Congratulations on your purchase of Locus.

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 ____________________________

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

Locus Processor

User's Guide

Magellan Corporation
471 El Camino Real
Santa Clara, Ca. 95050-4300

Phone and Fax Numbers

- Main
  - Voice: 408-615-5100
  - Fax: 408-615-5200
- Sales
  - US: 800-922-2401
  - Fax: 408-615-5200
- Europe
  - Voice: 44-1753-835-700
  - Fax: 44-1753-835-710
- Support
  - US: 800-229-2400
  - Fax: 408-615-5200

Internet

- support@ashtech.com
- http://www.ashtech.com
- support@ashtech.co.uk

Ashtech

Printed in the United States of America.
Part Number: 630211-01, Revision A
October, 1998

FCC Notice

The equipment described in this manual has been tested pursuant to Part 15 of the FCC Rules and found to comply with the limits for a Class A digital device for use in commercial business, and industrial environments. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. The equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio and television reception. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, you can try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna.
- Relocate the receiver relative to the equipment which it interferes.
- Power the equipment from a different AC receptacle so that this equipment and the interfered equipment are on different branch circuits. If necessary, contact the Ashtech customer service department or an authorized representative for additional advice.

LIMITED EQUIPMENT WARRANTY

Ashtech Inc. warrants, to the original buyer only, that the equipment (herein "Product") purchased by the buyer (a) conforms to Ashtech's published specifications for the model purchased, and (b) is free from defects in material or workmanship. The duration of this warranty is one year from date of delivery and any claim for breach of warranty must be brought to Ashtech's attention within such one year period and any action on any such claim must be brought within 12 months from the date of delivery. Within a reasonable period of time after a claim, Ashtech will correct any failure of the Product to conform to specifications or any defect in materials or workmanship. If Ashtech is unable to repair the Product to conform to the warranty after a reasonable number of attempts, Ashtech will provide, at its option, one of the following: (a) a replacement Product or (b) full refund of the purchase price. A repaired or replaced product is warranted for 90 days from the date of return shipment, or for the balance of the original warranty period, whichever is longer. These remedies are the buyers exclusive remedies for breach of warranty.

To obtain warranty service, the buyer must return the Product, postage-paid, with proof of the date of original purchase and the buyer's return address to Ashtech Inc. or an authorized service center. Ashtech Inc. will not be responsible for any loss or damage to the product incurred while it is in transit or is being shipped for repair. It is the buyer's responsibility to arrange for insurance, if the buyer so desires.

Ashtech does not warrant (a) any product, components or parts not manufactured by Ashtech, (b) defects caused by failure to provide a suitable installation environment for the Product, (c) damage caused by disasters such as fire, flood, wind, and lightning, (e) damage caused by unauthorized attachments or modification, (f) damage during shipment, (g) any other abuse or misuse by the buyer, (h) that the Product will be free from any claim for infringement of any patent, trademark, copyright or other proprietary right, including trade secrets, (i) any failure of the Product to conform to published specifications arising directly or indirectly out of the Government's changes to/of control over the GPS or GLONASS system; (j) damage caused by failures or inaccuracies of the GPS or GLONASS system or its satellites.

THE FOREGOING WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND IF APPLICABLE, IMPLIED WARRANTIES UNDER ARTICLE 35 OF THE UNITED NATIONS CONVENTION ON CONTRACTS FOR THE INTERNATIONAL SALE OF GOODS.

In no case shall Ashtech be liable for any special, incidental, or consequential damages arising directly or indirectly out of the ownership, use or operation of the Product regardless of whether such damages are predicated or based upon breach of warranty, breach of contract, negligence, strict tort, or any other legal theory. Such damages include, but are not limited to, loss of profits, loss of savings or revenue, loss of use of the Product or any associated equipment, cost of capital, cost of any substitute equipment, facilities or services, the claims of third parties, including customers and injury to property. This limitation does not apply to claims for personal injury. Some states do not allow limits on warranties, or on remedies for breach in certain transactions. In such states, the limits in this paragraph and the preceding paragraph may not apply.

Unless modified in writing and signed by both parties, this warranty is understood to be the complete and exclusive agreement between the parties, superseding all prior agreements, oral or written, and all other communications between the parties relating to a warranty of the Product. No employee of Ashtech or any other party is authorized to make any warranty in addition to those made in this document. This warranty allocates the risks of product failure between Ashtech and the buyer. This allocation is recognized by both parties and is reflected in the price of the goods. The buyer acknowledges that it has read this warranty, understands it, and is bound by its terms.

This limited warranty is governed by the laws of the State of California, without reference to its conflict of law provisions or the U.N. Convention on Contracts for the International Sale of Goods.

SOFTWARE LICENSE AGREEMENT

IMPORTANT: BY OPENING THE SEALED DISK PACKAGE CONTAINING THE SOFTWARE MEDIA, 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 ASHTECH INC. ("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 License Agreement or the Limited Warranties and Limitation of Liability, please contact in wrrting: Magellan Corporation, 471 El Camino Real, Santa Clara, CA. 95050

Table of Contents

List of Figures

List of Tables

Introduction

What is the Locus Processor

The Locus Processor is a new, state-of-the-art automatic post-processing software package. It is extremely user-friendly, simplifying many of the office tasks, a fact which will be appreciated by novice and experienced users alike. The Locus Processor runs on the Windows 95/98 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, including:

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

The Locus Processor 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, Locus Processor continuously updates a graphical display to provide a a true representation of your fieldwork.

Role of the Locus Processor in Performing a GPS Survey

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

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

Where to Find Information

You can find information about Locus as follows:

- **Locus Processor -** this manual
- **Locus Receiver and Optional Handheld -** Locus System Manual
- **Tutorial**
- **On-line help**

How to Use This Manual/Conventions

This manual assumes a basic familiarity with standard Windows™ operating procedures. If you are new to Windows™, please refer to the Microsoft Windows™ literature for information on setup and getting started.

System Requirements

Table 1.1 defines the requirements for your office personal computer (PC).

Table 1.1: Office PC System Requirements

Parameter	Requirement
CPU	Pentium 90 MHz or faster. Locus Processor runs on a slower Pentium or an older 486, but productivity will be impaired.
Operating system	Windows 95, 98, or NT 4.0
Hard disk	35 MB for installation of Locus Processor software
RAM	32 MB minimum
Removable disk	CD ROM drive
Serial port	Spare serial port for data transfer between PC and receiver/handheld
Pointing device	Compatible pointing device

Software Installation

Install the Locus software as follows:

1. Start Windows or, if Windows is already running, close all applications.
2. Insert the Locus CD in the CD ROM drive.

3. On most computers, the autorun utility starts automatically. The Setup utility allows you to install Locus Processor, install Adobe Acrobat™, or explore the CD without installing. To install Locus, click on **Install Locus Processor**. 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. The Locus software installs itself after agreeing 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 Locus documentation to familiarize yourself with content and organization.
2. Following the instructions in the *Locus System Operation Manual*, use the Locus receiver to do an actual miniature survey, such as a parking lot or park.

   - OR -

3. Spend some serious time working through the examples in the tutorial so that you will understand the reasoning and terminology underlying the Locus software.
4. Transfer your data to your PC, and run the Processor software as instructed in the Locus Processor manual.
5. Print out your data in the format that you want.

Getting Started

This chapter describes the fundamentals of the Locus Processor including starting the software, navigating through the software, and using the different windows.

Starting Locus Processor

To launch Locus Processor from your Windows 95/98 or Windows NT desktop:

From the **Start** menu **Programs** folder, select **Project Manager** from the **Locus Processor** folder.

After the **Locus Processor Splash** screen displays, the **Welcome to Locus** dialog box opens (Figure 2.1).

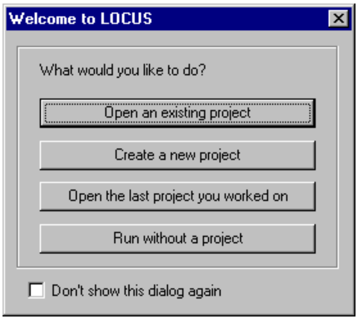


Figure 2.1: Welcome to Locus Dialog Box

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

Click the checkbox to disable **Welcome to Locus** dialog box when starting Locus Processor.

Quitting Locus Processor

You can terminate Locus Processor 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 Locus Processor 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 occupations for each receiver or file loaded into the project. This graphical display provides a quick and easy look at the occupation time for each site.

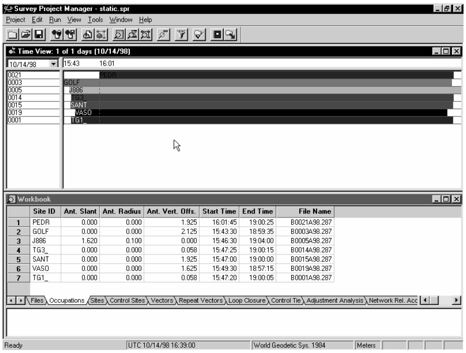


Figure 2.2: Time View Window

The 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, Time View 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 occupation. Double-click a receiver to view information about the receiver. If you did not collect data with the handheld option, the filenames will appear in the left pane instead and the occupations will have site names of ???.

Locus Processor automatically uses different colors for each site in the project, and every occupation for a site appears in the same color for easy reference. Above the right pane is the date and time scale to view when data collection for the occupation occurred.

Zooming

Should you need to view a segment of occupation 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 occupation you want to zoom in on, and drag the rubber band to define the area to zoom in. Upon releasing 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 occupation information
- Include or exclude an occupation in processing
- Print the Time View
- Trim data from an occupation

Using the Map View Window

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

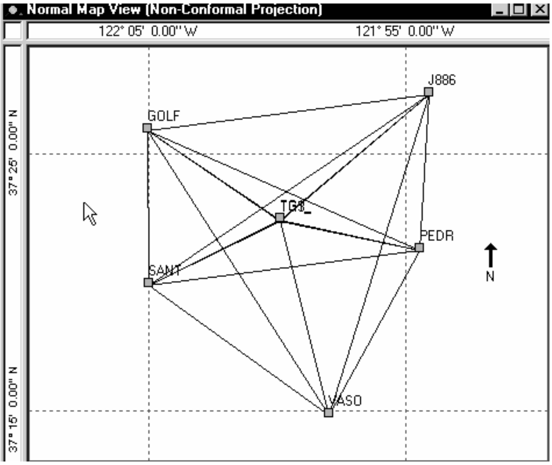


Figure 2.3: Map View Window

- **Normal -** displays sites and vectors without any special mode of QA filtering.
- **Process -** displays sites and vector coordinates from processed data. Default after processing. Failed vectors are shown in red.
- **Adjustment -** displays adjusted sites and vectors. Default after network adjustment. Vectors that fail Tau test are shown in red.
- **Repeat Vector -** displays repeated vectors that fail QA tests in red.
- **Control Tie -** displays control site coordinates and misclosures. Sites that fail Control Tie QA test are shown in red.
- **Loop Closure -** you can select vectors for loop closure tests. Loops that fail Loop Closure QA test are shown in red.
- **Network Precision-** displays error regions between adjusted site pairs. Site pairs that fail Network Precision QA test are shown in red. All QA thresholds except the processing QA test are user-defined.

Use the right-click menu to switch between views. The visible tab in the **Workbook** window corresponds to the map view.

Legend, Colors and Symbols

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

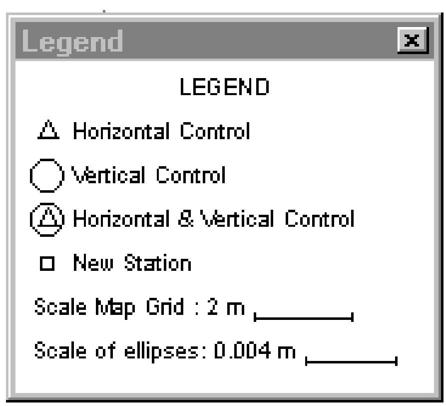


Figure 2.4: Map View Window Legend

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

Site Symbols and Colors

Table 2.1 outlines the scheme for site symbols in all map views:

Table 2.1: Site Symbols

Site Type	Symbol
Unprocessed Site	(white)
Selected Site	(yellow)
Processed Site	(blue)
Adjusted Site	(green)
Bad Site	(red)
Fixed horizontal control site	Δ
Fixed vertical control site	
Fixed horizontal and vertical control site	

Vector Colors

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

Table 2.2: Vector Colors

Map View	Vector Colors
Normal	Unprocessed vectors as dashed lines, others as solid black
Processed	Red- Processing QA fail Green- Processing QA pass
Adjusted	Red- Adjustment QA fail Green- Adjustment QA pass Black- Not adjusted
Control	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	Dashed and yellow
Excluded	Gray

Error Displays

After adjusting 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.

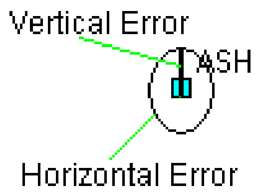


Figure 2.5: Error in the Map View Window

Zooming

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

To zoom-in - Click and drag the rubber band 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 several tabs to display many different kinds of information, from coordinates to network precision statistics. Several tabs have editable fields.

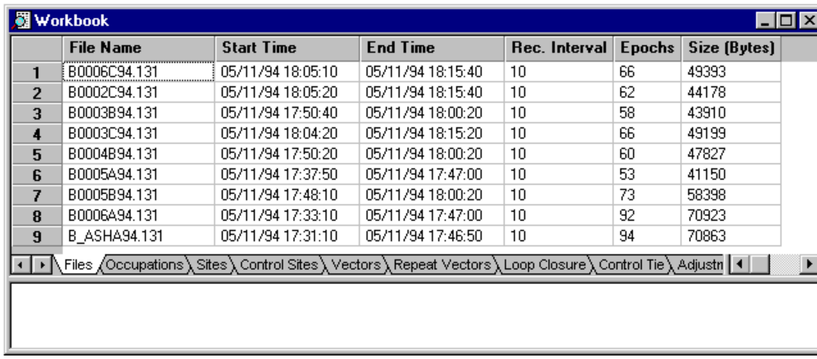


Figure 2.6: Workbook Window - Files Tab

Switch between displays by clicking a different tab.

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

Table 2.3 describes each tab and things to do in the tab.

Table 2.3: Workbook Window Tabs

Tab Name	Description	Things to do in Tab
Files	Information on the raw data files loaded into the current project.	Delete file from project
Occupations	Information on each occupation in the current project.	Edit site ID Edit antenna height Edit antenna radius Edit antenna vertical offset View occupation property sheet
Sites	Information on all sites including position, uncertainties and whether the point is held fixed.	Edit site ID Enter or edit site name Delete a site View site property sheet

Table 2.3: Workbook Window Tabs (continued)

Tab Name	Description	Things to do in Tab
Control Sites	Information on control sites with position, uncertainties and whether the point is held fixed.	Select a control site Edit control site coordinates Delete control site Set control type Set control status
Vectors	Information on the most recently computed values for all vectors after vector processing.	Exclude View vector properties
Repeat Vectors	Information on any vectors with more than 1 period of data.	View only
Loop Closure	Information on loops defined in the project.	View loops Delete a loop
Control Tie	Information to compare known coordinates of control sites with adjusted coordinates for the same sites	View only
Adjustment Analysis	Information on the most recently computed values for all vectors after network adjustment	View only
Network Rel. Accuracy	Information on the most recently computed precision values for all vectors after network adjustment.	View only

Note that in all tabs, the right mouse button brings up a menu of actions in at least one column.

Message Window

Below the tabs is the **Message Window**, 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 via the right mouse button menu.

The Locus Processor Toolbar

The **Toolbar** provides easy access to frequently used commands in Locus Processor.

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

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

Table 2.4 describes each button on the **Toolbar**.

Table 2.4: The Locus Toolbar

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.
	**Project Settings Button -** Click this button to open the Project Settings Dialog box.

Table 2.4: The Locus Toolbar (continued)

Button	Description
	**Report Button-** Click this button to generate a report of project data.
	**Export Button -** Click this button to export project data to a file.

Projects

Introduction

Locus Processor 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 manually in a logbook or in the handheld).

Creating a Project

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

To create a project with Locus Processor running:

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

The project currently open is closed and the new project opens. Refer to page 16 for project setup.

To create a project at startup:

1. Start Locus Processor. A splashscreen appears for a few seconds, followed by the Welcome to Locus dialog, Figure 3.1. Check the checkbox if you do not want this dialog displayed during startup.

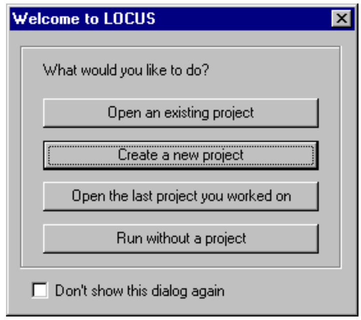


Figure 3.1: Welcome to Locus Dialog

2. Click on **Create a new project**. The **New Project** dialog box opens, as shown in Figure 3.2.

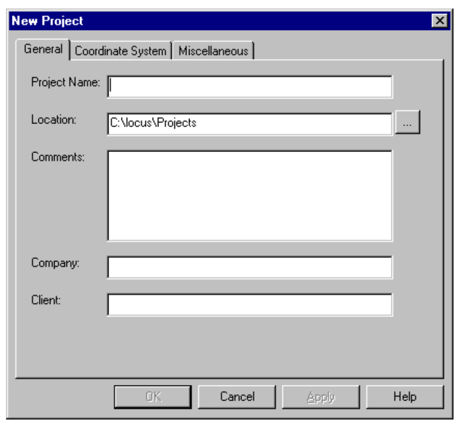


Figure 3.2: New Project dialog

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 should enter the project name in this field prior to entering a location because Locus Processor automatically creates a directory based on the project name.

- **Location**—This is the directory where the new project file will be stored. If the directory shown on the screen is not the directory you want to use, use the mouse to move the insertion point to the first letter in the current directory, use the **Del** key to delete the current directory, and then type in the new directory, after entering the project name. You may also use the Browse button to select a directory.

3. Type in applicable administrative data in the remaining fields.
4. Click on **Coordinate System** to switch to the Coordinate System tab (Figure 3.3).

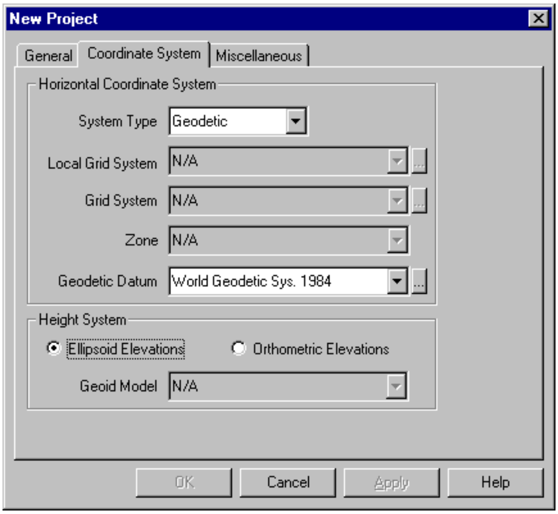


Figure 3.3: New Project Dialog Box—Coordinate System Tab

This tab lets you define your coordinate system. The defaults are WGS-84, Geodetic System, and ellipsoidal height. These parameters 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 settings.

Projects

5. Click **Miscellaneous** to switch to the Miscellaneous tab (Figure 3.4).

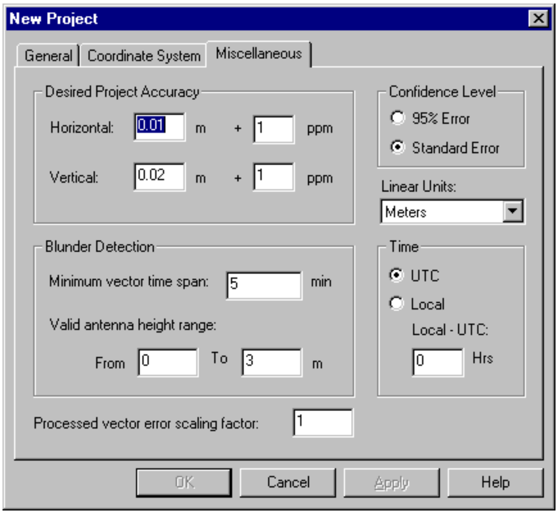


Figure 3.4: New Project Dialog Box—Miscellaneous Tab

6. Set project parameters to the values you want to use. Table 3.1 describes the components of this dialog box.

Table 3.1: Miscellaneous Dialog Box Description

Component	Description
Desired Project Accuracy	Horizontal and vertical; • default horizontal 0.01m+1ppm • default horizontal 0.02m+1ppm
Confidence Level	95% error or Standard Error (68%)
Linear Units	Meters, US feet, or International Feet
Blunder Detection	Minimum vector time span (there must be at least this much common data between two sites for Locus to process the baseline between them) and valid antenna height range
Time	UTC or Local
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**

In the **Time** block, select the time system you are using, **UTC** or **Local**. If you select Local time, type in the offset. This offset is the difference in hours between your local time and UTC, as shown in Figure 3.5.

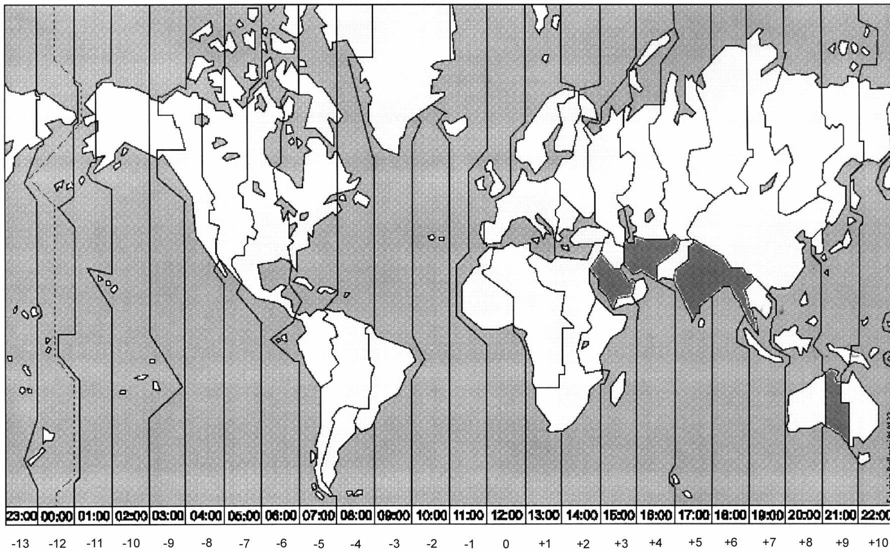


Figure 3.5: Offset from UTC

For daylight savings time, move one time zone to the east.

7. Once you have finished setting up the project, click **OK**. The **Add Files** dialog box opens, Figure 3.6. For information on how to add files to your project, refer to Chapter 4, **Adding Data Files**.

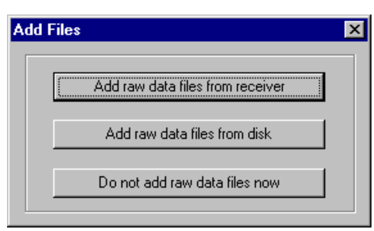


Figure 3.6: Add Files Dialog Box

Opening an Existing Project

To open a previously created project:

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

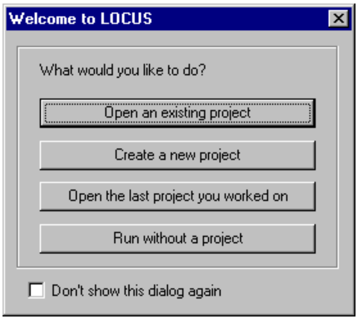


Figure 3.7: Welcome to Locus Dialog Box

-OR-

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

2. In the **Open** dialog box (Figure 3.8), navigate to the filename of the project you want to open.

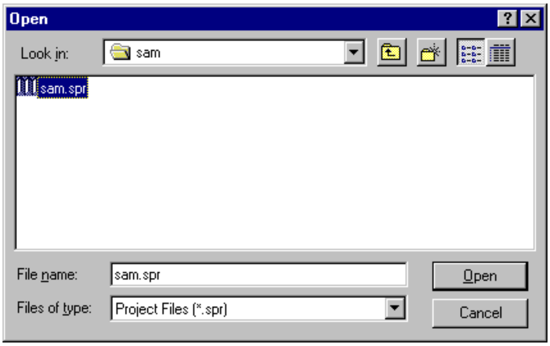


Figure 3.8: Open dialog With Project Selected

3. Double-click the filename, or highlight the filename and click **Open**. Each project file has the extension .spr.
4. The project opens with the **Time View**, **Map View**, and **Workbook** windows open. Locus Processor displays the project name in the title bar as shown in Figure 3.9.

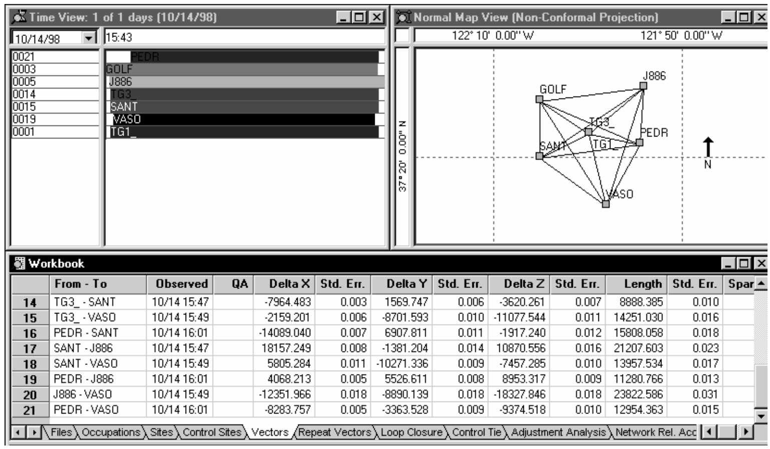


Figure 3.9: Typical Project

5. Once you have opened the 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 by performing one of the following:

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

You may also save the current project under another name. To save the project under another name, click **Save As** from the **Project** menu.

Project Settings

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

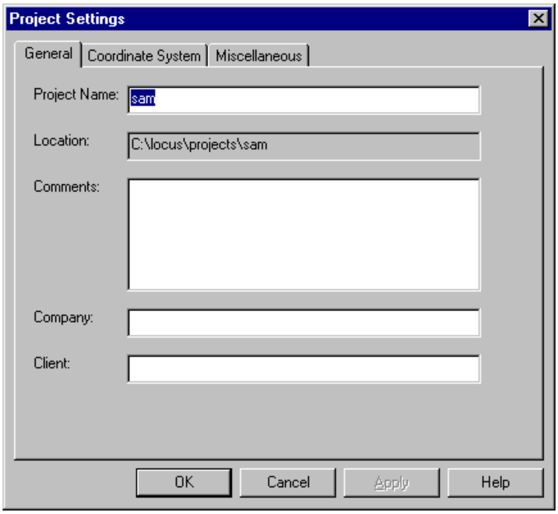


Figure 3.10: Project Settings Dialog Box

This dialog box is the same as the **New Project** dialog. You may edit any of the parameters within the **General**, **Coordinate System**, or **Miscellaneous** tabs. Once you have modified the parameters, click **OK** and Locus Processor updates the project settings.

Removing Data From a Project

Once data files have been added to a project, you may wish to remove specific files. 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 right-click the mouse and select **Delete**.

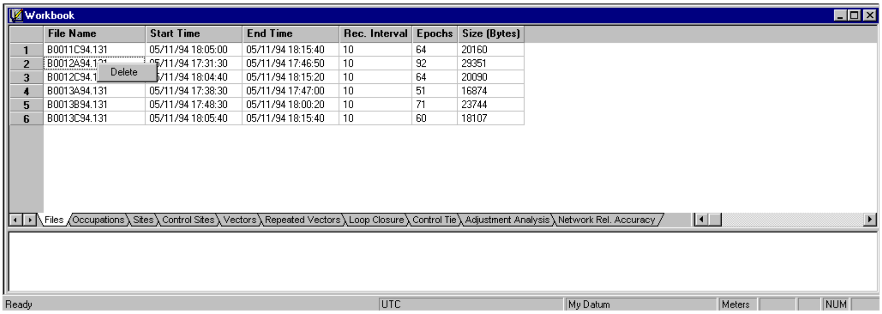


Figure 3.11: Deleting a Data File

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

Projects

4

Adding Data Files

Introduction

This chapter describes the tasks necessary to add data files to a project. This process uses the **Locus Download** module of Locus Processor. 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

Add Data From a Receiver or Disk

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

If a project has already been created and you wish to add data files, choose one of the following:

- 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

Connecting a Receiver

1. As demonstrated in Figure 4.1, place the Locus receiver within 24 inches of the IR device and position both units so that the IR ports face each other. The IR device should not be closer than nine inches when both the IR device and receiver lie flat on a table surface. If the IR ports are aligned at the same height, they can be as close as one half inch.

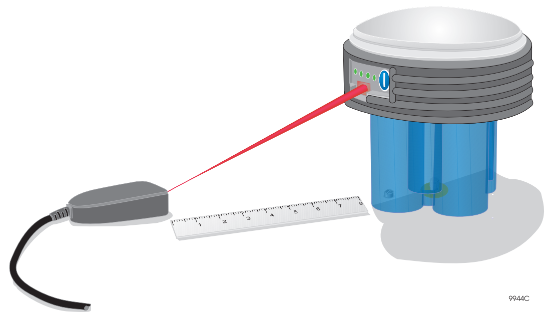


Figure 4.1: Locus Receiver Communicating via IR Device

2. Turn on the Locus receiver. If you are downloading more than one Locus receiver, turn on only one receiver at a time to avoid data transfer mishaps.

Using Locus Download

1. Click **Add raw data files from receiver**. The **Locus Download** main window opens (Figure 4.2)

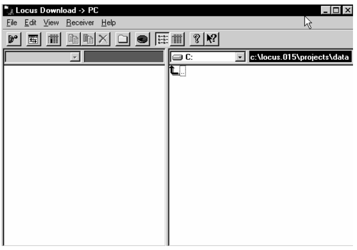


Figure 4.2: Download Main Window

This screen consists of two panes. The right pane (PC pane) lists the files, if any, in the project directory of the PC. The left pane (Receiver or Handheld pane) lists the files in the receiver.

The left pane remains blank until the receiver establishes communication with the PC.

The commands available through the toolbar are described in Table 4.1

Table 4.1: Toolbar Button Descriptions

Toolbar Buttons	Description
	**Connect Button** - Click this button to open the Connect to Receiver dialog box and connect to a receiver.
	**Switch Pane Button** - Click this button to change the active pane.
	**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 files 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.

2. Select **Connect** from the **File** menu. The **Connect via IR** dialog box opens (Figure 4.3).

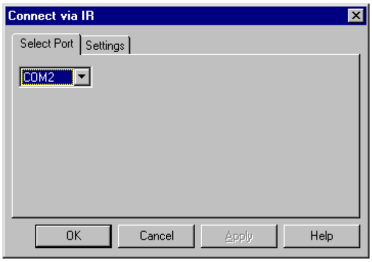


Figure 4.3: Connect via IR Dialog Box

3. In the Select Port tab, select the COM port which has the attached IR device.
4. Switch to the Setting tab (Figure 4.4).

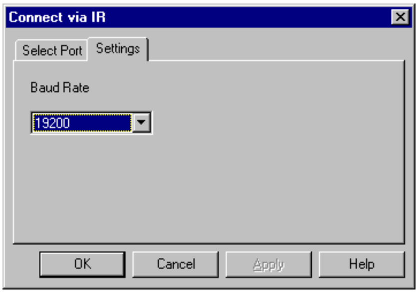


Figure 4.4: Setting Tab

5. Change the baud rate to 57,600, which is the fastest rate the Locus receiver can support.
6. Verify the Locus receiver is turned on, the IR ports aligned, and click **OK** to connect to the receiver. Download will connect and display the contents of the receiver memory.

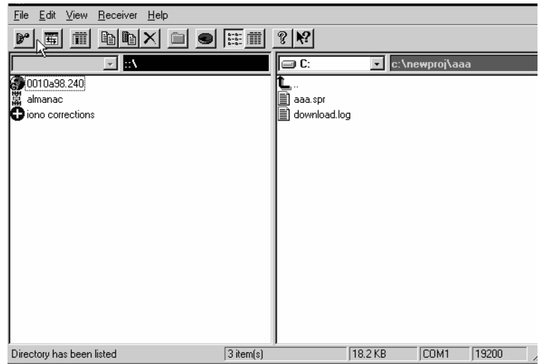


Figure 4.5: Locus Download Screen

The example in Figure 4.5 shows:

- **0010a98.240**—raw GPS data file, with “0010” as the receiver serial number, “a” as the session, “98” as the year, and “240” as the day of the year (other data files may be listed)
- **almanac**—GPS satellite information file, which should be used with **Mission Planning** (refer to Appendix A)
- **iono corrections**—GPS satellite ionosphere corrections file

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

7. Verify the destination directory in the PC pane is the project directory or the directory where you want the data files 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 recognize. Usually it is best to put the data files in the project directory.
8. Now click anywhere on the Receiver pane to activate the pane.
9. Using the mouse, select the file(s) that you want to copy and drag them to the PC pane.

   To select a group of contiguous files, hold the **Shift** key while selecting. To select more than one file, hold down the **Ctrl** key while selecting files.
10. Locus Download copies the selected files to the PC. A progress dialog appears showing the status of the download.

If the receiver memory is full, the download will take about 30 minutes.

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. You can also use the "Move" function which copies and then deletes the files.

It is good practice to delete the data files in the receiver after you have verified 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.

