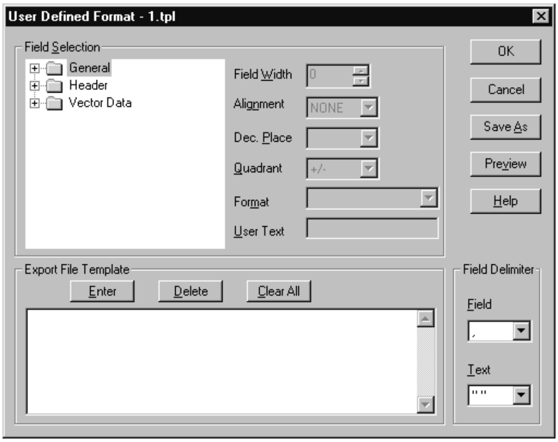


Figure 8.5. User-Defined Format Dialog Box with Vector Data

3. Use this dialog box to define the fields and structure of the ASCII export file.

Table 8.3 describes the components of the User Defined Format dialog box.

Table 8.3. User Defined Format Dialog Box

Component	Description
Field Selection	
Field Selection List	Provides a list of available fields (refer to Table 8.4 for a description of the available field names)
Field Width	Specified maximum length of the field
Alignment	Left, justified, or right alignment of text
Decml. Place	Indicates precision (number of places after decimal). Active only for numeric fields.
Quadrant	Indicates either N/S and E/W, or +/-. Available only for Latitude and Longitude fields.
Format	Provides format for date and time field. Available formats are indicated in list.
User Text	Available only for Text field. Limited to 120 characters.
Export File Template	
Enter Button	Click this button to add the highlighted field to the template at current cursor position.
Delete Button	Click this button to delete the highlighted field from the template.
Clear All Button	Click this button to delete all fields from the template.
Field Structure	Provides a real-time structure of the ASCII template which will reflect modifications through the use of the **Enter**, **Delete**, and **Clear All** buttons.
Field Delimiters	
Field	Indicates choice of delimiters between each field (comma, semicolon, or vertical bar).
Text	Indicates choice of delimiters between text (single quotes, double quotes, or none)
Buttons	
OK Button	Click this button to save any changes made to the export templates and close the dialog box.
Cancel Button	Click this button to close the dialog box disregarding any changes.
Save As Button	Click this button to save the template to different template name.
Preview Button	Click this button to view a preview of the field structure for the selected template with simulated data (refer to Figure 8.6)

Table 8.3. User Defined Format Dialog Box (continued)

Component	Description
Help Button	Click this button to access the help system.

Table 8.4 describes the available field types.

Table 8.4. User-Defined Format Field List

Field Name	Description
Information in File Header	
[File Header Start]	Start of the file header, *fields between this and an end field only display once at the beginning of output file*.
[File Header End]	The end of the header for the file
[Project Name]	Name of the project
[Project File Name]	Name of the project file
[Date/Time]	Date. Can be in any one of the format selected in Format Choice
[Linear Units]	Name of the selected linear unit
[Confidence Level]	The uncertainty level the user selected. “95% Error” or “Std. Error”
[Desired Hor. Accuracy]	Horizontal accuracy specified by the user
[Desired Vert. Accuracy]	Vertical accuracy specified by the user
[Height System]	Height system used. Either “Orthometric” or “Ellipsoidal”
[Coordinate System]	The name of the coordinate system used
Information in Body of Report	
Vectors Only	
[From Site ID]	The site ID of the fixed point
[To Site ID]	The site ID of the unknown point
[Date and Time]	The date and time of the start of the common data for the vector.
[Measurement Type]	The type of data used in the vector solution: L1 GPS, L1 GPS/GLN, L1/L2 GPS.
[Number of Satellites]	The average number of satellites contained in the data used to compute the vector.

Table 8.4. User-Defined Format Field List (continued)

Field Name	Description
[PDOP]	The average PDOP (Position Dilution of Precision) calculated from the observed data used to compute the vector.
[Processed Vector Length]	Length of the processed vector
[Proc. Vector length error]	The uncertainty of the length at the selected confidence level
[Proc. X component]	X component of vector
[Proc. Y component]	Y component of vector
[Proc. Z component]	Z component of vector
[Proc. X comp. error]	Error in X component of vector
[Proc. Y comp. error]	Error in Y component of vector
[Proc. Z comp. error]	Error in Z component of vector
[Proc. XY Corr.]	The XY correlation of the processed vector
[Proc. XZ Corr.]	The XZ correlation of the processed vector
[Proc. YZ Corr.]	The YZ correlation of the processed vector
[Site Pair Distance]	Distance between sites
[Site Pair Horz. Relative Error]	The relative uncertainty between the two sites.
[Adj. X component]	Adjusted X component of vector
[Adj. Y component]	Adjusted Y component of vector
[Adj. Z component]	Adjusted Z component of vector
[Adj. X comp. error]	Error in adjusted X component of vector
[Adj. Y comp. error]	Error in adjusted Y component of vector
[Adj. Z comp. error]	Error in adjusted Z component of vector
[Adj. XY Corr.]	The XY correlation of the adjusted vector.
[Adj. XZ Corr.]	The XY correlation of the adjusted vector.
[Adj. YZ Corr.]	The XY correlation of the adjusted vector.
Sites Only	
[Site ID]	The ID of the site
[The site descriptor]	The site name
[Latitude]	Latitude

Table 8.4. User-Defined Format Field List (continued)

Field Name	Description
[Longitude]	Longitude
[Latitude Error]	Uncertainty in latitude
[Longitude Error]	Uncertainty in longitude
[Grid Northing]	Northing in grid system
[Grid Easting]	Easting in grid system
[Grid EN Corr.]	The EN correlation of the grid position.
[Grid EH Corr.]	The EH correlation of the grid position.
[Grid NH Corr.]	The NH correlation of the grid position.
[Local/Ground Northing]	Northing in either the local grid system or the ground system (whichever is currently active).
[Local/Ground Easting]	Easting in either the local grid system or the ground system (whichever is currently active).
[Local/Ground EN Corr.]	The EN correlation of either the local grid system or the ground system (whichever is currently active).
[Local/Ground EH Corr.]	The EH correlation of either the local grid system or the ground system (whichever is currently active).
[Local/Ground NH Corr.]	The NH correlation of either the local grid system or the ground system (whichever is currently active).
[Convergence]	The grid convergence angle at the site.
[Scale Factor]	The grid scale factor at the site.
[Elevation factor]	The elevation factor at the site.
[Ellipsoidal Height]	Ellipsoidal height
[Orthometric Height]	Orthometric height
[Ellipsoid Height Error]	Uncertainty in Ellipsoid height
[Hor. Fix Status]	Horizontal fix status (“Fixed” or empty)
[Vert. Fix Status]	Vertical fix status (“Fixed” or empty)
[Control Type]	“Hor” for horizontal only, “Ver” for vertical only and “Hor/ Ver” for both.
[Position Status]	“Raw”, “Processed”, or “Adjusted” depending on status of position.

4. Select the component or field you wish to add to the template, and click **Enter**.

   If you want the template to have a header, you must place the header fields at the beginning of the template.
5. Continue adding parameters to build the template to your specifications.
6. Click the **Preview** button to view a preview of the field structure for the selected template with simulated data.

   Figure 8.6 shows the **User-Defined Format** dialog box with a template built, and Figure 8.7 shows the Preview dialog box for the template containing simulated data.

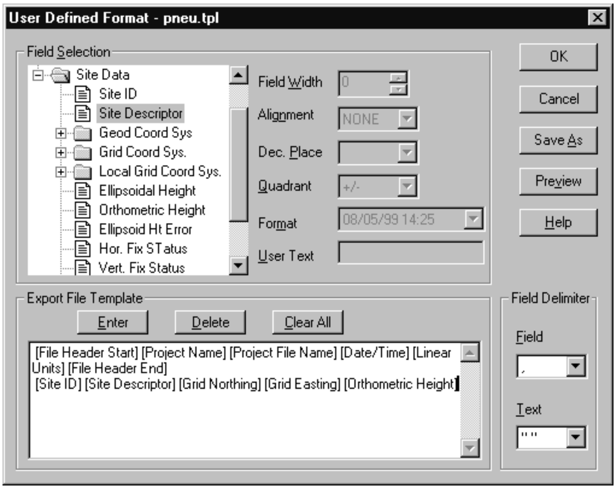


Figure 8.6. User-Defined Format Dialog Box with Template

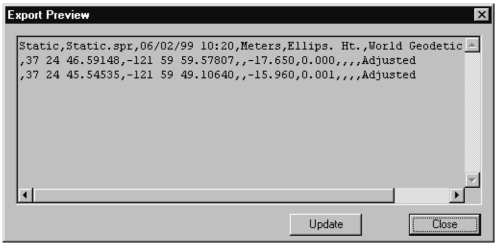


Figure 8.7. Preview Dialog Box with Simulated Data

7. Click **Save As** in the **User-Defined Format** dialog box to save the template.
8. Click **OK** in the **User ASCII Template** dialog box to use selected template and close dialog box.

Exporting Data

9. Click **Save** in **Export Data** dialog box to export data in user-defined ASCII export file.

Promoting a Data Type

If you would like a User ASCII Template to be available as a selection in the **Save as type** list of the **Export Data** dialog box, click **Promote** in the **User ASCII Template** dialog box when the template is selected. There is no requirement to promote a template. All templates are saved and accessible for future use in the **Template List** of the **User ASCII Template** dialog box.

Using Exported Data

Using User-Defined ASCII Files

Create a user-defined ASCII files to customize the table of information you want to import into a third-party software package.

A user-defined ASCII file can be loaded into Microsoft Excel™ so further modifications and data analysis can be done.

Using O-Files

The O-file is a binary format of the vector-only data in the project. After you select O-file in the **Export Data** dialog box, Ashtech Solutions exports the processed and/or adjusted vector information to the proprietary standard file. After you select Ashtech O-file in the **Export Data** dialog box, Ashtech Solutions exports the processed vector information to the O-file format. This file can be imported into other projects or other software packages.

Using TDS Coordinate Files

The TDS Coordinate file format *.cr5 is the standard TDS coordinate output file which you can use to import position information into other software packages.

Using Bluebook Files

Ashtech Solutions creates NGS Bluebook B-file and G-file formats for vectors and site positions to import into other software packages.

Since Ashtech Solutions contains only a subset of the information required in the NGS B-file and G-file, you may need to supplement the generated files with additional information. Use the NGS CR8BB and CR8G programs for this task.

9

Coordinate Transformations

One of the primary advantages of Ashtech Solutions is the ability to work within your own coordinate system from the start of your project - you no longer need to be concerned with transforming to and from the WGS-84 datum, to which all GPS data references. Ashtech Solutions allows you to work in four types of horizontal coordinate systems: Local Grid, Grid System, Ground, or Geodetic. In addition you can choose to use either ellipsoidal heights or orthometric heights. Although Ashtech Solutions includes many predefined grid systems and geodetic datums, you can easily create your own custom coordinate system.

The four types of coordinate systems can be seen to build upon one another. At the heart of any system lies the geodetic datum, with a known relationship to WGS-84, represented by the Geodetic system. On top of that might exist a Grid system, consisting of one or more zones, each utilizing one of the several available projections. Finally, a Local Grid can be superimposed over a Grid system. A Ground system builds upon a Geodetic system only. It has no relationship to a selected Grid or Local Grid system.

Typically you select or define the coordinate system you wish to use when you create a new project. From that point on, all coordinates are presented in that system. However, it is possible at any time to change to a different system, and all your coordinates automatically transform to the new system.

Experience indicates that users work primarily in the same coordinate system - for convenience, the coordinate system in a new project is automatically set to the system that was used last.

Selecting a Predefined Coordinate System

To select a predefined coordinate system:

1. From the **Coordinate System Tab** of the **Project Settings** dialog box, select a **System Type** (Local Grid, Grid, Ground, or Geodetic).
2. After you select **System Type**, the available choices appear on the display.
3. Select the appropriate choice (s) and click **OK**.

Defining a New Geodetic Datum

If a Geodetic Datum you want to use does not already exist in the pre-defined datum database, you can define and store a new Geodetic Datum for use in this and future projects.

In Ashtech Solutions, defining a new datum means defining the relationship between the new datum and the WGS84 datum. Since GPS observations are referenced to WGS84, defining the relationship between WGS84 and other datums allows for point coordinates determined by GPS to be transformed to these other datums.

To properly define the relationship between WGS84 and a new Geodetic Datum, the following transformation seven parameters must be known:

- The X,Y, and Z translation between the origins of the two datums
- The rotation about the X, Y, and Z axis to align the axes of the two datums.
- Scale difference between the two datums.

These parameters must be supplied to Ashtech Solutions in a manner that defines the transformation **from** the new Geodetic Datum **to** WGS84.

If the transformation parameters relating your new datum to WGS84 are unknown, you can use Ashtech Solutions to estimate them. To estimate the set of transformation parameters, you must have the following information:

- Two points with known horizontal coordinates in both the WGS84 and new datums.
- Three points with known vertical coordinates in both the WGS84 and new datums.

This is the minimum set of known coordinate values required to compute the seven-parameter relationship between WGS84 and the new datum. Additional values allow for calculating statistics defining the quality of the estimated parameters and identifying problems with the known coordinates.

1. From the **Coordinate System Tab** of the **Project Settings** dialog box, select Geodetic as the system type.

2. Select **NEW** as the Geodetic datum, and click the **Define** button ...
3. In the **Datum Definition** dialog box, Figure 9.1, enter the name for the new datum.

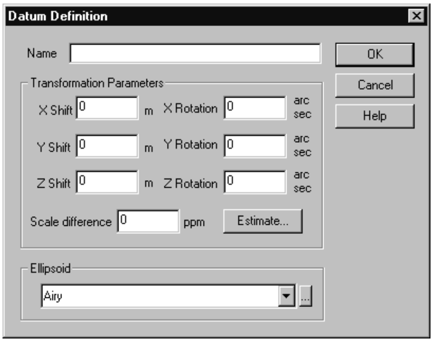


Figure 9.1. Datum Definition Dialog Box

4. Select the ellipsoid which the new datum uses (refer to “Defining an Ellipsoid” on page 101).
5. Enter the shifts and rotations in the x, y, and z directions, and the scale difference.

   To estimate the transformation parameters using a set of points, refer to “Estimating Datum Transformation Parameters” on page 102.
6. Click **OK** to save the datum parameters and close the **Datum Definition** dialog box.

Defining an Ellipsoid

An ellipsoid is a primary component in the definition of a datum. If you wish to define a datum that is based on an ellipsoid not found in the predefined ellipsoid database, you can define a new ellipsoid.

The definition of a new ellipsoid requires values of the following ellipsoid parameters:

- Semi-major axis
- Inverse flattening

If the semi-minor axis is known rather than the inverse flattening, the inverse flattening can be calculated using the following equation:

$$1/f = (a/(a-b))$$

where:

1/*f* = Inverse flattening

a = Semi-major axis

b = Semi-minor axis

1. In the **Datum Definition** dialog box, select **NEW** in the **Ellipsoid** dialog box, and click the **Define** button ....
2. In the **Ellipsoid Definition** dialog box, Figure 9.2, enter the name for the new ellipsoid, the semi-major axis, and the inverse flattening.