Switch Data Source

If you have another receiver to download data, perform the following steps:

11. Select **Switch Data Source** from the **File** menu. Locus Download turns off the current receiver and prompts you to align a different device.
12. Turn on the next receiver and align the IR ports.
13. Click **OK**.
14. Locus Download connects to the new receiver.

Downloading Data From a Handheld

If you have a handheld which was used to collect site information perform the following additional steps:

15. Select **Switch Data Source** from the **File** menu. A dialog box appears asking you to change the device.
16. Turn on the handheld and start its download program. Then place its IR port within two (2) inches of the PC IR device 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.

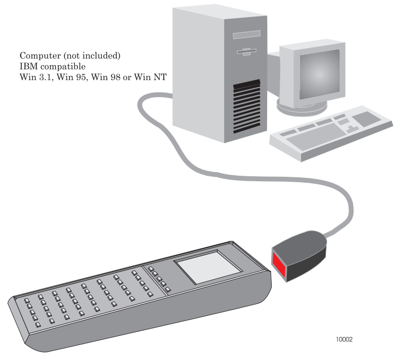


Figure 4.6: Setup for Transferring handheld D-Files

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 (called a "D-file").

17. 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.

18. The progress dialog box indicates status of the download. Upon completion, the D-file is shown in the PC pane and the handheld automatically disconnects from the PC.

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

Ending the Download Process

19. When you are finished transferring all the data files from the receiver(s) and handheld(s), exit Locus Download by selecting **Exit** in the **File** menu.
20. View the **Workbook** window to verify that all files have been added to the project.

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".

Adding Data from Disk

You may add data files residing on your hard drive to the project. To do this:

1. Either Click **Add data from disk** or click **F4**. The **Add Files** dialog opens (Figure 4.7).

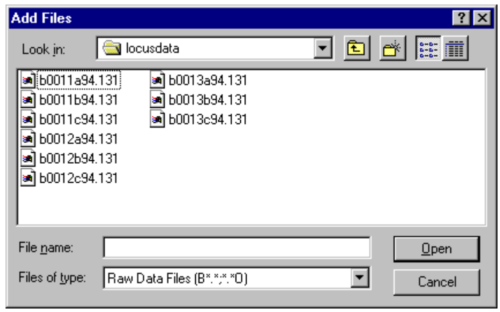


Figure 4.7: Add Files Dialog Box

2. In the **Files of type** dropdown list choose one of the following:
   - Raw Data Files—both Ashtech and RINEX format
   - Ashtech Raw Files—Locus 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**. Locus adds the files to the project.
6. The Files tab in the **Workbook** window lists all selected data files added to the project.

Only B-files are shown in the dialog. Upon choosing Open, associated D and E files are loaded as well.

Add Processed Vectors

The Locus Processor provides the ability to 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 by other Locus projects.

1. Select **Add Processed Vectors...** from the **Project** menu. The **Add Vectors** dialog opens (Figure 4.8):

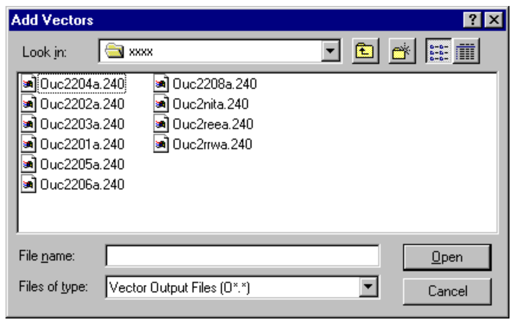


Figure 4.8: Add Vectors Dialog Box

2. Navigate to the directory where the vector files are stored. Locus can import standard Ashtech binary O-files containing vector information.
3. Select the processed vector you wish to add to your project and click **OK**.
4. Use the Vectors tab in the **Workbook** window to verify that the vectors have been added to the project.

Removing Data From a Project

Once data files have been added to a project, you may wish to remove specific files. 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 right-click the mouse and select **Delete**.

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

Set Recording Interval & Kinematic Warning Flag

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

1. Verify Locus Download is connected to a receiver.
2. Select **Receiver Parameters** from the **Receiver** menu. The Receiver Setup dialog opens (Figure 4.9).

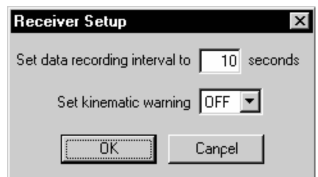


Figure 4.9: Receiver Setup Dialog

The default receiver recording interval is 10 seconds. This interval is good for static surveys. Increasing the interval (say 30) will allow for greater occupation time before the receiver memory is full. Lowering the interval will cause the memory to fill more quickly, but is desirable when conducting kinematic surveys.

3. Enter the recording interval in seconds; the range of values is 2—998.
4. Select **ON** to activate the kinematic warning flag, or **OFF** to deactivate this flag.
5. **Click OK** to send the parameters to the receiver and close the **Receiver Setup** dialog box.

Data Processing

Introduction

Raw data collected by a Locus 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 Locus Processor.

The data processing module is a sophisticated engine which 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 Locus, 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.

Processing of GPS data is performed in three basic steps:

- **Pre-process data analysis**

  Site and occupation 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-process Data Analysis

The processing of GPS vectors relies on two sources of data, raw GPS data collected by the Locus Receiver, and occupation and site specific data provided by the user. When using a Locus Handheld, much of the user supplied data can be entered in the field during data collection. In this case, the data should be verified prior to processing. If a handheld was not used, this data will need to be entered manually.

Verification and editing of user supplied occupation and site data can be performed in more than one location within Locus Processor. Primarily, the Occupation property sheets will be used for this task. Table 5.1 on page 39 outlines the user supplied data that can be viewed and edited from each of these sheets. The remainder of this section presents how to utilize the property sheets to analyze the user supplied occupation and site data.

Before you process your data, we suggest you analyze them. 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 preprocess analysis:

1. If you have not done so already, load all the data files for your project by selecting **Add GPS Raw Data** from the **Project** menu. You may add files directly from the receivers, or from your hard drive.
2. Navigate to the directory where the data files are stored in the **Add files** property sheet (Figure 5.1). Select all the files by clicking on the first filename, and then holding the <Shift> key down and clicking on the last filename.

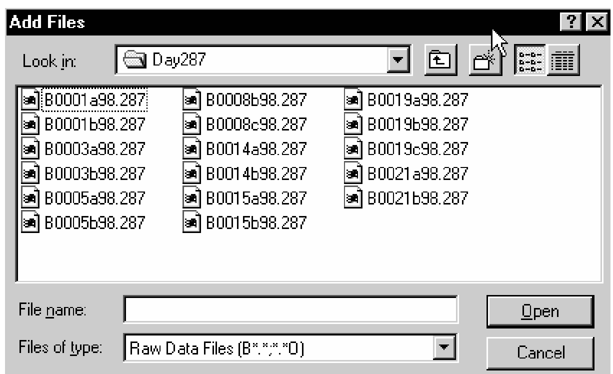


Figure 5.1: Add Files Dialog

3. Click **Open** to add the files to the project.

   The **Time View** window and the **Workbook** window with the **Occupations** tab opens. In the diagram, the horizontal bands of color are associated with different site ID's. All occupations of a site are in the same color, i.e. each occupation of site ???? is displayed in green. The Occupations tab lists the associated antenna heights, start and stop times, and file name for each occupation.

If you loaded static data from receivers without using a handheld, the site IDs appear as ???? and you must rename each occupation with the correct Site ID. You will also need to enter correct antenna heights.

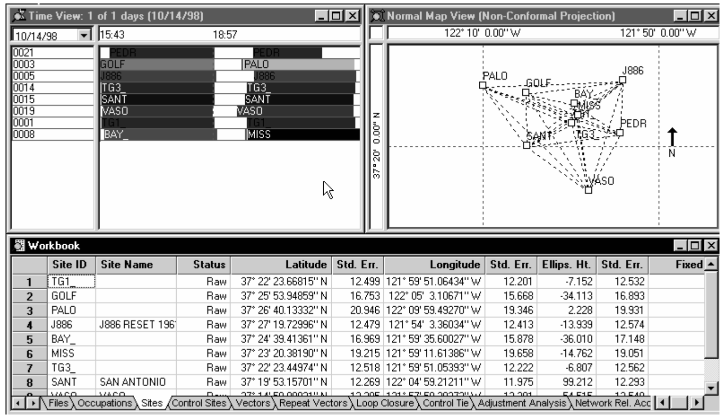


Figure 5.2: Project Manager Main View

Filtering Data

There are times during data processing and adjustment when it is beneficial to isolate a segment of data for individual attention. This can be accomplished with the Filter function of Locus Processor. Data can be filtered based on the day the data were collected. 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. Once you filter data, all subsequent actions, including processing and adjustment, are performed only on the data selected in the Filter dialog. Data that have been filtered out is not visible and no action is taken on it.

Data Processing

To filter data:

1. Select **Filter** from the **Edit** menu.

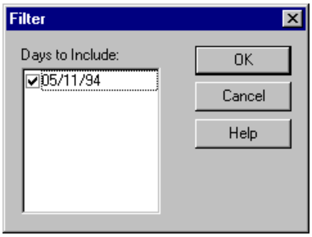


Figure 5.3: Filter Dialog

2. In the **Filter** dialog, 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.

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

Another way of selectively viewing data exists in Time View. This view shows one day of data at any one time, but you may easily switch to a different day by clicking on the dropdown list box in the top left of the window and selecting the desired date. The Time View will then be updated. Note that this only affects what is visible in this view and does not affect any other views or actions which you may perform in Locus.

Editing Data

If you were using the handheld unit in the field and have confirmed that site IDs, occupation time and antenna heights are correct, then you may skip the following steps for editing, and proceed directly to the "Processing Data" on page 53.

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 using a handheld, you need to set the site IDs and antenna heights for every occupation.

Viewing Occupation Properties

User supplied occupation data consists of the occupation site ID and antenna height parameters. As stated earlier, the use of a Locus Handheld during data collection will eliminate the need to manually enter this information. The only task would be to verify that the site ID and antenna height parameters were entered correctly. On the other hand, if a handheld was not used, this data will need to be manually entered prior to processing.

Occasionally, occupation start and stop times may need to be adjusted. For example, during data collection of a kinematic survey, a user may accidentally move from a site while data was still being collected for this site. The end time of the site occupation 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 occupation by double-clicking on the time bar for an occupation or by selecting **Properties** from the right-mouse click menu of an occupation in the **Time View** window. In the Occupation Properties dialog (Figure 5.4), you can change the Site ID and antenna parameters.

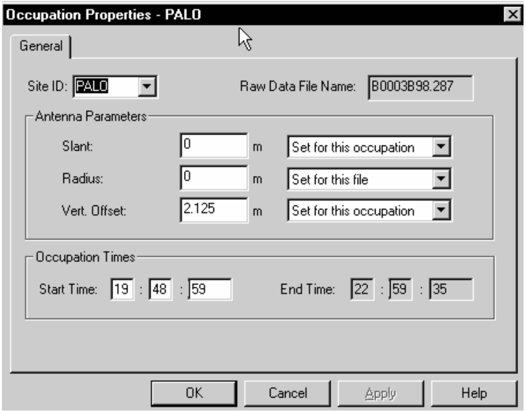


Figure 5.4: Occupation Properties Dialog

Table 5.1 describes the components of the Occupation Properties sheet.

Table 5.1: Occupation Properties Sheet

Parameter	Description
Site ID	A four character alpha-numeric identifier for the survey point. Each survey point must have a unique site ID. Otherwise, the processor has problems determining which site each occupation 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 receiver serial number, session letter, year, and day of the calendar year (B001A94.131).

Table 5.1: Occupation Properties Sheet

Parameter	Description
Antenna Parameters	
• Slant	• The distance from the survey marker to the outside edge of the antenna or, for Locus receivers, the antenna ring attachment. Processing uses the antenna height to determine the location of the survey marker on the ground. Locus Processor uses the antenna slant height and radius to compute the true vertical antenna height. You can set the slant measurement for: **this occupation**, **this file**, or **this receiver**.
• Radius	• The horizontal distance from the geometric center of the antenna to the outer edge. Locus Processor uses the antenna slant height and radius to compute the antenna height. You
• Vert. Offset	• If you know the true vertical height of the antenna you may enter it here. This is useful when using a fixed height pole. When computing the true vertical, be sure to account for the 0.125 meter phase center offset created by Locus itself.
Occupation Times	
• Start Time	• The time data started recording for the occupation 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 occupation in either Local Time or UTC Time. The Time Frame is specified in the **Miscellaneous Tab** of the **Project Settings** property sheet.
Buttons	
• **OK**	• Accepts parameters and closes dialog
• **Cancel**	• Does not accept parameters and closes dialog
• **Apply**	• Not used
• **Help**	• Displays help topic for this dialog

You may edit any of these parameters except for the **Raw Data File Name**. You may edit the start and stop times of an occupation. However, there is one exception to this; if the start or stop time of the occupation coincides with the the beginning or end of a data file, you will not be able to edit that time. Instead, you should insert a new occupation (see Trimming Occupation data later in this chapter) and then edit the times.

Viewing Site Properties

User supplied site data consists of site ID, site name, 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. It is recommended that processing begin with known coordinates at a minimum of one site. This is referred to as the seed coordinates for processing. Locus Processor can process raw data without seed coordinates. In such a case, Locus Processor will select one site to use as the control for processing. The coordinates estimated for this site from the raw data will be 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.

Processing of 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 the Kinematic Initialization bar, the base site should be identified as a control site. If this site does not have known coordinates, use those computed by Locus Processor.

Each site has a **Site Properties** dialog with three tabs which allow you to view and set site data. You can view the **Site Properties** dialog of each site by double-clicking on site or left-clicking on a site in the Map View or Sites Tab, and selecting **Properties**.

GENERAL

The **General** tab lists the site name, site ID, solution type, and whether it is a control site and held fixed. You can edit the Site ID or Site Name.

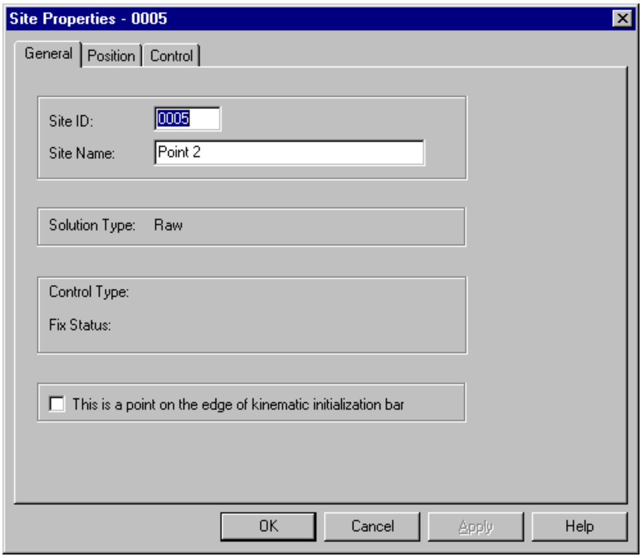


Figure 5.5: Occupation Parameters Dialog - General Tab

Data Processing

Table 5.2 describes the components of this dialog.

Table 5.2: Site Properties Dialog - General Tab Parameters

Parameter	Description
Site ID	A four character alpha-numeric 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 occupation's site name.
Site Name	20 Character alpha-numeric name or description for the Site ID to help you identify this site.
Solution Type	• Raw—initial point position determined by the receiver • Processed— at least one vector including this site has been processed. • Adjusted— site has been adjusted using processed vectors.
Control Type	Indicates if the site is a control site for the project.
Fix Status	Indicates if the position is fixed vertically or horizontally.
This is a point on the edge of kinematic initialization bar	Flag indicating this site is the Rover initialized site on the Kinematic Initialization bar.

POSITION

The **Position** tab (Figure 5.6) 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.

As discussed in Chapter 8, only the system type selected in the Coordinate System tab, and the types below it, will be available.

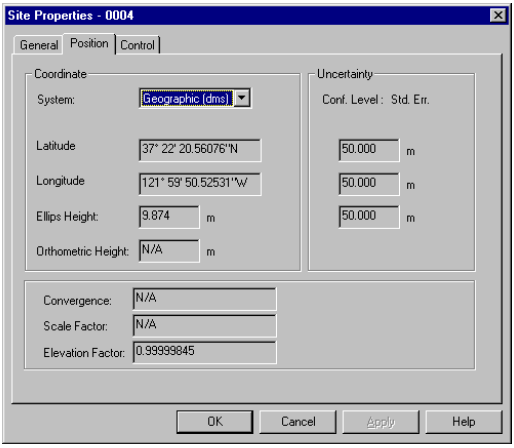


Figure 5.6: Site Properties Dialog - Position Tab

Table 5.3 describes the components of this dialog.

Table 5.3: Site Properties Dialog - Position 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) of the point
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	This is the statisically derived confidence level of each component of the position.
Convergence	If using a grid system, this is the angle between the direction of grid north and the meridian passing through the point.
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.

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

Parameter	Description
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

The **Control** tab (Figure 5.7) is used to set the site as a control point, hold the site fixed, and enter the control site coordinates.

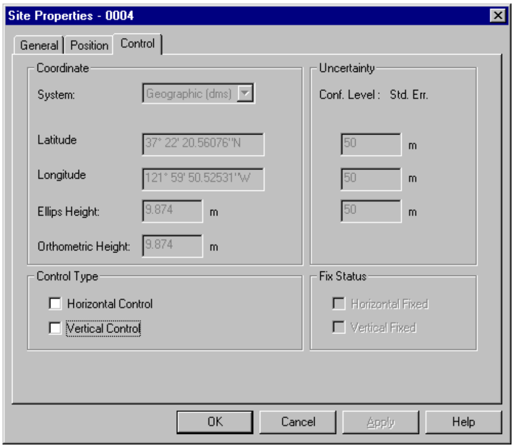


Figure 5.7: Site Properties Dialog - Control Tab

Table 5.4 describes the components of this dialog.

Table 5.4: Site Properties Dialog - 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) of the point
Longitude/Northing	The longitude or the northing (y) of the point.
Ellips Height	The ellipsoidal height of the point, if available

Table 5.4: Site Properties Dialog - Control Tab Parameters (continued) (continued)

Parameter	Description
Orthometric Height	The orthometric height of the point, if available.
Conf. Level	This is the statistically derived confidence level of each component.
Control Type • Horizontal • Vertical	Allows editing of both the horizontal and vertical controls. If neither box is checkmarked, none of the fields in **Coordinate, Uncertainty,** or **Fix Status** are accessible. • Click this checkbox to set the site as a horizontal control site, then enter the control coordinates for the site. • Click this checkbox to set the site as a vertical control site, then enter the control coordinates for the site.
Fix Status	Check these boxes to indicate that the position is fixed vertically 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. To delete a site, 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, simply edit the occupation site IDs to the old ID.

Using Occupations in Processing

INCLUDING

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

REMOVING

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

To remove an occupation, rename the Site ID to **????**. Refer to “Editing Site ID” on page 46.

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 referred to as seed coordinates and the site is referred to as 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, Locus automatically chooses a site and sets it as the control site.

To set a control site:

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).

   Locus 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, but not both, 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).
6. Once a control site is set for processing, the symbol for that site in the **Map View** window becomes a circle within a triangle inside it.

Editing Site ID

There may be times when you want to change the Site ID—such as when you want to remove occupations 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 occupation bar of a site in the **Time View** window to open the **Occupation Parameters** dialog 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** window and double-click (or right-click) on the Site ID and modify the name.

Changing the Site ID in the **Site Properties** sheet has a slightly different effect than changing it in the **Occupation Properties** sheet. In the **Site Properties** sheet, a change in the Site ID will change all occupations containing this site ID to the new value. In the **Occupation Properties** sheet, a change of the site ID only affects that particular occupation.

Kinematic Initialization Site

When a kinematic survey is initialized using the Kinematic Initialization bar, Locus Processor must be made aware of which site is the rover initialization site on the end of the bar. Kinematic data collection can only be performed using a Locus Handheld. During collection, the handheld will identify the rover initialization site. This will result in the site being identified automatically in Locus Processor, i.e. this flag will be set. If the rover initialization site ID is changed, the new site ID will need to be identified as the rover initialization site by setting this flag.

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 HI, reading the HI incorrectly, or occupying the wrong point.

If incorrect data (or no data) was entered into the data files, the Locus Processor 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 which should have been recorded during the survey(s).

To verify the antenna parameters:

1. Double-click on the occupation bar in the **Time View** window to open the **Occupation Parameters** dialog.
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 occupation, all occupations for the file, or all occupations for the receiver.

You may also edit antenna parameters by clicking on the Occupation tab of the Workbook window.

Trimming Occupation Data

To change a start time or stop time of an occupation that coincides with the start or stop time of a data file, the Trim Data feature must be used. Trim Data allows you to insert an occupation at the start or end of the data file. This occupation will fill the space left open by the editing of the start or stop time of the occupation that previous occupied this time period. Let's look at an example. Assume you have an occupation at the end of a data file which ends at 08:15:00. For some reason, you want to stop this occupation at 08:10:00. Since this occupation continues to the end of the data file, you will not be able to edit the end time unless you insert a filler occupation in its place. Using the Trim Data feature, an occupation can be inserted at the end of the file that begins at 08:10:00 and ends at 08:15:00. This occupation would most likely be given a site ID of ????. sites.

BEFORE

Trim Before renames the first part of an occupation.

1. Right-click an occupation in the **Time View** window and select **Trim Before**.

   The **Occupation Properties** dialog opens with **????** for the **Site ID** with no values for the **Slant**, **Radius**, and **Vert. Offset** parameters (Figure 5.8). The

Occupation Time will be the start time of the occupation you had selected. The raw data file name is still the same.

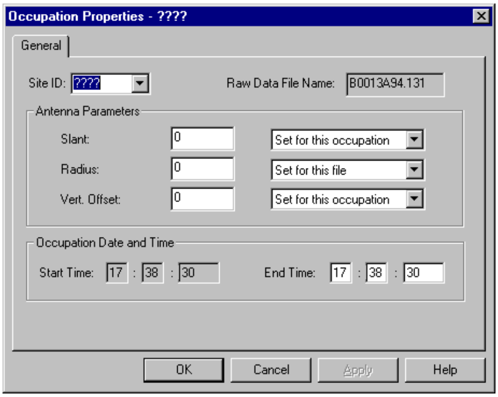


Figure 5.8: Occupation-Trim Before (1)

Notice that the start time for the Occupation Date and Time is grayed out. This means you are inserting an occupation at the start of a data file and therefore cannot change the time to before the file started.

2. Enter a different end time for the occupation (in this case we choose 17:45:30) and click **Ok** to save changes.

3. The **Time View** window now displays the occupation that was formerly Site ID 0005 with **????** and replaced the color.

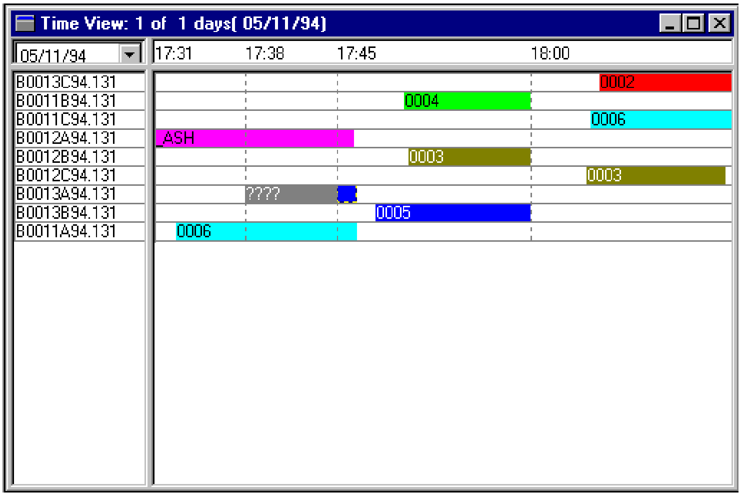


Figure 5.9: Map View with Site **????** updated

4. By double-clicking on the **????** bar, Locus displays the Occupation Properties dialog with the updated data.

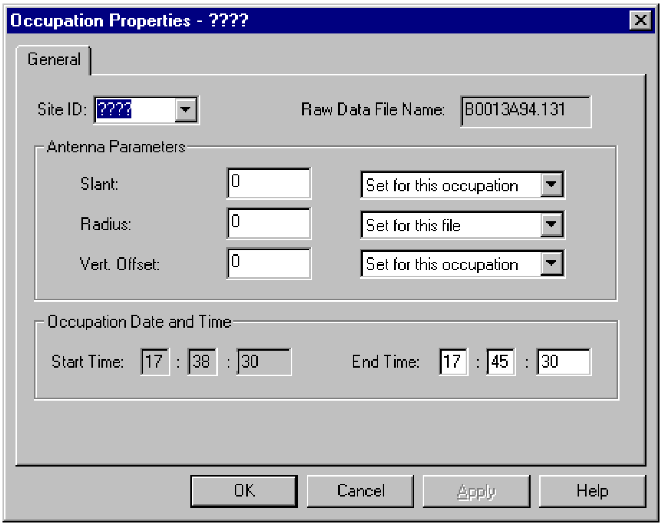


Figure 5.10: Occupation

Notice the Occupation Start Time and End Time correspond to when the occupation began and the time you entered it to end, respectively. With the Site ID as **????**, Locus will not use the Occupation during processing.

To change the Site ID back to 0005, click the down button in the Site ID selection box and select 0005. Once you click **OK**, Locus will update the Time View window.

AFTER

1. Right-click an occupation in the **Time View** window and select **Trim After**.

   The Occupation Properties dialog opens with **????** as the **Site ID**. There will be no values for the Slant, Radius, and Vert. Offset parameters. The

Occupation Time will be the end time of the occupation you had selected. The raw data file name is still the same.

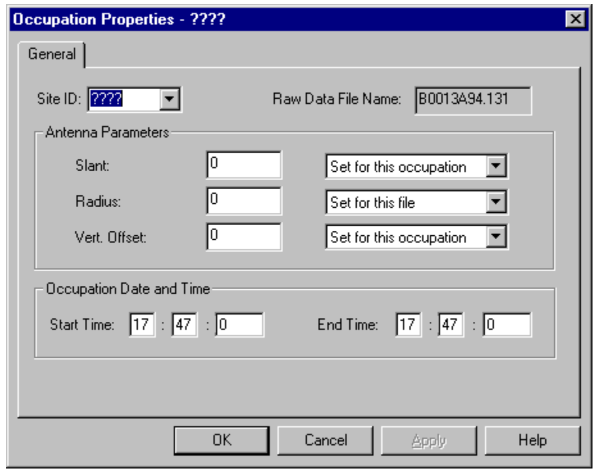


Figure 5.11: Occupation-Trim After (1)

2. Enter a different start time for the occupation (in this case we choose 17:40:00) and click **Ok** to save changes.
3. The **Time View** window now displays the occupation that was formerly Site ID 0005 with **????** and replaced the color.

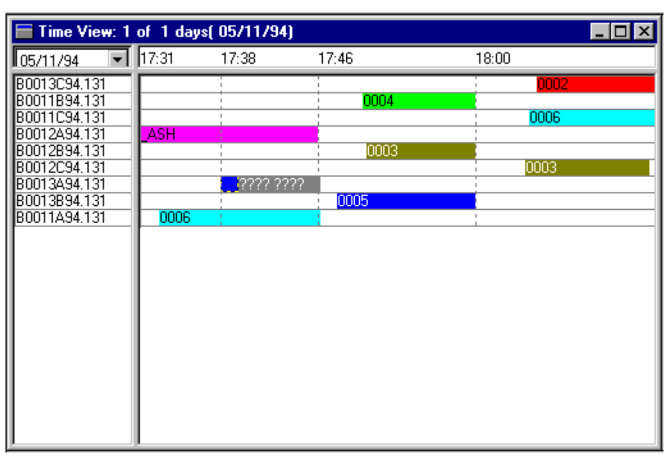


Figure 5.12: Map View with Site **????** updated

4. By double-clicking on the **????** bar, Locus updates the Occupation Properties dialog.

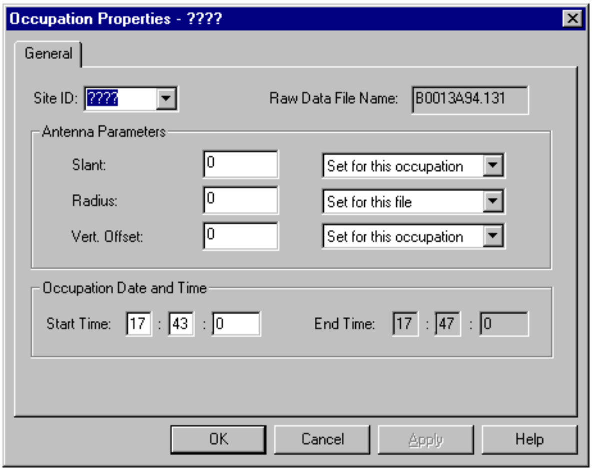


Figure 5.13: Occupation

Notice the Occupation Start Time and End Time correspond to the times you entered for it to begin and to end. With the Site ID as **????**, Locus will not use the Occupation during processing.

To change the Site ID back to 0005, click the down button in the Site ID selection box and select 0005. Once you click **OK**, Locus will update the Time View window.

Processing Data

Processing data is simple. Once you select either **Process All** or **Process Unprocessed**, the program begins processing and continues until it is done, all the while updating the **Time View**, **Map View**, and **Workbook** windows with processed data information. Processing involves the following steps:

1. Prior to beginning the actual processing, Locus checks to see if you selected a seed site. If you have not, Locus displays a message similar to the one below:

```
WARNING - Seed site missing: No fixed site selected to seed processing. Site 0005
has been chosen by default. Continue?
```

2. If you wish to select your own seed site, click **No** and go to step 4.

3. If the specified site is acceptable, click **Yes** and Locus will process the data using the specified seed site.
4. Click on the **Control Sites** tab in the **Workbook** window.
5. Click on the **Site ID** field to select a site as a seed site.
6. Select **Process All** or **Process Unprocessed** from the **Run** dropdown menu. Locus begins to process the raw GPS data.

Process All

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

If any vectors already exist, the user is warned that they will be over-written. From the warning, the user can cancel the operation or proceed.

Process Unprocessed

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

Post-process Data Analysis

The primary product of processing GPS raw data between two sites is a vector defining the relationship between these sites. A by-product of the processed vector are site coordinates. When processing a vector, 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 to them, the presented coordinates will be derived from the last vector processed. Adjustment of the data will result in more accurate and reliable site coordinates.

Locus Processor supplies you with indicators to help determine the quality of processed vectors and computed site coordinates. The quality indicators for processed vectors includes a process QA flag and vector uncertainties. Quality indicators for computed site coordinates are site position uncertainties and a position status flag.

The vector uncertainties supply you with an estimate of the quality of the processed vector. Experience will help you to determine what level of uncertainties can be expected for varying vector lengths. In general, the uncertainties should be similar to the measurement accuracy specifications of the Locus System. Also, vectors of similar lengths should have similar uncertainty values.

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 process 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 Locus System. It is important to remember that a flagged vector does not indicate conclusively that the vector is bad. The QA test is designed to simply warn of potential problems with a vector. If an adjustment is to be performed, include flagged vectors. The analysis tools in the adjustment will give more ammunition to determine if the vector is indeed problematic. If so, it can be eliminated.

The site uncertainties supply you with an estimate of the quality of the computed site position. These uncertainties are derived directly from the vector uncertainties for this site. If multiple vectors exist for this site, the site will adopt the uncertainties from the last vector processed. Performing an adjustment on the data will improve the site coordinates and uncertainties.

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

The quality indicators discussed above are presented in different ways within Locus Processor, depending on which view is being used for analysis. The remainder of this section presents how to analyze these indicators in graphical and tabular form.

Graphical Review

Once Locus has processed the raw GPS data, the Map View window changes from **Normal** to **Process**. Figure 5.14 shows the components of this window.

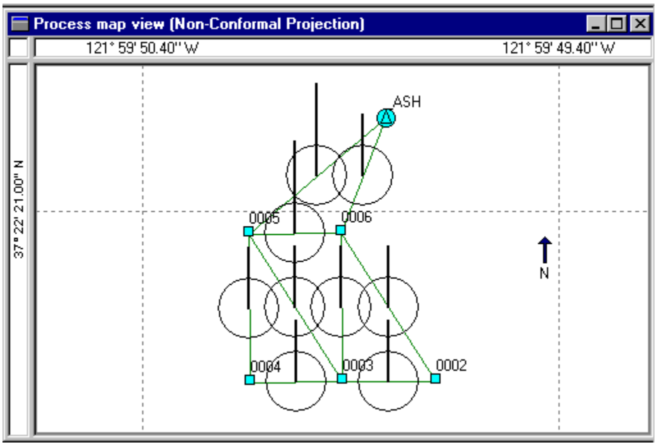


Figure 5.14: Map View - Process

Figure 5.15 is a somewhat different view of the same data but unprocessed.

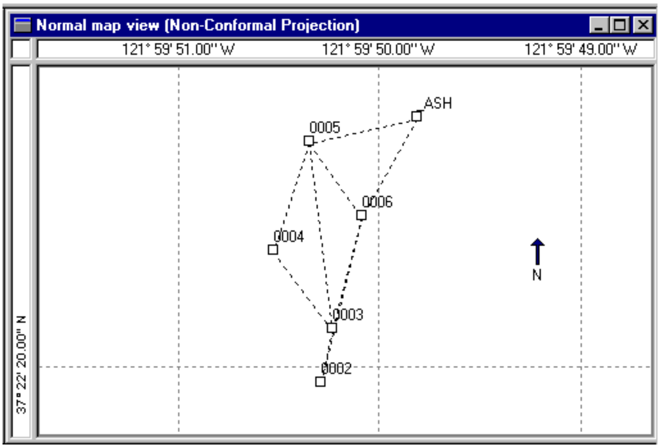


Figure 5.15: Map View - Unprocessed Data

In Figure 5.14, the sites from the raw data have been processed and various visual information is displayed.

- **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 representation of the horizontal uncertainties of the vectors.
- **Vertical Error Bar**—graphical representation of the vertical uncertainties of the vectors.
- **Vectors**—a solid line is drawn representing each vector processed. If the vector passes the QA test, the line will be green. If the vector fails the test, the vector will be red.

If Locus encountered errors during processing, the **Map View** window would display these errors.

Workbook Review

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

Vectors

1. Click the **Vectors** tab in the **Workbook** window.
2. For each vector, view the **QA** column.
3. If each processed vector passes the preset QA threshold, the field is blank.
4. If a processed vector does not pass the QA threshold, the field has the word "**Failed**."

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

Sites

1. Click the **Sites** tab in the **Workbook** window.
2. For each site, view the **Status** column.
3. If Locus was able to process any vectors to a site, the field has the word "**Processed**."
4. If Locus was not able to process any vectors to a site, the field contains the word "**Raw**.".

Message Window

5. If processing was conducted successfully, 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 processed, you know that a problem exists.

The processing engine has done the best possible job of interpreting the data but problems still exist. Try adjusting the data and if there is still a problem it may be necessary to reobserve the vector.

Conclusion

Once you have performed :

- pre-process analysis
- processing
- post-process analysis

and are satisfied the processed data have no observable errors, you can adjust the data.

6

Adjustment

Introduction

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.

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 through this stage 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. This is 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.

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, the reader is encouraged to read the appendix on Post-Adjustment Analysis. You will find it helpful to review this appendix before actually performing an adjustment.

Tasks

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.
2. Notice all the fields are blank. No data is 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 will automatically use 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.

   You will see a progress dialog as the adjustment progresses; you may cancel the adjustment at any time. Relevant messages are displayed in the message window of the Workbook.

4. Once Locus Processor has performed an adjustment to the data set, data is displayed in the **Adjustment Analysis** tab and the **Network Rel. Accuracy** tab.

   Table 6.1 represents 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 vector component in the x or easting direction.
Res. X	The residual of the adjusted vector component.
Delta Y/Delta Northing	The vector component in the y or northing direction.
Res. Y	The residual of the adjusted vector component.
Delta Z/Delta Elevation	The vector component in the z or vertical direction.
Res. Z	The residual of the adjusted vector component.
Length	The 3D spatial distance of the vector in the linear unit system selected in the Project Setup.
Radial Res	The radial residual of the adjusted vector.

5. The first test Locus Processor 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. You will see text similar to the following 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.

6. Locus Processor then performs a Chi-square test.

   For more information about the Chi-square test, refer to Appendix C, **Post-Adjustment Analysis**. You will see the following text 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.

   If the chi-square test fails, you should check the value for the variance of unit weight, which appears in the Message Window, after the chi-square test. If the value is much less than one, you might need to rescale the vector uncertainties by increasing the **Processed vector error scaling factor** in the **Miscellaneous** tab of the **Project Setting** dialog. If it is much greater than one, check if some of the residuals are larger than the others and are flagged as failing the tau test. If so, it is possible your data contains blunders. If not, then again, you might need to rescale the vector uncertainties. For the reasoning behind this, please refer to Appendix C, **Post-Adjustment Analysis**.

7. If the Chi-square test passes for each vector, Locus Processor then performs a Tau test.

   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 will be 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 OK 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 of these can be used to identify problem vectors - you can can exclude them from further adjustment if needs be. Appendix C, **Post-Adjustment Analysis** describes these tests in detail.

8. If no residuals are flagged, you should now have a blunder free adjustment.
9. Once Locus Processor 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.

   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.
10. If you have selected several control points (remember that you should hold no more than one fixed at this stage) Locus processor will perform 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.
11. 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. In order to do this:

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

   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.

This will provide the relative accuracy values of all the site pairs. The relative accuracy of your survey is the lowest relative accuracy in the network. Table 6.2 describes this tab.

The accuracy may fall below your accuracy specification if you have held a bad control point(s) fixed.

Table 6.2: Network Relative Accuracy Tab

Component	Description
Site Pair	Vector identifier. Format is xxxx – yyyy, where xxxx and yyyy are Site Ids.
QA	Displays FAIL if either the horizontal relative accuracy or vertical relative accuracy exceeds the network specifications.
Horizontal Relative Error	Horizontal relative error of the vector.
Vertical Relative Error	Vertical relative error of the vector.
Horizontal Relative Accuracy	The precision calculated using the horizontal relative error and the vector length.
Vertical Relative Accuracy	The precision calculated using the vertical error estimate and the vector length.
Distance	The 3D spatial distance of the vector in the linear unit system selected in the Project Setup.

5. Any site pair which fails the accuracy specification will be flagged as a FAIL in the QA column.

   Short vectors may be flagged as failures because the constant part of the accuracy specification has such a high influence over short distances.
6. If you look at the **Map View** window, you will 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.
7. If this test passes, you have a constrained adjustment.

   Uncertainties present estimated accuracy of adjusted points. The lowest relative accuracy dictates the relative accuracy of 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 6.3 contains a graphical representation of the tasks listed in this chapter.

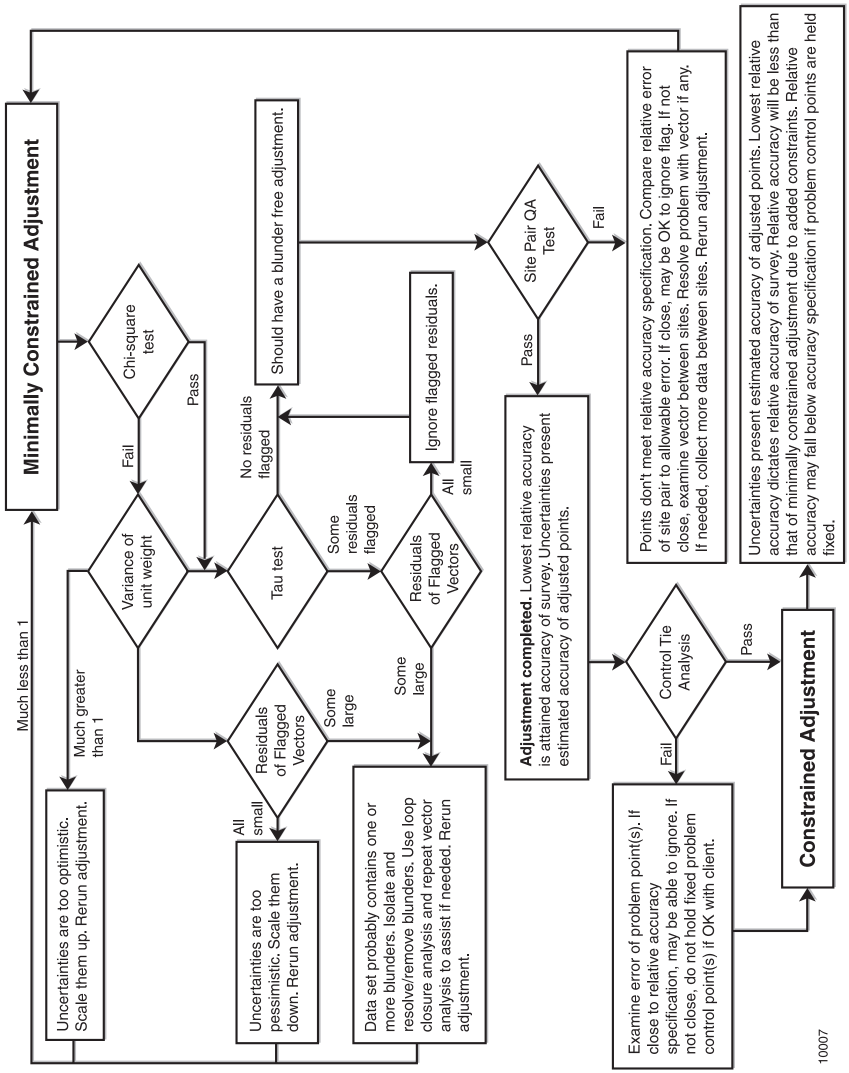


Figure 6.3: Adjustment Flowchart

Reports

Introduction

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 then 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 Locus, you can change the Report Editor program at any time in the Program Setup dialog box.

Applications Locus supports as a report editor include:

- MS Word 6.0, 95 (7.0), and 97 (7.0).
- WordPad
- Write

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

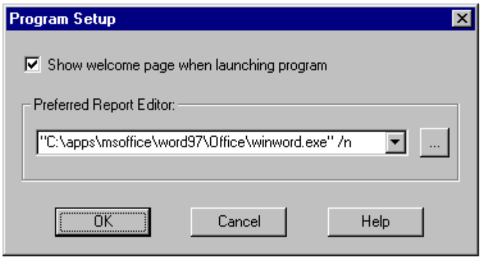


Figure 7.1: Program Setup Dialog

The **Preferred Report Editor** field lists the full path for the selected 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 list presented.

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 (Figure 7.2), and click Select.

Figure 7.2: Select Report Editor Dialog

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

Generating a Report

Locus Processor has pre-specified reports than can easily be generated to view site positions, project summaries, adjusted measurements, processed vectors, control tie analysis, occupation information, etc... If you want a specialized format for your report, you can create one using the export functions described in the **Export** chapter.

1. Select **Report** from the **Project** menu to open the **Project Report** dialog (Figure 7.3).

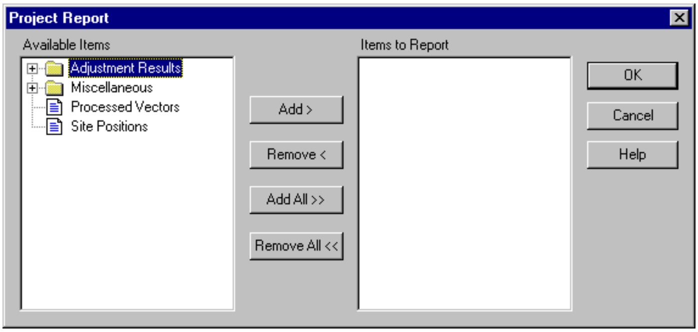


Figure 7.3: Project Report Dialog

Use the **Project Report** dialog 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 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 represent 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 Name		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 Diagram Windows

1. Verify that the window is active that you wish to print.
2. Select **Print** from the **Project** menu.

   The **Print Setup** dialog opens (Figure 7.6).

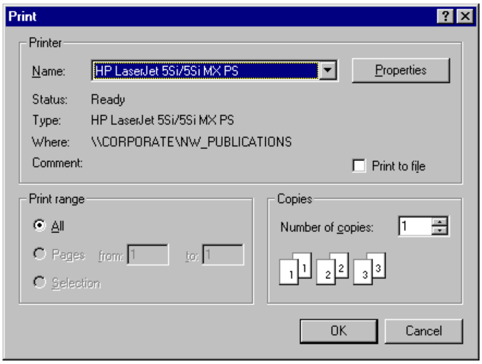


Figure 7.6: Print Setup Dialog

3. Set the printer options as necessary and click **OK**.

   Locus Processor sends an image of the active window to the printer.

Printing the Workbook Window

1. Verify that the tab with information you want printed is active in the **Workbook** window. Select the appropriate tab for the information that you want to print.
2. Select **Print** from the **Project** menu.

3. The **Print Setup** dialog opens (Figure 7.7).

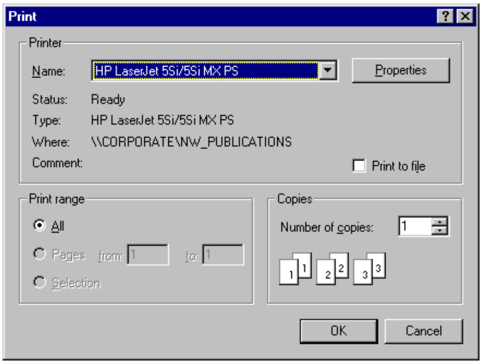


Figure 7.7: Print Setup Dialog

4. Set the printer options as necessary and click **OK**.

   Locus Processor sends the information from the current tab to the printer.

   You may also see a Print Review of the selected Window by selecting Print Preview under the Project Menu.

Exporting Data

Introduction

Locus allows you to create customized ASCII export formats containing a wide range of information from your project. You may save the formats you create for convenient reuse, and use formats that others have created on different machines. Additionally, you may export vector information in the form of Ashtech O-files, which can be imported by separate network adjustment packages.

Exporting Data

The Export Data dialog is the standard File Save As dialog box, shown in Figure 8.1. It allows you to export vector data into formats, into a specified directory.

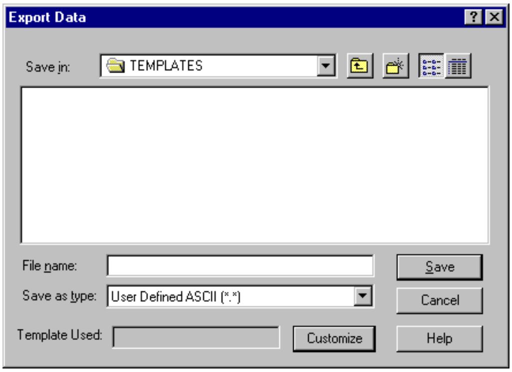


Figure 8.1: Export Data Dialog

Table 8.1 explains the various components of this dialog:

Table 8.1: Export Data Dialog

Name	Function
Save In	Determines which drive and directory the exported file will be saved.
File Name	Enter the name of the export file. The program will create file names with certain extensions required by format specification.

Table 8.1: Export Data Dialog (continued)

Name	Function
Save as type listbox	A list of export formats available.
Buttons • **Save** • **Cancel** • **Help** • **Customize**	• Select **Save** to retrieve the selected export file name, begin the export process, and exit the Export Data dialog. If the selected file already exists, the program will display an overwrite message. • Select **Cancel** to cancel the export process, and exit the Export Data dialog. • Provides help on the **Export Data** dialog • Displays the **User ASCII Template** dialog. This button is only available if **User Defined ASCII** is selected in the **Save as type** listbox.

Available Export Formats

The following is a list of the available export formats that may be selected in the **Save File As Type** listbox:

- 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 may create one file containing all vectors, or one file for each vector in the project.

Export File Format Descriptions

This section describes each of the Export File Formats.

User Defined ASCII Files

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

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 appears (refer to Figure 8.1).

2. Click **Customize** to open the User ASCII Template.

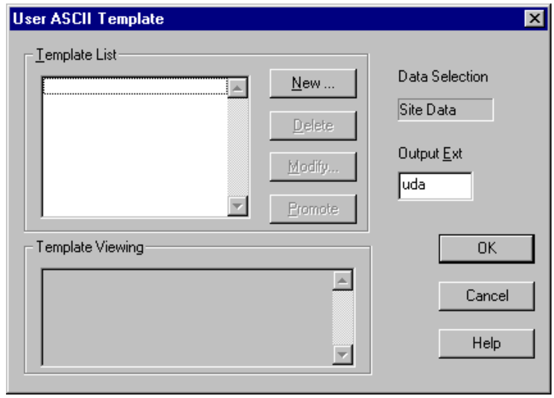


Figure 8.2: User ASCII Template Dialog

Table 8.2 describes the components of this dialog.

Table 8.2: User ASCII Template Dialog

Component	Description
Template Listbox	Provides a list of all default and previously saved ASCII export file templates
Template List Buttons • **New** • **Delete** • **Modify** • **Promote**	 • Creates a new template with a name and opens the User Defined Format dialog. • Deletes the selected template. • Opens the **New Template Name** dialog for the selected template. Enter a unique name and select either Site or Vector Data output. • Opens the **Promote A Data Type Based on: xx.tpl**. This dialog allows you to enter a description and extension for the type of template you are generating.
Data Selection • **Site Data** • **Vector Data**	 • Export of Project site information • Export of Project baseline information
Output Ext	Allows user to define extension of output file (default is**.uda**).
Template Viewing	Provides list of fields for selected template in Template listbox.
Buttons • **OK** • **Cancel** • **Help**	 • Uses the template selected by user for export file format and closes dialog. • Does not use selected template and closes dialog. • Opens the help dialog for the User ASCII Template dialog

3. Create a new or modify an existing ASCII template with the appropriate Output File option.

User Defined Format

If you click **New** or **Modify** in the User ASCII Template dialog, Locus displays the **New Template Name** dialog.

Clicking New allows you to name a new template, while clicking Modify allows you to modify an existing template listed in the Templates List.

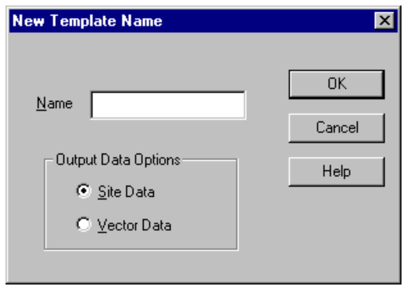


Figure 8.3: New Template Name dialog

This dialog allows you 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.

Once you enter a name and click **Ok**, Locus displays the **User Defined Format** dialog. This dialog will contain Site Data or Vector Data in the **Field Selection** depending on whether you select **Site** or **Vector** output data in the **New Template Name** dialog.

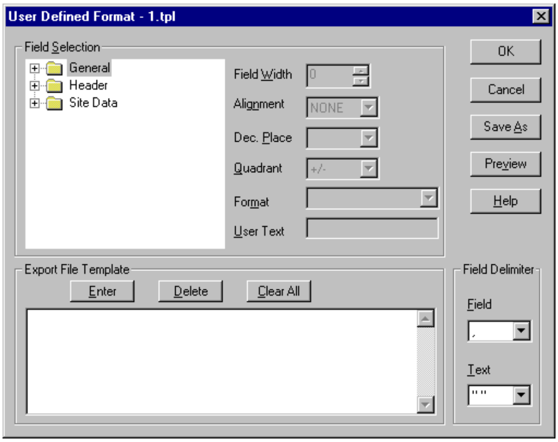


Figure 8.4: User Defined Format dialog with Site Data

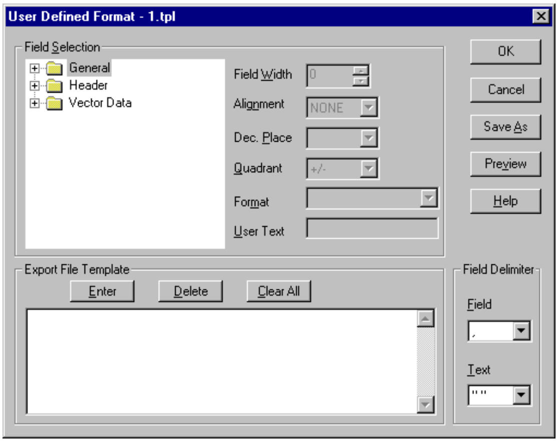


Figure 8.5: User Defined Format dialog with Vector Data

This dialog is used to define the fields and structure of the ASCII export file. Table 8.3 describes the components of this dialog.

Table 8.3: User Defined Format dialog

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 listbox.
User Text	Available only for Text field. Limited to 120 characters.
Export File Template	
Buttons • **Enter** • **Delete** • **Clear All**	 • Enters highlighted field from Field Selection and places in template at current cursor position. *Double-click on a field to highlight it.* • Deletes highlighted fields in template. • Deletes all fields in 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** • **Cancel** • **Save As** • **Preview** • **Help**	• Checks template to ensure position type matches Map System settings. Once it determines the template is **OK**, saves template settings and closes dialog. • Closes dialog without saving template modifications. • Checks template to ensure position type matches Map System settings. Once it determines the template is **OK**, saves template modifications to another template name. • Shows a preview of the field structure for the selected template with simulated data (refer to Figure 8.6) • Displays help for User Defined Format dialog.

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 will 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.
[Processed Vector Length]	Length of the processed vector
[Proc. Vector length error]	The uncertainty of the length at the chosen 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. XX 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

Table 8.4: User Defined Format Field List (continued)

Field Name	Description
[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
Sites Only	
[Site ID]	The ID of the site
[Site Name]	The site name
[Latitude]	Latitude
[Longitude]	Longitude
[Grid Northing]	Northing in grid system
[Grid Easting]	Easting in grid system
[Local Grid Northing]	Northing in local grid system
[Local Grid Easting]	Easting in local grid system
[Ellipsoidal Height]	Ellipsoidal height
[Orthometric Height]	Orthometric height
[Latitude Error]	Uncertainty in latitude
[Longitude Error]	Uncertainty in longitude
[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)
[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.
[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.

Figure 8.6 shows the User Defined Format dialog with a preview of the ASCII export file containing simulated data.

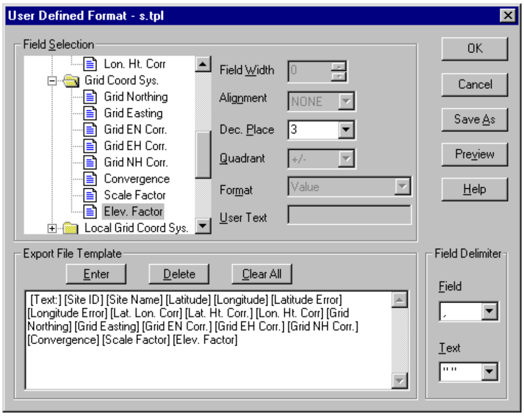


Figure 8.6: User Defined Format dialog with Preview

4. Modify the field selection, field template structure, and field delimiters of the User Defined ASCII export file.
5. Click **Save As** in the User Defined Format dialog to save the template.
6. Click **OK** in the User ASCII Template dialog to use selected template and close dialog.
7. Click **Save** in Export Data dialog to export data in User Defined ASCII export file.

Promoting a Data Type

By clicking **Promote**, you will include the selected template in the **Save as type** dropdown selection in the Export dialog. The “promoted” template will be available the next time you export a User Defined ASII file.

Ashtech O-File Format

The O-file is a binary report of the vector-only data in the project. Once you select O-file in the Export Data dialog, Locus exports an Ashtech proprietary standard file containing processed and/or adjusted vector information. Locus automatically assigns the project day as the extension of the file. This file can be imported into other Ashtech and third-party software packages.

The Effects of Filtering

Remember that filtered data will not export (refer to Chapter 5, **Data Processing**).

Exporting Processed Versus Unprocessed Data

Locus 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.

Using Exported Data

Using User Defined ASCII Files

User defined ASCII files are created so that you can customize the table of information that you want to import into a third-party software package.

The file can even be loaded into Microsoft Excel™ so that further modifications and data analysis can be done.

Using Ashtech O-Files

O-files containing binary processed vector information can be imported into various Ashtech and third-party software packages.

Coordinate Transformations

Introduction

One of the primary advantages of using the Locus processor package is the ability to work within your own coordinate system from the very start of your project - you no longer need to be concerned with transforming to and from the WGS84 datum, which is what all GPS data are referenced to. The Locus processor gives you the option of working in three types of horizontal coordinate systems - Local Grid, Grid System or Geodetic. In addition you may choose to use either ellipsoidal heights or orthometric heights. Although Locus includes many predefined grid systems and geodetic datums, it is easy to create your own custom coordinate system.

The three types of coordinate systems can be seen to build on one another. At the heart of any system lies the geodetic datum, with a known relationship to WGS84, represented by the Geodetic system type. On top of that might exist a Grid System, consisting of one or more zones, each utilizing one of the several projection types available in Locus. Finally, a Local Grid can be superimposed over a Grid System.

You will typically select or define the coordinate system you wish to work in when you create a new project. From that point on, all coordinates will be presented to you in that system. However, it is possible at any point during the project to change to a different system, and all your coordinates will be automatically transformed to it.

Based on our experience from customer feedback it is common for our users to do many projects in the same coordinate system - for your convenience, the coordinate system in a new project is automatically set to the system that was last chosen.

Selecting a Predefined Coordinate System

To select a predefined coordinate system:

1. From the **Coordinate System Tab** of the **Project Settings** dialog box, select system type (Local Grid, Grid, or Geodetic).
2. When you select a certain coordinate system type it activates, the associated listbox which lists all the available choices.
3. Select the appropriate choice and click Ok.
4. Click **Cancel** if you do not wish to select a choice.

Defining a New Geodetic Datum

When creating a custom Geodetic Datum, you must tie the new system to the WGS-84 datum. You must have the following information to produce accurate post-processed GPS data using a custom datum:

- Shifts and rotations in x, y, and z axes
- Scale difference
- OR a set of three or more points with coordinates for both the WGS84 and custom datum. A minimum of four coordinate pairs are recommended and required to produce meaningful statistics from the estimation.

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, enter the name for the new datum.

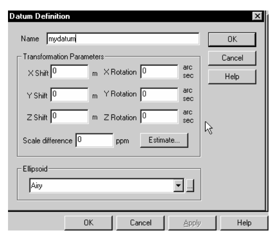


Figure 9.1: Datum Definition dialog box

4. Select the ellipsoid which the new datum uses (refer to "Defining an Ellipsoid" on page 83).
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 83.
6. Click **OK** to write the parameters to the datum, and close the **Datum Definition** dialog box.

Defining an Ellipsoid

You can also define a custom ellipsoid for a custom datum. In order to define a new ellipsoid you must have the following:

- Semi-major axis value
- Inverse flattening value

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

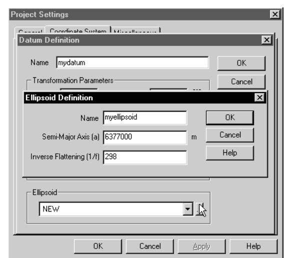


Figure 9.2: Ellipsoid Definition dialog box

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. Locus Processor uses industry standard equations to calculate transformation parameters (7-parameter similarity transformation).

Although you can calculate transformation parameters with only three data points, at least four are required to compute residual data, and at least five well distributed points should be used to ensure all points are valid points.

If you have loaded data into the project, the sites can be used in the transformation calculation. After selecting a site, both WGS84 and local coordinates are displayed. The coordinates can be edited, and any changes made are saved to the data set for those points actually used in the estimation.

1. From the Datum definition dialog box, click on the **Estimate.....** button to bring up the Datum Transformation dialog box.
2. Enter the point's Site ID, or if you have loaded data into the project, select a site by clicking the arrow at the right of the Site ID box and selecting a site.
3. With the **Datum Transformation Parameter Estimation** dialog box open, click the **On** check box for the first point.
4. If you selected a site, both the WGS84 and local datum coordinates are listed.
5. Edit the latitude, longitude, and elevation for both the local and WGS84 systems, if necessary.
6. Repeat for all points.

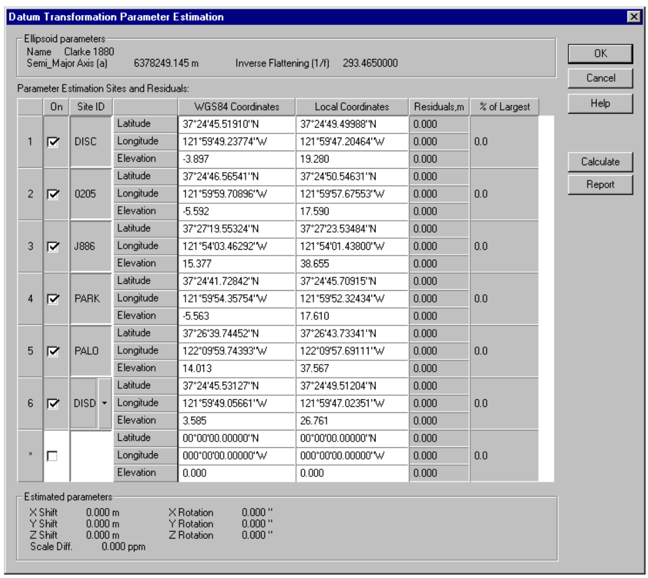


Figure 9.3: Data Transformation Parameter Estimation

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.

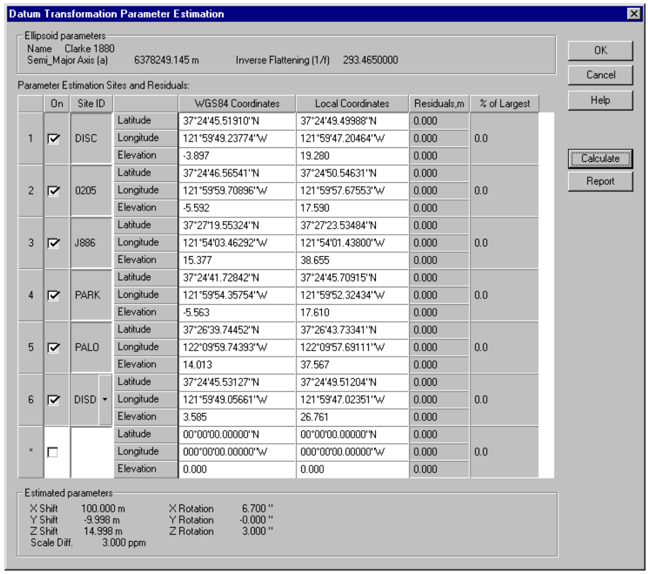


Figure 9.4: Data Transformation with Estimated Parameters

If you entered more than three data points to calculate the transformation parameters, Locus Processor also 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, you may want to recalculate the transformation parameters excluding that point. To exclude a point, uncheck the **On** check box and click **Calculate** to recompute the transformation parameters.

Defining a New Grid System

When creating a custom Grid System, you must tie the system to a datum and define zones for it. You must have the following information to produce accurate post-processed GPS data using a custom grid:

- Reference geodetic datum
- Projection type
- Projection parameters for the zone(s) you define.

1. From the **Coordinate System Tab** of the **Project Settings** dialog box, select **Grid** as the system type.
2. Select **NEW** as the Grid System, and click the **Define** button.

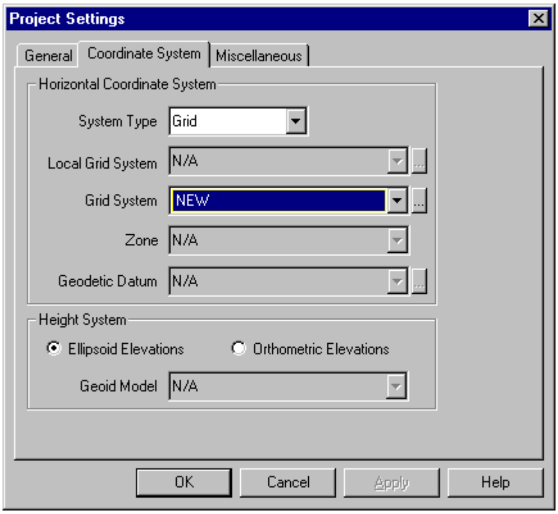


Figure 9.5: New Grid System

3. In the **Grid System Definition** dialog box, enter the name for the Grid System.

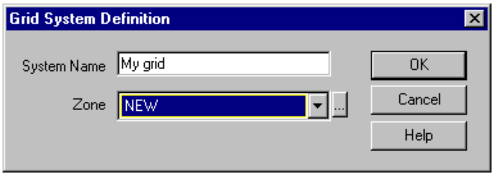


Figure 9.6: Grid System Definition

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

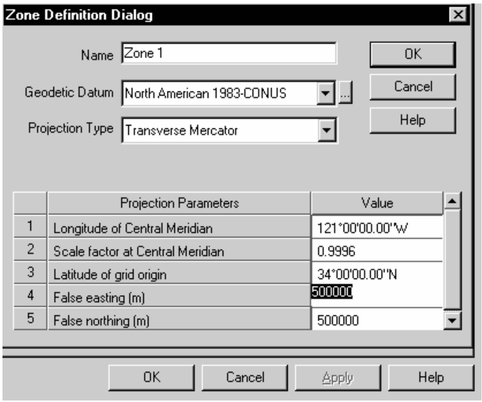


Figure 9.7: Zone Definition

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

When creating a custom Local Grid System, you must tie the custom system to an existing Grid System (Base Grid) and Zone (Base Zone). You can use computed transformation parameters to convert to the custom grid system, or enter the local and base grid coordinates for a minimum of two points, and have Locus Processor estimate the transformation parameters.

You must have one of the following to produce accurate post-processed GPS data using a custom local grid:

- Easting and Northing shifts (x and y translations), Rotation about a vertical axis, and the Scale difference between the base and custom grid systems in parts per million (PPM).
- OR Grid coordinates in both systems for a minimum of two sites. Three or more sites are recommended and essential for deriving meaningful statistics from the estimation.

To define a new local grid system:

1. From the **Coordinate System Tab** of the **Project Settings** dialog box, select Local Grid as the system type.
2. Select **NEW as** the Local Grid System, and click the **Define** button.

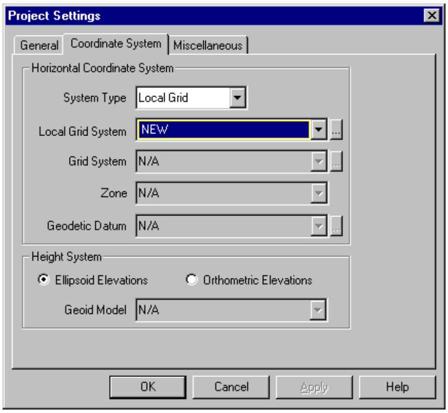


Figure 9.8: Project Settings—New Local Grid System

3. In the **Local Grid System Definition** dialog box type the name for the local system.

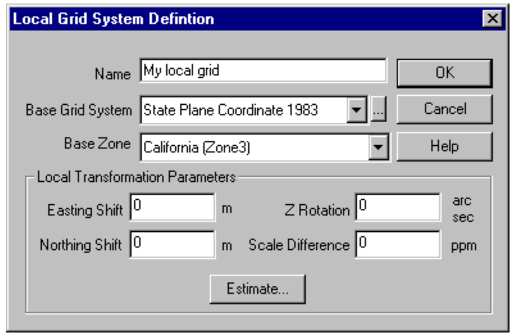


Figure 9.9: New Local Grid Definition

4. Select a Base Grid System and Base Zone. You can define your own grid 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), and Scale Difference 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 90.