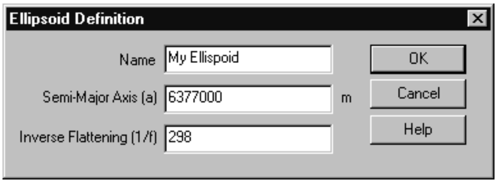


Figure 9.2. Ellipsoid Definition Dialog Box

3. Click **OK** to save the new ellipsoid and close the **Ellipsoid Definition** dialog box.

Estimating Datum Transformation Parameters

If you do not know the transformation parameters for a custom geodetic datum, but know the coordinates in both the local and WGS84 datums for a common set of points, you can estimate the transformation parameters. Ashtech Solutions uses industry standard equations to calculate transformation parameters (7-parameter similarity transformation).

To estimate the set of transformation parameters between WGS84 and a new datum, you must have the following information:

- Two points with known horizontal coordinates in both the WGS84 and new datums.
- Three points with known vertical coordinates in both the WGS84 and new datums.

This is the minimum set of known coordinate values required to compute the 7-parameter relationship between WGS84 and the new datum. Additional values allow for calculating statistics defining the quality of the estimated parameters and identifying problems with the known coordinates.

If you have loaded data into the project, the sites are available to use for the transformation calculation. After selecting a site, the coordinates appear as base coordinates. The base coordinates can be edited, and any changes made are saved to the data set.

1. From the **Datum Definition** dialog box, click the **Estimate.....** button to open up the **Datum Transformation** dialog box, Figure 9.3.

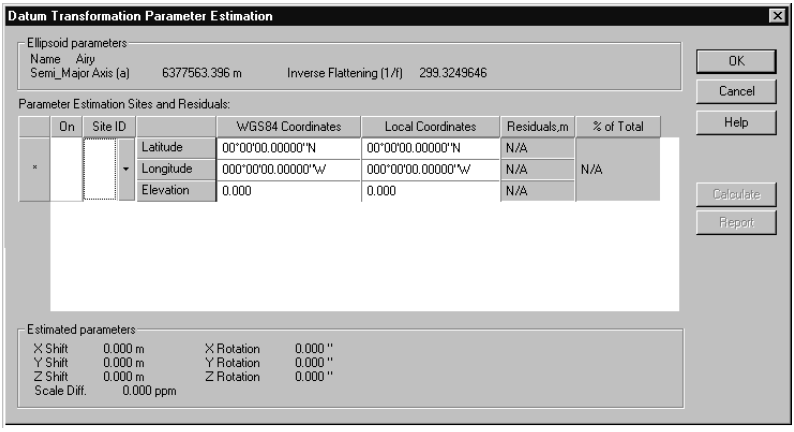


Figure 9.3. Data Transformation Parameter Estimation Dialog Box

2. Any sites set as control sites in the project are listed in the **Data Transformation Parameter Estimation** dialog box. If you do not wish to use any of these control sites in the transformation calculation, uncheck the **ON** box.
3. Select a site loaded into the project by clicking the arrow at the right of **Site ID** and selecting a site

   -OR-

   Enter the point's Site ID in the Site ID display.

   If you selected a site, both the WGS-84 and local datum coordinates are listed.
4. Enter or edit the latitude, longitude, and elevation for both the local and WGS-84 systems, if necessary.
5. Verify the **On** box is checked for the point.
6. Repeat for all points
7. After entering all points, click **Calculate** to calculate the transformation parameters. The **Estimated Parameters** box at the bottom of the dialog box box lists the computed transformation parameters (Figure 9.4).

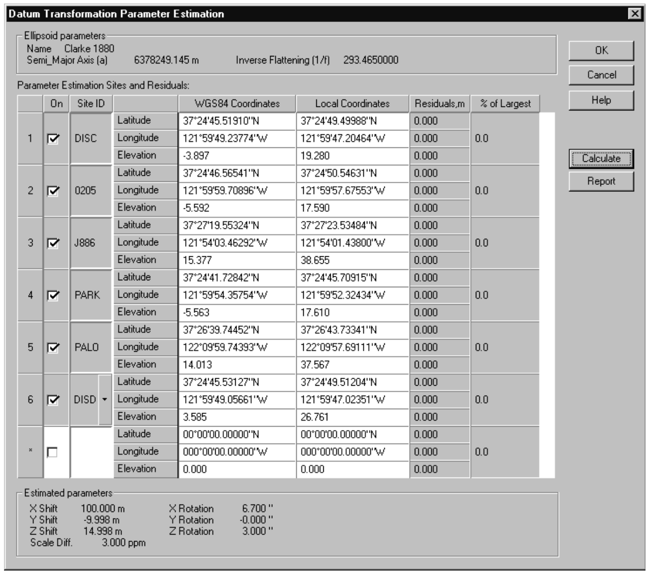


Figure 9.4. Transformation Parameter Dialog Box with Estimated Parameters

If you entered more than the minimum number data points to calculate the transformation parameters, Ashtech Solutions also computes residuals for each point.

8. Click **OK** to save the transformation parameters to the datum, and close the dialog box.
9. The actual point information is not saved and is not displayed the next time the **Data Transformation Parameter Estimation** dialog box is opened.

Defining a New Grid System

If a Grid System you want to use does not already exists in the pre-defined Grid System database, you can define and store a new Grid System for use in this and future projects.

The following parameters are required to define a new Grid System:

- Reference Geodetic Datum- the new Grid System must be based on a defined geodetic datum. You can select an existing pre-defined datum from the database or define a new datum.
- Projection type- you must select a projection type for your Grid System from the following projection types:
    - Lambert Conformal Conic
    - Lambert Conformal Conic 27 (for State Plane Coordinate System 1927)
    - Transverse Mercator
    - Transverse Mercator 27 (for State Plane Coordinate System 1927)
    - Oblique Mercator
    - Stereographic
    - Stereographic Double
- Projection parameters for each desired zone of the Grid System- you must enter the defining parameters of your Grid System. A different set of parameters are required based on the projection type selected. If more than one zone will exist in your new Grid System, defining parameters are required for each zone.

1. From the **Coordinate System Tab** of the **Project Settings** dialog box, select **Grid** as the **System Type**.
2. Select **NEW** in the **Grid System** combo box, and click the **Define** button ....
3. In the **Grid System Definition** dialog box, enter the name for the Grid System.

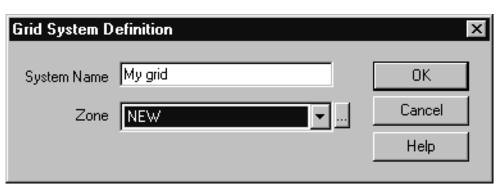


Figure 9.5. Grid System Definition Dialog Box

4. Click the **Define** button to open the **Zone Definition** dialog box and create the zone for the grid system.

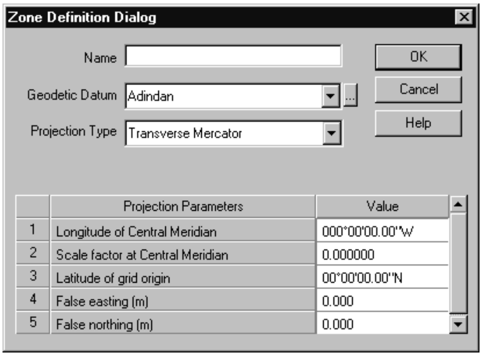


Figure 9.6. Zone Definition Dialog Box

5. Enter the name of the zone in the **Name** field.
6. Select the Geodetic Datum on which the zone is based.
7. Select the map projection type you wish to use for the project and zone.
8. Enter the projection parameters for the zone.
9. Click **OK** to save the zone and close the **Zone Definition** dialog box.
10. Click **OK** in the **Grid Definition** dialog box to close it and return to the **Coordinate System** dialog box.

Defining a New Local Grid System

If a desired Local Grid System does not already exist in the Local Grid System database, you can define and store a new system for use in this project and future projects.

A Local Grid System is based on a regional Grid System, such as State Plane Coordinate System 1983 (SPCS83), or a global Grid System, such as Universal Transverse Mercator (UTM). Starting with the regional or global Grid System, transformation parameters are defined to transform these Grid System coordinates to the Local Grid System. In Ashtech Solutions, the regional Grid System or global Grid System on which the Local Grid System is based is called the Base Grid System.

Defining a Local Grid System can be accomplished in one of two ways:

- You can enter the known transformation parameters between the Local Grid System and the Base Grid System. The required transformation parameters are Easting and Northing translations between the origins of the coordinate systems, Rotation about the vertical axis, and Scale difference between the systems.

- Supply the software with a least two points with known horizontal coordinates in both the Local Grid System and the Base Grid System. From these two points, the transformation parameters relating the two systems will be calculated.

These parameters must be supplied in a manner that defines the transformation **from** the Base Grid System **to** the Local Grid System.

To define a new local grid system:

1. From the **Coordinate System Tab** of the **Project Settings** dialog box, select Local Grid in the **System Type** display.
2. Select **NEW** in the **Local Grid System** display, and click the **Define** button .
3. In the **Local Grid System Definition** dialog box, type the name for the local system.

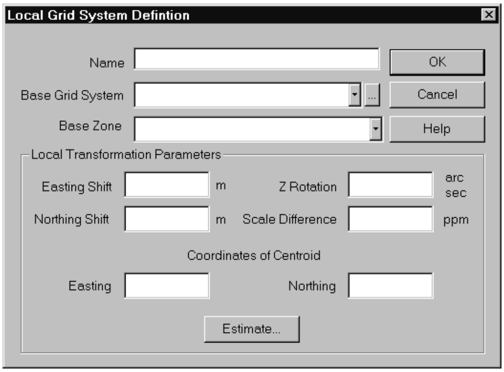


Figure 9.7. New Local Grid Definition Dialog Box

4. Select a Base Grid System and Base Zone. You can define your own base grid system by clicking the **Define** button.
5. If you know the transformation parameters, enter the Easting Shift, Northing Shift, Z Rotation (rotation about a vertical axis), Scale Difference, and centroid coordinates (optional) to convert the selected base grid to the local grid system. Otherwise you need to calculate the parameters - refer to “Estimating Local Grid Transformation Parameters” on page 108.

   Positive rotation from the base grid to the local grid is in a counterclockwise direction.
6. Click on **OK** to save the local grid.

Coordinate Transformations

Estimating Local Grid Transformation Parameters

If you do not know the transformation parameters for a local grid system, but know the coordinates in both the local and base grid systems for a common set of points, you can estimate the transformation parameters. The base grid system is arbitrary. It can be any pre-defined regional (State Plane Coordinates 1983 for example) or global (UTM for example) grid system that is pertinent to your area.

To estimate the set of transformation parameters between WGS84 and a new datum, you must have two points with known horizontal coordinates in both the local grid system and the base grid system.

This is the minimum set of known coordinate values required to compute the transformation parameters relating the two systems. Additional values allow for calculating statistics defining the quality of the estimated parameters and identifying problems with the known coordinates.

If you have loaded data into the project, the sites are available to sue for the transformation calculation. After selecting a site, the existing coordinates appear as base coordinates. The base coordinates can be edited, and any changes made are saved to the data set.

1. From the **Local Grid System Definition** dialog box, click the **Estimate...** button to open the **Local Grid Transformation Parameter Estimation** dialog box, Figure 9.8.

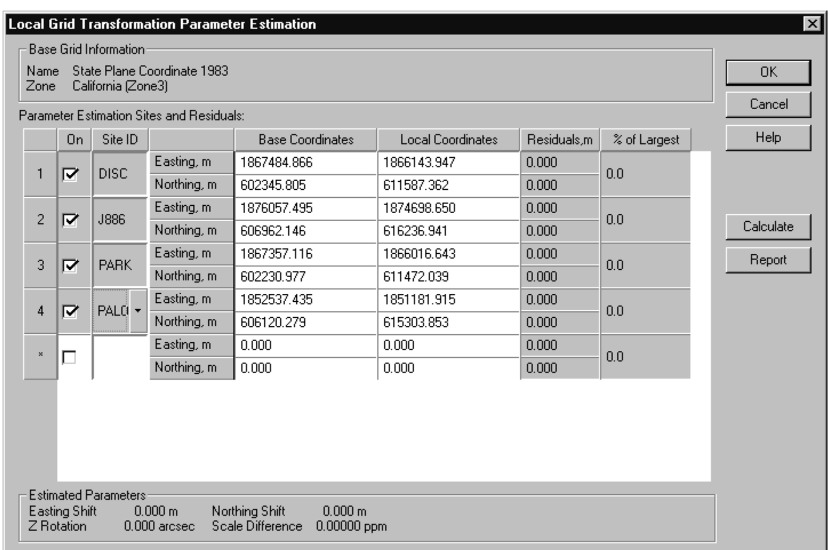


Figure 9.8. Local Grid Transformation Parameters Estimation Dialog Box

2. Any sites set as control sites in the project are listed in the **Local Grid Transformation Parameter Estimation** dialog box. If you do not wish to use any of these control sites in the transformation calculation, uncheck the **ON** box.
3. Select a site loaded into the project by clicking the arrow at the right of the **Site ID** display and selecting a site

   -OR-

   Enter the point's Site ID in the Site ID display.

   If you selected a site, both the WGS-84 and local datum coordinates are listed.
4. Enter or edit the northing and easting grid coordinates for both the local and base grid systems, if necessary.
5. Verify the **On** box is checked for the point.
6. Repeat for all points
7. After entering all points, click **Calculate** to calculate the transformation parameters. The **Estimated Parameters** box at the bottom of the dialog box lists the computed transformation parameters (Figure 9.9).

   If you entered more than two data points to calculate the transformation parameters, the program computes residuals for each point. You can use the residuals to determine if any point is inconsistent with the others. If a point has residuals much greater than the other points, the data point may be suspect (or incorrectly entered).

   The far right column in the dialog box gives you a quick indication of the relative sizes of the residuals. Verify the coordinates and recalculate, or recalculate the transformation parameters excluding the point(s). To exclude a point, uncheck the **On** check box and click **Calculate** to recompute the transformation parameters. Now the residuals for all checked points are 0 indicating that they are consistent.

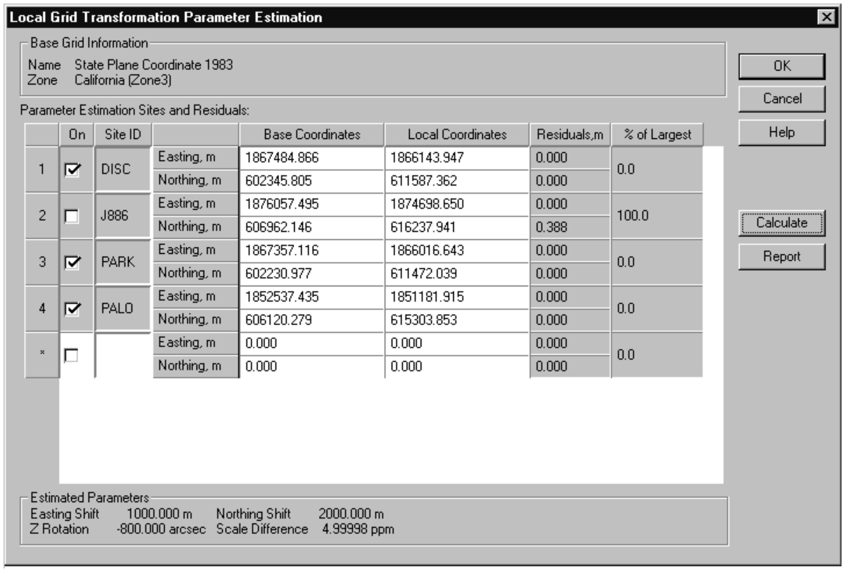


Figure 9.9. Local Grid Transformation with Estimated Parameters

8. Click **OK** to save the transformation parameters to the local grid, and close the **Local Grid Transformation Parameters Estimation** dialog box.
9. To produce a final report of your parameter estimation, click the **Report** button.