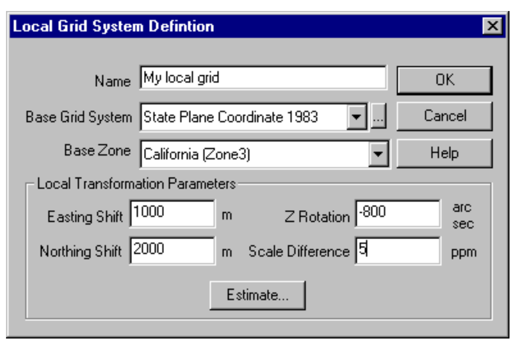


Figure 9.10: New Local Grid Definition with Transformation Parameters

Note the “direction” of the parameters is from the base grid to the local grid, and that rotation is positive in a counter clockwise direction. Click on **OK** to save the parameters to the database.

Estimating Local Grid Transformation Parameters

The Local Grid Transformation Parameter Estimation dialog box is used to enter grid coordinates of survey points, and calculate transformation parameters if you do not know the transformation parameters. Locus Processor uses industry standard equations to calculate transformation parameters.

Although you can calculate transformation parameters with only two data points, at least three are required to compute residual data, and at least four should be used to ensure all points are valid points.

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

From the Local Grid System Definition dialog, click on **Estimate...**.

1. With the **Local Grid Transformation Parameter Estimation** dialog box open, enter the point's Site ID or if you have loaded data into the project, click the arrow at the right of the Site ID box and select a site.

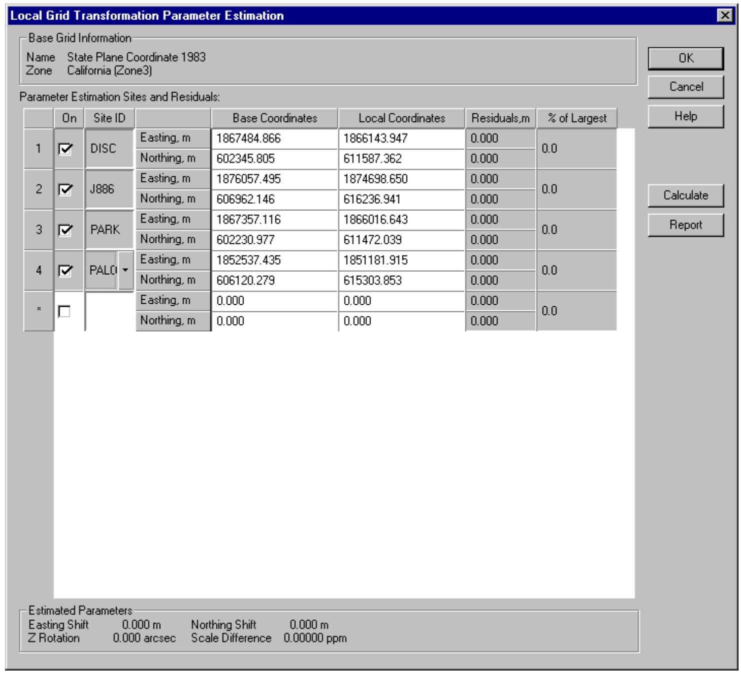


Figure 9.11: Estimating Local Grid Transformation

2. Edit the northing and easting grid coordinates for both the local and base grid systems, if necessary.
3. 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.

   If you entered more than two data points to calculate the transformation parameters, Locus Processor also 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). For example, in Figure 9.12 you can see that Point J886 has the largest residual. This may indicate that the coordinate is wrong.

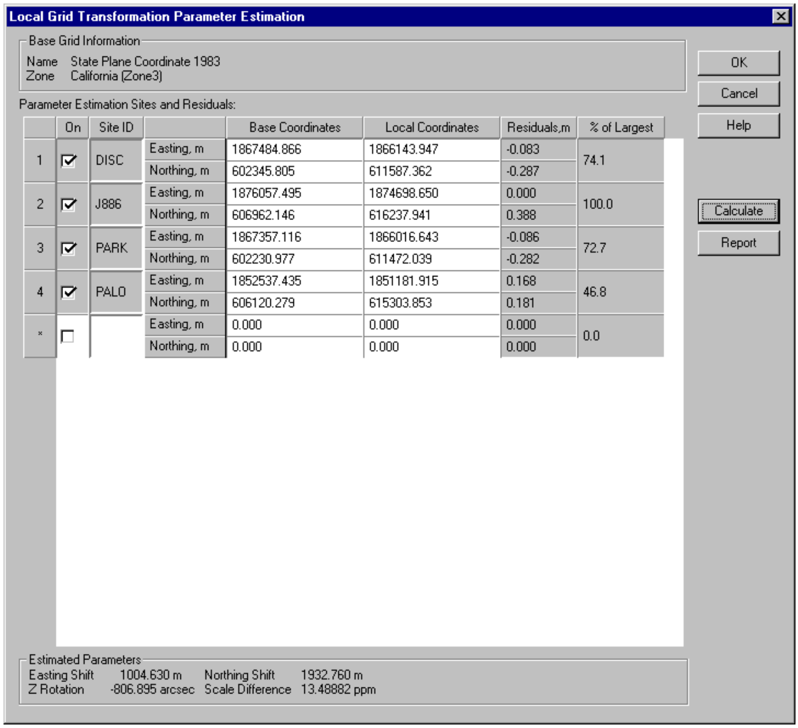


Figure 9.12: Local Grid Transformation Parameter Estimation

The last column in the dialog 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.

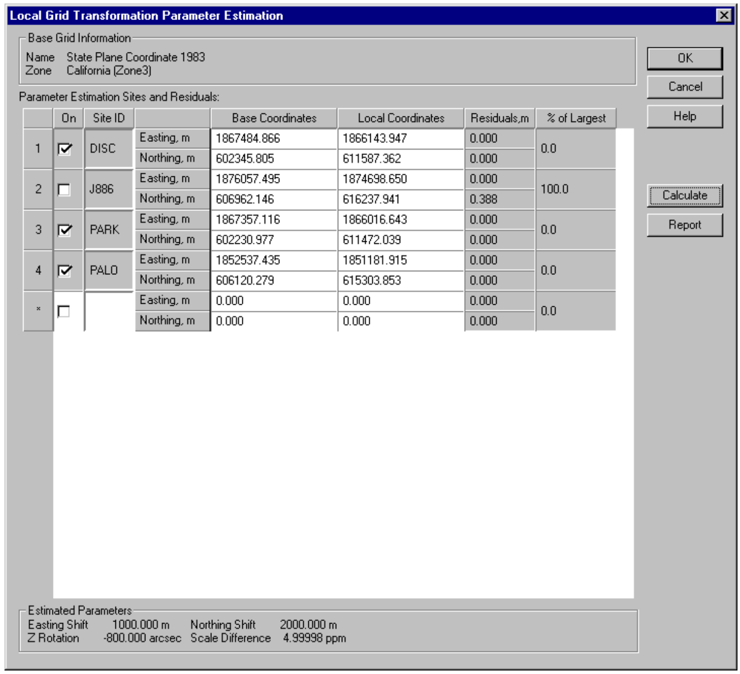


Figure 9.13: Local Grid Transformation With Estimated Parameters

4. Click **OK** to write the parameters to the local grid definition, and close the **Local Grid Transformation Parameters Estimation** dialog box.

   The points used to calculate the transformation parameters are saved in the **Local Grid Transformation Parameter Estimation** dialog box.

5. You may produce a final report of your parameter estimation by clicking **Report**. This will display a predefined report format showing the points used in the estimation, new parameters, and the residuals.

Height Systems

The Locus processor gives you 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 during project creation.

In the Coordinate System tab of the Project Settings dialog, you can see that there is a simple selection between ellipsoidal and orthometric systems. If you choose orthometric, you must choose a geoid model as well. The geoid model is used to define the relationship between the orthometric heights you will be using and the ellipsoidal heights that the Locus processor uses to process and adjust your survey data. We have provided several geoid models in Locus, including Geoid96 (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. This is 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 this will be more accurate for your area.

The height displayed throughout Locus depends on the system you select here.

The use of local height systems which vary considerably from M.S.L. for orthometric heights may adversely affect your results.

A Note Concerning NADCON

If you select a datum which uses the NADCON transformation, you will be forced to use orthometric heights. This is because NADCON is a 2-D transformation, and ellipsoid heights are therefore 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 will cause unpredictable and erroneous results.

10

Tutorial #1 - Using the Locus Planning Module

Planning is important for the success of a GPS project. Planning involves selecting your control stations, verifying that they are usable for GPS observations, setting new stations in usable sites, and establishing a plan for occupying these stations. As much as possible, we want to consider our surveys as networks so that we can use the benefits of the least - squares adjustment routine, and plan accordingly. An important part of the Planning process is the scheduling of the observations and the Locus planning module. With these routines we can determine the best times for our observations, and if we have obstructed sites, we can enter in those obstructions graphically and see their effects on the satellite geometry.

1. Start the program. From the Windows 95 or NT™ taskbar, select in order...**Start | Programs | Locus Processor | Mission Planning**. The Mission Planning splash screen displays for a moment and then the main planning window will appear.

You can also start the program from within the Locus Project Manager by selecting Tools from the Planning menu.

An information box may be encountered: “WARNING. The almanac file is over 60 days old.”

We’ll use this almanac anyway for consistency in the tutorial. For your own work, download a more recent almanac from Locus

The almanac file used in this tutorial is called ALM98.257 and is installed automatically.

2. From the planning menu bar, select **Open** from the **Site List** menu.

3. From the file selection box, select the **bin** folder the Locus folder by double clicking on it.

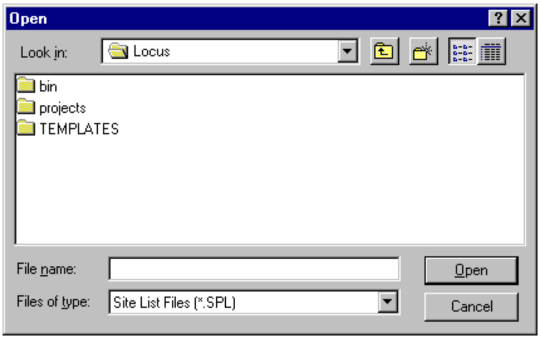


Figure 10.1: File-Open Dialog

4. Select the **usasites.spl** file by double clicking on it, or by single-clicking on it and then clicking the **Open** button.

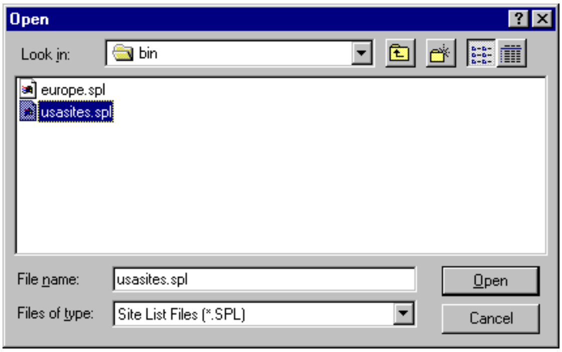


Figure 10.2: Selecting a Sites File Dialog

5. The Site Editor dialog box opens listing US cities, with Ashtech as the current location. You can select any city or create a new site, but for the

tutorial, use the Ashtech, Inc ....simply click on the **Select** box in the lower right portion of the **Site Editor** dialog box.

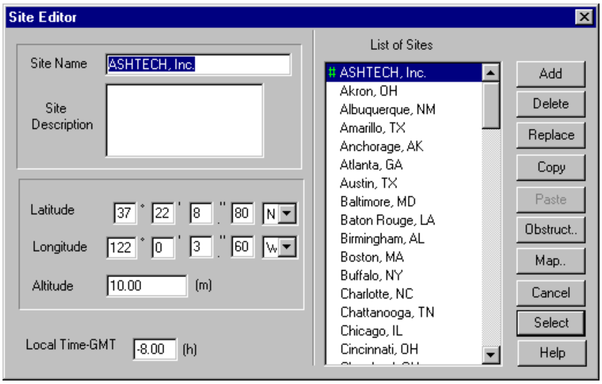


Figure 10.3: Site Editor Dialog Box

Make sure that the Local Time-GMT offset is correct for your time zone, and the time of the year. The example shown is -8.00 hours for Pacific Time in the winter. For Daylight Savings Time in the summer, this value should be -7.00 hours.

1. Click on the **DOP Plot** button.

   A 24 hour plot displays the number of satellites available, and the associated Position Dilution of Precision (PDOP) values. This is the single most important plot for planning our observations. We see both the number of satellites available at any time, and we also see the corresponding strength of the satellite geometry. For static surveys, weak geometry requires longer observation. For dynamic surveys, we want to have a minimum of 5 satellites available so that we can reasonably count on having the absolute minimum of 4 and still allow for the occasional obstruction of a satellite.

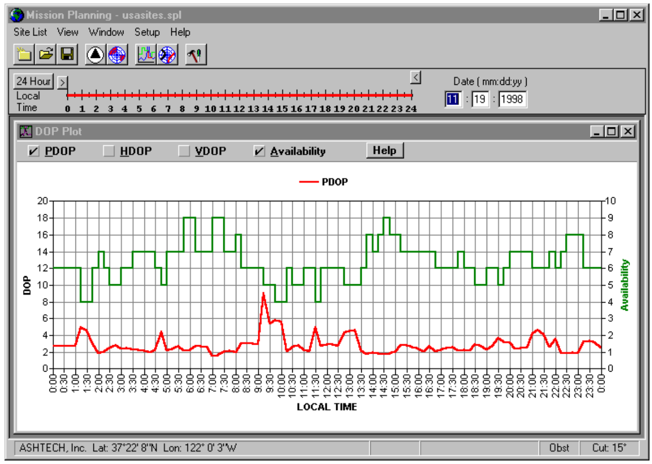


Figure 10.4: DOP Plot Display

2. By default, the date is set to the current date. For this tutorial, change the date to 11:19:1998

The smaller the PDOP value, the stronger the satellite geometry, therefore achieving accurate GPS measurements.

In our example, we see that there are two periods where the PDOP is 5 or higher. Let’s zoom into the 1 hour period of 09:15 to 10:00. To do this, move > and < arrow buttons above the Time Bar so that only the span between

09:15 and 10:00 is red. Single-click in the display window to display Figure 10.5.

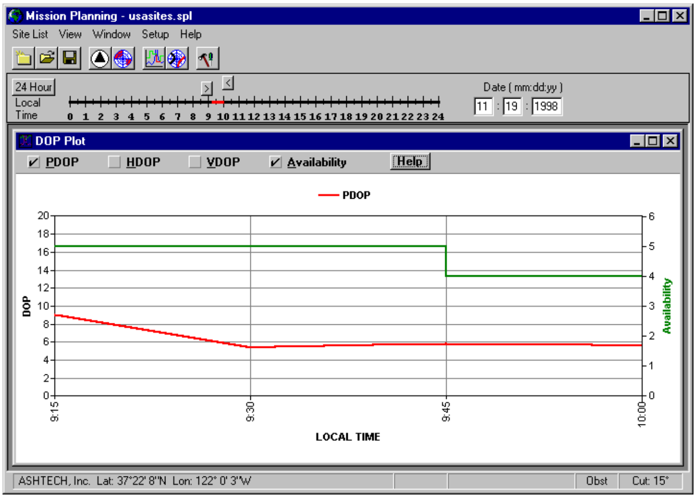


Figure 10.5: Zooming in on the DOP Plot

Now let's see what the sky plot looks like for this period of time. Simply click on the **Sky Plot** button in the toolbar to open the Sky Plot.

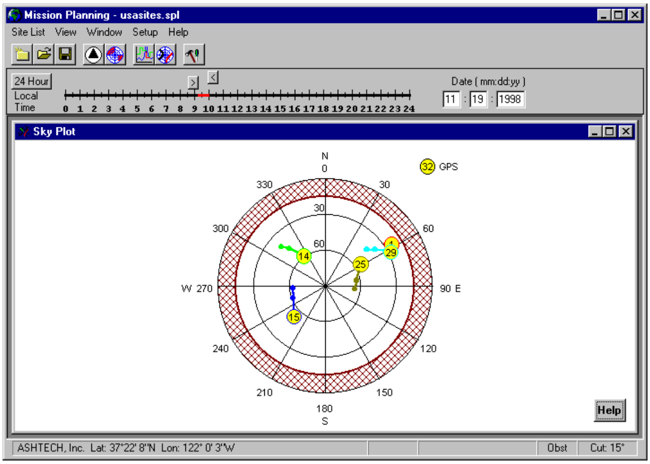


Figure 10.6: Sky Plot Display

You can see that we have lost two low satellites. We only have five remaining. Four of the five are lined up, so that the geometry is weak. This is not a good time for dynamic surveying and it should be avoided. If we are going to be doing static observations during this time, we should schedule the session to start and end with good geometry on either side of the weak period, or schedule the sessions to avoid the weak period.

Values of PDOP over 4.0 usually flag time periods that are marginal for GPS surveying.

Suppose there is a large building to the northeast of the survey station. Let's enter the obstruction and see its effect on our geometry. Click the **Obstructions** button on the Toolbar to open the **Obstruction Editor**.

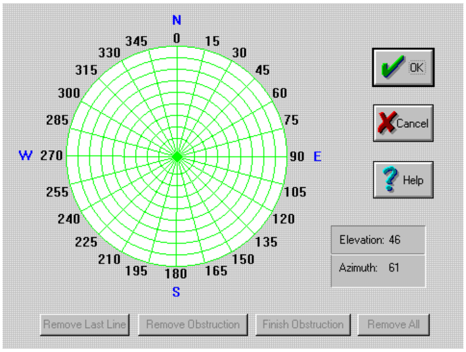


Figure 10.7: Obstruction Editor

Enter the obstruction.

1. Move the mouse to about 30 degrees of azimuth and 0 degrees of elevation and click.
2. Move the mouse to about 30 degrees of azimuth and 40 degrees of elevation and click. You should see a line between the two points. If not, you may not have selected the first point correctly- try again.
3. Move the mouse to about 60 degrees of azimuth and 40 degrees of elevation and click.
4. Next, move the mouse to 60 degrees of azimuth and 0 degrees of elevation and click.

5. Finally click the **Finish Obstruction** button to complete the obstruction and display it as a hatch-mark area (Figure 10.8).

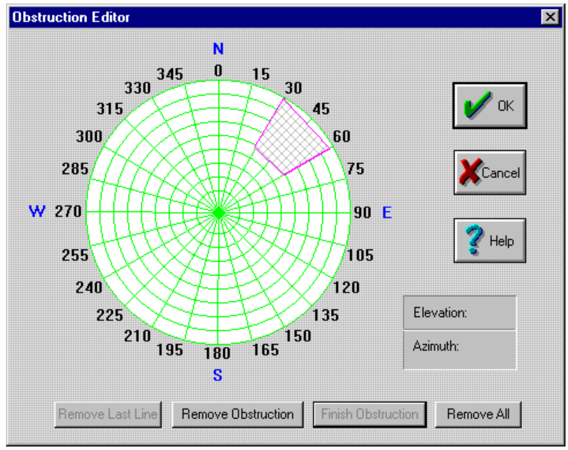


Figure 10.8: Obstruction in Place

6. Click on the **OK** button to display the Skyplot with the obstruction in view.

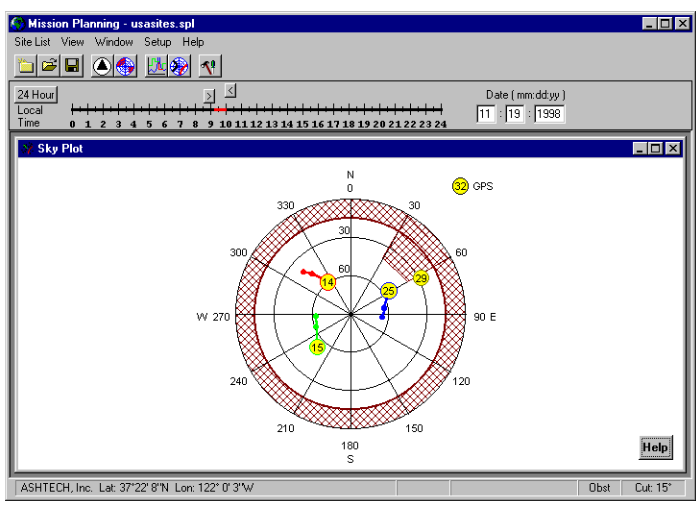


Figure 10.9: Sky Plot After Entering an Obstruction

To see the effect of the obstruction on the PDOP, click the **PDOP Plot** button. Notice that the DOP line disappears (the DOP value goes above our scale) and that the number of satellites drop to 3 for the entire session. This is not a good time to occupy this station.

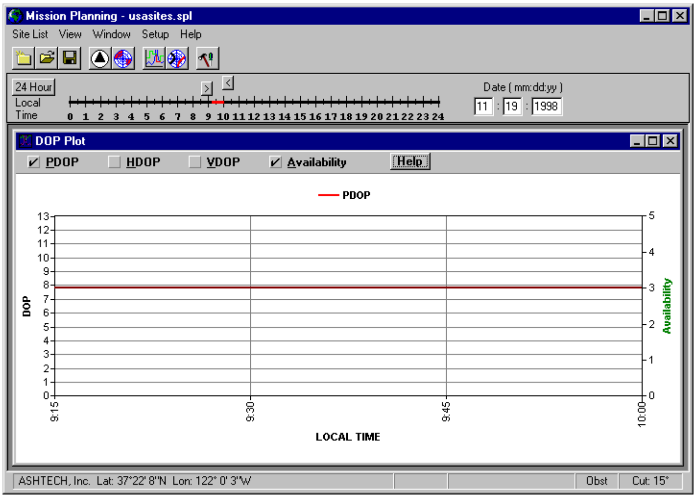


Figure 10.10: DOP Plot Zone after Obstruction

To get a 24 hour view of the DOP Plot and select a better observation time, click the **24 Hour** button.

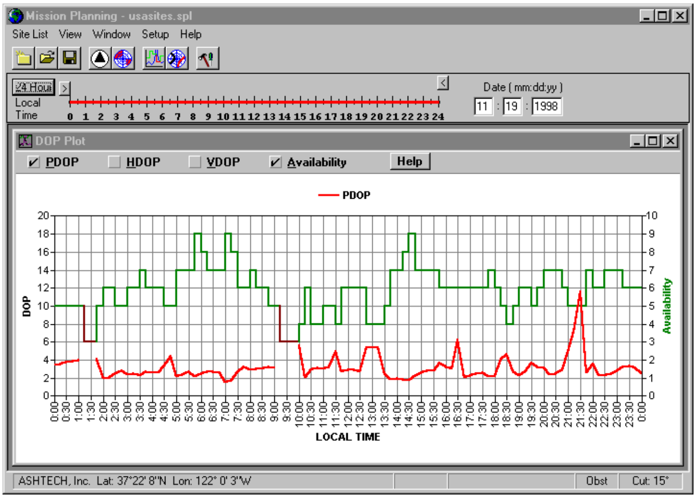


Figure 10.11: 24-Hour View

With the existence of the obstruction, there are periods of poor geometry around 01:00, 09:00, 11:30, 13:00, 16:30, 18:30, and 21:30. It would be better to observe this station sometime between 02:00 and 04:00, or perhaps between 05:00 and 07:30.

7. Print the graph by selecting from the **Site List** menu.
8. Save the plot by selecting from the **Site List** menu.
9. Exit the program by selecting **Exit** from the Site List menu.

   Refer to the Appendix A, **Mission Planning** for further details.

11

Tutorial # 2 - Downloading

Locus Receivers and Handheld Receivers

Your receiver will not come from the factory with any data files. In order to follow along with the download steps you will have to collected at least one data file in your receiver.

We will download data into a new project, although you may also use Locus Download without a project.

1. Start Locus Processor Project Manager, from the Start menu in Windows™.
2. From the Locus menu line select **New** from the **Project** menu (or if you are just starting the program, select **Create a new project** from the startup screen) and the program will present you with the New Project window. Choose to create a new project.

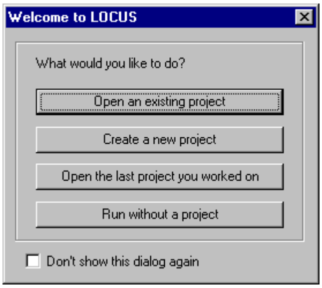


Figure 11.1: Locus Intro Screen

3. Enter the name of your project. We will use the project name **Download** for the tutorial, so we don't overwrite any existing files or projects.

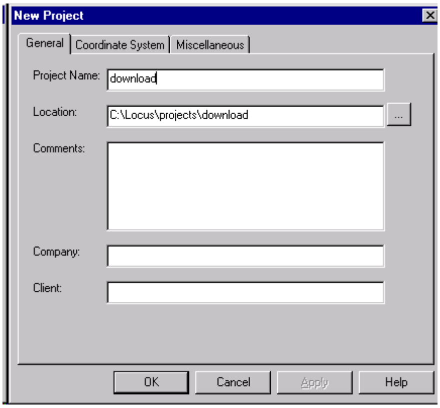


Figure 11.2: New Project - General Tab

4. Select the **Coordinates System** tab to setup the project's coordinate system. As an example, we are going to use California Zone 3 State Plane 83 coordinates and orthometric heights. Our geoid model will be the NGS Geoid96 model. For your data, you should use the appropriate System for your area.

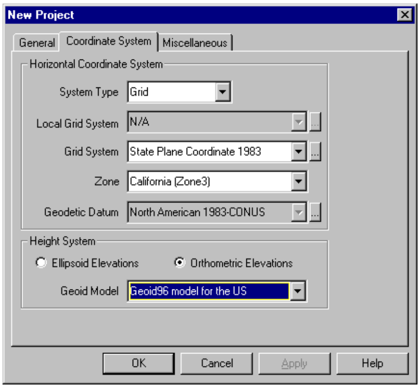


Figure 11.3: New Project - Coordinate System Tab

5. Next switch to the **Miscellaneous** tab to set the project's units and accuracy thresholds. The screen below shows some example values.

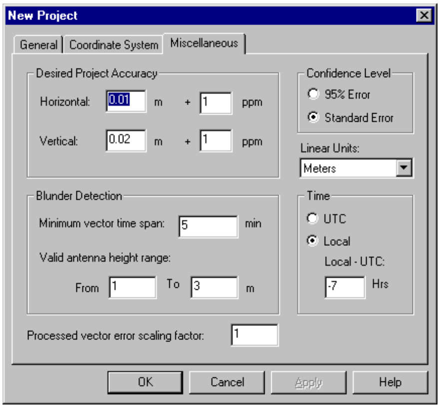


Figure 11.4: New Project - Miscellaneous Tab

6. When you click **OK** you will be prompted for your data source.
7. Select **Add raw data files from receiver**.

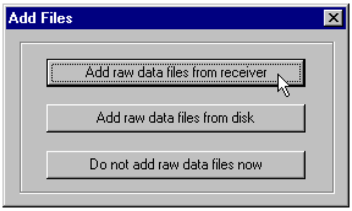


Figure 11.5: Add Files Dialog

The program will then display the Locus Download window showing the files in the current project directory on the right side. If the displayed directory is not where you want the files to go, change it by double-clicking the up arrow icon in the directory list and the pull down list box above it, if necessary.

8. Connect the IR device to any available serial port.
9. Turn on the Locus receiver on and position it within six to twenty four inches of the IR device which should be pointed at the receiver's IR window.

For best results, pay attention to the alignment of the IR devices! (Refer to Chapter 4, Adding Data Files).

Steps within the Download Program

1. From the pull down menu, select **Connect** from the **File** menu.
2. Select the com port that you have connected the Locus IR device to.

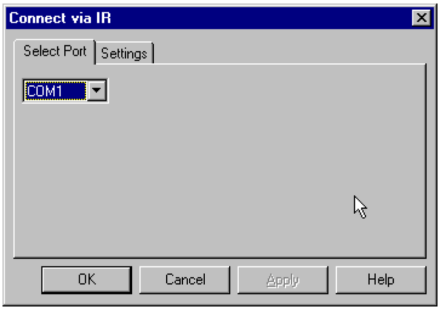


Figure 11.6: Connect Via IR Dialog - Select Port

3. Click on the **Settings** tab and select a baud rate of **57600**.

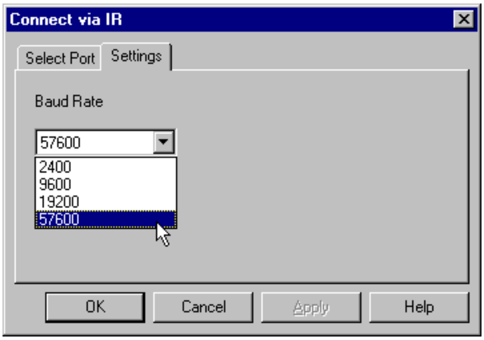


Figure 11.7: Connect Via IR Dialog - Settings

4. Click the **OK** button.

   The program searches for the receiver on the com port and set the baud to your selected rate. You will see a couple of animated icons, a flashlight searching and a magnifying glass examining a file folder as the software inspects the receiver memory, and then you will see a list of the files on the receiver. The files may be different than shown.

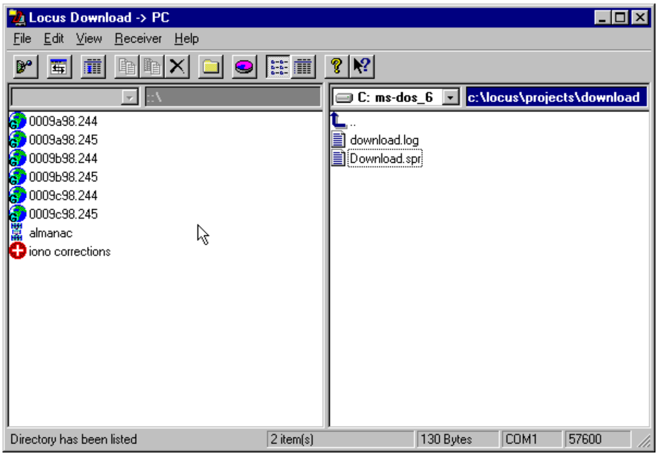


Figure 11.8: Receiver Files Listing

5. Highlight the files you wish to download, then drag and drop them to the PC Pane.

Tutorial #2

To highlight multiple files use the <Ctrl> or <Shift> keys while clicking with the mouse.

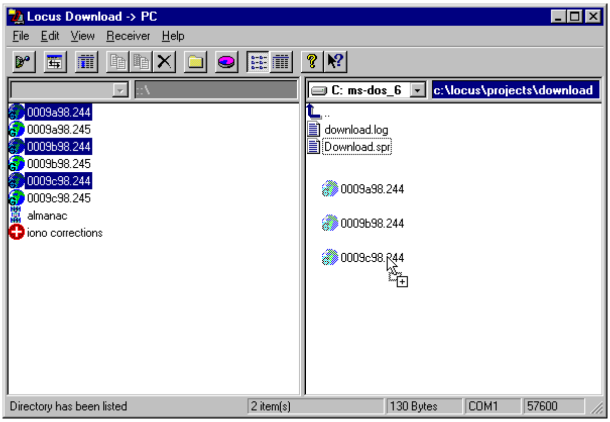


Figure 11.9: Dragging and Dropping a File

6. A copying box shows the percentage of each file completed. When the download is complete, the new B and E files are listed on the right side of the screen.

   Each data file in the receiver will have a corresponding B and E file. You should also download the almanac file if yours is outdated, (more than 60-

days old) and place it in the Locus \BIN directory for the mission planning software to use.

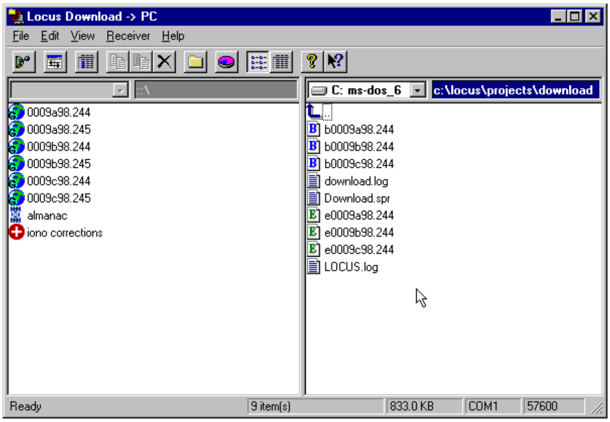


Figure 11.10: Download Results

If you have only one receiver and have not used a handheld, then jump ahead to step 11.

7. Select **Switch Data Source** from the **Files** menu.

The current receiver will be turned off and the following prompt (Figure 11.11) will appear. The next device can be either another receiver or a handheld. For our example, we will use a handheld.

Figure 11.11: Switch Data Source Message

Turn on the Locus handheld and make sure the HP48 Locus program is running. For more information on starting the Locus program, refer to the *Locus System Operation Manual*.

8. Press the **E** Key **[DNLD]** on the Handhelf
9. Point the HP at the IR device and press the **B** Key **[STRT].**

10. Now activate the connection by choosing **OK** from the Switch Data Source Message.

The PC download program will search for the new device and change the baud rate if necessary. When the new device is connected, the files it contains will be displayed in the left half of the download window. Drag and drop the appropriate files to the right side of the screen. The handheld will always have only a single file.

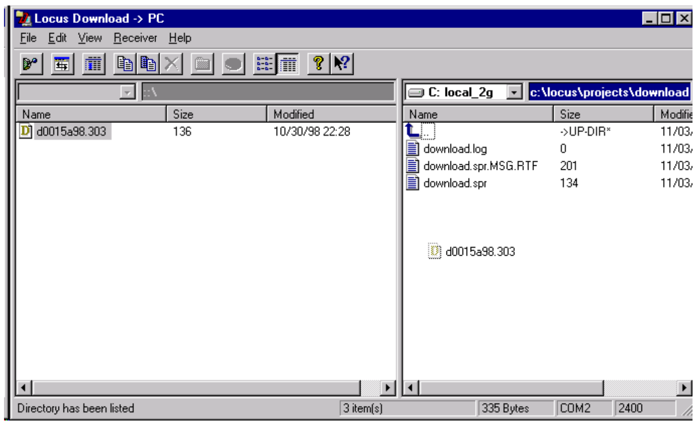


Figure 11.12: Dragging a Locus Handheld D-File

The copying box will appear and show the progress of the copy.

When the copy is finished repeat the above steps using **Switch Data Source** until all the devices have downloaded.

The handheld will disconnect after each download. To reestablish a connection, choose "File - Connect" when the next device is in place and switched on.

In this example we have downloaded one receiver and one handheld. It would probably be more efficient to download all the receivers, and then download all the HP 48's (if any). There would be less switching of baud rates and the process should proceed a little faster.

11. When all devices have been downloaded, select **Exit** from the Files menu.

The data is then loaded into the project database and displayed in both a timeline view and a workbook view as shown below.

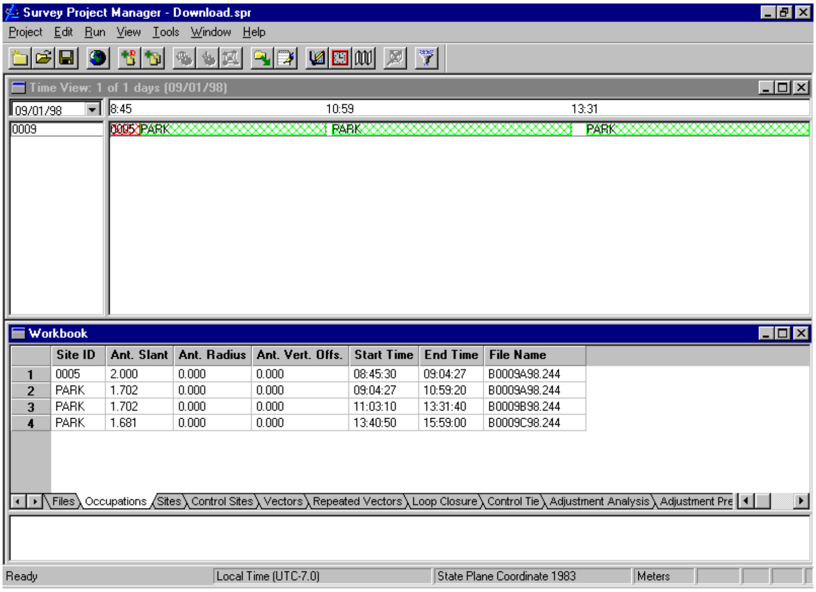


Figure 11.13: Downloaded Files Populate Program Manager

If we have downloaded all the receivers, and any HP 48’s, we should be ready to process.When all the receivers and the handhelds have been downloaded, you are ready to begin processing.

12

Tutorial #3 - Locus Processing, Adjusting, Exporting and Reporting

At this point the data have been downloaded from the receiver into a project directory and we are ready to process them. If a project file had been opened before downloading the receivers, the data would have been automatically imported into the project database and we could skip to step 15. However, we are going to use data that have already been downloaded separately, so we will create a new project and import the data from the disk rather than from the receiver.

1. From the **Welcome to Locus** dialog box, select **Create a new project**.

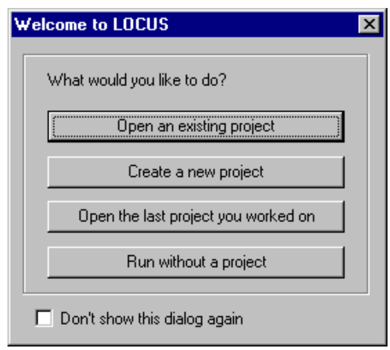


Figure 12.1: Welcome to Locus Dialog box

This opens the new project window.

2. Enter **Tutor Static** in the **Project Name** field. **Comments**, **Company**, and **Client** may also be entered at this time, but are not necessary. You may enter them at any time.

For the best outcome, use the name of the directory in which you placed your data as the project name.

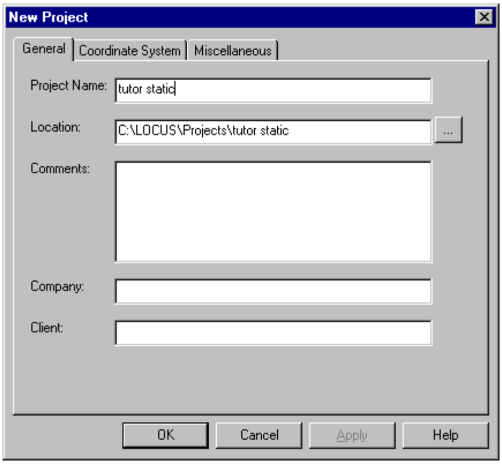


Figure 12.2: New Project General Tab

3. Click on the **Coordinate System** tab.
4. Select **Grid** as the **System Type**.
5. Select the **State Plane Coordinate 1983** option in the **Grid System** list box.
6. Select the **California (Zone 3)** option from the **Zone** list box.
7. Click the radio button next to **Orthometric Elevations** under **Height System.**

8. Select the **Geoid96 model for the US** from the **Geoid Model** list box.

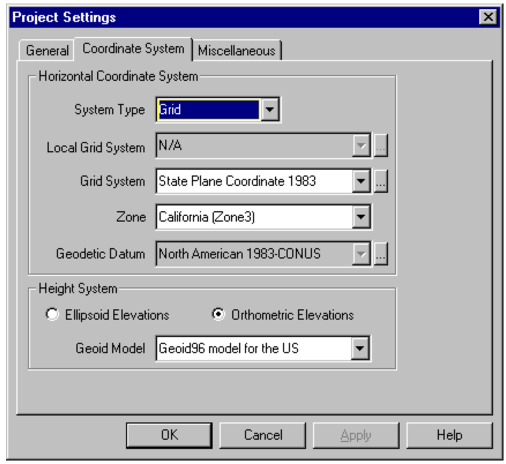


Figure 12.3: New Project Coordinate System Tab

9. Click on the **Miscellaneous** tab.
10. Set the miscellaneous settings as shown in Figure 12.4.

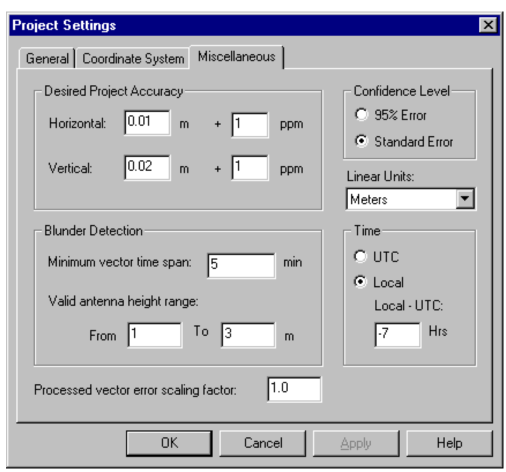


Figure 12.4: New Project Miscellaneous Tab

11. Click on the **OK** button and you will be asked for the location of your data.

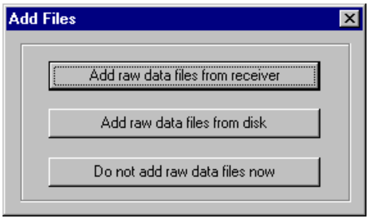


Figure 12.5: Add Files Prompt

12. Click on the **Add raw data files from disk** button and the **Add Files** dialog box appears.

    Using the drop down list box, find the data files in the **Tutor Sta\Day 98.266** directory. A list of the files in the project directory should appear. Select all the files by clicking on the first filename, and then holding the <**Shift**> key down and clicking on the last filename, or select all the files by pressing the <**Ctrl**>+<**A**> keys.

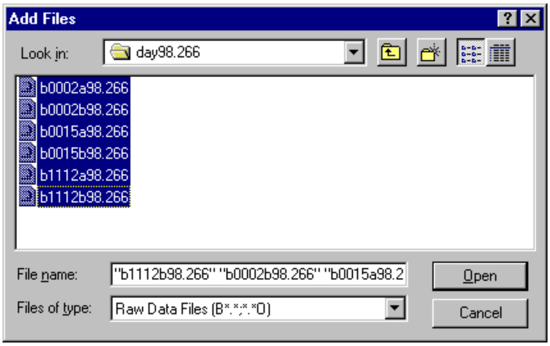


Figure 12.6: Add Files Dialog

13. Click the **Open** button, and the **Time View Diagram** window and the **Workbook Project** window appear with the **Occupations** tab active. In the **Time View Diagram**, you see horizontal bands of color associated with the different site ID's. All occupations of a site are in the same color, i.e. each occupation of site DISC is shown in green. The actual color may differ slightly on your machine due to system settings. In the **Occupations** tab the associated antenna heights, start and stop times, and file names for each occupation are listed.

This occupation information should be verified with the operator's field logs, however for this tutorial we will assume that the given information is correct. Time View assigns colors to sites as they are encountered, so your display may not exactly match the example.

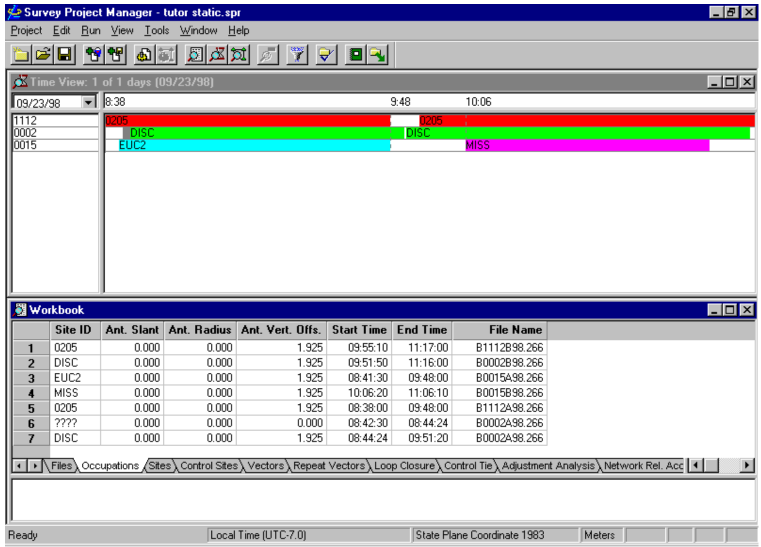


Figure 12.7: Project Manager - Static Data

14. For the best possible results, we will select a known station to start our processing. Click on the **Control Sites** tab and then click on the small down-arrow to the right of the **Site ID** input box.

Tutorial #3

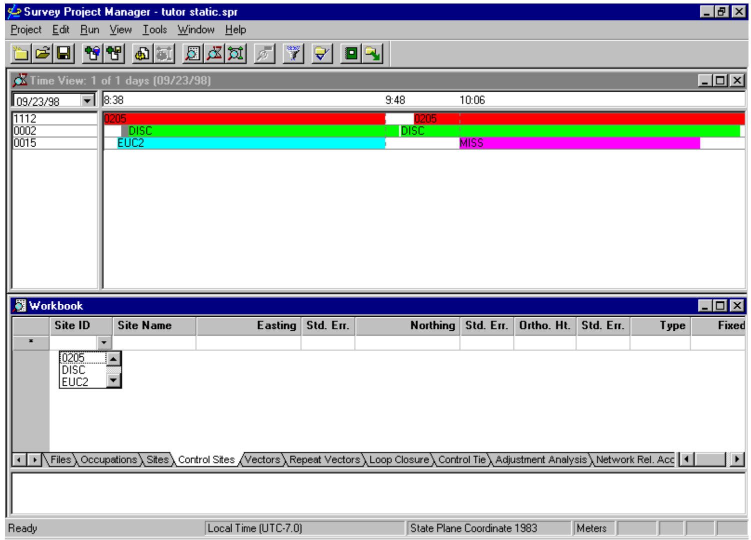


Figure 12.8: Select a Control Site

15. Select site **MISS** from the list by clicking on it (use the scroll bar if MISS is not visible in drop menu).

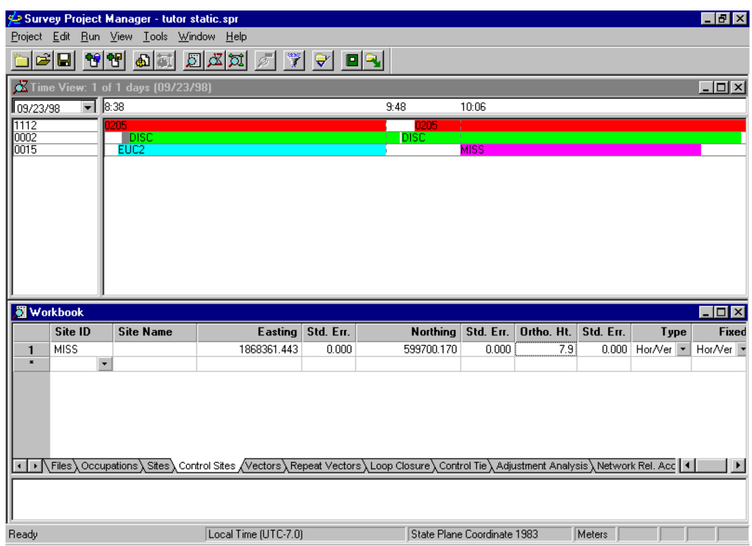


Figure 12.9: Control Site Coordinates

16. Edit any coordinate values by double-clicking in the edit box to highlight the value and then entering in the correct value (given here in meters).
    - Easting 1868361.443
    - Northing 599700.170
    - Ortho Ht. 7.9

Make sure the last field changed is not in active edit mode (highlighted).

Processing the Locus Data

1. Select **All** from the **Processing** menu of the **Run** menu.

   The Map View opens, and Locus Processor processes the data vector by vector. It provides us with the six vectors measured between our 4 stations during the two occupation sessions. In the **Workbook** window, the **Vectors** tab is on top. Notice that the QA fields are blank for all six vectors indicating that the standard errors are below the threshold QA values and believed to have correctly fixed integer ambiguities.
2. After processing, inspect the vectors tab and **Map View**.

Higher than expected standard error estimates and failed QA tests may indicate the solution is float.

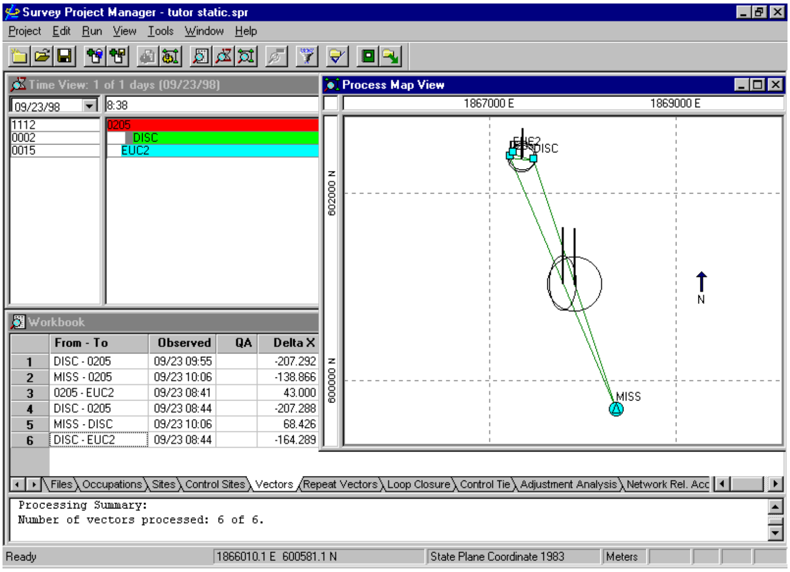


Figure 12.10: Processed Data

3. We now want to add more raw data from another day. Select **From Disk** from the **Add GPS Raw Data** menu, in the **Project** menu.
4. Select all the files in the **Tutor Static\Day 98.273** directory.
5. Select **Unprocessed** from the **Processing** menu in the **Run** menu to process only the new vectors. After the processing is complete for the ten new vectors, the screen should appear similar to the one below.

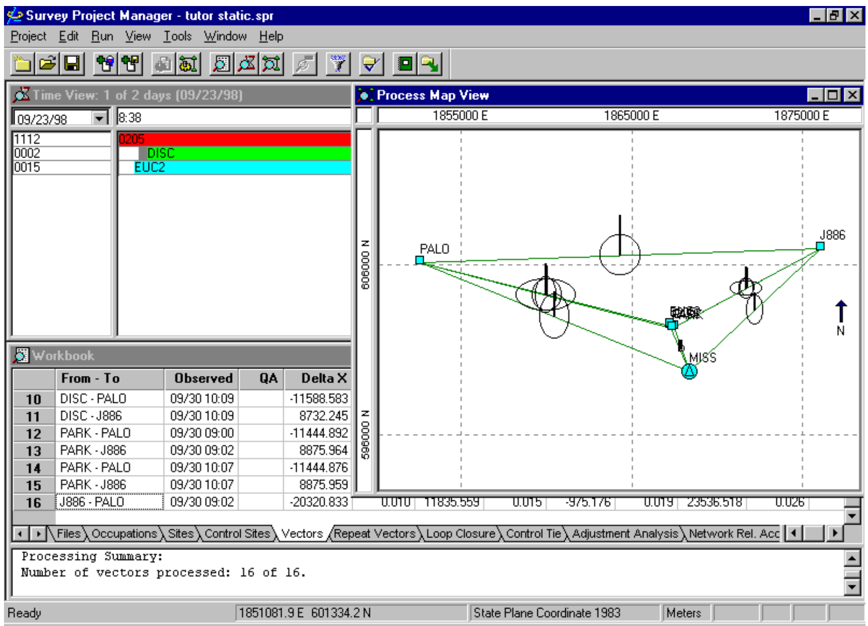


Figure 12.11: Additional Data Added

6. Click on the **Control Sites** tab, add sites PALO and J886 to the control list and edit the coordinates to the following values:

- PALO Easting 1852536.083
  Northing 606119.504
  Ortho Ht. 20.69
- J886 Easting 1876056.263
  Northing 606961.400
  Ortho Ht. 21.172

7. Using the right scroll bar arrow on the bottom right side of the **Workbook** window, scroll to the right and then change the **Fixed** values to **None** for PALO and J886.

At this stage we only want to have one station fixed so that we can perform a "free" adjustment of the data to verify the quality of the vectors without any influence from the control positions.

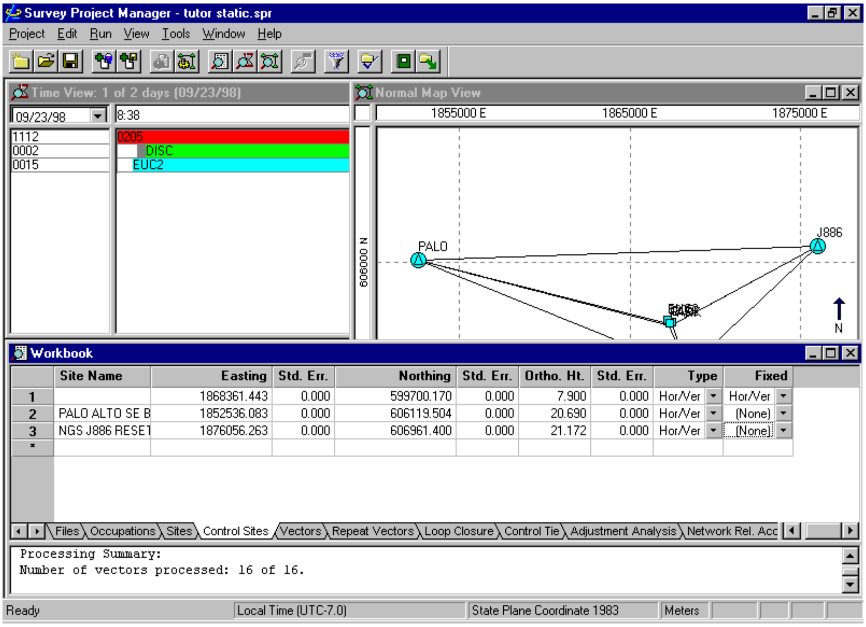
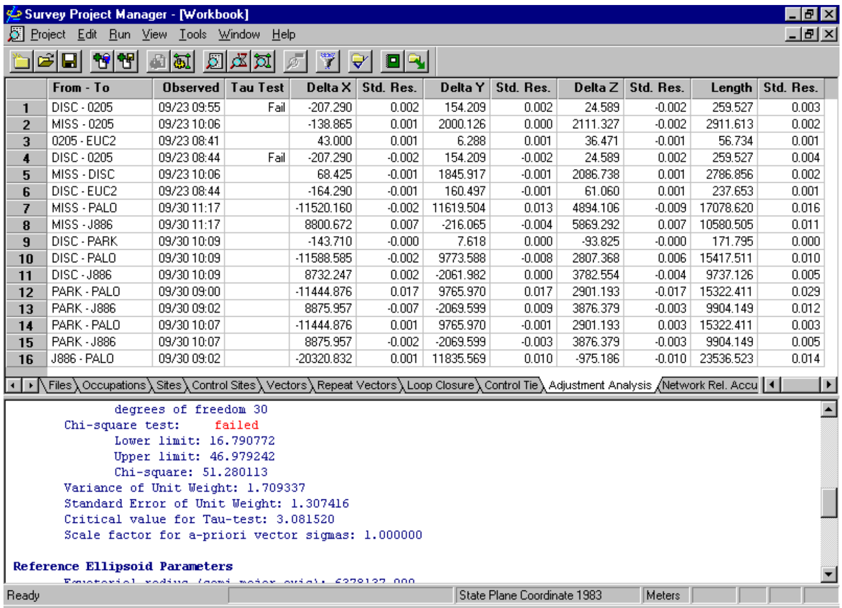


Figure 12.12: Three Control Sites

8. Select **Adjustment** from the **Run** menu to run a free adjustment of our processed vectors. This is a good check to see if there are any obvious blunders.

9. Maximize the **Workbook** window by clicking on the button with the square in the upper right corner of the window.
10. Put the cursor over the line between the **Workbook** tabs and the message window and drag it down so that you see all 16 vectors.
11. Click on the up-arrow of the message window scroll bar to the right of the message window at the bottom of the screen to bring the **Standard Error of Unit Weight** into view. Your screen should appear similar to Figure 12.13.



	From - To	Observed	Tau Test	Delta X	Std. Res.	Delta Y	Std. Res.	Delta Z	Std. Res.	Length	Std. Res.
1	DISC - 0205	09/23 09:55	Fail	-207.290	0.002	154.209	0.002	24.589	-0.002	259.527	0.003
2	MISS - 0205	09/23 10:06		-138.865	0.001	2000.126	0.000	2111.327	-0.002	2911.613	0.002
3	0205 - EUC2	09/23 08:41		43.000	0.001	6.288	0.001	36.471	-0.001	56.734	0.001
4	DISC - 0205	09/23 08:44	Fail	-207.290	-0.002	154.209	-0.002	24.589	0.002	259.527	0.004
5	MISS - DISC	09/23 10:06		68.425	-0.001	1845.917	-0.001	2086.738	0.001	2786.856	0.002
6	DISC - EUC2	09/23 08:44		-164.290	-0.001	160.497	-0.001	61.060	0.001	237.653	0.001
7	MISS - PALO	09/30 11:17		-11520.160	-0.002	11619.504	0.013	4894.106	-0.009	17078.620	0.016
8	MISS - J886	09/30 11:17		8800.672	0.007	-216.065	-0.004	5869.292	0.007	10580.505	0.011
9	DISC - PARK	09/30 10:09		-143.710	-0.000	7.618	0.000	-93.825	-0.000	171.795	0.000
10	DISC - PALO	09/30 10:09		-11588.585	-0.002	9773.588	-0.008	2807.368	0.006	15417.511	0.010
11	DISC - J886	09/30 10:09		8732.247	0.002	-2061.982	0.000	3782.554	-0.004	9737.126	0.005
12	PARK - PALO	09/30 09:00		-11444.876	0.017	9765.970	0.017	2901.193	-0.017	15322.411	0.029
13	PARK - J886	09/30 09:02		8875.957	-0.007	-2069.599	0.009	3876.379	-0.003	9904.149	0.012
14	PARK - PALO	09/30 10:07		-11444.876	0.001	9765.970	-0.001	2901.193	0.003	15322.411	0.003
15	PARK - J886	09/30 10:07		8875.957	-0.002	-2069.599	-0.003	3876.379	-0.003	9904.149	0.005
16	J886 - PALO	09/30 09:02		-20320.832	0.001	11835.569	0.010	-975.186	-0.010	23536.523	0.014

Figure 12.13: Free Adjustment Results

Even though we have two vectors that have failed the tau test, their residuals are not large, and our Standard Error of Unit Weight is fairly close to one, so we have no obvious blunders in our data. Also, you can see that all the vectors meet our accuracy specifications in the Network Rel. Accuracy tab; however, the chi-square test has failed. This could indicate that our vector error estimates are a little too optimistic. We can use the Standard Error of Unit Weight (S.E.) as an initial guess to scale our vector uncertainties.

12. Select **Settings** from the **Project** menu.
13. Switch to the Miscellaneous tab.
14. Set the **Processed vector error scaling factor** to *1.3* (Figure 12.14).

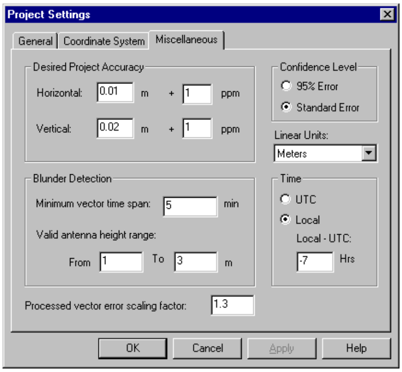
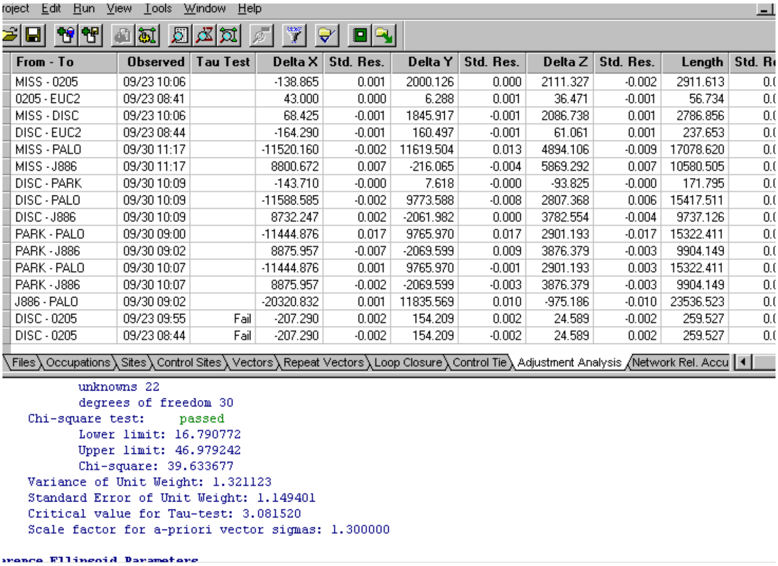


Figure 12.14: Changing the Project Setting

15. Click on the **OK** button.

When changes are made to items that would affect the adjustment outcome, the Adjustment Analysis and Network Rel. Accuracy tabs are cleared.

16. Select **Adjustment** from the **Run** menu to re-run the adjustment with the scaled error estimates.



From - To	Observed	Tau Test	Delta X	Std. Res.	Delta Y	Std. Res.	Delta Z	Std. Res.	Length	Std. Re
MISS - 0205	09/23 10:06		-138.865	0.001	2000.126	0.000	2111.327	-0.002	2911.613	0.0
0205 - EUC2	09/23 08:41		43.000	0.000	6.288	0.001	36.471	-0.001	56.734	0.0
MISS - DISC	09/23 10:06		68.425	-0.001	1845.917	-0.001	2086.738	0.001	2786.856	0.0
DISC - EUC2	09/23 08:44		-164.290	-0.001	160.497	-0.001	61.061	0.001	237.653	0.0
MISS - PALO	09/30 11:17		-11520.160	-0.002	11619.504	0.013	4894.106	-0.009	17078.620	0.0
MISS - J886	09/30 11:17		8800.672	0.007	-216.065	-0.004	5869.292	0.007	10580.505	0.0
DISC - PARK	09/30 10:09		-143.710	-0.000	7.618	-0.000	-93.825	-0.000	171.795	0.0
DISC - PALO	09/30 10:09		-11588.585	-0.002	9773.588	-0.008	2807.368	0.006	15417.511	0.0
DISC - J886	09/30 10:09		8732.247	0.002	-2061.982	0.000	3782.554	-0.004	9737.126	0.0
PARK - PALO	09/30 09:00		-11444.876	0.017	9765.970	0.017	2901.193	-0.017	15322.411	0.0
PARK - J886	09/30 09:02		8875.957	-0.007	-2069.599	0.009	3876.379	-0.003	9904.149	0.0
PARK - PALO	09/30 10:07		-11444.876	0.001	9765.970	-0.001	2901.193	0.003	15322.411	0.0
PARK - J886	09/30 10:07		8875.957	-0.002	-2069.599	-0.003	3876.379	-0.003	9904.149	0.0
J886 - PALO	09/30 09:02		-20320.832	0.001	11835.569	0.010	-975.186	-0.010	23536.523	0.0
DISC - 0205	09/23 09:55	Fail	-207.290	0.002	154.209	0.002	24.589	-0.002	259.527	0.0
DISC - 0205	09/23 08:44	Fail	-207.290	-0.002	154.209	-0.002	24.589	0.002	259.527	0.0


```
        unknowns 22
        degrees of freedom 30
Chi-square test:     passed
        Lower limit: 16.790772
        Upper limit: 46.979242
        Chi-square: 39.633677
Variance of Unit Weight: 1.321123
Standard Error of Unit Weight: 1.149401
Critical value for Tau-test: 3.081520
Scale factor for a-priori vector sigmas: 1.300000
```

Figure 12.15: Scaled Adjustment Results

The Chi-square test has now been passed. Two vectors still are shown as failing the tau test, but their residuals are very small and the failure is due mainly to the short length of the line, so we will leave them be.

17. Click on the **Network Rel. Accuracy** tab.

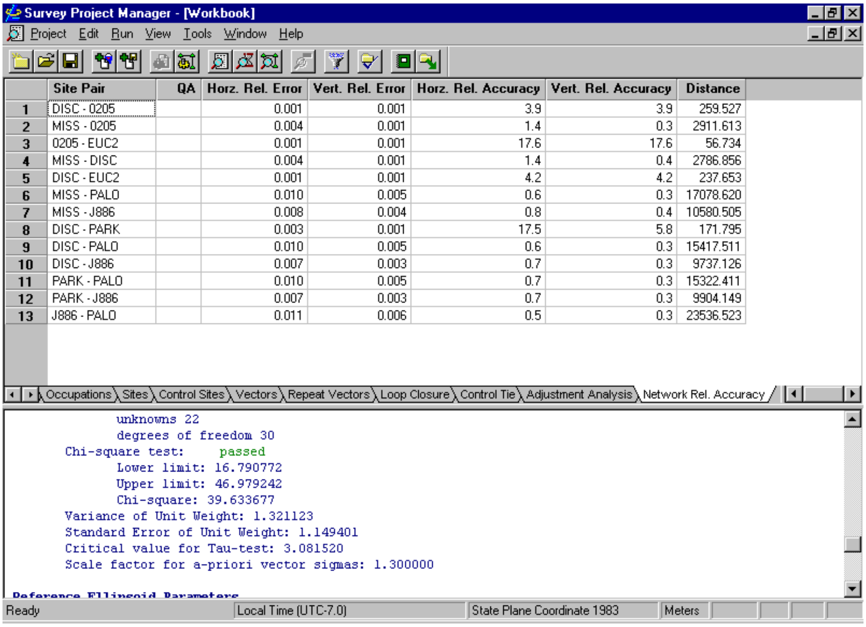


Figure 12.16: Network Relative Accuracy

As seen in the QA field, no failures are listed, thus, all site pairs have passed the accuracy specifications set in the Project Settings. Our adjustment should be considered good.

18. Now we need to constrain our adjustment to the control. If there are problems at this stage, it indicates a problem with the control, not the GPS vectors.
19. Click on the **Control Sites** tab and fix the two remaining control stations in both horizontal and vertical (Figure 12.17).