   A predefined report format opens in the pre-defined report editor, and lists the points used in the estimation, new parameters, and the residuals.

Defining a New Ground System

Create a custom Ground System when you wish to produce coordinates in your project area that are compatible with point coordinates derived using conventional total stations.

1. From the **Coordinate System** dialog box, or the **Coordinate System Tab** of the **Project Properties** dialog box, select **Ground** as the system type.

2. Select **NEW** as the **Ground System**, and click the **Define** button . to open the **Ground System Definition** dialog box (Figure 9.10).

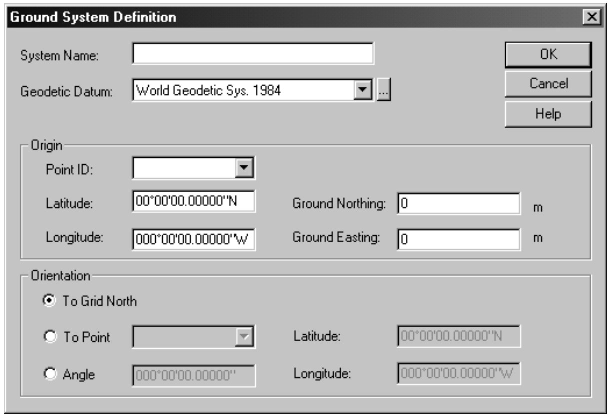


Figure 9.10. Ground System Dialog Box

3. Enter the name of the ground system in the **System Name** field.
4. Select the **Geodetic Datum** on which the ground system is based.

   Selecting a geodetic datum is required only if you wish to determine orthometric heights for the ground system by using a geoid model. A geoid model is specific to a datum. If you use a particular geoid model with your ground system, then select the geodetic datum which corresponds to the geoid model.
5. Click the arrow to the right of the **Point ID** field and select the origin point for the ground system from the list presented.

   After selecting an origin point, the latitude and longitude stored in the project for the selected point will be displayed.

   If you would rather set the origin point to a location other than an existing project point, simply enter the latitude and longitude of your origin without selecting a project point. By default, the ground coordinates of the origin point are defined as (0,0). You can enter values other that (0,0) as ground coordinates for the origin point. This is helpful when the origin point is in the center of the project site. Assigning ground coordinates such as (10000,10000) to the origin point will lessen the likelihood of some of the project points having negative ground coordinates.
6. Enter the desired coordinates of the origin point, in the ground system, in the **Ground Northing** and **Ground Easting** fields.

7. Click the radio button corresponding to the method for defining the 0° azimuth for the ground system: **To Grid North**, **To Point**, or **Angle**.
   - The **To Grid North** option defines 0° azimuth of the Ground System to match Grid North.
   - The **To Point** option defines 0° azimuth of the Ground System as the azimuth between the origin point and a second point defined by either selecting the point from the list of existing points in the project or defining a new point by entering the Latitude and Longitude of the point.
   - The **To Angle** option defines 0° azimuth of the Ground System as offset from Grid North by the entered angle. A positive angle results in the 0° azimuth of the Ground System being rotated counter-clockwise from Grid North.
8. Click **OK** to save the ground system and close the dialog box.

Height Systems

The program has the ability to work with either orthometric heights (heights above the geoid, or approximate mean sea level) or ellipsoidal heights (heights above the same datum used for your horizontal coordinates). It is important to know what height system your control coordinates are in so you can select it when creating the project.

In the **Coordinate System** tab of the **Project Settings** dialog box, check the box corresponding to the height system.

If you choose orthometric, you must select a geoid model as well. Use the geoid model to define the relationship between the orthometric heights used and the ellipsoidal heights that Ashtech Solutions uses to process and adjust survey data.

The program provides several geoid models, including Geoid99 (for the US), GSD95 (for Canada) and EGM96 (worldwide coverage). Depending on the datum you select, you may have the option to choose between several regional models, or you may be restricted to the global model, because each regional model is referenced to a specific datum. If you have more than one option, we recommend that you select a regional model since is more accurate for your area.

The height displayed depends on the height system selected in the **Coordinate System** tab.

The use of local height systems, which vary considerably from mean seal level (MSL) for orthometric heights, may adversely affect your results.

A Note Concerning NADCON

If you select a datum which uses the NADCON transformation, you must use orthometric heights, because NADCON is a 2-D transformation, and ellipsoid heights are meaningless.

It is very important that all vertical control heights are based on the same vertical datum, e.g., NAVD-29. Mixing heights from different vertical datums causes unpredictable and erroneous results.

A

Mission Planning

This appendix describes the planning operations to perform in the office prior to collecting data in the field. Efficient field operations require prior knowledge of satellite availability and configuration, that is, accurate data is obtained more quickly when more satellites are widely dispersed across the sky at higher elevations.

For example, there may be times when fewer than four satellites are available; or, all the available satellites may be clustered in one small area of the sky (i.e., poor geometry), or, some sites may be near buildings or structures that obstruct satellite visibility.

Mission Planning lets you determine optimum times for data collection, and set up various parameters and constraints:

- Determine DOP (dilution of precision) for a selected site during a specified time interval
- Define obstructions, if any, at selected sites
- Determine the number of satellites available at a selected site at a selected time

Ideally, you should plan your project so you have at least four satellites widely dispersed across the sky throughout the data collection period. If you are doing a kinematic survey, five satellites must be visible at all times during the survey.

Almanac Files

A current almanac is important for accurate planning. Mission Planning warns you when an almanac file is older than 60 days from the planning date. Although you can use Mission Planning with an almanac file older than 60 days, be aware the almanac information will not be current, thus satellite orbits and health may be incorrect.

The GPS receiver continuously updates its internal almanac file as it collects data. You can obtain a current almanac file by collecting data for at least 15 minutes, then downloading the almanac file from the receiver. By default, Mission Planning uses the latest almanac file available in the bin folder, unless you change the folder or almanac file using the Satellite Configuration dialog box.

Be aware that the almanac changes constantly, and a given almanac becomes invalid over time. You can tell the date of the almanac from the file name. For example, a typical almanac file might be named **alm 98.182**, where ***alm*** indicates the file is an almanac, ***98*** indicates the year, and ***182*** is the day of the year.

In actual practice, you would always use a current almanac, which you can obtain in either of two ways:

- Call Customer Support; Customer Support will send you a current almanac via e-mail.
- Set up your GPS receiver and collect data for about 15 minutes. The receiver automatically generates a current almanac using data received from the satellites. You can then download this almanac to your PC as described elsewhere in this manual.

When to Use Mission Planning

The usage of Mission Planning depends on the type of survey and obstructions that may exist at any of the sites in the project.

There are some locations and periods when satellite availability and geometry are poor, however, the locations are generally localized, and the time periods last a couple of hours at most. When data collection periods are long, 45 minutes or more, these short periods of poor availability and poor geometry normally have little effect on accuracy. But when data collection periods are short, 15 minutes or less, poor availability and geometry can greatly affect accuracy, especially in kinematic data collection. In kinematic mode, it is common to collect 10 seconds or less of data on a point. If a DOP spike (short period of time with a very high DOP value) occurs during that time period, the accuracy for this point degrades. The accuracy of other points in the same kinematic session could be very good. Therefore, Mission Planning plays a critical role when performing surveys with short observation times.

Obstructions at a site adversely affect satellite availability and geometry for that site. Obstructions can be so severe that the site may not be suitable for GPS observation. The only way to determine the impact of obstructions is to examine the effect of the obstructions on satellite availability and geometry at any obstructed site. Mission Planning lets you define obstruction information for each site in a survey. With the obstructions defined, satellite availability and geometry are analyzed to determine which sites are suitable for GPS observation and the best time to collect data at each obstructed site.

If there are no obstructions, enter one site into Mission Planning near the center of the survey area to examine satellite availability and geometry for the entire survey.

Starting Mission Planning

1. From the Windows 95 or Windows NT desktop, from the **Start** menu Programs folder, select **Planning** from the Ashtech Solutions menu.

   The **Mission Planning** main window opens, as shown in Figure A.1.

You can start Mission Planning from Ashtech Solutions by selecting Mission Planning from the Tools menu.

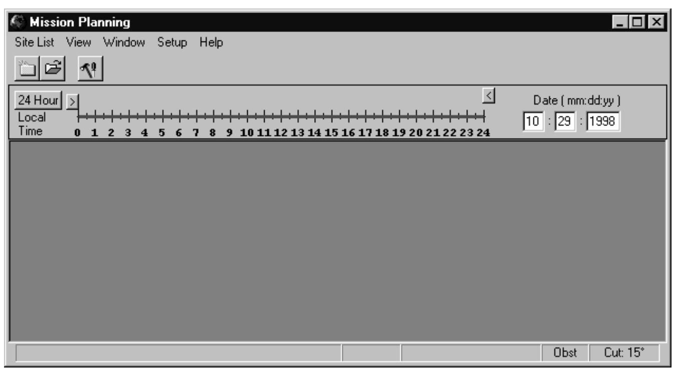


Figure A.1. Mission Planning Main Window

2. Near the top of the window is a 24-hour time scale (Figure A.2), to specify the time interval you want to determine DOP and satellite availability. Set the time interval using the two sliders [>] [<] above the scale. To set the start time of the interval, click on the left slider, hold the mouse button down, and move the

slider to the desired start time. Similarly, set the end time of the interval using the other slider. The specified interval appears in red.

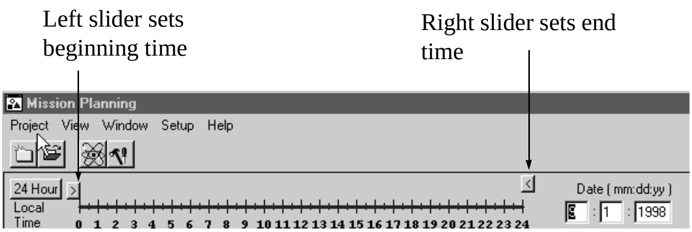


Figure A.2. Time Scale

Selecting Satellites and the Almanac

The setup menu allows you to change several parameters such as the satellite configuration, the almanac used, the satellite cut-off angle, and the display mode.

Satellite Configuration

Select **Satellite Configuration** from the **Setup** menu to open the **Satellite Configuration** dialog box, Figure A.3,.

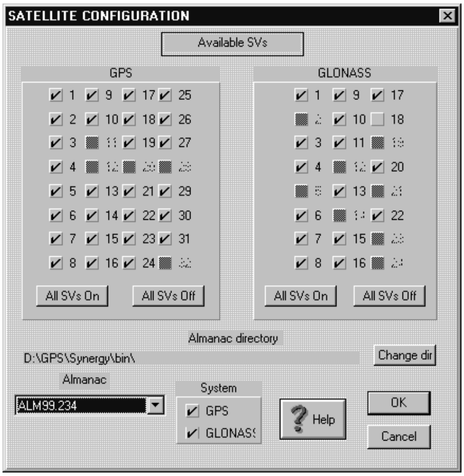


Figure A.3. Satellite Configuration Dialog Box

Use the Satellite Configuration Dialog Box to define:

- which satellite system to use
- which individual satellites use
- the directory where almanac files are stored (default is the executable directory).
- which almanac file to use in this project.

There are two lists of satellites, one each for GPS and GLONASS. In these lists, each satellite has a check box next to it. Additionally, there are two buttons at the bottom of each list to switch on/off all the satellites in a particular system. These buttons are useful if you wish to quickly select or clear all the satellites in the panel.

Use the **System** check boxes at the bottom of the screen to select which system to use. To select the satellite system(s) you want to use:

1. Check the GPS box to use only GPS.
2. Check the GLONASS box to use only GLONASS.
3. If you have a receiver and software capable of using both systems, check both GPS and GLONASS.

To select individual satellites, click on the check box next the satellite. A check mark indicates it is selected.

If a check does not appear it means that the system to which the satellite belongs has been deselected. Check the appropriate box in the **Systems** box.

If there is a red line underneath the satellite number, then that satellite is unhealthy according to the almanac. You may select unhealthy satellites, but be advised that your session may contain bad data.

If the box is grayed out, there is no entry in the almanac for that satellite and it is not available.

The satellite selections you make in this dialog box apply to all open windows in Mission Planning. For example if you have the **Sky Plot** open and deselect all GLONASS satellites, when you click **OK**, the **Sky Plot** updates automatically.

Changing the Almanac

An almanac file is a file downloaded from the receiver containing satellite location information, and it is important that the almanac file be as current as possible. By default, Mission Planning uses the most recent almanac file in the bin folder. Therefore copy the almanac file you downloaded from your receiver to this folder.

You can change the almanac file selected folder should you wish to store the almanac files with your project data.

1. If you need to change the path to the new almanac, click the **Change Dir** button to open the **Open File** dialog box in the **Satellite Configuration** dialog box.
2. Navigate to the directory where the almanac file is stored, and click **OK** to select the new path. If there are no almanac files in the directory you will not be able to click **OK** - in this case click **Cancel**.
3. Select the almanac you wish to use by click on the arrow to the right of the **Almanac** display and selecting an almanac from the list.

   The **Sky Plot**, **Satellite Visibility Plot**, and **DOP Plot** update to reflect the contents of the new file.
4. To accept changes, click **OK**. To cancel changes, click **Cancel**.

Creating a New Project

Mission Planning Projects are used to store sites, but are independent of Ashtech Solutions projects. In the `bin` folder of the Ashtech Solution directory is a sample Mission Planning project with many United States cities listed.

1. Select **New** from the **Site List** menu.
2. The **Site Editor** dialog box opens, Figure A.4, where you can enter new sites to view satellite availability. To create a New Site, see “Adding a Site to the Project” on page 122.

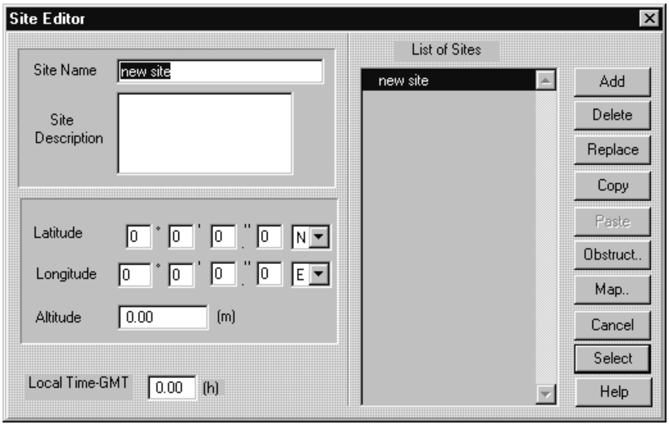


Figure A.4. Site Editor Dialog Box

Opening a Existing Project

1. Select **Open** from the **Site List** menu. The **Open** dialog box opens.

   The **Open** dialog box lists the available projects.
2. Navigate to the directory where the project file is located and select the project, or navigate to the bin folder and select **usacities.spl**.
3. Click **Open** to open the project and the **Site Editor** dialog box, Figure A.5.