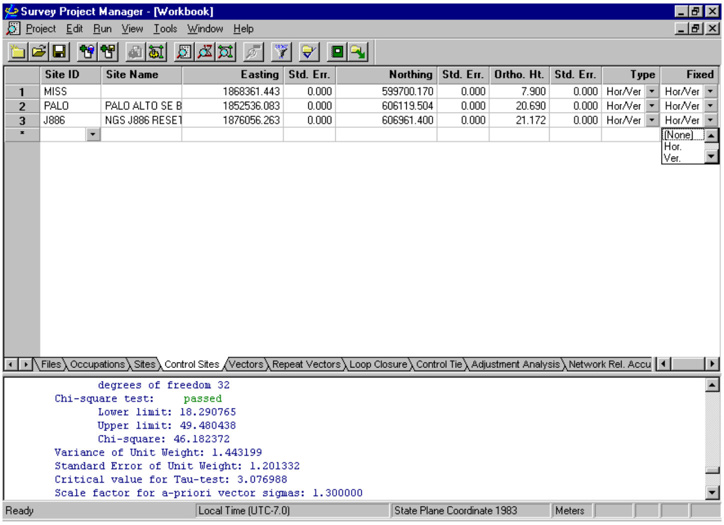


Figure 12.17: Fixing Additional Control Sites

20. Select **Adjustment** from the **Run** menu to run a constrained adjustment using the three horizontal and vertical control points we have entered.

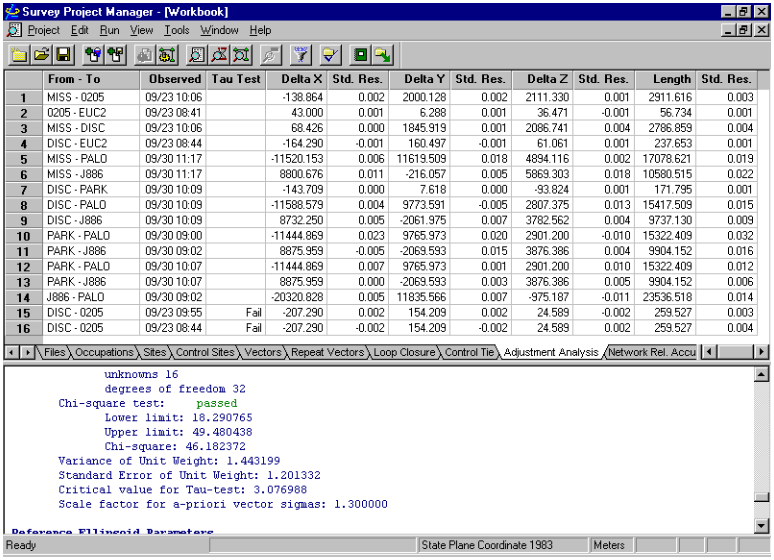


Figure 12.18: Constrained Adjustment Analysis

Tutorial #3

21. Click on the **Sites** tab to see the adjusted positions of the project.

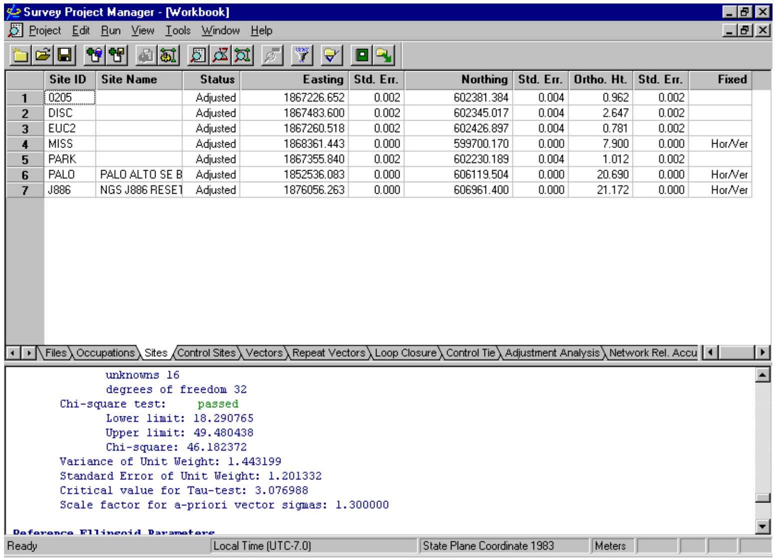


Figure 12.19: Adjusted Site Coordinates

22. To see the 95% or 2 sigma positional uncertainties, right-click on one of the Std. Err. columns and select **95%** (Figure 12.20).

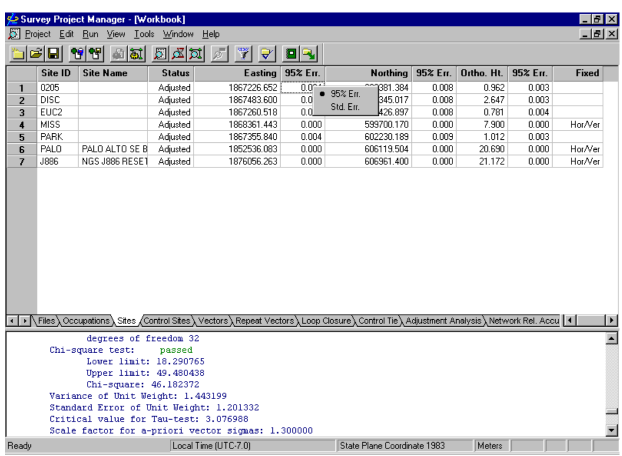


Figure 12.20: 95% Error

We have now finished our adjustment and will probably want to export the project coordinates to a coordinate geometry package. Using the export routine, you should be able to export your data in a format acceptable to any coordinate geometry or CAD package.

Exporting Locus Data

1. Select **Export** from the **Project** menu from the main menu line.
2. In the Save As type field select User Defined ASCII (*.*) then click the **Customize** button in the **Export Data** dialog box.

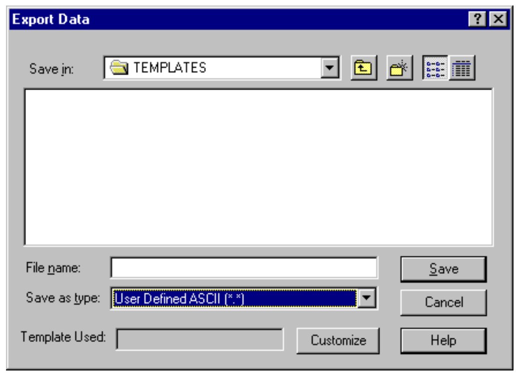


Figure 12.21: Export Data Utility

3. Click the **New...** button in the **User ASCII Template** dialog box.

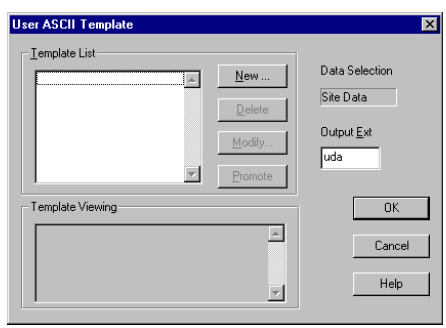


Figure 12.22: ASCII Template Dialog

Tutorial #3

4. Click the radio button next to **Site Data** and enter in **pneu** as the template name.

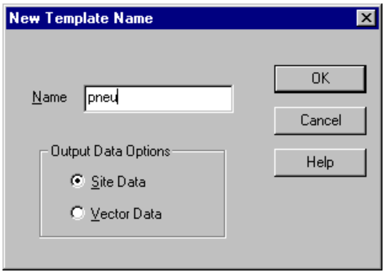


Figure 12.23: New Template Dialog

5. Click the **OK** button.
6. Click on the plus sign to the left of **Site Data** and then double-click on **Site ID** to put the site ID field in the template list.

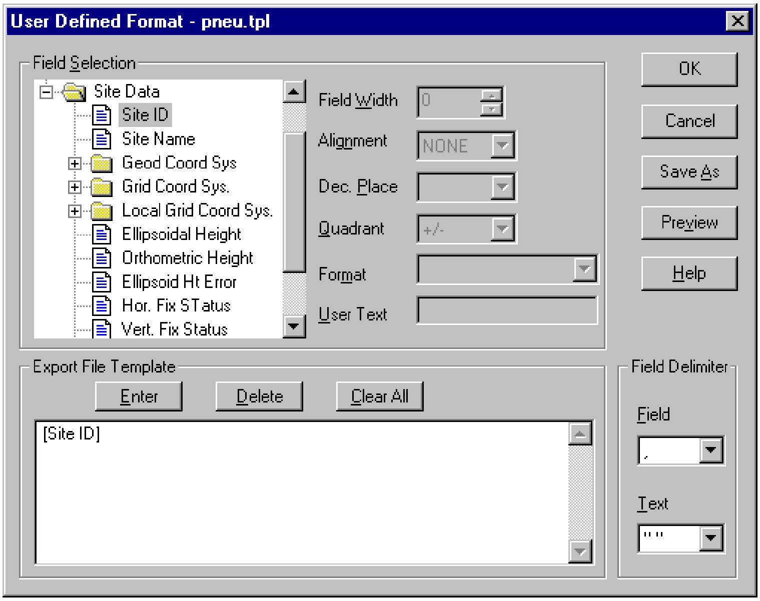


Figure 12.24: Populating the Template

7. Click on the plus sign next to **Grid Coord Sys.**

8. Double-click on **Grid Northing** to add it to the template list.

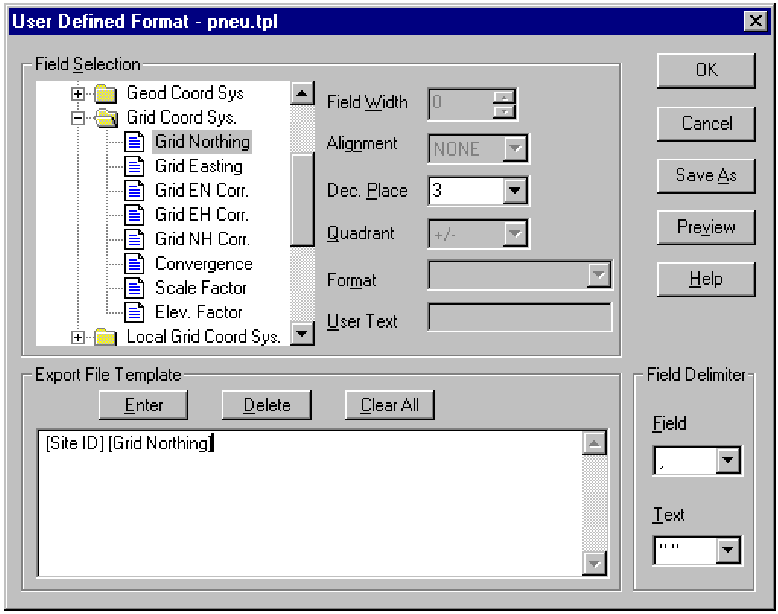


Figure 12.25: Adding Coordinate Information

9. Double-click on **Grid Easting** to add it to the template.

10. Scroll down using the scrollbar to the right of the element list and double-click on **Orthometric Height** to add the elevation to our template.

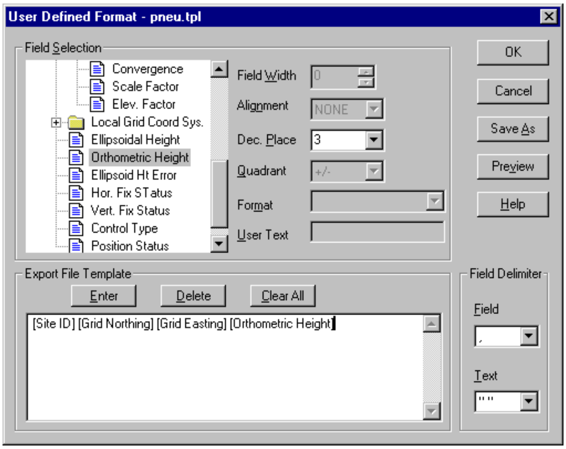


Figure 12.26: Adding Height Information

11. Our template is now complete. Click on the **OK** button in the **User Defined Format** dialog box. The **User ASCII Template** dialog box reappears with our new template filename highlighted and its elements listed in the **Template Viewing** list box.

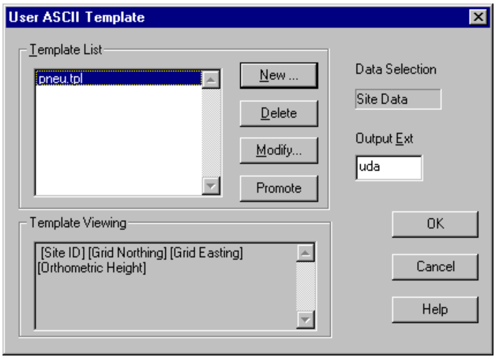


Figure 12.27: Completed ASCII Template

12. Click **OK** to select our new template.

The default extension of .uda (user defined ASCII) will be used for the extension of our export file. If you wish to use another extension such as .txt, simply change the three characters in the Output Ext field before clicking OK.

13. Enter a name for your output points file. For our example, use **Statpnts**.
14. Using the browsing tools next to the **Save in:** field, select our **Static** project directory to save the exported point list.

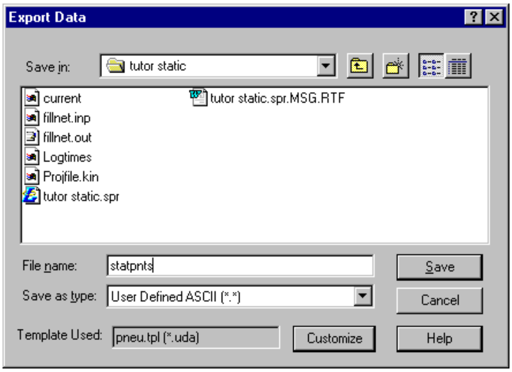


Figure 12.28: Saving the ASCII file

15. Click the **Save** button, to save **Statpnts** in the project directory.

Using a text editor, or a word processor in text mode, read in and print out the statpnts.uda file that we just created. We will use these coordinate values in our following kinematic tutorial.

16. Select **Save** from the **Project** menu to save the project.

The next task that we might want to do is create a report for our client. The following steps accomplish this.

17. Select **Report** from the **Project** menu.

18. To see all the sections available for the report, click on the plus sign to the left of **Adjustment Results** and then to the left of **Miscellaneous**.

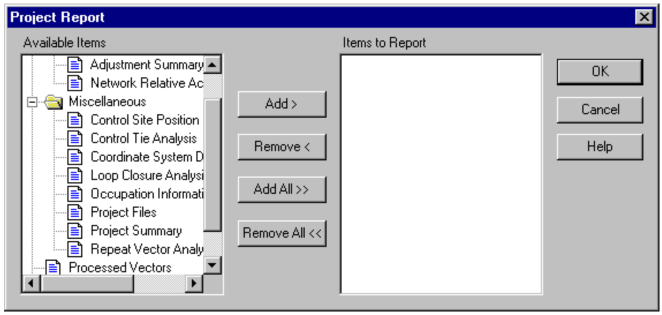


Figure 12.29: Project Report Dialog

To add any specific element to your report, click on the element in the Available Items lists to highlight it. Then click on the Add> button and it will be moved into the Items to Report list.

19. We are going to put all the items into the report, so click on the **Add All>>** button.

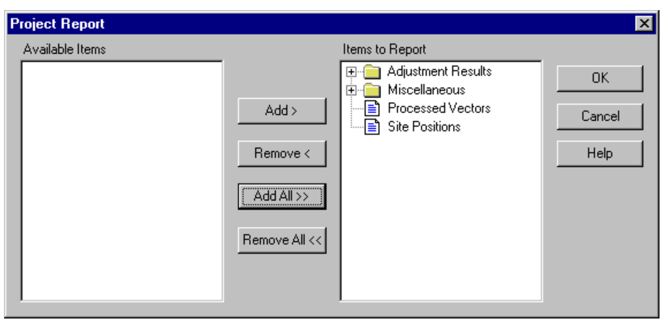


Figure 12.30: Adding All Report Items

If you wish to remove one or two items, highlight them in the Items to Report list and click on the Remove< button.

20. Click on the **OK** button and the program will shell out to the word processing program you specified in **Setup** dialog box.

The default word processor is the one associated with the RTF file type on your system. If you are using a different word processor, you should enter its path in the Program Setup dialog box. The easiest way is the use the ellipses button (...) and browse to your program executable file. The program you select must be able to read Rich Text Format (.RTF) files, e.g., Windows Wordpad.

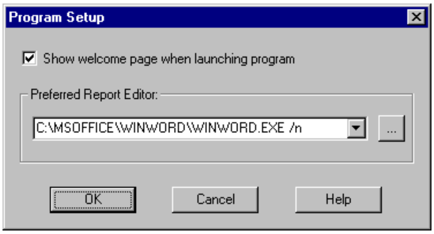


Figure 12.31: Program Setup Dialog

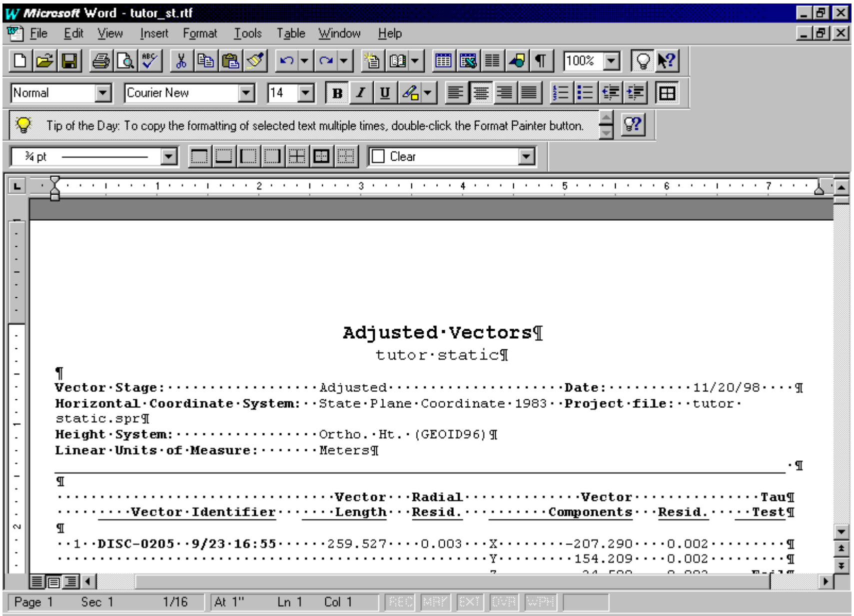


Figure 12.32: Viewing a Report

21. Print your report as is, edit it if you would like, and then save it in your word processor’s format.
22. Exit out of the word processing program.

O-File Export

A special vector binary file can be exported . This format (called an O-file) can be used by Locus Processor and other software packages that handle Ashtech data. The last part of the tutorial is to export an O-file to be used in another project later in this tutorial sequence.

1. Select **Export** from the **Project** menu.
2. Select the project directory **Static** as the **Save in:** directory. and select **Ashtech O-file (One file per PROJECT) (O*.*)** in the **Save as type:** field as seen below.

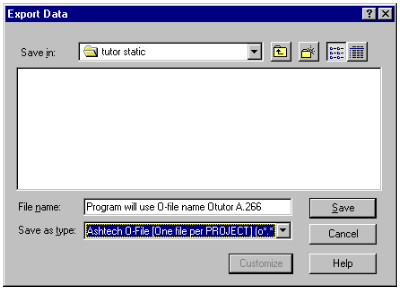


Figure 12.33: Export Data Dialog

3. Click the **Save** button and the O-file which includes the 16 baselines will be written to the Static directory. Locus Processor automatically generates an O-file name.
4. Select **Exit** from the **Project** menu. We are done.

We saved the project just before creating our report. Nothing has changed, so we did not save the project again.

Tutorial #4 - Kinematic Processing

1. From the **Welcome to Locus** dialog box select **Create a new project**.

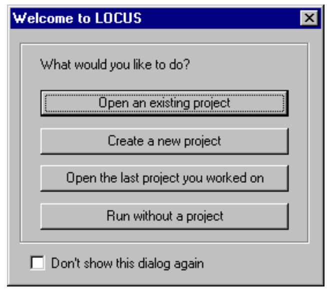


Figure 13.1: Welcome to Locus Dialog box

2. Enter **Tutor Stop&go** in the **Project Name** field. Comments, Company, and Client may also be entered at this time, but are not necessary.

Use a valid file or directory name as your project name.

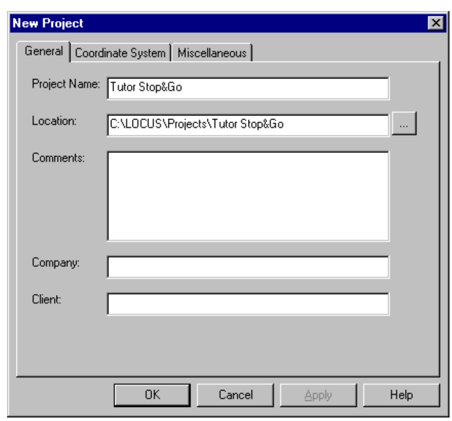


Figure 13.2: New Project General Tab

3. Switch to the **Coordinate System** tab.

If you have already done the Static tutorial, the values should appear as shown below and you can skip to step 9. If you are performing this tutorial separately, perform steps 4-8.

4. Select Grid as the **System Type**. For our tutorial let's use **Grid**.
5. Select the **State Plane Coordinate 1983** option in the **Grid System** list box.
6. Select the **California (Zone 3)** option from the **Zone** list box.
7. Click the radio button next to **Orthometric Elevations** under **Height System.**
8. Select the **Geoid96 model for the US** from the **Geoid Model** list box.

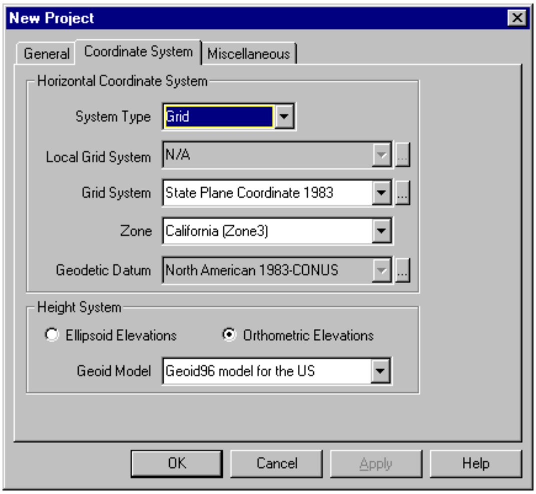


Figure 13.3: New Project Coordinate System Tab

9. Switch to the **Miscellaneous** tab.

If you have already done the Static tutorial, the values should appear as shown below and you can skip to step 11. If you are performing this tutorial separately, set the values as shown in step 10.

10. Set the miscellaneous settings as shown below.

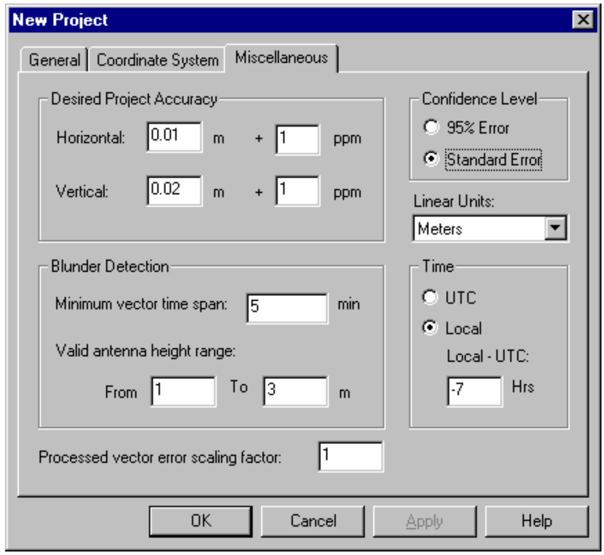


Figure 13.4: New Project Miscellaneous Tab

11. Click on the **OK** button and you will be asked for the location of your data.

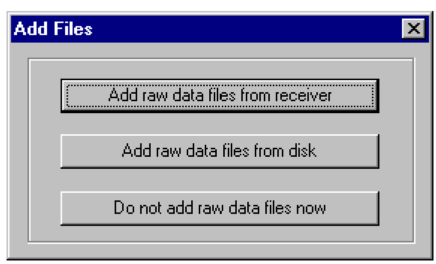


Figure 13.5: Add Files Data

12. Click on the ***Add raw data files from disk*** button and the **Add Files** dialog box appears.
13. Using the drop down list box, selected the data files in the **Tutorkin** directory by clicking on the first filename, and then holding the <**Shift**> key

down and clicking on the last filename, or select all the files by pressing the <**Ctrl**>+<**A**> keys.

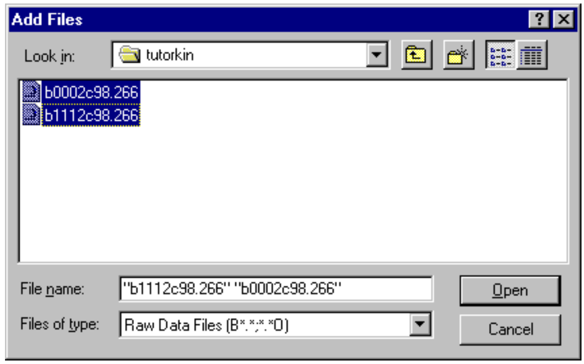


Figure 13.6: Add Files Dialog

14. Click the **Open** button, the **Time View Diagram** window opens. The lower half of the window shows the **Workbook Project** window with the active **Occupations** tab. The **Time View Diagram**, shows horizontal bands of color associated with the different Site ID's. In the **Occupations** tab you will see the associated antenna heights, start and stop times, and file names for each occupation.

The occupation information should be verified with the operator's field logs, however for this tutorial we will assume that the given information is correct.

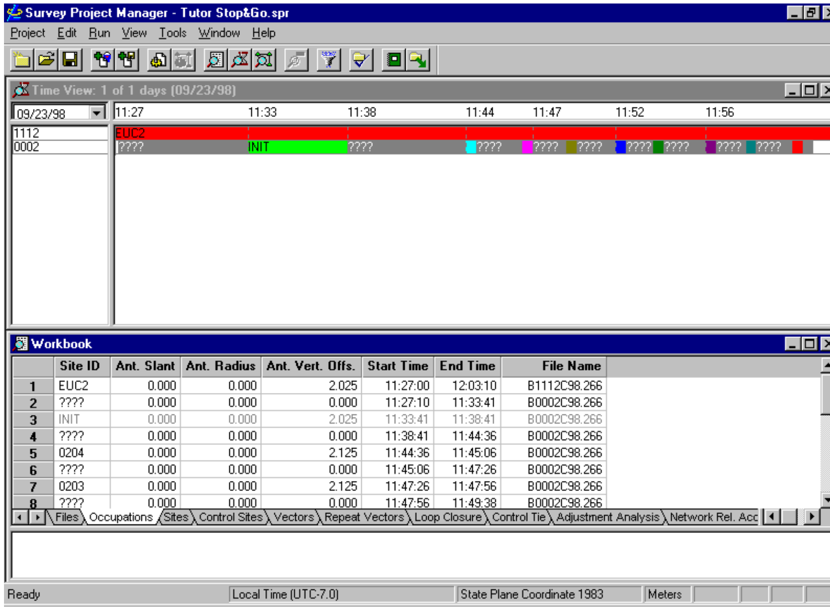


Figure 13.7: Project Manager - Kinematic Data

This kinematic survey was initialized using the initializer bar. The occupation of the rover receiver on the initializer bar is labeled INIT. The base station where the initializer bar was located at is EUC2. A kinematic survey must be initialized either by a five minute occupation of the rover on the initializer bar, or by a one minute occupation of the rover on a known point relative to the base station (a known baseline).

15. We must indicate the base station and the rover's known control point. Click the **Control Sites** tab and then click on the small down-arrow to the right of the **Site ID** input box.

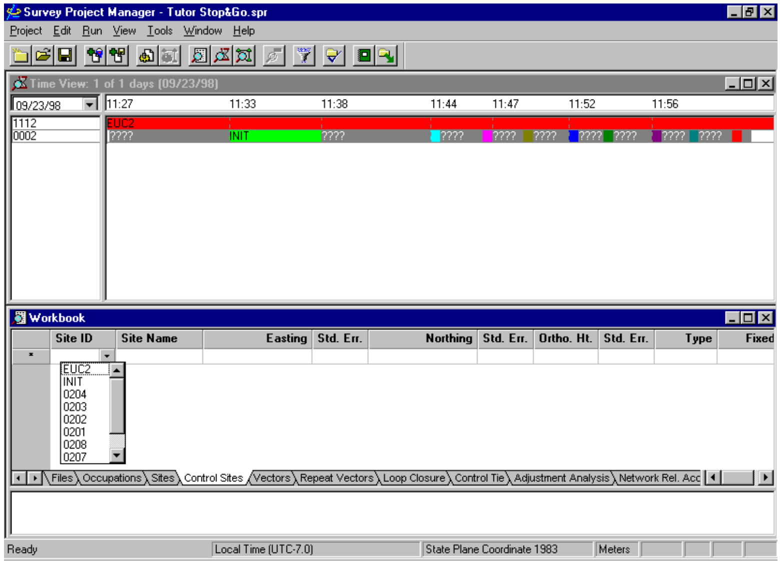


Figure 13.8: Selecting a Control Site

16. Select site **EUC2** from the list by clicking on it.
17. Edit the coordinate values of EUC2 by double-clicking in the edit boxes to highlight the value and then entering in the correct values given here in meters.

These values are from the statpnts.uda file created in our static processing tutorial.

- Easting 1867260.518
- Northing 602426.896
- Ortho Ht. 0.779

If we were initializing on a known baseline, we would also have to indicate the other station defining this baseline as a control site. But when using the initializer bar, we need to only indicate the base station as a control site. There is a site flag that is set by the Locus Handheld which indicates the occupation on the initializer bar. We should check to make sure that this flag is set, and if not, set it in the site properties dialog.

18. Click on the **Sites** tab.
19. Right click on site INIT and select **Properties**.

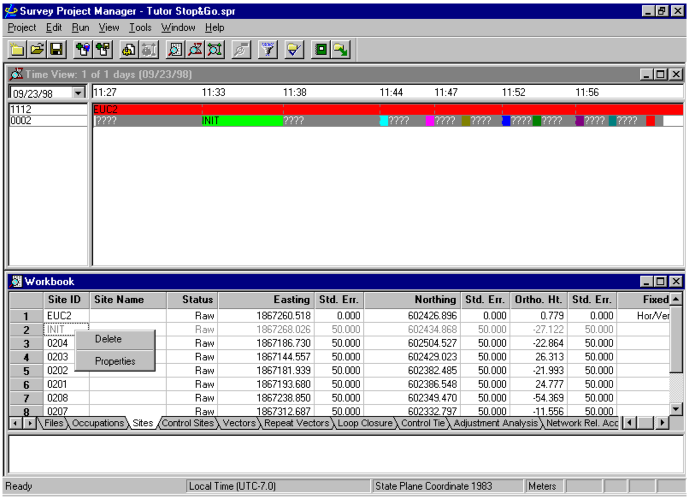


Figure 13.9: Selecting Initialization Point Properties

20. Verify that there is a check mark in the box to the left of ***Kinematic Initialization point using Initializer Bar*** as shown below.

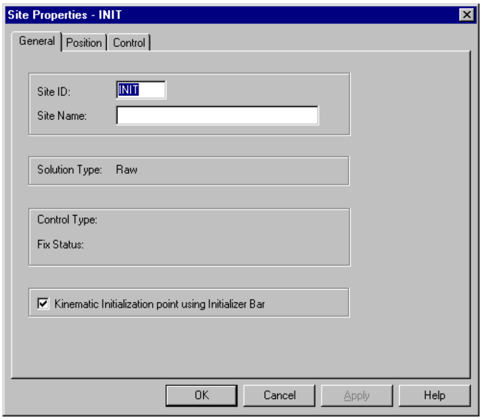


Figure 13.10: Viewing Initialization Point Properties

21. Click the **OK** button to clear the dialog box.
22. Select **All** from the **Processing** menu in the **Run** menu. When the processing is complete, we should have nine vectors (Figure 13.11).

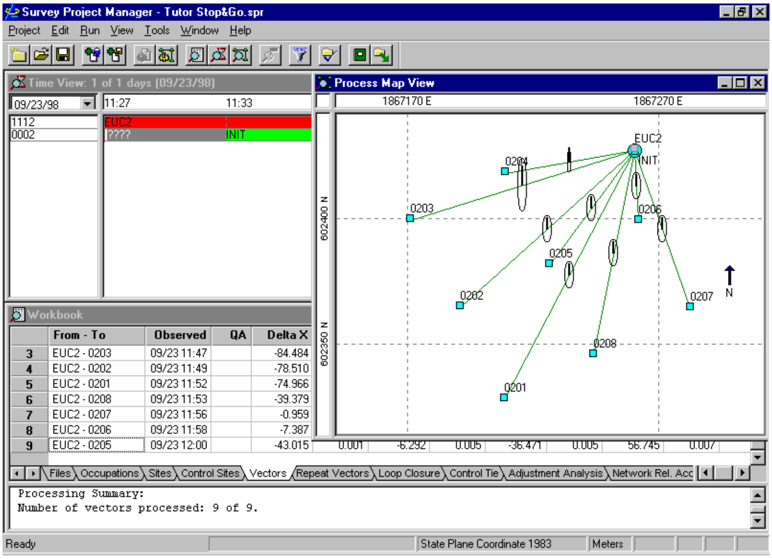


Figure 13.11: Processed Kinematic Data

With a kinematic survey like this there is no redundancy, and thus nothing to adjust. It is a radial survey of sideshots. However, if we perform a free adjustment, the values under the **Network Rel. Accuracy**, show that the vector between EUC2 and 0203 does not meet the accuracy specifications set in the **Project Settings** dialog box. Export these vectors so that we can use them later in a combined project and adjust them in a more meaningful situation.

23. Select **Export** from the **Project** menu.
24. In the **Export Data** dialog box, select the **Save as type:** to be **Ashtech O-file (One file per PROJECT) (O*.*)** as shown below.

25. Set the **Save in:** field to the directory you want to save the file. For the example we will use our Stop&go project directory.

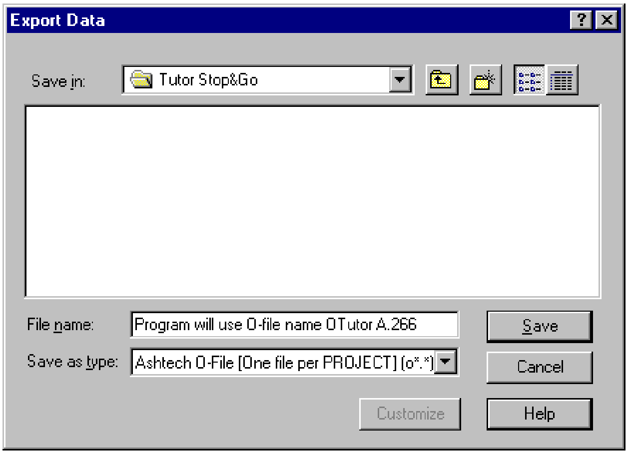


Figure 13.12: Export Data Dialog

26. Click the **Save** button and the file will be written to the selected directory. In our example, the file **OStop&gA.266** is written to the **Stop&go** directory.
27. Select **Exit** from the **Project** menu.

14

Tutorial #5 - Editing Data and Troubleshooting Tools

This tutorial chapter makes use of data generated in previous tutorial chapters. You may not be able to do all exercises until Chapters 12 and 13 have been completed.

Site Data Editing and Combining Projects

Radial surveying doesn't provide the ability to check our occupations other than to re-occupy them. This tutorial will demonstrate the best way to perform a radial survey and have some degree of confidence in the results. The data was gathered in the field with a static base station set on an unknown new point called PERI. The rover proceeded to occupy four existing control sites and two new sites, each for 20 to 30 minute occupations in no particular order. Multiple rovers could have been employed, but were not. The observations will be adjusted to fit to the existing points. The side shots to the new points will be rotated to fit the new system as well. The adjustment statistics should give us a small degree of confidence in our new stations which are lacking any redundant observations or repeat occupations.

At this point the data have been downloaded from the receiver into a project directory and we are ready to process them. We will therefore open a new project and import the data from the disk rather than from the receiver.

1. Create a new project called **Radial**, following the steps in the previous chapter on kinematic processing. Use the data in the **Tutorrad** directory.

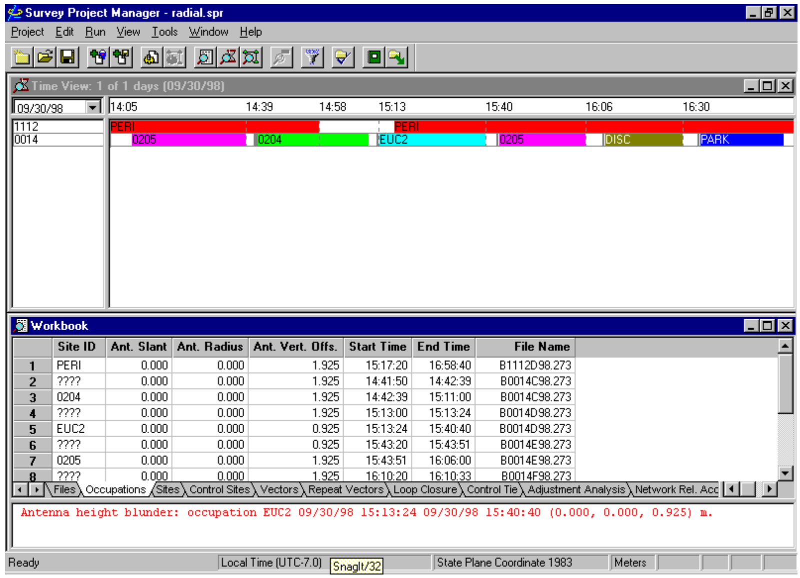


Figure 14.1: Data Needing Repair

The gap in the base receiver was caused when the receiver (Site PERI) was blown over because I had forgotten to tighten the third leg of a fixed height GPS pole. When I noticed it, I set it up again, turned it back on (apparently it had turned off when it hit the ground), and went back to work. It's always a good idea to check your base station from time to time.

The message in the Output window is telling us that there is a possible antenna height blunder at EUC2. We set the antenna height limits at 1 and 3 meters in the project miscellaneous settings, and the antenna height entered for EUC2 was 0.925. If 0.925 were a correct height, we would simply leave it. In our case, the antenna height should have been 1.925 and we will need to change it. (In a real situation, the antenna height should be verified by the operator's field log).

2. Right-click on the area labeled **EUC2** in the **Time View** window and select **Properties**.

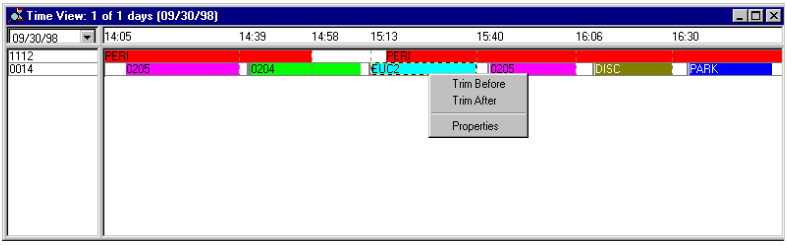


Figure 14.2: Selecting Occupation Properties

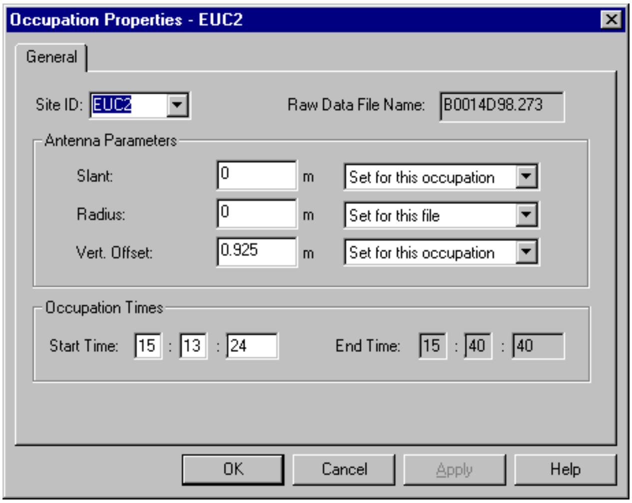


Figure 14.3: Viewing Occupation Properties

Tutorial #5

3. Change the **Vertical Offset:** value to **1.925**.

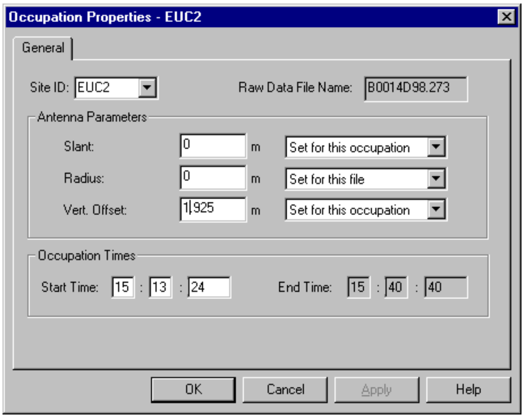


Figure 14.4: Editing an Antenna Height Blunder

There are three values that can be entered to produce an antenna height: Slant, Radius, and Vert. Offset. In our convention, the vertical offset is used to represent a pole height (fixed height). Any additional true vertical offset can be added to this value. If the measurement is slant, the default value of 0.1m is applied in the Locus handheld software and recorded in the D-file. If another receiver type was used, this radius field should be changed accordingly. If a slant and radius is entered, the program uses the Pythagorean Theorem to reduce the slant to a vertical value.

4. Click on the **OK** button to accept the change.

You can also change values by simply double clicking in the field in the Workbook window containing the value you wish to change, and typing in the correct value.

Looking at the **Time View**, we see two occupations of 0205. It was supposed to have been only occupied once. Looking at the field logs, or talking with the operator, we have determined that the second occupation of 0205 should really be site 0207. We need to change it.

5. In the **Occupations** tab of the **Workbook** window, double click on the second occupation of **0205,** at 15:43:51, and change it to *0207*.

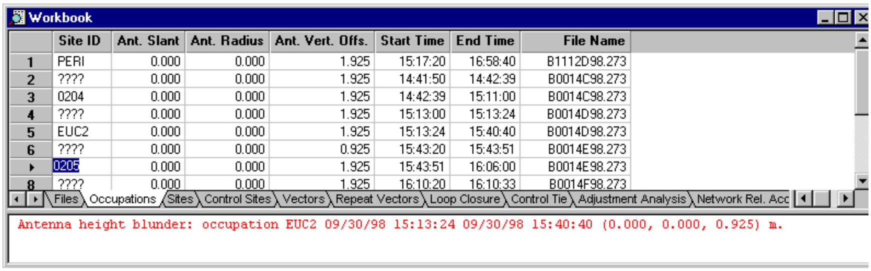


Figure 14.5: Changing a Site Name Blunder

When you hit the enter key, or click outside the field, the Time View area will change color and contain the new site ID as seen above.

6. It is recommended to start the processing from a known station, so click on the **Control Sites** tab and then click on the small down-arrow to the right of the **Site ID** input box. Select site **0205** from the list by clicking on it.

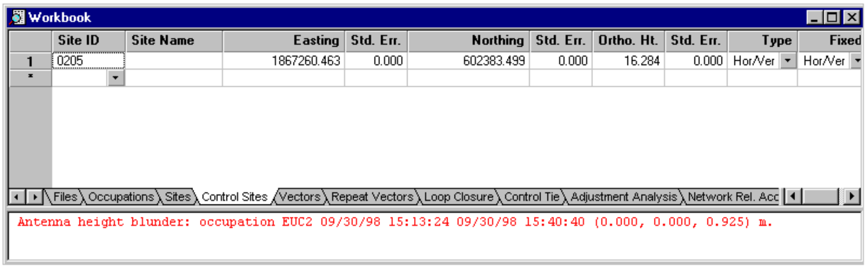


Figure 14.6: Selecting a Control Site

7. Edit the coordinate values by double-clicking in the edit boxes and then entering in the correct values, given here in meters.
   - Easting 1867226.652
   - Northing 602381.384
   - Ortho Ht. 0.960
8. Select **All** from the **Processing** menu in the **Run** menu.

At this time, the Locus Processor displays a map view and process the data vector by vector. It provides us with the six vectors measured between our base and the six radial stations. Notice that the QA fields are blank for all six vectors indicating they are below the QA threshold values and should be good solutions.

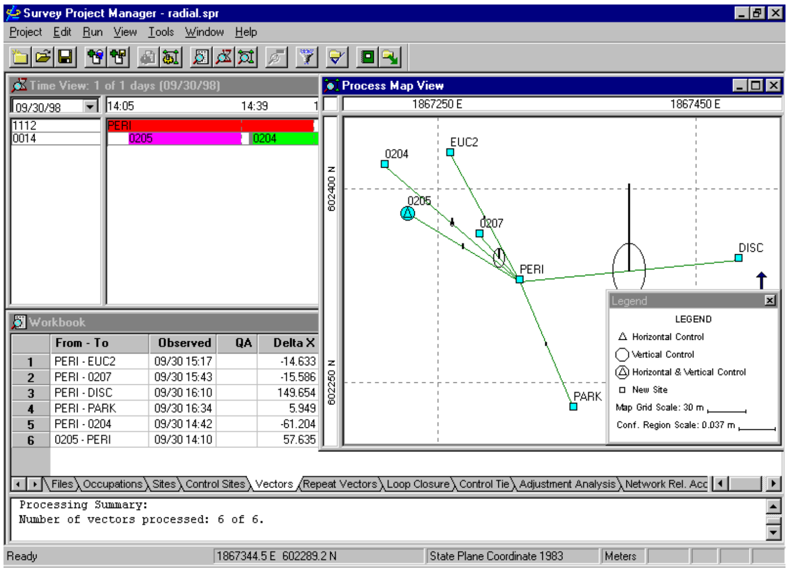


Figure 14.7: Processed Radial Data

Right-click the mouse button within the **Map View** will bring up a menu box. Select **Legend** to see the error ellipse scale and other items as shown below. This will show you the scale of the error regions. To remove the legend, click on the x in the upper right corner of the legend window.

A free adjustment of a radial survey is not very meaningful, so at this time we will import the o-files that we saved from the static and kinematic processing sessions and populate our project with more vectors.

9. Select **Add Processed Vectors** from the **Project** menu.

10. Navigate to the **Tutor Static** directory and highlight the O-file (Figure 14.8).

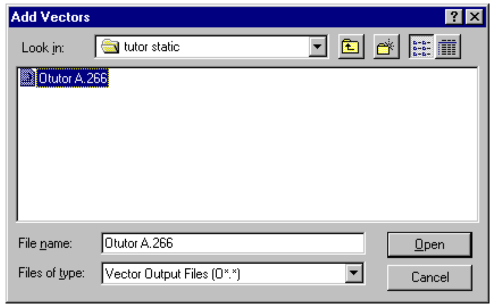


Figure 14.8: Selecting an O-File

11. Click the **Open** button and the static vectors will be added to the project.

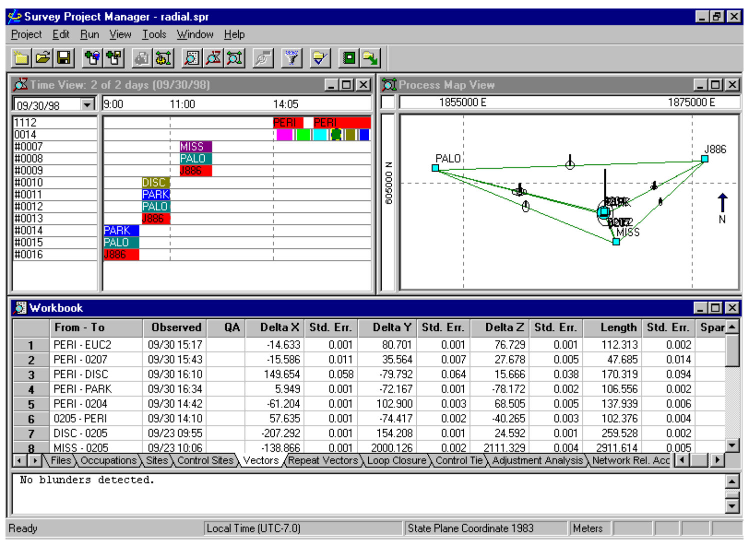


Figure 14.9: Viewing the Imported Data

12. Select **Add Processed Vectors** from the **Project** menu, but this time navigate to the **Stop&go** project directory and select the one O-file there. (The one O-file will contain all of the kinematic vectors).

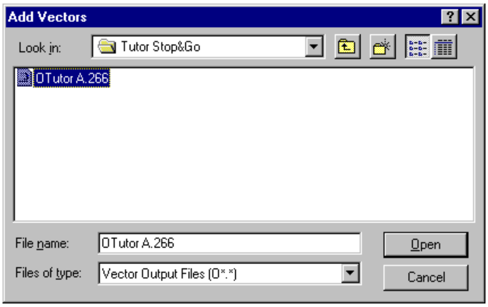


Figure 14.10: Selecting Another O-File

13. Click the **Open** button to add the O-file kinematic vectors to the project.

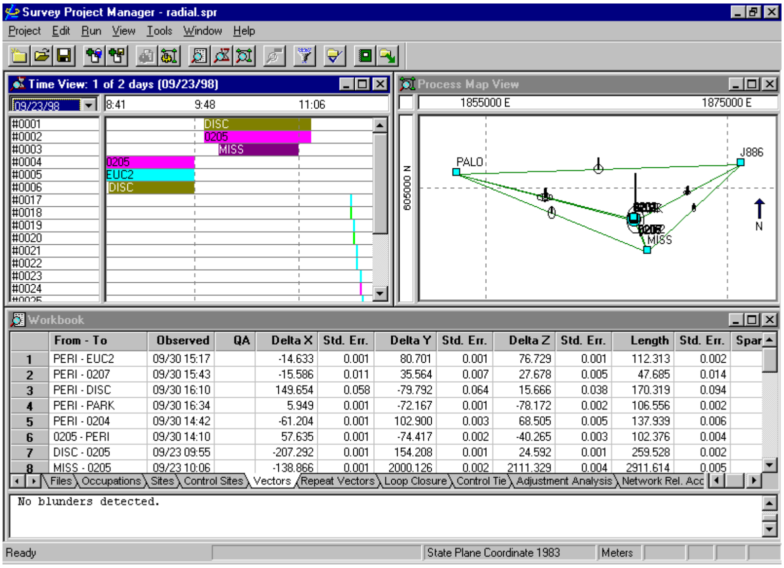


Figure 14.11: Viewing the Additional/Imported Data

You will need to select 09/23/98 from the pull down list in the upper left corner of the Time View window to see the kinematic vectors as shown above. Notice how much shorter the time span is for these vectors.

14. Let's look at our vectors in the Map View window. If necessary, select **Normal** from the right-click menu in **Map View**.

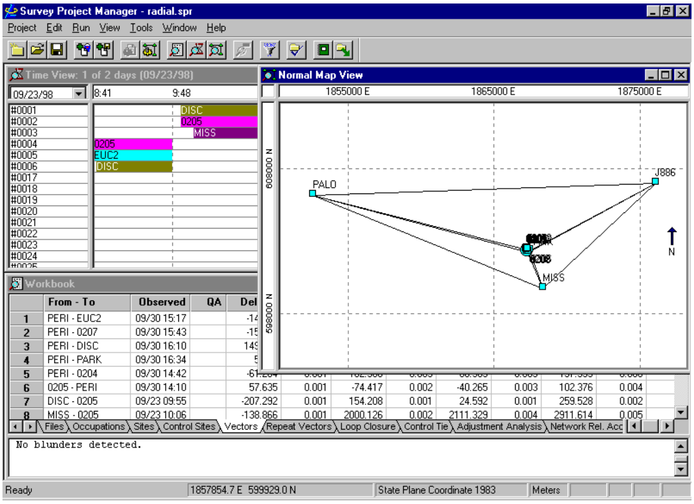


Figure 14.12: The Map "Normal" View

15. Zoom in by clicking and dragging a window around the points in the center of the network so that the view is similar to that shown below.

You will probably have to zoom in a couple of times.

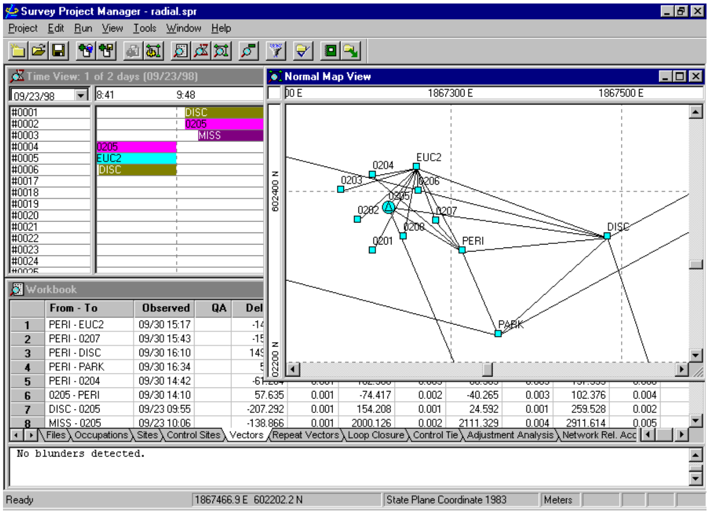


Figure 14.13: Zoom In on the Map View

You can see that we have some kinematic points which have no redundancy. They are 0201, 0202, 0203, 0206 and 0208. These will show up in the adjustment with zero residuals.

16. Click on the **Control Sites** tab.
17. Right-click on the site ID for **0205** and click on **Delete**.

We used 0205 to seed our radial processing, but we do not want to use it for our final project control.

18. Select MISS, PALO, and J886 as our control sites and edit them so they contain their published values given below, and so that only **PALO** is held fixed **Hor/Ver**. Both **MISS** and **J886** should be set to **(None)**.

- PALO Easting 1852536.083
  Northing 606119.504
  Ortho Ht. 20.69

- J886 Easting 1876056.263
  Northing 606961.400
  Ortho Ht. 21.172

- MISS Easting 1868361.443
  Northing 599700.170
  Ortho Ht. 7.9

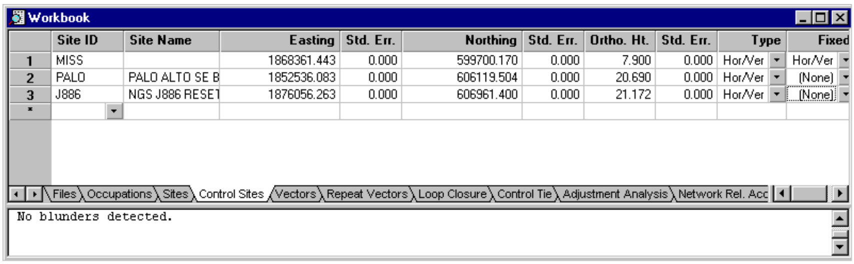


Figure 14.14: Changing the Control Sites

You probably will not need to edit the coordinate values. They were entered correctly in the Static tutorial and have been imported with the vectors.

19. Do a free adjustment with only one point fixed. Select **Adjustment** from the **Run** menu.

20. Maximize the **Workbook** window and click on the **Tau Test** heading box to sort the failed vectors to the top. Then size the **Message box** and scroll the messages so they appear similar to the figure below.

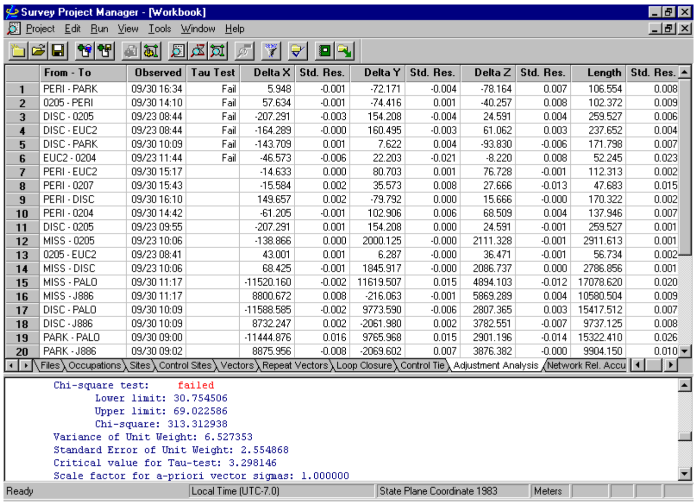


Figure 14.15: The Free Adjustment Result

21. Select **Settings** from the **Project** menu and switch to the **Miscellaneous** tab. Enter 2.6 as the **Processed vector error scaling factor**.

The Standard Error of Unit Weight (S.E.) is our guide to our scaling factor. The S.E. gives us a general indication of the agreement of our network data with our estimates of error. These estimates have been generated by the processing software and may be optimistic as they do no include real world conditions. The example above shows an S.E. of 2.55 so we have selected to scale our error estimates by 2.6.

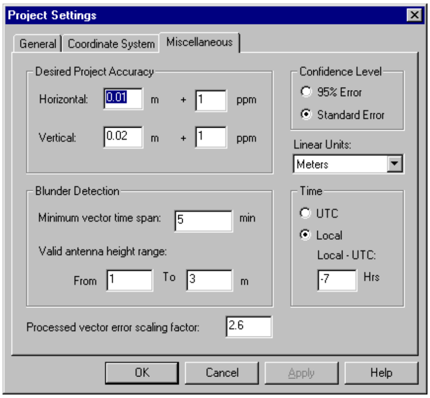


Figure 14.16: Setting the Scale Factor

22. Click the **OK** button.
23. Enter the **F7** key to readjust the data.

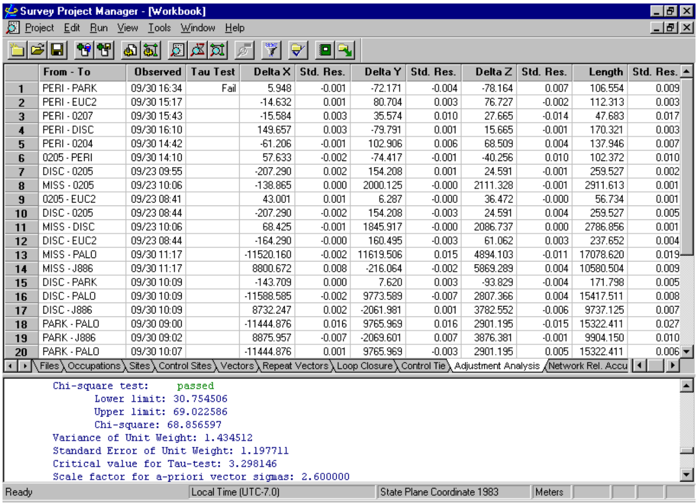


Figure 14.17: Viewing Readjusted Results

The chi-square test has passed, our Standard Error of Unit Weight is very close to one, and we have one vector failing the tau test, so we have a very good free adjustment.

24. Click on the **Network Rel. Accuracy** tab.

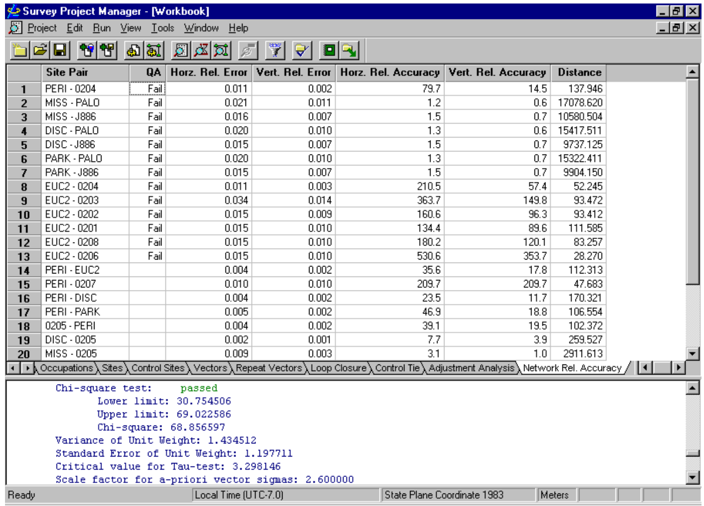


Figure 14.18: Viewing the Network Relative Accuracy Tab

We have 13 vectors that do not meet our accuracy specifications set in the project settings. Those specifications were: 1 centimeter plus 1 part per million of the baseline length for horizontal, and 2 centimeters plus 1 part per million for vertical. Maybe our accuracy specifications are too optimistic for our procedures. Increase the requirements to 2 centimeters horizontal and 3 centimeters vertical.

25. Select **Settings** from the **Project** menu and switch to the **Miscellaneous** tab.

26. Increase the horizontal to 0.02 and the vertical to 0.03.

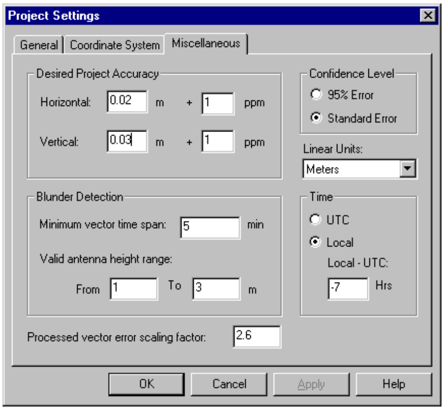


Figure 14.19: Changing the Desired Project Accuracy

27. Click the **OK** button.

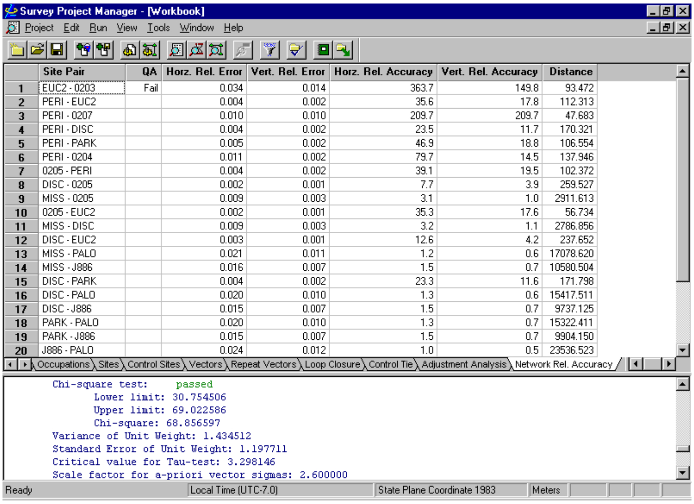


Figure 14.20: The New Network Relative Accuracy Tab

Now there is just one vector that doesn't meet our accuracy specifications. If it won't weaken the network, it can be excluded from the network and the network re-adjust.

Tutorial #5

28. Let's exclude the failing vector. Switch to on the **Vectors** tab of the **Workbook** window.
29. Click on the **From - To** header box to sort the vectors by station, and then right click on **EUC2-0203** and choose **Exclude**.

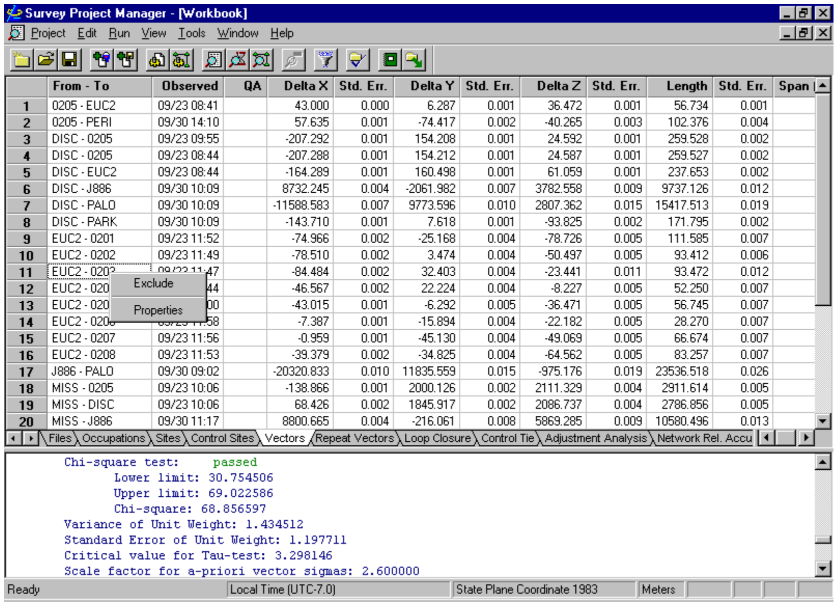
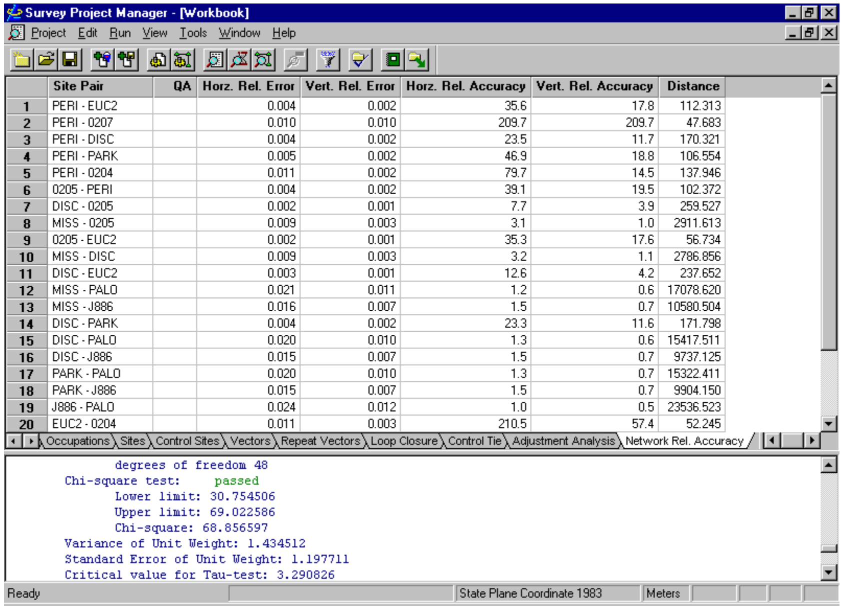


Figure 14.21: Selecting a Vector to Exclude

30. Click **Yes** in response to the question to readjust.

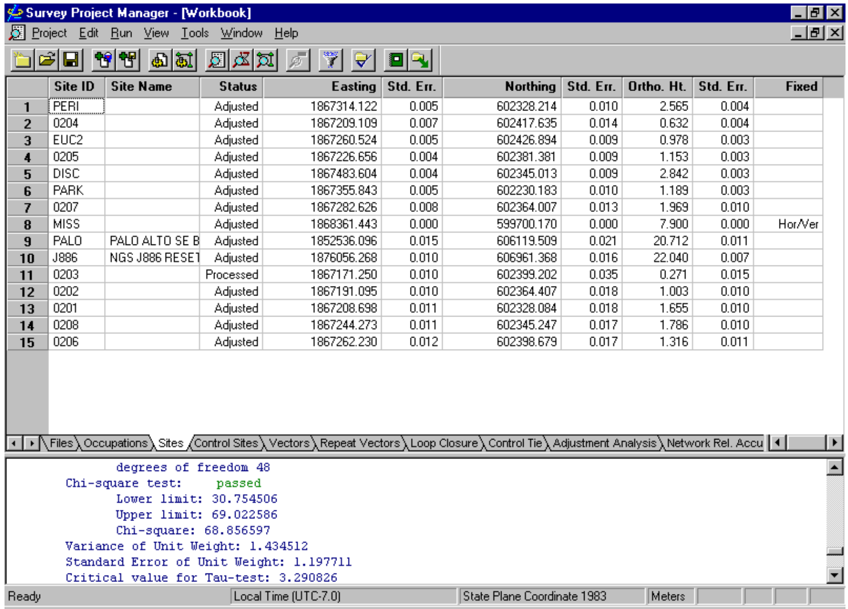


	Site Pair	QA	Horz. Rel. Error	Vert. Rel. Error	Horz. Rel. Accuracy	Vert. Rel. Accuracy	Distance
1	PERI - EUC2		0.004	0.002	35.6	17.8	112.313
2	PERI - 0207		0.010	0.010	209.7	209.7	47.683
3	PERI - DISC		0.004	0.002	23.5	11.7	170.321
4	PERI - PARK		0.005	0.002	46.9	18.8	106.554
5	PERI - 0204		0.011	0.002	79.7	14.5	137.946
6	0205 - PERI		0.004	0.002	39.1	19.5	102.372
7	DISC - 0205		0.002	0.001	7.7	3.9	259.527
8	MISS - 0205		0.009	0.003	3.1	1.0	2911.613
9	0205 - EUC2		0.002	0.001	35.3	17.6	56.734
10	MISS - DISC		0.009	0.003	3.2	1.1	2786.856
11	DISC - EUC2		0.003	0.001	12.6	4.2	237.652
12	MISS - PALO		0.021	0.011	1.2	0.6	17078.620
13	MISS - J886		0.016	0.007	1.5	0.7	10580.504
14	DISC - PARK		0.004	0.002	23.3	11.6	171.798
15	DISC - PALO		0.020	0.010	1.3	0.6	15417.511
16	DISC - J886		0.015	0.007	1.5	0.7	9737.125
17	PARK - PALO		0.020	0.010	1.3	0.7	15322.411
18	PARK - J886		0.015	0.007	1.5	0.7	9904.150
19	J886 - PALO		0.024	0.012	1.0	0.5	23536.523
20	EUC2 - 0204		0.011	0.003	210.5	57.4	52.245

Figure 14.22: Readjustment After Exclusion

Everything has now passed the QA test. The relative accuracy of some of the lines are low, but that is because they are very short. (Right-clicking in any of the relative accuracy fields will give the choice to display the accuracy in either ppm or as a ratio). Relative accuracies on short lines are not very meaningful. That is why most specifications are moving to a positional tolerance definition of accuracy.