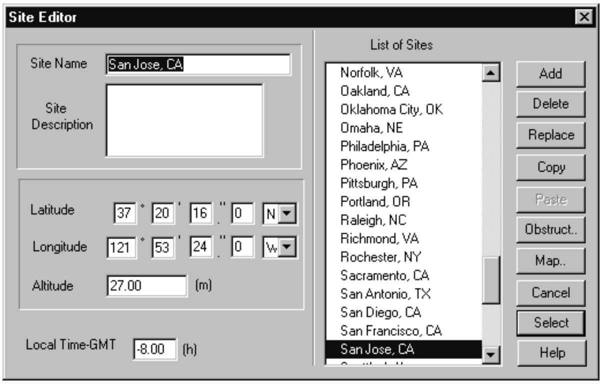


Figure A.5. Site Editor Dialog Box

The **Site Editor** dialog box displays the position and altitude data for a site. The **Local-GMT** field in the lower left corner is important and displays the hours difference between the local time and Greenwich Mean Time.

Make sure the **Local-GMT** number is correct for the site's time zone as listed in Table A.1.

Table A.1. Time Zone Table

Local Time Zone	Standard Time	Daylight Time
Eastern	-5	-4
Pacific	-8	-7
Central	-6	-5
Mountain	-7	-6

Saving a Project

To save the project with all sites and obstructions, select **Save** from the **Site List** menu.

Adding a Site to the Project

The Dilution of Precision (DOP), satellite geometry, and availability depend on a site's location. Typically these values remain fairly consistent over 1-2 degrees of latitude or longitude. Therefore if no sites in the projects have obstructions, then one site can be used for the entire project. Sites can be created by two methods in the site editor: entering a latitude and longitude, or by selecting a location on a world map.

1. In the **Site Editor** dialog box, Figure A.6, enter a name for the site in the **Site Name** field.

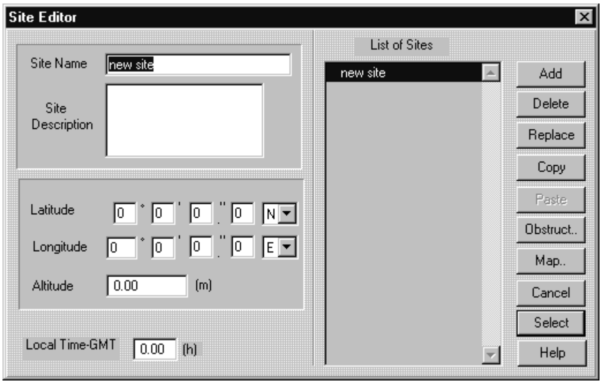


Figure A.6. Site Editor Dialog Box

2. If necessary, enter a brief description of the site to assist you in referencing the site in the **Site Description** box.
3. Enter the site's latitude and longitude in the corresponding fields.

   -OR-

   Click the **Map** button to open the **Site Location on Map** dialog box, Figure A.7, and click on the approximate site location. Then click OK to accept the site and close the dialog box.

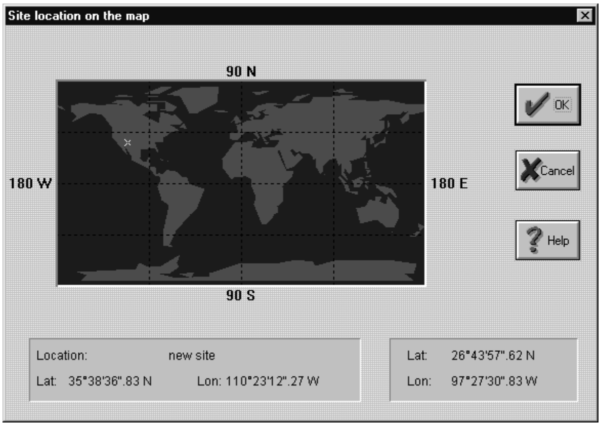


Figure A.7. Site Location on Map Dialog Box

4. Enter the approximate altitude of the site above sea level.
5. Make sure the **Local-GMT** number is correct for the site's time zone (Table A.1).
6. Click **Add** to save the site to the project.
7. Click **Select** to close the **Site Editor** dialog box, and use the site when viewing the DOP and Sky Plots.
8. The Status bar lists the selected site name and coordinates.

Options

Use the **Options** dialog box to define

- Mode
- The display time interval
- The cut-off angle
- Whether obstructions are on or off
- To use the last-used almanac automatically at start-up

To open the **Options** dialog box, Figure A.8, select **Options** from the **Setup** menu.

Positioning Mode

You can choose between 2-D and 3-D positioning modes. If you are solely interested in horizontal positioning and are not concerned with height, you may choose 2-D. This option had more importance in the past when there were fewer satellites available and there were no receivers capable of simultaneous GPS and GLONASS data collection. Constraining the positioning mode to 2-D meant that you could work with only three satellites, a sometimes common occurrence. However, this should be much less of a consideration now that there are always more than four satellites in view. The recommended selection is 3-D.

Display Time

You may also select the time interval at which the DOP and availability values are calculated. You have a choice between 5 and 15 minutes. The basic difference is that 15-minute intervals allow quicker calculation of the DOPs, while a 5-minute interval is slower but gives a better picture of how the satellite constellation changes over time when you are zoomed in on a small time span.

CutOff Angle

The cutoff angle is the angle above the horizon below which you wish to ignore satellites. It is a good idea to have a value of at least 10 degrees here, since satellites at low angles are subject to atmospheric refraction and multipath reflection. By default the cutoff is set to 15°.

To change the Cutoff Angle:

1. Select **Options** from the **Setup** Menu to open the **Options** dialog box opens (Figure A.8).

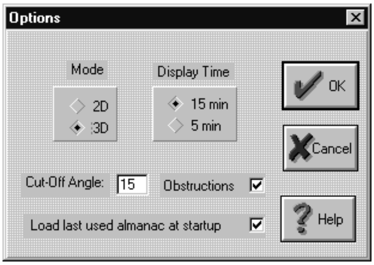


Figure A.8. Options Dialog Box

2. Enter a new cutoff angle and click **OK**. The **Options** dialog box closes and the **Sky Plot** and **DOP Plot** windows updates after you click in them.

Obstructions On/Off

There is a check box to apply or remove any obstructions you have defined for the current site. The obstructions are not destroyed if you deselect this box - they are merely ignored and can easily be restored by rechecking the box.

Load Last Almanac

The final option in this dialog box allows you to use the last-used almanac the next time you start Mission Planning. This overrides the default behavior of Mission Planning which is to load the most recent almanac in the current directory.

Clicking **OK** updates all open windows with changes.

Clicking **Cancel** ignores changes.

Satellite Plots

Having selected a site and setting the desired options, you are now ready to view the satellite plots to plan your mission.

Mission planning provides three different plots and graphs that you can examine. Each plot provides a different perspective on satellite visibility, location, and availability. All plots are accessed from the VIEW menu. The three plots that are available are:

- The **Satellite Visibility Plot** indicates when individual satellites are visible
- The **DOP Plot** indicates the total number of satellites available and the DOP values versus time
- The **Sky Plot** is a polar plot of the satellites as they move across the sky.

You decide which plot is most useful. However, in general, the **DOP Plot** is the most helpful, as the availability and strength of the geometry are usually the most important factors in planning a mission.

Using the Satellite Visibility Plot

The **Satellite Visibility Plot**, Figure A.9, shows when satellites are available.

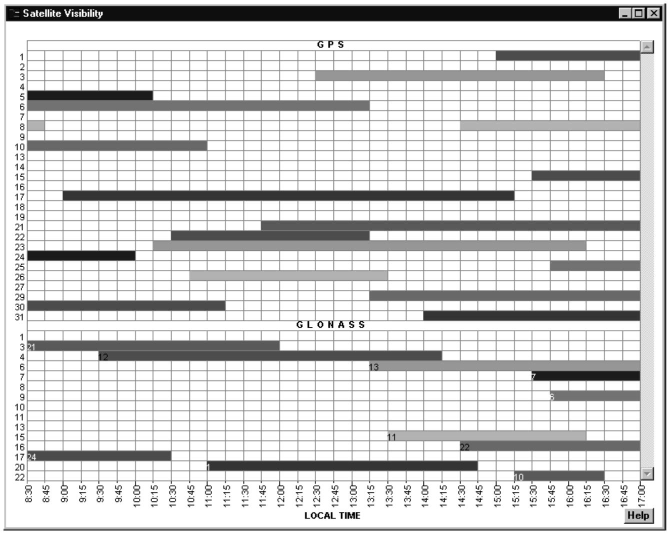


Figure A.9. Satellite Visibility Chart

The time scale on the horizontal axis corresponds to the selected time span in the **Time Control** bar. The vertical axis lists the satellite PRN numbers for the satellites you have selected in the **Satellite Configuration** dialog box.

If you have selected both GPS and GLONASS, there may be too many satellites too fit in the window vertically. In this case a vertical scroll bar becomes active on the right side of the screen. Use this to move up and down the list.

A color bar to the right of the satellite ID number indicates when it is visible at the selected site.

Select a time period for your survey when the most satellites are available for an extended period. For any particular time you can find the number of satellites available by counting the number of bars crossing that time period.

This window is most useful for detecting when individual satellites are visible. For example, if you are interested in GPS satellite 28 you can easily see it on this graph. A more useful view for seeing the total number of satellites available is the combined **Sky Plot**.

Using the DOP Plot

The **DOP Plot** displays the DOP components and satellite availability for the site on the specified day and time.

1. With a site selected, select **DOP Plot** in the **View** Menu.
2. The **DOP Plot** window opens for the selected site, the selected date, and the selected time (Figure A.10).

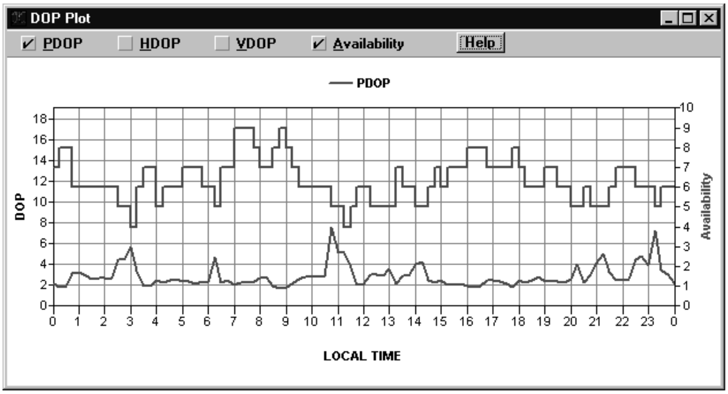


Figure A.10. DOP Plot

The DOP scale on the left edge of the display shows the DOP values; a DOP value of 4 is generally considered the maximum allowable for reliable data collection.

The illustration shows two peaks in the DOP value, one peak just before 17:00 hours, and another just before 21:00 hours; thus it would be best not to collect data during these two peaks, spanning 16:00 to 17:00 hours, and 20:00 to 21:00 hours.

The plot near the top of the display shows the number of satellites available at any time during the selected time interval. Note that DOP peaks generally occur when there are few satellites available (e.g. near 09:30 and 17:00 hours), but may also occur when more satellites are available, but the satellite geometry is poor (e.g., near 21:00 hours).

3. Close the **DOP Plot** window by clicking on the close box.

Using the Sky Plot

If you want to examine the satellite geometry for the survey interval, use the **Sky Plot** window.

1. Select **Sky Plot** from the **View** menu to open the **Sky Plot** display (Figure A.11).

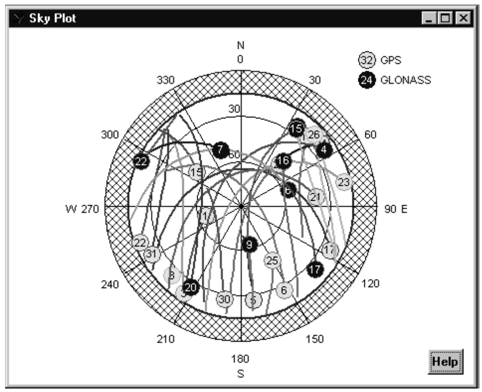


Figure A.11. Sky Plot

This display is an overhead hemishpere showing the satellite status during the specified time interval: the satellites available and their trajectories across the sky.   The numbers in the circles are the satellite designations. The cross-hatch annular ring is the elevation mask, in this case 15 degrees, as indicated by **Cut 15** in the Status Bar.

Obstruction Editor

The obstruction editor lets you define obstructions near the active site; obstructions such as large buildings or structures impair satellite visibility, and increase the DOP value. Once obstructions have been defined for a site, they are incorporated in any future calculations of satellite availability and dilution of precision (DOP) for the site. Be aware that heavily obstructed sites (e.g., a street between tall buildings) may not be suitable for GPS observations. After you define the obstructions for a site, you can examine satellite availability and DOP to determine if enough data can be collected at the site to accurately determine its position.

1. Select **Obstruction** from the **Site List** menu (or click **Obstruct.** in the S**ite Editor** dialog box) to open the **Obstruction Edito**r dialog box, Figure A.12.

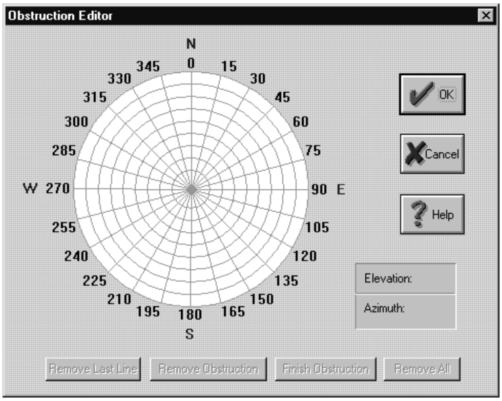


Figure A.12. Obstruction Editor Dialog Box

Use the **Obstruction Editor** dialog box to define obstructions, if any, at the selected site. Obstructions can affect the DOP, and could make the collected data unreliable. You must tell the software that an obstruction is present at the site; knowing that an obstruction is present, the software can calculate the effect of the obstruction on the DOP, then display the adjusted DOP in the DOP plot.

The circle in the **Obstruction Editor** dialog box represents the upper hemisphere of sky view at the site. The radial lines from the center represent azimuth, and the concentric circles represent elevation from 0 to 90 degrees in increments of ten degrees. To create an obstruction, you literally “draw” the obstruction in terms of its azimuth and elevation.

2. Click within the circle to place the first point of the obstruction.
3. Click within the circle a second time to place the second point of the obstruction.
4. Each additional point specified in the obstruction connects a line to the previous point.
5. Continue specifying points until the obstruction shape has been defined.

Mission Planning

6. After outlining the obstruction shape, click **Finish Obstruction** to close the obstruction shape from the last point to the first point. The **Obstruction Editor** dialog box closes the obstruction shape using the shortest route .

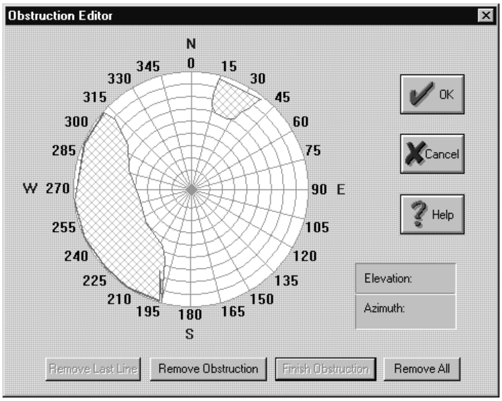


Figure A.13. Drawing the Obstruction

- Use the **Remove Last Line** button to delete the last line drawn in the obstruction shape. You can repeat this function for all lines in the current obstruction shape.
- Click the **Remove Obstruction** button and then an obstruction line to delete it.
- Use the **Remove All** button to delete all obstructions for the site.

7. Click in the **DOP Plot** and **Sky Plot** to update the windows.

B

RINEX Converter

RINEX (**R**eceiver **IN**dependent **EX**change) is a standard format for GPS, GLONASS, or GPS+GLONASS data supported throughout the industry.

The **RINEX Converter** utility provides a means to translate single or multiple RINEX-formatted data files from any receiver to Ashtech-formatted files, and, alternatively, convert Ashtech data files to RINEX format. **RINEX Converter** supports RINEX format version 2.01.

Preliminary Operations

Before you perform any conversions, you must create four directories and do the following preliminary operations in your computer to avoid confusion.

- **Rinexin** - Create this directory and load your **RINEX** files into it.
- **Rinexout** - Create this directory. Later, you will put your converted Rinex-Ashtech files in this directory.
- **Ashin** - Create this directory and load your **Ashtech** files into it.
- **Ashout** - Create this directory. Later, you will put your converted Ashtech-Rinex files in this directory.

The directory names listed above are suggestions; you can use whatever directory names you prefer.

Starting Rinex Converter

Select the **Rinex Converter** application in the Ashtech Solutions in the **Programs** menu from the **Start** Bar.

-or-

Select **RINEX Converter** from the **Tools** menu.

The **RINEX to Ashtech** dialog box opens (Figure B.1).

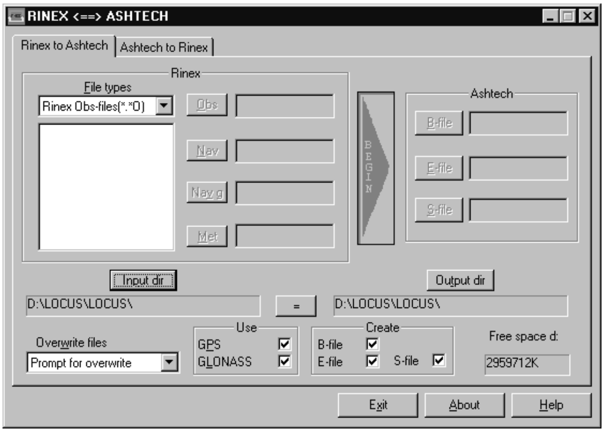


Figure B.1. RINEX-to-Ashtech Dialog Box

Use this dialog box to select the files you want to convert, and define the conversion options.

Table B.1 describes the fields in the **RINEX to Ashtech** dialog box.

Table B.1. RINEX to Ashtech Dialog Box Parameters

Item	Description
File types	Lists the file types: RINEX Observation files (*.*O), All files (*.*). RINEX NAV-files*.*N, RINEX Nav g-files*.*G, RINEX Met-files *.*M. To select a file type, click the down arrow D at the right end of the field and select file type from the list.
Available files list	The white area below **File Types**. List of files in current directory. To select a file, click on the file. To select multiple files, select the first file, hold down the **Ctrl** key, and select additional files by clicking with the cursor.
Obs	This field lists the file name of the observation data file corresponding to the selected RINEX data file in the available files list.

Table B.1. RINEX to Ashtech Dialog Box Parameters (continued)

Item	Description
Nav	This field lists the file name of the GPS navigation data file corresponding to the selected RINEX data file in the available files list.
Navg	This field lists the file name of the GLONASS navigation data file corresponding to the selected RINEX data file in the available files list. The field is empty if GLONASS data were not collected.
Met	This field lists the file name of the Meteorological data file corresponding to the selected RINEX data file in the available files list. The field is empty if meteorological data were not collected.
BEGIN	Click this button to begin converting the RINEX files to Ashtech format.
B-File	This field lists the suggested file name for the output B-file (raw measurement data).
E-File	This field lists the suggested file name for the output E-file (ephemeris data).
S-File	This field lists the suggested file name for the output S-file.(site information). The field is empty if site data were not entered into receiver.
Input dir	Click this button to open the **Set input directory** dialog box. See next entry in this table.
Set input directory	This combo box lets you select the directory where the RINEX files are stored.
=	Click this button to set the output directory the same as the input directory.
Output dir	Click this button to open the **Set output directory. See next entry in this table.**
Set output directory	Select the directory where converted data files will be stored.
Overwrite files	Select the overwrite options: Prompt for **Overwrite**, **Always overwrite**, or **Never overwrite**. To select an overwrite option, click the down arrow at the right end of the field and select an overwrite option from the list presented.
GPS	Click this box if GPS data will be used in conversion. This option is on by default.
GLONASS	Click this box if GLONASS data will be used in conversion (on by default). You will have GLONASS data only if your receiver is capable of receiving GLONASS signals.
B-File	Click this box to create a B-file (position data) when converting RINEX files.
E-File	Click this box to create a E-file (ephemeris data) when converting RINEX files.
S-File	Click this box to create a S-file (site information) when converting RINEX files. The S-file is created only if site data is included in the RINEX file.
Free Space	This field displays the available disk drive space for the selected output directory.
Exit	Closes RINEX Converter.
About	Displays software version number.
Help	Opens on-line help system.

Converting RINEX to Ashtech Format

Rinex files from any GPS receiver can be converted to Ashtech format for post-processing. The following procedure specifies how to convert RINEX data files to Ashtech format.

1. In the **RINEX to Ashtech** dialog box, click **Input di**r to open the **Set input directory** dialog box (Figure B.2).

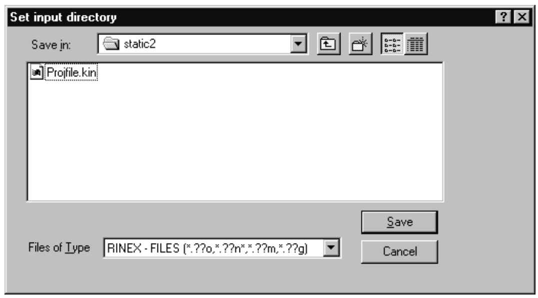


Figure B.2. Set Input Directory Dialog Box

2. Using standard Windows file navigation procedure, navigate to the directory where the RINEX input files are located and then click **Save**.

If you are converting RINEX files translated from a RINEX converter that does not use the standard RINEX naming format, the observation files may not have the format *.*O. If the files are not listed in the Available Files list, change the File Types to All Files on the Rinex to Ashtech tab and All Files in the Input Directory.

3. The **Set Input** directory dialog box closes. The **Input Directory** list lists the directory path, and the **Available Files** list lists the RINEX files in the input directory (Figure B.3).

Depending upon the type of file (i.e. Obs or Nav), the **OBS**, **NAV**, **B-File** and **E-File** fields populate with suggested file names. **Nav g**, **Met**, and **S-file** names may also appear if the information is contained in the Rinex file.

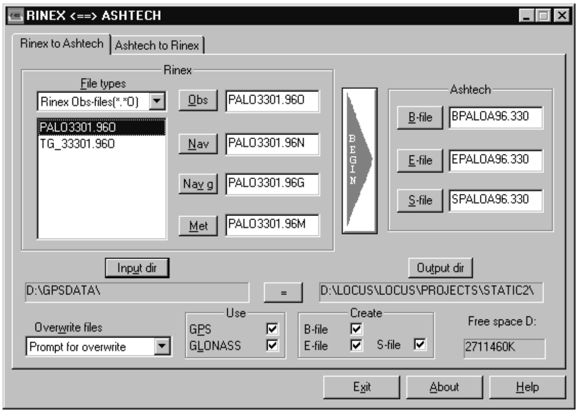


Figure B.3. Rinex-to-Ashtech Dialog Box with Suggested Output File Names

4. Click **Output dir** to open the **Set Output directory** dialog box (Figure B.4).

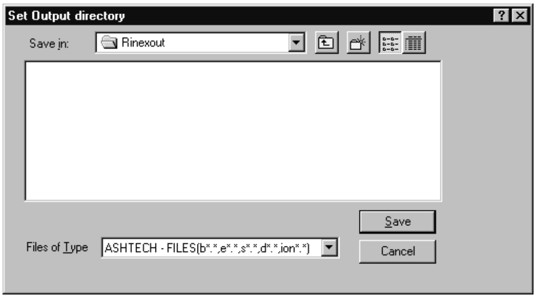


Figure B.4. Set Output Directory Dialog Box

5. Using standard Windows navigation procedure, navigate to the directory where you want to store the converted files, and then click **Save**.

To avoid confusion, save the converted Ashtech files to a directory different than where the RINEX files are located.

The **Output Directory** list lists the directory path.

To avoid confusion, do not change the suggested file names. To restore the original suggested output file name, double-click the filename in the available files list.

6. Select the **Overwrite files** option by clicking the arrow to the right of the **Overwrite files** list, and selecting an option from the list. There are three overwrite options:
   - **Prompt for Overwrite** - (Default setting). If RINEX Converter detects that a converted file has the same name as an existing file, meaning the new file will overwrite the existing file, a dialog box asks if you wish to overwrite the existing file. If you click NO, RINEX Converter skips the file, and continues to the next file.
   - **Always Overwrite -** This option always writes over existing files with a new file.
   - **Never Overwrite -** This option does not overwrite data for a given file if a file with the same name already exists.

   By default, RINEX Converter assumes that the RINEX files use both GPS and GLONASS (Nav g) data; however, there is no Nav g file unless a GLONASS receiver was used to collect data.

   By default, RINEX Converter creates a B-File (GPS position data), an E-File (satellite ephemeris), and an S-File (site parameters, if recorded) in Ashtech format. If you do not want one or more of these file types created, click the corresponding check boxes to remove the check mark. Be aware that the S-file is not created unless the site information is recorded in the receiver file.
7. Click **BEGIN** to convert the selected RINEX files to Ashtech format. The **Conversion status** dialog box opens (Figure B.5).

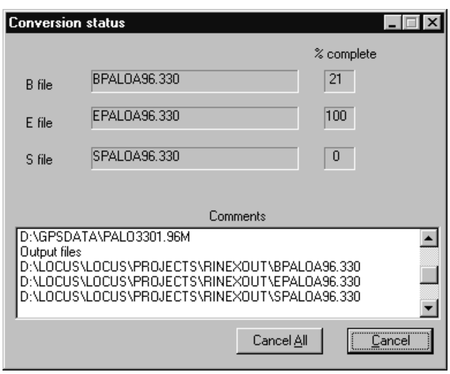


Figure B.5. Conversion Status Dialog Box

8. The **Conversion status** dialog box shows the status of each file as it is converted. Upon completion, the display indicates 100% for each file, or 0 if a file were not converted for lack of data, e.g. GLONASS data, as noted above.
    - Click **Cancel** to cancel the conversion to the current file type and proceed to the next file type.
    - Click **Cancel All** to cancel the entire conversion.
9. A *.log file is created in the directory containing all conversion activity. When restarted, RINEX converter overwrites the existing log file. To save the old log file, rename or move the file before restarting RINEX Converter.

The selected RINEX files are now in Ashtech format and can be used with data files from Ashtech receivers for post-processing.

Converting Ashtech Files to RINEX Format

RINEX Converter can convert Ashtech files from any GPS or GPS+GLONASS receiver into RINEX format. The following procedure describes how to convert Ashtech files to RINEX format.

1. Click the **Ashtech to RINEX** tab to switch to the **Ashtech to Rinex** tab (Figure B.6).

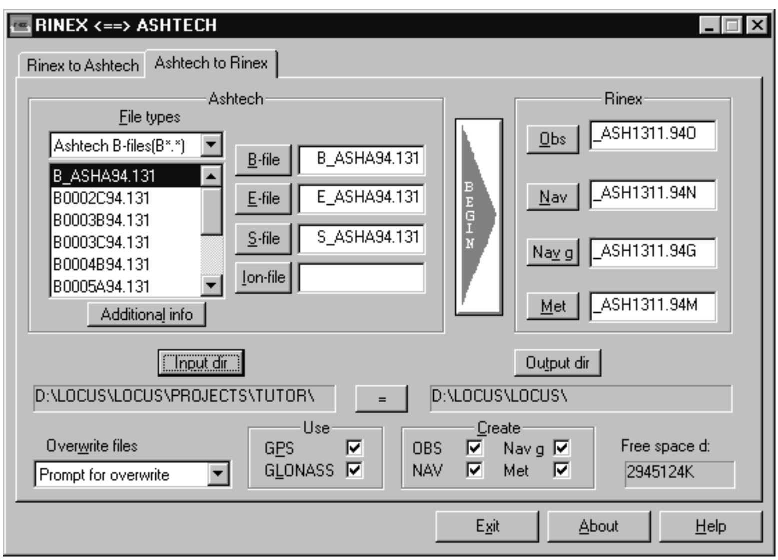


Figure B.6. Ashtech to Rinex Dialog Box

Table B.2 describes the fields in the **Ashtech to RINEX** dialog box.

Table B.2. Ashtech to RINEX Dialog Box Fields

Item	Description
File Types	Lists the files types: Ashtech B-Files (B*.*), Ashtech E-files (E*.*), Ashtech S-files (S*.*) or All files (*.*). To select a file type, click the arrow to the right of the field and select file type from the list presented.
Available files list	This is the white area below **File Types**. Lists files in current directory. To select a file, click on the file. To select multiple files, select the first file and then hold the **Ctrl** key while selecting additional files with the cursor.
B-File	This field lists the file name of the B-File corresponding to the selected Ashtech data file in the available files list.
E-File	This field lists the file name of the E-File corresponding to the selected Ashtech data file in the available files list.
S-File	This field lists the file name of the S-File corresponding to the selected Ashtech data file in the available files list.
BEGIN Button	Click this button to open the **Conversion Status** dialog box and begin converting the Ashtech files to RINEX file format.
Obs	This field lists the suggested file name for the converted observation data file.
Nav	This field lists the suggested file name for the converted navigation data file.
Navg	This field lists the suggested file name for the converted GLONASS navigation data file.
Met	This field lists the suggested file name for the converted meteorological data file.
Input dir	Click this button to open the **Set input directory** dialog box. See next entry in this table.
Set input directory	This combo box lets you select the directory where the converted files will be stored.
=	Click this button to set the output directory the same as the input directory.
Output dir	Click this button to open the **Set output directory** dialog box. See next entry in this table.
Set output directory	This combo box displays the directory path where converted RINEX files are stored.

Table B.2. Ashtech to RINEX Dialog Box Fields (continued)

Item	Description
Overwrite files	Select the overwrite options: Prompt for overwrite, Always overwrite, or Never overwrite. To select an overwrite option, click the arrow D at the right end of the field and select an overwrite option from the list presented.
GPS	Click this box if GPS data will be used in conversion. This option is on by default.
GLONASS	Click this box if GLONASS data will be used in conversion (on by default). There will be no GLONASS data unless a GLONASS receiver was used to collect data.
Obs	Click this box to create an observation file when converting to RINEX.
Nav	Click this box to create a navigation file when converting to RINEX files.
Navg	Click this box to create a GLONASS navigation file when converting to RINEX.
Met	Click this box to create a meteorological file when converting to RINEX. Will be created only if meteorological data available.
Free Space	This field displays the disk drive space available for the selected output directory.
Exit	Close RINEX Converter.
About	Opens the dialog box which displays the software version number.
Help	Opens the on-line help system.

2. Click **Input dir** to open the **Set input directory** dialog box (Figure B.7).

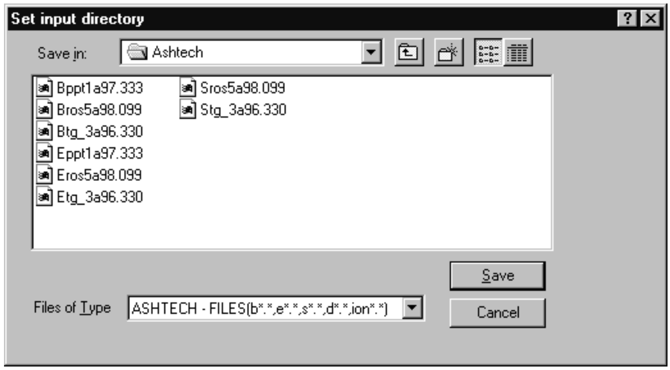


Figure B.7. Set Input Directory Dialog Box

3. Using standard Windows navigation procedure, navigate to the directory that contains the Ashtech files you wish to convert.
4. Click **Save** to accept the directory and close the **Set Input Directory** dialog box.
5. The **Input Directory** lists the directory path, and **Available Files** list lists the Rinex files in the input directory (Figure B.8).

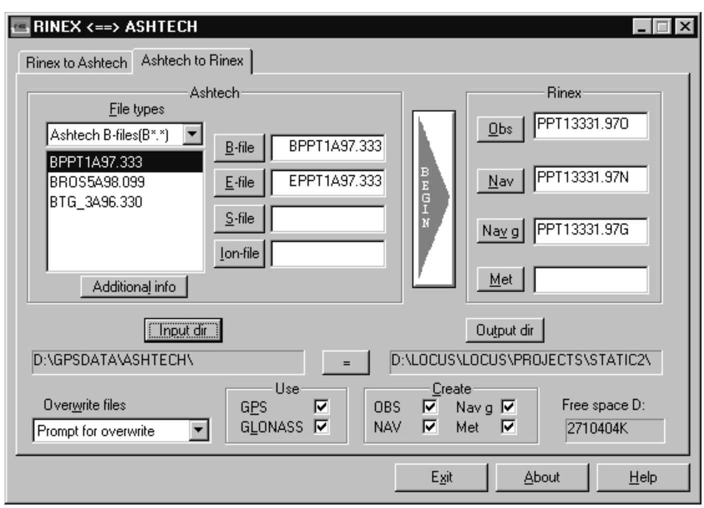


Figure B.8. Ashtech Files in Selected Ashtech Input Directory

6. Select the file(s) you wish to convert to RINEX in the **Available Files** list.

   You can select multiple files by holding down the **Ctrl** key while selecting files with the cursor and clicking the mouse button.

   After selecting a file(s) to convert, the **B-File**, **E-File**, **S-File**, **OBS**, **NAV**, **NAVG**, and **MET** fields, as applicable to the data in the file, populate with suggested file names. If you selected multiple files, the filenames listed are associated with the last file selected.

To avoid confusion, do not change the file names.

7. Click **Output dir** to open the **Set output directory** dialog box (Figure B.9).

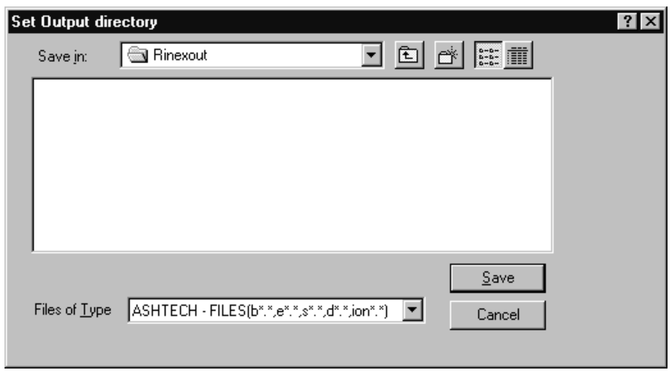


Figure B.9. Set Output Directory Dialog Box

8. Using standard Windows navigation procedure, navigate to the directory where you want to store the converted files.

To avoid confusion, save the converted Ashtech files to a different directory than where the RINEX files are located.

9. Click **Save** to accept the directory and return to the **Set input directory** dialog box.

   The **Output Directory** field lists the directory path.

10. Click **Additional Info** to open the **Additional info for selected files** dialog box to the **OBS** Tab (Figure B.10).

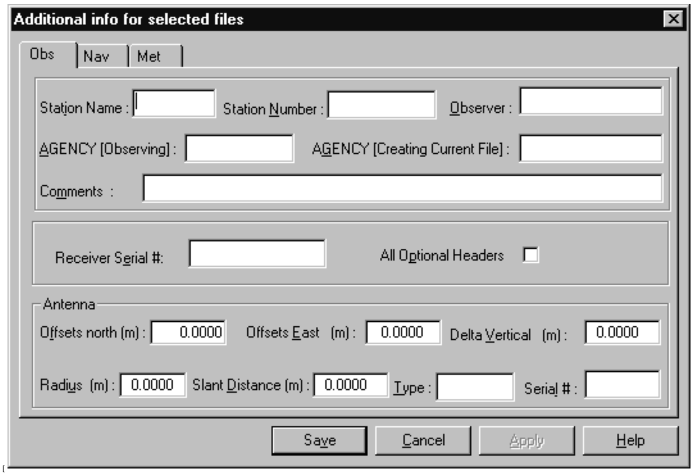


Figure B.10. Additional Info for Selected Files Dialog Box - OBS Tab

The information listed in these tabs are stored in RINEX files to give you reference information about the data. Although this additional information is optional, it provides a useful reference for future use.

11. Complete the fields in the **OBS** Tab. The information entered in the **OBS** dialog box is stored in the observation data file. Table B.3 describes each field.

Table B.3. Additional Info for Selected Files Dialog Box - OBS Tab

Field	Description
STATION INFORMATION	
Station Name	Name of the survey point or station where data was collected.
Station Number	Number of the survey point or station where data was collected.
Observer	Name or code of the surveyor who collected the data.
AGENCY (Observing)	Name of the company or agency who collected the data.
AGENCY (Creating Current File)	Name of the company or agency who converted the data to RINEX.
Comments	Any comments pertaining to the station, data quality, cover, GPS/GLONASS, etc. 50-character length limit.

Table B.3. Additional Info for Selected Files Dialog Box - OBS Tab (continued)

Field	Description
RECEIVER INFORMATION	
Receiver Serial #	Serial number of the receiver that collected the data.
All Optional Headers	Check this box if you want all non-mandatory fields to be filled in the RINEX file header.
ANTENNA INFORMATION	
Offsets north (m)	Horizontal distance, in meters, that the antenna is offset from the marker in the north/south direction. + is north, - is south.
Offsets East (m)	Horizontal distance, in meters, that the antenna is offset from the marker in the east/west direction. + is east, - is west.
Delta Vertical (m)	True vertical distance, in meters, between the bottom of antenna and the marker.
Radius (m)	Radius of the antenna in meters.
Slant Distance (m)	Measured distance, in meters, from the edge of the antenna to the marker. If a value for an antenna are entered, it over-writes the values in the S-file.
Type	Type of antenna used in data collection.
Serial #	Serial number of antenna used for data collection.

12. Click **Apply** to save the changes made to the **OBS** tab, and click **Nav** to switch to the **Nav** tab (Figure B.11).

You can enter information for all three tabs and save all the data using the Save button. The best practice, however, is to save the data using the Apply button for each tab immediately after entering the data in case of a computer or power failure.

The Save button saves the data entered on the active tab only, and closes the Additional info for Selected Files dialog box.

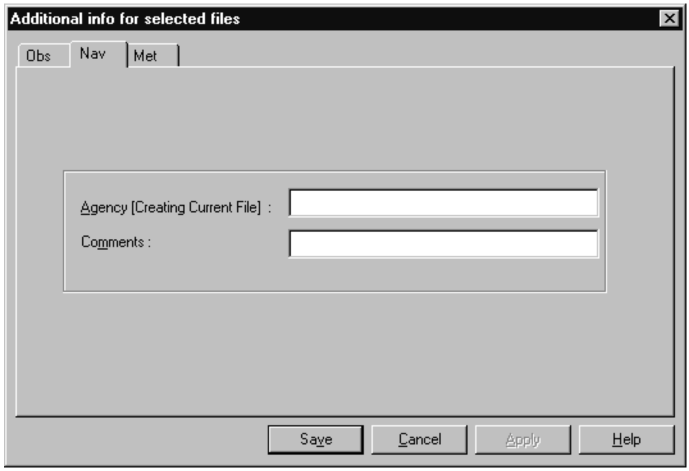


Figure B.11. Additional Info for Selected Files Dialog Box - NAV Tab

13. Complete the fields in the **NAV** dialog box. The information entered in the **NAV** dialog box is stored in the navigation data file. Table B.4 describes each field.

Table B.4. Additional Info for Selected Files Dialog Box - NAV Tab

Field	Description
Agency (Creating Current File)	Name of the company or agency who converted the data to RINEX.
Comments	Any comments pertaining to the station, data quality, cover, GPS/GLONASS, etc. 50-characters maximum.

14. Click **Apply** to save the changes made to the **NAV** dialog box, and click on the **MET** tab to switch to the **MET** tab (Figure B.12).

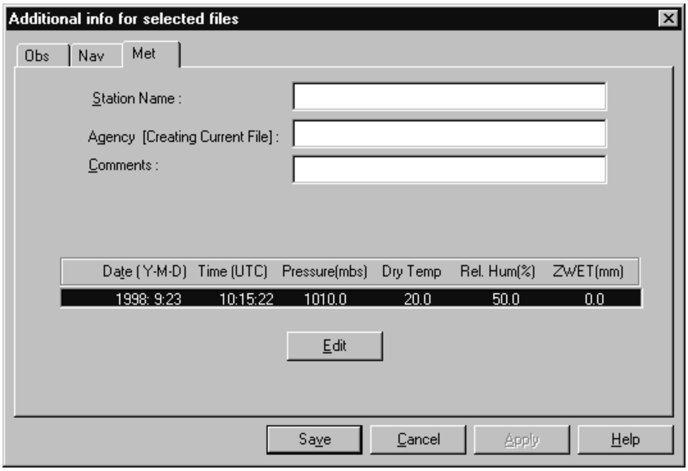


Figure B.12. Additional Info for Selected Files Dialog Box - MET Tab

15. Complete the fields in the **MET** dialog box. The information entered in the **MET** dialog box is stored in the meteorological data file. Table B.5 describes each field.

Table B.5. Additional Info for Selected Files Dialog Box - MET Tab

Field	Description
Station Name	Name of the survey point or station where data was collected.
Agency (Creating Current File)	Name of the company or agency that converted the data to RINEX.
Comments	Any comments pertaining to the station, data quality, cover, GPS/GLONASS, etc. 50-character limit.
Meteorological Data List	Date and time atmospheric data was collected (atmospheric pressure, temperature, relative humidity, and ZWET (Zenith Wet Tropospheric Delay).
Edit	Click this button to open the Edit dialog box and edit the selected meteorological data line.

16. Click **Edit** to open the **Edit** dialog box (Figure B.13) and inspect or change the meteorological data.

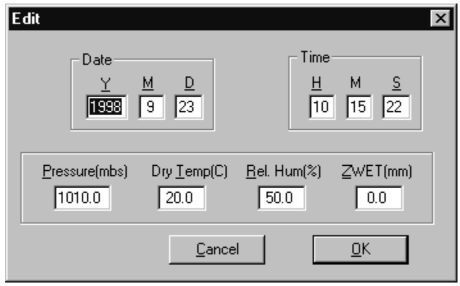


Figure B.13. Edit Dialog Box

17. Enter the meteorological data, the date and the UTC time that the data was taken, and click **OK**. Table B.6 describes the fields in the **Edit** dialog box.

Table B.6. Edit Dialog Box Parameters

Field	Description
Date	The year, month, and date that the data was recorded. D is the day of the month (not Julian day) the data was recorded.
Time	The time the data was recorded. H is the hour of the day the data was recorded in UTC time (24 hour time scale) M is the minute of the hour the data was recorded in UTC time. S is the second of the minute the data was recorded in UTC time
Pressure (mbs)	The recorded barometric pressure of the atmosphere in millibars.
Dry Temp (C)	The recorded temperature of the air not corrected for humidity, in degrees Celsius.
Rel. Hum (%)	The recorded relative humidity of the air in percent.
ZWET (mm)	Zenith Wet Tropospheric Delay—in millimeters (default = 0)

18. Click **OK** to accept the meteorological data and close the **Edit** dialog box.

19. Click **Save** to save the changes made to the **Met** tab and close the **Additional info for selected files** dialog box.
    - The **Apply** button saves any changes made to the active tab, and does not close the **Additional info for selected files** dialog box.
    - The **Save** button saves any changes made any tab, and closes the **Additional info for selected files** dialog box.
20. Click **Begin** to convert the selected Ashtech files to RINEX format. The **Conversion Status** dialog box opens (Figure B.14), showing the status of the conversion process. Upon completion, the dialog box indicates 100% for each file.

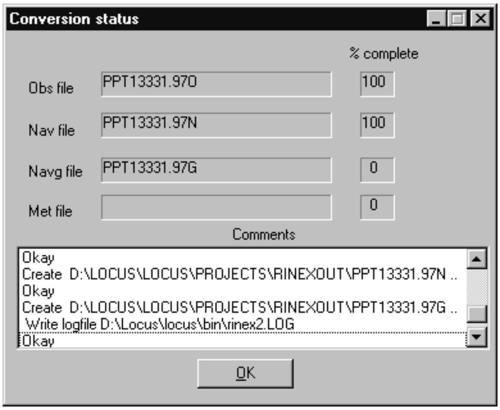


Figure B.14. Conversion Status Dialog Box

21. Click **OK**.

    A ***.log** file is created in the conversion directory. When started, RINEX converter overwrites the previous *.log file. To save the previous *.log file, rename or move the file before starting RINEX converter.

Converting More than One File at a Time (Batch Processing)

To convert more than one file at a time:

- If the files are contiguous, hold down the **Shift** key, select files with the cursor, and click each file.
- If the files are scattered throughout the directory, hold down the **Ctrl** key, select files with the cursor, and click each file.

C

Post-Adjustment Analysis

A least-squares adjustment of survey observations is one of the most important steps in a GPS survey. Properly used, a least-squares adjustment helps isolate blunders in the observations being adjusted and improves the accuracy and reliability of the point positions being determined. The mathematics and statistics involved in performing and analyzing a least-squares adjustment is somewhat complex but the basic concepts of the task accomplished by an adjustment are straight forward.

The primary components of a least-squares adjustment are the survey observations (angles, distances, elevation differences, and, in this case, GPS vectors) and the uncertainties (confidence) associated with these observations. Due to measurement limitations of the surveying instruments and the influence of the instrument operators, these observations include some level of error. These errors cause loops not to close perfectly and result in the ability to compute different positions for the same point in the network based on which observations were used to compute the position.

The ultimate goal of a least-squares adjustment is to produce a set of observations where all loops close perfectly and only one position can be computed for any point in the network. In order to accomplish this task, the observations going into the adjustment must be changed slightly, i.e. adjusted. Of course, you do not want the observations to be changed much since this it what was physically observed in the field, but the observations do contain some level of error. Any error associated with an observation is predictable because of the measurement accuracy of the survey instruments used. So, do not be concerned that the observations are adjusted as long as the amount of adjustment to any given observation is not significantly greater than the expected error in the observation. These are the fundamental guidelines to a least-squares adjustment. A successful adjustment is one where observations are changes as little as possible, and the amount of change (adjustment) to any observation is within expected levels, i.e. about the same magnitude as the uncertainty in the observation.

Unfortunately, there are a number of obstacles that can stand in the way of producing a successful adjustment. Primary on this list are blunders, errors in the observations due to equipment malfunction or operator error. Examples are an incorrectly measured instrument height, an instrument not properly centered over the survey mark, insufficient data to produce a high quality GPS vector, assigning the wrong Site ID to a point, etc. The list is long. Fortunately, tools exist to assist in overcoming these obstacles. These adjustment analysis tools have been incorporated into the adjustment module of Ashtech Solutions.

The adjustment analysis tools fall into two main categories, blunder detection tools and quality analysis tools. Each of these tools is explained in detail below. The explanation includes how the tool works, the purpose of each tool, and when to use each tool.

After discussion of the available analysis tools, there is a section describing the process of analyzing an adjustment. From start to finish, each step of the analysis process is listed showing the sequence of when and how to use the analysis tools.

Before proceeding, there are few things you must remember when analyzing an adjustment with this tool set.

1. Many of the analysis tools are statistically based. These statistically based tools utilize the GPS vector uncertainties (error estimates) as the basis for their testing. It is critical the observation uncertainties are realistic for the statistically based tools to function properly. Unrealistic uncertainties will cause the analysis tools to function unpredictably and, in the worst case, may make a bad adjustment look good.

   The vector-processing module is responsible for assigning uncertainties to the processed GPS vectors. A great deal of effort has gone into insuring that realistic uncertainties are determined. Unfortunately, this is not always an easy task and at times, the uncertainties may be a little optimistic (too small) or pessimistic (too large). Recognizing this, methods were developed to help identify when uncertainties are unrealistic and to help rectify this situation. These methods are explained in detail below.

2. Adjustment analysis tools cannot function properly without redundancy in the adjusted observations. It is impossible to detect a blunder in an observation establishing the position of a point if there is only one observation at this point. When designing a survey network, be sure to include sufficient redundancy in the observations. The best case would be to include more than one observation of each point being established. Unfortunately, this is not practical and really not necessary. Select a certain percentage of points to receive multiple observations. Thirty to fifty percent is recommended. This

redundancy will significantly increase the likelihood that observation blunders will be detected by the adjustment.

In the discussion of the analysis tools below, it is assumed that sufficient redundancy exists in the adjusted observations.

3. It is also important to remember that no analysis tool gives a definitive indication of the existence of blunders or the quality of an adjustment. No one tool should ever be solely relied upon. All tools must be used together for an effective analysis of an adjustment.
4. Blunder detection should always be performed on minimally constrained adjustments. Attempting to detect blunders in a constrained adjustment is very difficult since a detected problem can either be caused by a blunder or a error in the control position fixed in the adjustment. The first step in the adjustment process should always be a minimally constrained adjustment. Use this adjustment to detect and eliminate blunders from the data set, and determine the internal quality of the survey data. After the data set is clean of blunders and it is determined that the survey meets the relative accuracy specification, a constrained adjustment can be performed.

   In the discussion of blunder detection tools below, it is assumed that the tools are being used on a minimally constrained adjustment.

Blunder Detection Tools

The blunder detection tools are designed to assist you in detecting problems with an adjustment. The tools assist in determining if blunders exist in any of the observations used in the adjustment, or if any problems exist in the network construction that would hamper the ability for an adjustment to be performed. Each tool is presented in detail below.

Network Connectivity Test

In order to properly adjust an entire data set of observations, there must be connectivity between all sections of the data set. For example, look at a survey of a pipeline that will require multiple days of work to complete. Two survey crews begin work on the project, one on the north end and one on the south end. At the end of day 1, each crew will have a surveyed a number of points at each end of the project. The two data sets have no observations between them yet. These two data sets cannot be adjusted together because they are not connected.

The network connectivity test examines the data set prior to adjustment to determine if there are subsets of the data set that are not connected by observations.

Variance of Unit Weight/Standard Error of Unit Weight

The Variance of Unit Weight and the Standard Error of Unit Weight (the square-root of the Variance of Unit Weight) monitor the relationship between the uncertainties assigned with the observations and the magnitude of the change required to each observation (residuals) in the adjustment. Changes to the observations should be small and should not be significantly greater than the uncertainties associated with the observations.

The Variance of Unit Weight and Standard Error of Unit Weight gauge the magnitude of the observation changes (residuals) compared to the observation uncertainties for the entire network. Analysis of the magnitude of the computed Variance of Unit Weight and Standard Error of Unit Weight reveals one of the following three conditions regarding the quality of the adjustment:

1. A computed value close to 1 is an indication that the changes to the observations (residuals) are within expected levels, i.e. within the uncertainties associated with the observations. Since this is the desired outcome, a value close to 1 is normally an indication of a good adjustment.
2. A computed value significantly smaller than 1 indicates an imbalance between the observation residuals (changes) and observation uncertainties. Specifically, the observation uncertainties are too pessimistic (too large).
3. A computed value significantly larger than 1 is also an indication of an imbalance between the observation residuals (changes) and observation uncertainties. Specifically, one of two problems exist with the adjustment. Either one or more blunders exist in the observations causing the observation residuals to be much larger than the observation uncertainties, or the observation uncertainties are too optimistic (too small).

To fully comprehend the significance of a Standard Error of Unit Weight being significantly smaller or larger than 1, it is first imperative that any observation blunders that may exist in the observations be removed from the adjustment. Later in this chapter you will find additional tools that are specifically designed to isolate blunders. With the absence of blunders in the network observations, the magnitude of the Standard Error of Unit Weight can be examined to determine its significance. In a blunder free adjustment, the magnitude of the Standard Error of Unit Weight the magnitude of the disagreement between the uncertainties associated with the observations and what the adjustment determines should be the observation uncertainties.

For example, if the Standard Error of Unit Weight is computed to be 2 and the adjustment is blunder free, the adjustment had determined, based on the size of the observation residuals, that the observation uncertainties should be 2 times larger than they are currently stated to be. If the computed Standard Error of Unit Weight is 0.5, then the observation uncertainties should be 2 time smaller than they are currently stated to be. Why is this important? For two reasons:

1. Many of the tools used to analyze the quality of the adjustment are statistically based. For them to work properly, the observation uncertainties going into the adjustment must be realistic, i.e. close to the real uncertainties. The Standard Error of Unit Weight computed from a blunder free adjustment gives an indication of the quality of the observation uncertainties. If the Standard Error of Unit Weight is much greater than or smaller than 1, this is an indication that the observation uncertainties are not realistic. Fortunately, Ashtech Solutions automatically compensates for this problem. All post-adjustment statistics used to measure the quality of the adjustment utilize the computed value for the Standard Error of Unit Weight to automatically compensate for unrealistic uncertainties. No action on the part of the user is required.
2. A great deal of effort went into ensuring that the vector processing of Ashtech Solutions assigned realistic uncertainties to the processed vectors. But since this is not yet an exact science, there are conditions that may cause the computed uncertainties to be too small or too large. In most cases, you should find that the computed Standard Error of Unit Weight falls between 1 and 3. In addition, you should find that this value is relatively consistent for similar types of surveys. If you find that for most of your surveys, the Standard Error of Unit Weight for a blunder free adjustment is 1.5 and today you are working on an adjustment with a Standard Error of Unit Weight of 6, there probably is something wrong with the adjustment.

Chi-Square Test

The Chi-Square test is a statistical test evaluating the computed value for the Variance of Unit Weight. Its purpose is to determine if the computed value for the Variance of Unit Weight is statistically equivalent to 1. As stated earlier, a Variance of Unit Weight equal to 1 indicates a balance between observation residuals and observation uncertainties. It is very seldom that the computed value for the Variance of Unit Weight will exactly equal 1. But an exact value of 1 is not required. The Chi-Square test examines the computed value to determine if it is statistically equivalent to 1. If the test passes, the computed value is considered equivalent to 1.

Due to the difficulties in computing observation uncertainties due to the many variables involved, in many cases the Variance of Unit Weight will be larger or smaller than 1. This causes the Chi-Square test to fail. Ashtech Solutions automatically compensates for observation uncertainties being too large or too small, therefore the passing or failure of the Chi-Square test has no true bearing on the quality of the adjustment. If, by using the other blunder detection tools available, you are confident that all blunders have been removed from the adjustment and you are happy with the relative size of the observation residuals, then a failure of the Chi-Square test should not be a concern. The Chi-Square test can be made to pass, if desired, by scaling the observation uncertainties using the **Processed vector error scaling factor** found in the **Miscellaneous** tab of the **Project Settings** dialog box. Scale the vector uncertainties by the computed Standard Error of Unit Weight.

Observation Residuals

In a least-squares adjustment, small corrections are applied to the observations to obtain the best fit of all observations producing one solution for all points. The best fit is the solution that produces the least amount of corrections to the observations. These small corrections are termed residuals. Each observation will have one or more residuals. GPS observations have three residuals, one for each component of the GPS vector (X,Y,Z or N,E,U).

The reason that observations have to be corrected at all in order to produce a good fit is due to errors in the observations. If observations contained no errors, than an adjustment would not be needed. All observations would fit together perfectly. Two types of errors can be found in survey observations, random errors and blunders. Random errors will cause small corrections to be needed in observations in order to make them fit together properly. If only random errors exist in the data set, all residuals will likely be small. On the other hand, if large blunders exist in the data set, large residuals will likely be produced.

Examining the size of observation residuals can help in identifying blunders in the observations used in the adjustment. Ashtech Solutions will display and output the residuals for all observations. These residuals should be examined in an attempt to identify blunders. If blunders are identified, they must be removed from the data set, and the adjustment rerun. If the observation containing the blunder is a critical observation of the data set, it should be examined to determine the cause of the blunder. Once repaired, the observation can be returned to the adjustment. If the observation is critical to the strength of the network and cannot be repaired, the data will need to be re-observed.

There are two main difficulties in using residuals to identify blunders in a data set.

1. Blunders, if large enough, will produce large residuals for the observation containing the blunder. But large residuals do not always indicate a blunder, in an observation. It is possible for a good observation to have large residuals. This obviously complicates the use of residuals to find blunders but this obstacle can be overcome with the understanding of why a good observation will produce large residuals.

   A least-squares adjustment tends to distribute the effects of blunders throughout the entire network. In other words, a blunder in one observation usually affects the residuals in other observations. The affect is greater on observations closer to the blunder and diminishes further out. The trick is to find the observation with the blunder among all the observations containing large residuals due to the blunder.

In most cases, the observation with the largest residuals is the observation containing the blunder. Remove this observation and rerun the adjustment. If all residuals look good at this point, the blunder was identified and removed. If large residuals still exist, again remove the observation with the largest residuals and rerun the adjustment. Do this until the adjustment looks good. It is possible that some of the observations removed do not contain blunders. At this time, each observation removed should be added back to the adjustment one at a time, rerunning the adjustment each time an observation is added. If the adjustment looks good, that particular observation did not contain a blunder. If the adjustment looks bad after adding back one of the observations, the chances are very good that the observation contains a blunder.

This process can be complicated even further if multiple blunders exist in the data set. But systematic removal and replacement of observations will result in identifying the blunders.

2. Throughout this section, we have talked about large residuals and their roll in identifying blunders. A natural question is 'What is a large residual?'. Unfortunately, there is no easy answer to this question. For GPS vectors, random errors in the observations increase as the length of the vector increases. Therefore, residuals will increase with baseline length. A residual of 0.10 meters on a 20-kilometer line may solely be due to random errors but the same residual on a 2-kilometer line almost surely indicates a blunder. So, a residual being large or small is dependent on the GPS vector length.

   There are a few guidelines that can be used to help examine residuals. First, all vectors of similar length should have similar residuals. Second, residuals should not be much greater than the measurement accuracy of the equipment. For example, if the equipment being used is capable of making observations at an accuracy level of 0.01m + 2ppm, the residuals for an observations should not be much greater than this capability. An accuracy specification of 0.01m + 2ppm allows for an error of 0.03m on a 10 kilometer baseline. A residual 2-3 times larger than this allowable error is suspect and should be examined closely for the possible presence of a blunder.

   Sometimes the size of a residual will be border line as to whether or not a blunder exists. If this is the case, the observation should be inspected closely to see if the cause of the blunder can be determined. If not, it is a judgement call as to whether or not the observation should be removed. If the observation is not critical to the strength of the network, it can be removed without impact. If the observation is needed but does not seem to have an adverse affect on the accuracy of the adjusted points, it can be left in.

The program presents residuals in two forms. You can examine the size of the residual in linear units (meters or feet) as discussed above, or you can examine normalized residuals. Normalized residuals take into account that residuals generated by random errors are somewhat predictable statistically. Normalized residuals are unitless scaled values of the actual residual. Evaluation of the normalized residuals will reveal one of three things:

1. A value of 1 indicates that the residual is as large as expected based on its standard error. This is usually an indication that the observation contains no blunders.
2. A value of less than 1 indicates that the residual is smaller than expected. This also is usually an indication that the observation contains no blunders.
3. A value greater than 1 indicates that the residual is larger than expected. For example, a value of 2 indicates the residual is 2 times larger than expected, and a value of 3 indicates that the residual is 3 times larger than expected.

   Since residuals are expected to be normally distributed, approximately 68% of residuals caused by random errors should only have a normalized value of 1 or less, approximately 95% should be 2 or less, and approximately 99% should be 3 or less. Therefore, a normalized residual greater than 3 is either one of the 1% that is caused by random errors (good residual) or represents an observation containing a blunder.

   Since there is such a small chance that a normalized residual greater than 3 belongs to a good observation, any normalized residual greater than 3 should be suspect and examined as being a potential blunder.

The normalized residual is an alternative to looking at the size of the residual to determine if the residual belongs to an observation that contains a blunder. In some aspects, the normalized residual is easier to evaluate since vector length is compensated in the scaling of the residual. A value greater than 3 should be suspect, independent on the length of the vector.

In summary, use observation residuals to help identify blunders in the adjustment data set.

- If all residuals are small or if the normalized residual is less than 3, this is a good indication that no blunders exist.
- If large residuals are found or normalized residuals greater than 3, blunders may exist in the data set. Remove the observation with the largest residuals or normalized residuals and rerun the adjustment. Repeat this one observation at a time until the residuals for the remaining observations look good. Since good observations may have been removed in this process, add each observation back into the network one at a time, and examine its affect on the adjustment. Those observations

returned to the network that do not adversely affect the adjustment should be left in.

- Closely examine any observation that has been removed to determine if the cause of the blunder can be determined. If yes, fix the blunder and return the observation to the adjustment.
- Be aware that these are only guidelines to finding blunders. Do not remove an observation from the adjustment just because the normalized residual is 4 or 5 or the residuals look large. This could represent a good observation. Look at other quality indicators to determine if there is a problem in the adjustment. Remove the observation and see what the effect is on the adjustment. If there is no great affect on other observations or position estimates, put the observation back. The more good observations in the data set, the better the final solution.

Tau Test

Examining residuals is a good indicator of the quality of individual observations. As stated earlier, the expected value of residuals/normalized residuals are predictable since they are expected to follow a normal distribution.

The tau test utilizes this predictability to automatically test the residuals of an observation to determine if the residuals could represent an observation containing a blunder. The tau test utilizes the normalized residuals for an observation to determine if statistically the residual is within expected limits. A threshold value is computed to test each normalized residual against. Each normalized residual is tested with two possible outcomes:

- The tau test passes indicating that the magnitude of the normalized residual is not greater than the expected limit for the residual. This is usually a good indication that the observation is free of blunders.
- The tau test fails indicating that the magnitude of the normalized residual is greater than expected. The observation failing the test should be checked for blunders.

The tau test is automatically performed by the adjustment module of Ashtech Solutions. Each residual is tested and the outcome of the test is presented along with the residuals for each observation.

It is important to understand, that if a residual does not pass a statistical test, it does not mean that there is a blunder in that observation. The observation is merely flagged so that it can be examined and a decision about its retention or rejection can be made. Blind rejection is never recommended. A blunder in one observation usually affects the residuals in other observations. Therefore, the tests will often flag other observations in addition to the ones containing blunders. If one or more observations are flagged, the search begins to determine if there is a blunder.

In summary, the tau test examines observation residuals in an attempt to locate observations that may contain blunders. Each residual is tested to determine if it passes or fails the test.

- If a residual passes the tau test, this is a good indicator that the observation does not contain blunders.
- If the residual fails the tau test, the observation should be closely examined to determine if it contains a blunder.
- Remember that if a residual fails the tau test, this is not a certain indicator that a blunder exists. Simply removing observations that have failed the tau test is not recommended. These observations must be examined carefully to determine if a blunder exists.

Loop Closure Analysis

In a well designed survey network, a number of closed loops, generated by GPS vectors, will exist. If all observations contained zero error, performing loop closures with various vectors throughout the network would result in loops with zero misclosure. Since in the real world, absolutely perfect survey observations are impossible, loops will generate some level of misclosure. Misclosures due to random errors in the observations should be of predictable magnitude, i.e. a magnitude similar to the measurement accuracy of the instrument used. Misclosures due to blunders are unpredictable in magnitude, ranging in size based on the size of the blunder. Due to this, loop closures can be an effective method to isolate blunders in the data set.

When a large blunder or multiple blunders exist in a data set, it is sometimes difficult to find the blunder(s) from analysis of the adjustment output. This is due to the tendency of least-squares adjustments to distribute the error from these blunders throughout the survey network. In such cases, loop closures can be an effective tool to assist in isolating the blunders. By performing multiple loop closures in the area where a blunder(s) is suspected to exist, the vector(s) causing the blunder(s) can normally be isolated. Once the problem vector(s) is isolated, it can be examined and repaired or removed.

Ashtech Solutions supplies the tools for you to perform a loop closure analysis of the survey network to assist in isolating blunders. By selecting vectors, you can create multiple loops throughout the network. The results of each loop closure are presented for analysis. In addition, the resulting closure is compared to you defined relative accuracy specification as a quality test of the closure.

- If the misclosure is smaller than the allowable error determined from the specification, the QA test passes. This may be an indication that no blunders exist in the vectors used in the loop. This would not be true if the blunder is the kind that would not be found based on the vectors used in the test. For example, if a blunder of 0.5 meters existed in the HI measurement at a point, all vectors observed during that session would contain the blunder. Therefore, if a loop closure were performed using these vectors, the blunder would not be found. On the other hand, suppose that same point was observed at another time producing a different set of vectors going into the point. If a loop was performed using a combination of the vectors from the two observation periods, this blunder would be detected.

- If the misclosure is larger than the allowable error determined from the specification, the loop fails the QA test. Flagged loops should be examined closely to determine if a blunder exists in one of the vectors used in the loop.

Repeat Vector Analysis

When performing a GPS survey, it is recommended that a certain percentage of observed vectors be repeated, i.e. observed more than once. These repeat vectors can be used to analyze the repeatability of the observations, giving a clue to the overall quality of the final survey. In addition, repeat observations can be useful in identifying blunders if a problem arises with one of the repeated observations.

Ashtech Solutions automatically performs an analysis of all repeat vectors in the network. All repeat vectors are compared to each other and differences in the observations are presented for analysis. In addition, the resulting differences between repeat observations are compared to the user-defined relative accuracy specification.

- If the difference between the repeat observations of a vector is smaller than the allowable error computed from the accuracy specification, the repeat vectors pass the QA test. This is normally a good indication that no blunder exists in the vectors, and that the vectors are of sufficient quality to produce a network that will meet the desired relative accuracy.
- If the difference between the repeat observations of a vector is larger than the allowable error computed from the accuracy specification, the repeat vectors are flagged as having failed the QA analysis test. Any repeat observations that fail the test should be examined closely to determine if a blunder exists.

Control Tie Analysis

For many surveys, there is a requirement to tie the survey into a local, regional, or national control network. Many times, the exact control points to be used for this purpose will be specified. To meet this requirement, these control points will need to be held fixed in the final constrained adjustment, therefore computing positions for the new survey points in relation to the specified control points.

In addition to the requirement for tying into a control network, most surveys will also have a relative accuracy specification that must be met. Under certain circumstances, these two requirements may conflict with each other. If the relative accuracy of the control points held fixed in the constrained adjustment is not greater than or equal to the relative accuracy specification of the survey, there is no hope to meet the relative accuracy specification by holding these control points fixed. The error in the relationship between the control points will, when held fixed in the constrained adjustment, induce this error into the survey network being adjusted, degrading the accuracy of the network to the relative accuracy of the control. For example, if after performing a minimal constraint adjustment, the relative accuracy of the survey is found to be 1:250,000, and if a constrained adjustment is performed holding fixed control points with a relative accuracy of only 1:90,000, the highest possible resulting network accuracy will be 1:90,000. If the relative accuracy specification for the survey was 1:100,000, the survey no longer meets the requirement. This, of course, is of no fault of the surveyor. The surveyor conducted a survey that has an internal relative accuracy of 1:250,000. The control points specified in the requirements are the cause of the degradation in the accuracy. At this point, the surveyor should inform the client of the issue. It then becomes the client's responsibility to determine if these control points are held fixed at the cost of the network relative accuracy.

In a situation where multiple control points have been specified for use in the survey, it is possible that only one of the control points is responsible for the degradation. It is possible that only one of the control points has a relative accuracy of 1:90,000 compared to the other points, and that the other control points tie to an accuracy that would support the relative accuracy specification. In such a case, it would be useful to know which point is causing the problem. This way, if allowed by the client, this point could be disregarded and a final constrained adjustment could be performed using the remaining control points. To do this, you would have to compute the relative accuracy between all control points in the survey.

The control tie analysis feature automatically computes the relative accuracy between control points. This is accomplished by holding one of the control points fixed in the minimally constrained adjustment and comparing the adjusted position of the other control points to the known control position. The difference between the positions is computed and presented along with the relative accuracy, based on the distance between the control points tested. A test then compares the user-entered relative accuracy specification to the computed relative accuracy for each pair of control points.

- If the QA test passes, the computed relative accuracy of the tested control point pair meets or exceeds the relative accuracy specification. This is an indication that holding this pair of control points fixed will not degrade the relative accuracy of the network below the required relative accuracy for the survey.

- If the QA test fails, the computed relative accuracy of the control point pair is of lower accuracy than the relative accuracy specification. Holding these two control points fixed in an adjustment will cause a degradation of the network accuracy below the required accuracy specification. In such a case, the control points should be examined in detail to determine if a blunder occurred during entry of the control values. If no blunder is found, a decision must be made to determine if these points should be held fixed in the final constrained adjustment, i.e., do not hold the problem control points fixed in the final adjustment, or hold them fixed despite their relative accuracy. This is normally a decision made by the final recipient of the adjusted network, i.e. the client.

Note that the control tie analysis is only valid on adjustments that are free of blunders. If blunders exist in the data set, the results of the adjustment do not represent the true relationship between the control points, and therefore, cannot be used in an analysis of the control.

Quality Analysis Tools

The quality analysis tools in the adjustment module are designed to assist you in determining the overall quality of an adjustment. The tools assist in qualifying the attained accuracy of the survey network. Each tool is described in detail below.

Relative Error

The main purposes for performing a least-squares adjustment are: 1) locate blunders in the data set, 2) compute the best position for all points in the survey, and 3) determine the accuracy of the newly established points. Relative error is one of the components used in determining the survey's positioning accuracy.

Relative error supplies an estimate to the uncertainty in the relative position of two adjusted points (site pairs) both in horizontal and vertical position. The vertical relative error of a site pair is one-dimensional, therefore it is represented by one number. The horizontal relative error of a site pair is two-dimensional, and is represented by two numbers which define a region in the horizontal plane.

Examining relative error between points gives you an indication as to the level of uncertainty in the relationship between the two points estimated by the adjustment. The adjustment module computes and presents the relative error between all site pairs linked together by a direct observation (GPS vector). Examine the horizontal and vertical relative errors. Look at their magnitudes and especially compare relative error values for site pairs which have similar distances between them. Site pairs with similar distances should have similar relative errors. If one site pair has a relative error significantly larger than others, this may indicate a problem with an observation of these points, or a lack of sufficient data to reliably position one of the points.

Relative Accuracy

The most common method of specifying the accuracy of a survey is in relative terms. For example, if the accuracy specification for a survey is 1:100,000 or 0.01m + 10ppm, this is a relative accuracy specification. It is classified as relative because it is distance-dependent. The relative accuracy specification refers to the relative accuracy between newly established points. If the relative accuracies between all point pairs (site pairs) are found to be 1:100,000 or better, the entire survey is said to meet the 1:100,000 accuracy specification.

To assist in determining the achieved relative accuracy of a survey, the adjustment module computes and presents the relative accuracy between all site pairs linked together by a direct observation (GPS vector). Compare each relative accuracy value to the relative accuracy specification of the survey:

- If all site pairs have a relative accuracy that exceeds that of the specification, the survey meets the required accuracy.
- If any site pair has a relative accuracy below the required accuracy specification, the observation between the site pair needs to be examined to determine if anything can be done to improve the relative accuracy. If needed, more observations may need to be collected to get the relative accuracy of the site pair achieve the required accuracy specification.

When analyzing the relative accuracy between site pairs, it is important to keep in mind the measurement capabilities of the equipment being used. This is especially important for equipment that has a measurement specification that includes a base error. GPS equipment falls into this category. On very short baselines, the base error may limit the attainable relative accuracy. The following example will illustrate this issue.

Assume that the measurement accuracy for a GPS system is specified as (0.010m+2ppm. The base error here is 0.010m. This means that you can expect to see an error of at least 0.010m on all measurements. The 2ppm (1:500,000) part of the specification is distance-dependent. The longer the length of the measurement, the greater the error. Using this specification, the expected error on a 10-kilometer observation would be 0.010m+(2ppm of 10,000 meters). This results in an expected error of 0.010m+0.020m for a total of 0.030m. An error of 0.030m on a 10-kilometer observation gives a relative accuracy of 1:333,333. If in this example the required relative accuracy of the measurement was 1:100,000 there is no problem.

Now assume a shorter measurement length. Using the same measurement accuracy of (0.010m+2ppm, let's look at a much shorter measurement. On a 1-kilometer observation, the expected error would be 0.010m+(2ppm of 1,000 meters). This results in an expected error of 0.010m+0.002m for a total of 0.012m. An error of 0.012m on a 1-kilometer observation gives a relative accuracy of 1:83,333. If, in this example, the required relative accuracy of the measurement were 1:100,000, the required accuracy was not met with this observation. Yet, the observation meets the measurement accuracy of the equipment. Nothing can be done to improve these results.

This example shows the problem encountered when working with relative accuracy specifications using only a relative term. All required accuracy specifications should include a base component. In the example above, if the required relative accuracy specification for the survey were changed from 1:100,000 to 0.010m+1:100,000, the 1-kilometer observation would have met the accuracy specification. The allowable error would have increased to 0.020m on a 1-kilometer observation using this new specification.

Site Pair QA Test

Site pairs are used to determine the relative accuracy of a survey. The relative accuracy is computed between each site pair linked together by a direct observation (GPS vector). The relative accuracy for each site pair is compared to the desired relative accuracy specification for the survey. If all site pair relative accuracies are better than the required accuracy, the survey is said to meet the accuracy specification.

The program lets you enter the desired relative accuracy specification for a survey. From this relative accuracy specification, a maximum allowable error is computed for each site pair based on the distance between the two sites. This maximum allowable error is then compared to the relative error computed for the site pair. If the relative error is smaller than the allowable error, the site pair meets the relative accuracy specification of the survey.

The program automatically tests each site pair to determine if the relative accuracy of the site pair meets the required relative accuracy of the survey. This test is termed the Site Pair QA test.

- If the test passes, the relative accuracy of the site pair tested meets or exceeds the relative accuracy specification of the survey. If all site pairs pass the test, then the entire survey can be said to meet the required relative accuracy specification.
- If the test fails, the relative accuracy of the site pair tested does not meet the relative accuracy specification of the survey. The observation between the site pair needs to be examined to determine if anything can be done to improve the relative accuracy. If needed, more observations may be

required to bring the relative accuracy of the site pair up to the required accuracy specification.

Uncertainties

One of the products of a least-squares adjustment is an estimation of the error associated with each adjusted observation (GPS vector) and each adjusted parameter (GPS points). These uncertainties can be examined to determine the quality of the final adjustment, and also to indicate problem areas in the adjustment.

The program computes and displays uncertainties for all adjusted observations and parameters. These uncertainties can be presented at two confidence levels, standard error and 95% error. Standard error defines an error region within which there is a 68% chance that the true value of the observation or parameter lies. 95% error defines an error region within which there is a 95% chance that the true value of the observation or parameter lies. The uncertainties are presented in both the horizontal and vertical frames of reference.

As part of the quality analysis of an adjustment, the uncertainties for adjusted vectors and points should be examined. Vectors of similar length should have similar uncertainties; points resulting from vectors of similar lengths should have similar uncertainties. Any vector or point having uncertainties that seem too large should be examined closely to determine the cause.

There is a move in industry circles to do away with relative accuracy specifications and adopt absolute accuracy specifications. The absolute accuracy specifications will define an allowable error for adjusted points vs. relative accuracy specifications which define an allowable error between points. To determine the absolute accuracy for adjusted points, the uncertainties for these points would be used. If the point uncertainties are smaller than the absolute accuracy specification, then the points and the survey meet the specification. If any point uncertainties are greater than the absolute accuracy specification, then the point and vectors leading to the point need to be examined to determine if anything can be done to lower the uncertainties. In may cases, this may require additional observations to the point.

Index

Symbols

Numerics

A

B

C

D

E

F

G

H

I

Q

R

S

T

U

V

W

Z