31. To see the positional tolerances of our points, click on the **Sites** tab.



	Site ID	Site Name	Status	Easting	Std. Err.	Northing	Std. Err.	Ortho. Ht.	Std. Err.	Fixed
1	PERI		Adjusted	1867314.122	0.005	602328.214	0.010	2.565	0.004	
2	0204		Adjusted	1867209.109	0.007	602417.635	0.014	0.632	0.004	
3	EUC2		Adjusted	1867260.524	0.005	602426.894	0.009	0.978	0.003	
4	0205		Adjusted	1867226.656	0.004	602381.381	0.009	1.153	0.003	
5	DISC		Adjusted	1867483.604	0.004	602345.013	0.009	2.842	0.003	
6	PARK		Adjusted	1867355.843	0.005	602230.183	0.010	1.189	0.003	
7	0207		Adjusted	1867282.626	0.008	602364.007	0.013	1.969	0.010	
8	MISS		Adjusted	1868361.443	0.000	599700.170	0.000	7.900	0.000	Hor/Ver
9	PALO	PALO ALTO SE B	Adjusted	1852536.096	0.015	606119.509	0.021	20.712	0.011	
10	J886	NGS J886 RESET	Adjusted	1876056.268	0.010	606961.368	0.016	22.040	0.007	
11	0203		Processed	1867171.250	0.010	602399.202	0.035	0.271	0.015	
12	0202		Adjusted	1867191.095	0.010	602364.407	0.018	1.003	0.010	
13	0201		Adjusted	1867208.698	0.011	602328.084	0.018	1.655	0.010	
14	0208		Adjusted	1867244.273	0.011	602345.247	0.017	1.786	0.010	
15	0206		Adjusted	1867262.230	0.012	602398.679	0.017	1.316	0.011	

Figure 14.23: Site Coordinates

32. When we have confidence in the accuracy of our data, the free adjustment is complete. Now we need to constrain the occupied control sites to fit the data into the existing control network.

33. Click on the **Control Sites** tab and make sure all three control points are fixed horizontally and vertically.

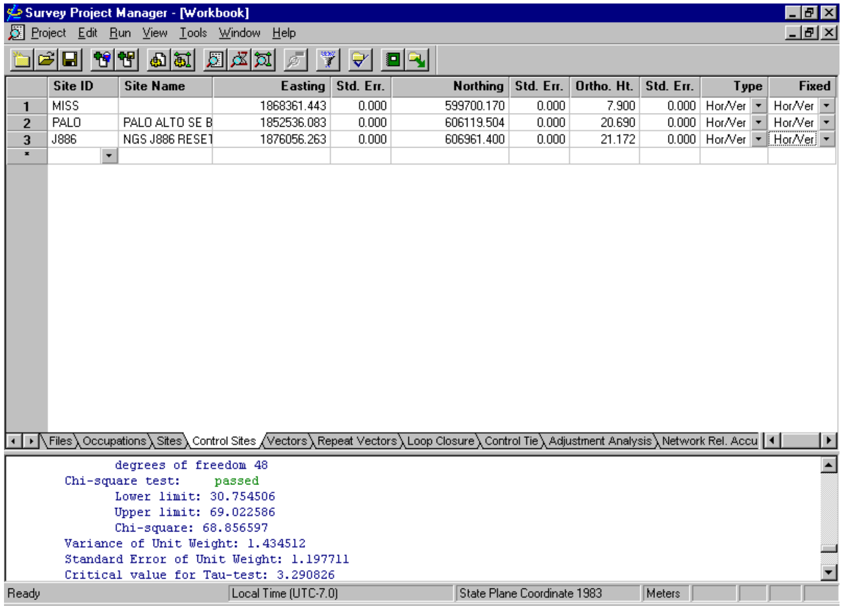
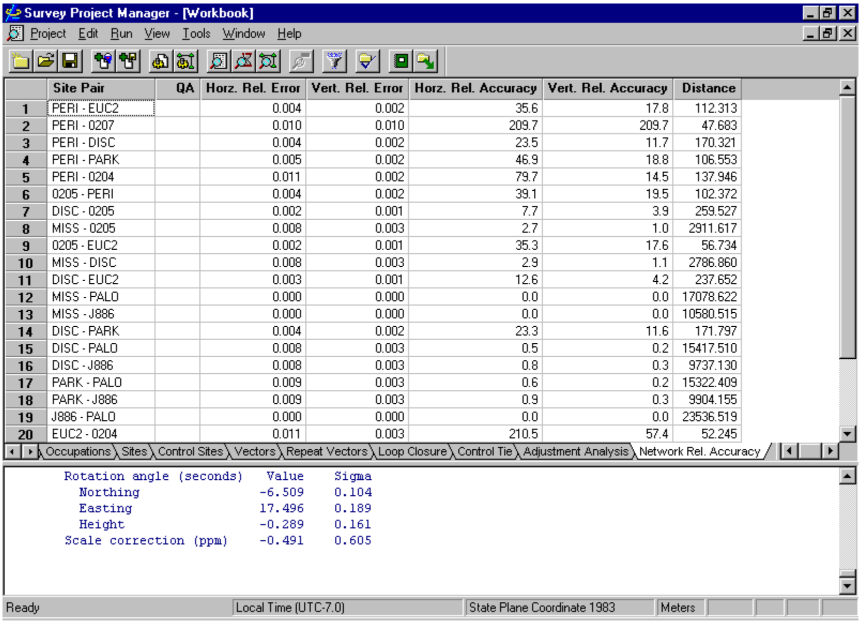


Figure 14.24: Fixing Control Sites

34. Hit the **F7** key to perform the constrained adjustment.

35. Click on the **Network Rel. Accuracy** tab.



	Site Pair	QA	Horz. Rel. Error	Vert. Rel. Error	Horz. Rel. Accuracy	Vert. Rel. Accuracy	Distance
1	PERI - EUC2		0.004	0.002	35.6	17.8	112.313
2	PERI - 0207		0.010	0.010	209.7	209.7	47.683
3	PERI - DISC		0.004	0.002	23.5	11.7	170.321
4	PERI - PARK		0.005	0.002	46.9	18.8	106.553
5	PERI - 0204		0.011	0.002	79.7	14.5	137.946
6	0205 - PERI		0.004	0.002	39.1	19.5	102.372
7	DISC - 0205		0.002	0.001	7.7	3.9	259.527
8	MISS - 0205		0.008	0.003	2.7	1.0	2911.617
9	0205 - EUC2		0.002	0.001	35.3	17.6	56.734
10	MISS - DISC		0.008	0.003	2.9	1.1	2786.860
11	DISC - EUC2		0.003	0.001	12.6	4.2	237.652
12	MISS - PALO		0.000	0.000	0.0	0.0	17078.622
13	MISS - J886		0.000	0.000	0.0	0.0	10580.515
14	DISC - PARK		0.004	0.002	23.3	11.6	171.797
15	DISC - PALO		0.008	0.003	0.5	0.2	15417.510
16	DISC - J886		0.008	0.003	0.8	0.3	9737.130
17	PARK - PALO		0.009	0.003	0.6	0.2	15322.409
18	PARK - J886		0.009	0.003	0.9	0.3	9904.155
19	J886 - PALO		0.000	0.000	0.0	0.0	23536.519
20	EUC2 - 0204		0.011	0.003	210.5	57.4	52.245

Figure 14.25: The Constrained Adjustment Results

The adjustment statistics are good. If some vectors that didn't quite meet the project settings accuracy specifications, the problem may likely be due to the effects of the control.

If satisfied that the new stations meet the project requirements, we have completed the adjustment process and can use the final coordinates, and their uncertainties, for their intended purpose. If we believe the control is suspect, the Control Tie analysis can be used to help isolate the problem. An example using the Control Tie analysis is given in the next section. You can also refer to the manual for additional information about using this tool.

TroubleShooting Tips

Loop Closures

1. Select **Loop Closure Mode** from the **Map View** menu in the **View** menu.

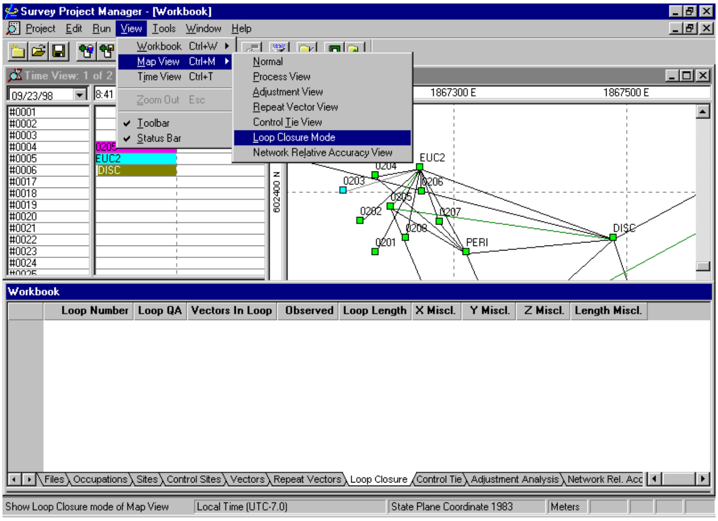


Figure 14.26: Selecting Loop Closure Mode

2. Maximize the **Map View** window and zoom in around the center part as shown below.

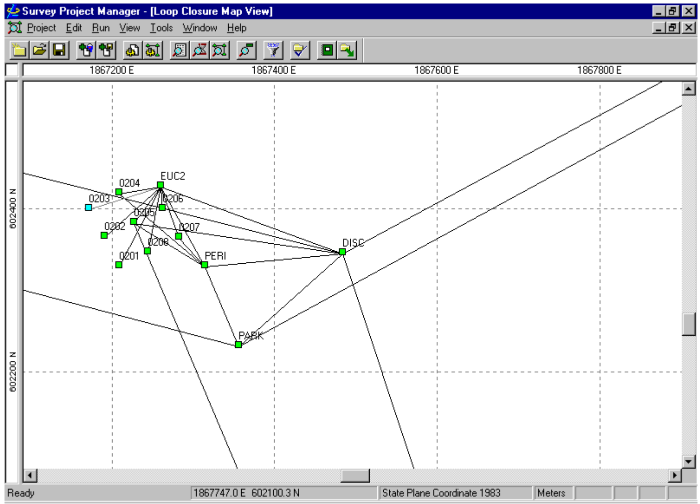


Figure 14.27: Zoom In on Map View

The title bar at the very top of the screen indicates loop closure mode.

3. Move the cross hair over the vector between PARK and DISC. Click and the vector will become dashed.
4. Move the cross-hair over the vector between DISC and J886 and click. J886 is off the edge of Figure 14.27.
5. Move the cross-hair over the vector between PARK and J886 and click, and a vector selection box appears because there are two observations of this vector.

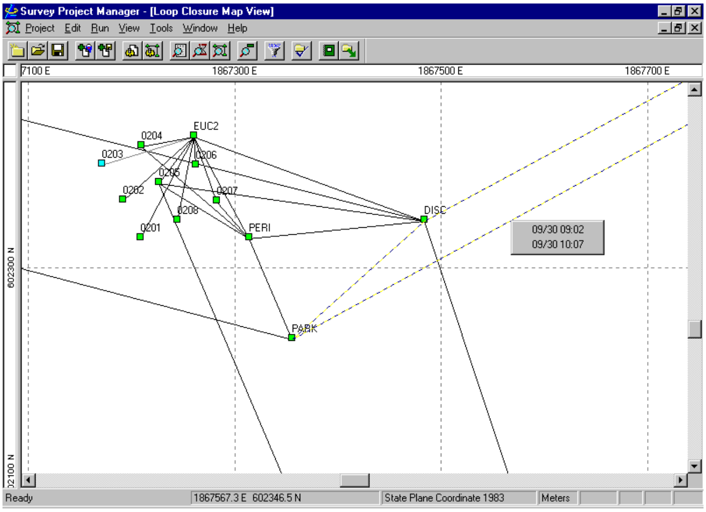


Figure 14.28: Selecting One Vector from a Repeat Site

6. Select the **09/30 09:02** observation by clicking on it.

7. Select **Loop Closure** from the **Workbook** menu in the **View** menu to display the closure information.

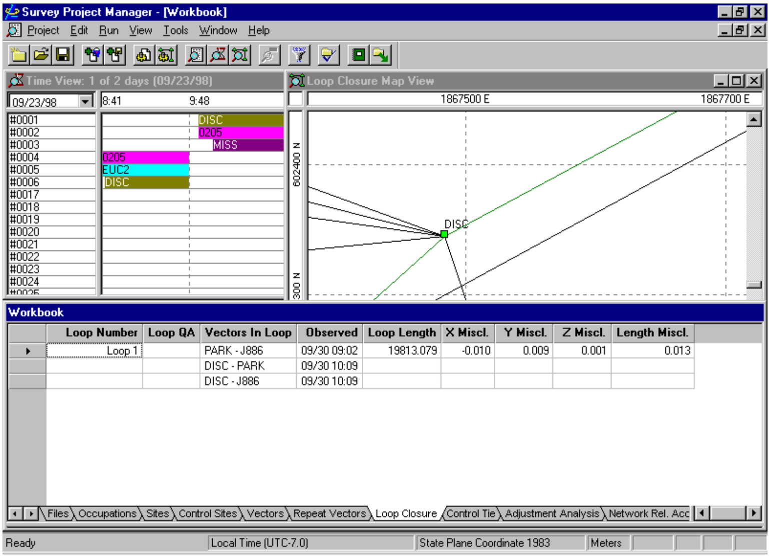


Figure 14.29: Viewing the Loop Misclosure

Right-clicking on one of the misclosures will display either XYZ or ENU misclosures. These misclosures can be displayed as the actual linear distances, as a part per million error representation, or as a ratio.

Control Ties

Once you have performed an adjustment, you can check how the control matches the data. In this example we have used three control stations for both horizontal and vertical control. This gives a slight redundancy for the solution of the rotation and scale parameters, but there is no redundancy for the vertical rotations in the north and east directions. Any errors in the vertical control will disappear in the rotation parameters. Notice in the previous adjustment example, the constrained adjustment shows that the vertical rotation parameters are fairly high (Northing and Easting), especially the easting, while the azimuth rotation and scale (Height and Scale) are small as seen below.

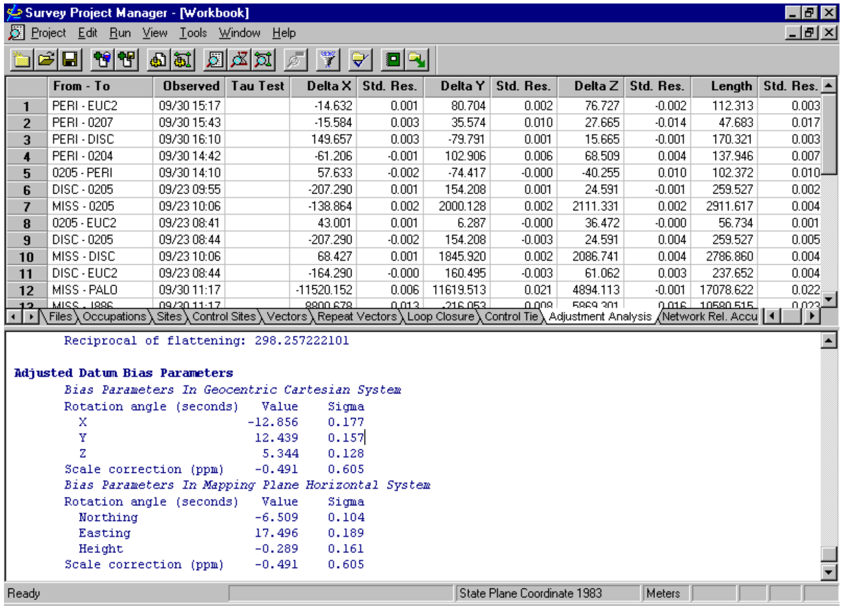


Figure 14.30: Adjusted Datum Bias Parameters

To check our control ties we need to unfix all but one of the stations.

1. Click on the **Control Sites** tab.
2. Set the **Fixed** values of MISS and J886 to **(None).**
3. Hit the **F7** key to perform another free adjustment.

4. Click on the **Control Tie** tab.

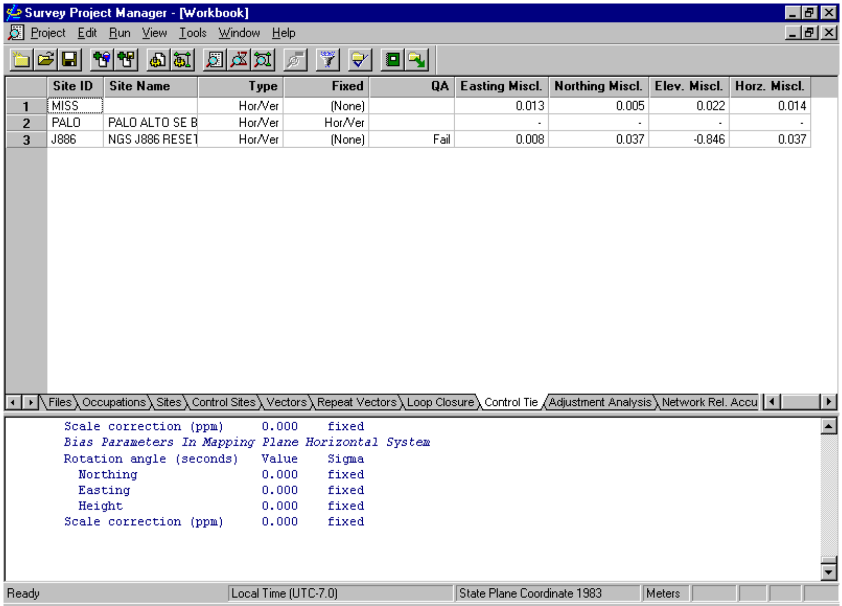


Figure 14.31: Control Tie Analysis Tab

The vertical difference at J886 (the most eastern point), is .84 meters. This is more than the undulation of the geoid model supports, so there is a problem somewhere. There isn't enough vertical control or enough redundancy in the measurements to see this in the adjustment statistics, except for the rotation parameters in the constrained adjustment. The problem could be an antenna height measurement, a published elevation, a data entry mistake...with some investigation, the height held fixed for MISS is only listed as 4th order Class II. This uncertainty makes the height a good suspect for potentially high distortions. If additional vertical control is available the problem can be more easily isolated and eliminated.

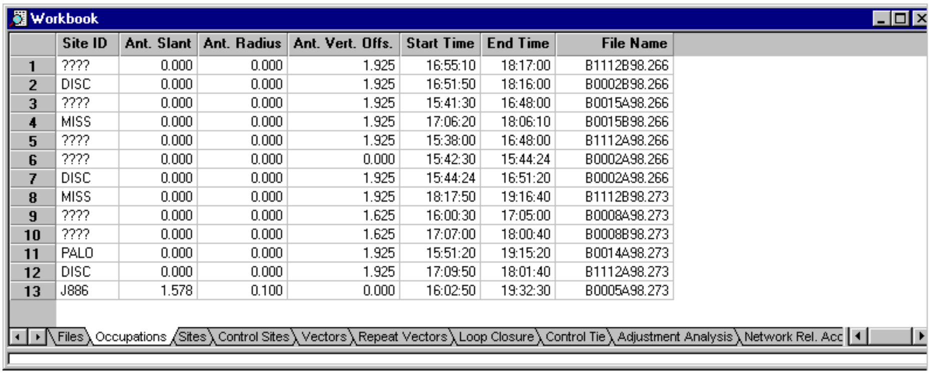
Free Adjustment Examples

The next examples assume that you are familiar with starting a project and navigating within the software. If you have problems, it may mean that you need to work on the earlier tutorials a little more.

Let’s try a couple of adjustments to get acquainted with some of the statistical outputs and unique analysis tools available in the Locus software. The first example uses a part of the TUTORSTA project.

Start a new project named ‘Adjustment’ and import the raw data from …\TUORSTA\DAY98.266 and \DAY98.273. The project should be setup for California Zone 3 State Plane Coordinate 1983, and the linear units should be meters. On the SITES tab, use the right mouse click to delete all of the sites except PALO, DISC, MISS, and J886.

The Project occupations tab should look similar to Figure 14.32.


Workbook

	Site ID	Ant. Slant	Ant. Radius	Ant. Vert. Offs.	Start Time	End Time	File Name
1	????	0.000	0.000	1.925	16:55:10	18:17:00	B1112B98.266
2	DISC	0.000	0.000	1.925	16:51:50	18:16:00	B0002B98.266
3	????	0.000	0.000	1.925	15:41:30	16:48:00	B0015A98.266
4	MISS	0.000	0.000	1.925	17:06:20	18:06:10	B0015B98.266
5	????	0.000	0.000	1.925	15:38:00	16:48:00	B1112A98.266
6	????	0.000	0.000	0.000	15:42:30	15:44:24	B0002A98.266
7	DISC	0.000	0.000	1.925	15:44:24	16:51:20	B0002A98.266
8	MISS	0.000	0.000	1.925	18:17:50	19:16:40	B1112B98.273
9	????	0.000	0.000	1.625	16:00:30	17:05:00	B0008A98.273
10	????	0.000	0.000	1.625	17:07:00	18:00:40	B0008B98.273
11	PALO	0.000	0.000	1.925	15:51:20	19:15:20	B0014A98.273
12	DISC	0.000	0.000	1.925	17:09:50	18:01:40	B1112A98.273
13	J886	1.578	0.100	0.000	16:02:50	19:32:30	B0005A98.273

Files | Occupations | Sites | Control Sites | Vectors | Repeat Vectors | Loop Closure | Control Tie | Adjustment Analysis | Network Rel. Acc

Figure 14.32: Project Occupations Tab

The Map View should look similar to Figure 14.33.

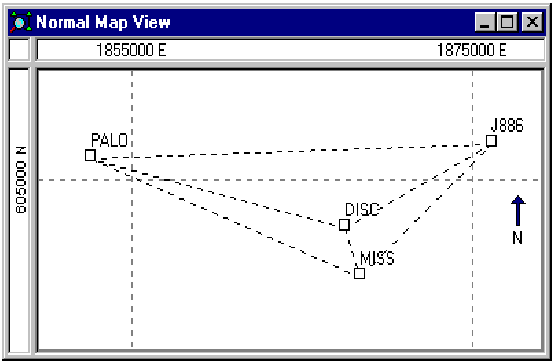
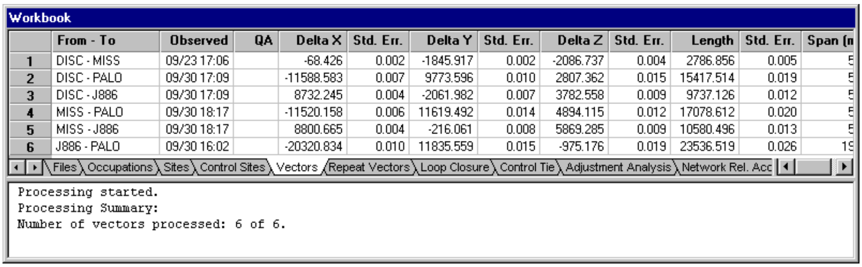


Figure 14.33: Map View

Set DISC to be held fixed as the control site and process the data. Use the following coordinate for DISC.

Easting	1867483.594
Northing	602345.071
Ortho. Ht.	1.828

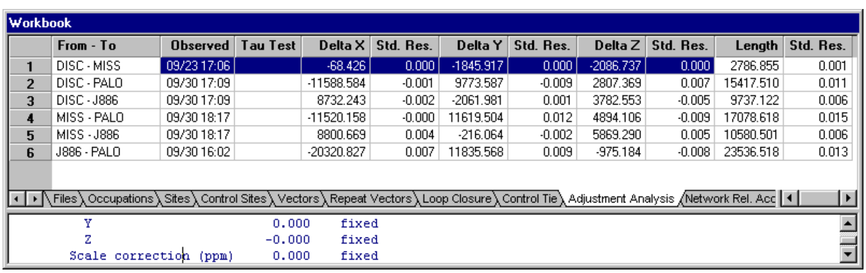
The vectors tab will look like Figure 14.34.



	From - To	Observed	QA	Delta X	Std. Err.	Delta Y	Std. Err.	Delta Z	Std. Err.	Length	Std. Err.	Span (m
1	DISC - MISS	09/23 17:06		-68.426	0.002	-1845.917	0.002	-2086.737	0.004	2786.856	0.005	5
2	DISC - PALO	09/30 17:09		-11588.583	0.007	9773.596	0.010	2807.362	0.015	15417.514	0.019	5
3	DISC - J886	09/30 17:09		8732.245	0.004	-2061.982	0.007	3782.558	0.009	9737.126	0.012	5
4	MISS - PALO	09/30 18:17		-11520.158	0.006	11619.492	0.014	4894.115	0.012	17078.612	0.020	5
5	MISS - J886	09/30 18:17		8800.665	0.004	-216.061	0.008	5869.285	0.009	10580.496	0.013	5
6	J886 - PALO	09/30 16:02		-20320.834	0.010	11835.559	0.015	-975.176	0.019	23536.519	0.026	1

Figure 14.34: Vectors Tab

Adjust the data holding DISC fixed.



	From - To	Observed	Tau Test	Delta X	Std. Res.	Delta Y	Std. Res.	Delta Z	Std. Res.	Length	Std. Res.
1	DISC - MISS	09/23 17:06		-68.426	0.000	-1845.917	0.000	-2086.737	0.000	2786.855	0.001
2	DISC - PALO	09/30 17:09		-11588.584	-0.001	9773.587	-0.009	2807.369	0.007	15417.510	0.011
3	DISC - J886	09/30 17:09		8732.243	-0.002	-2061.981	0.001	3782.553	-0.005	9737.122	0.006
4	MISS - PALO	09/30 18:17		-11520.158	-0.000	11619.504	0.012	4894.106	-0.009	17078.618	0.015
5	MISS - J886	09/30 18:17		8800.669	0.004	-216.064	-0.002	5869.290	0.005	10580.501	0.006
6	J886 - PALO	09/30 16:02		-20320.827	0.007	11835.568	0.009	-975.184	-0.008	23536.518	0.013

Figure 14.35: Adjustment Analysis Tab

Finding an Antenna Height Blunder

This network is designed to minimize the occupations. From the Vector info or Time View we can see that Stations DISC and MISS are occupied more than once. This is a requirement for blunder detection unless the station coordinates are known (Control Points). Also important for seeing blunders is to apply appropriate accuracy expectations. For this example let's apply a horizontal accuracy of 0.01m + 1ppm and a vertical accuracy of 0.02m + 4ppm in the **Miscellaneous** tab of the **Project Settings** dialog box.

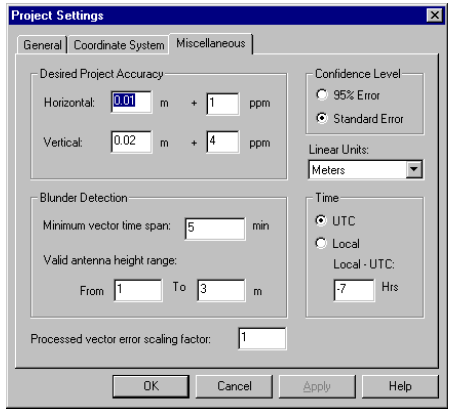


Figure 14.36: Changing the Desired Accuracy

There are two problems which are very common in GPS networks and that can be used to illustrate how the Adjustment Analysis Tab is used to detect them. One of the most common problems is an incorrect H.I.. There are many places where the H.I values can be corrupted. Typical problem areas would be when the information is measured and recorded in the field and when entered in the office. A second common problem is when a baseline simply doesn't fit. This can be caused by things like using an incorrect seed position, incorrectly determined integer ambiguities, use of float positions, etc.

Let's take a look at the first case. Since this is the most common of all error sources, LOCUS was designed to assist in detection in it's Field Log design, Pre-Processing Analysis, and automatic blunder detection. Also available for detection under given conditions are the Repeat Baseline Analysis and Loop Closure Testing. Even with all these tool we will find the case where the H.I. error is present in the network.

Let's create a example. Remember that a requirement for detecting errors in the Adjustment Analysis is that the station is observed twice. Only two stations in our example network meet this conditions - MISS & DISC. Note that neither of these stations were used in repeat baselines so one of our error checking tools is not applicable. Review of the current vector uncertainties shows that all baselines were processed and accepting the small Standard Errors, are believed to have correct ambiguity resolutions. Network residuals are small indicating internal conformity. We will refer to this as the network base state.

The easiest way to induce a H.I. error is in the Occupations Tab. After entering this tab, I entered an incorrect Vertical Antenna Offset of 2.025 m for the second occupation of station MISS . . .

Workbook

	Site ID	Ant. Slant	Ant. Radius	Ant. Vert. Offs.	Start Time	End Time	File Name
1	PALO	0.000	0.000	1.925	15:51:20	19:15:20	B0014A98.273
2	MISS	0.000	0.000	1.925	17:06:20	18:06:10	B0015B98.266
3	MISS	0.000	0.000	2.025	18:17:50	19:16:40	B1112B98.273
4	J886	1.578	0.100	0.000	16:02:50	19:32:30	B0005A98.273
5	DISC	0.000	0.000	1.925	16:51:50	18:16:00	B0002B98.266
6	DISC	0.000	0.000	1.925	15:44:24	16:51:20	B0002A98.266
7	DISC	0.000	0.000	1.925	17:09:50	18:01:40	B1112A98.273
8	????	0.000	0.000	1.925	16:55:10	18:17:00	B1112B98.266
9	????	0.000	0.000	1.925	15:41:30	16:48:00	B0015A98.266

Files | Occupations | Sites | Control Sites | Vectors | Repeat Vectors | Loop Closure | Control Tie | Adjustment Analysis | Network Rel. Acc

Scale correction (ppm) 0.000 fixed

Figure 14.37: Introducing an Error

This change affects the computed Vectors which are Ground to Ground. The site position is likewise changed and the network adjustment is void. These changes can be seen in the respective workbook tabs. After the H.I. change it is necessary to reprocess the corresponding vectors. The option "Process New" can be used to reprocess the changed baselines. The new vectors are listed in the following table:

Workbook

	From - To	Observed	QA	Delta X	Std. Err.	Delta Y	Std. Err.	Delta Z	Std. Err.	Length	Std. Err.	Span (m
1	DISC - MISS	09/23 17:06		-68.426	0.002	-1845.917	0.002	-2086.737	0.004	2786.856	0.005	5
2	DISC - PALO	09/30 17:09		-11588.583	0.007	9773.596	0.010	2807.362	0.015	15417.514	0.019	5
3	DISC - J886	09/30 17:09		8732.245	0.004	-2061.982	0.007	3782.558	0.009	9737.126	0.012	5
4	MISS - PALO	09/30 18:17		-11520.200	0.006	11619.425	0.014	4894.175	0.012	17078.612	0.020	5
5	MISS - J886	09/30 18:17		8800.623	0.004	-216.129	0.008	5869.346	0.009	10580.496	0.013	5
6	J886 - PALO	09/30 16:02		-20320.834	0.010	11835.559	0.015	-975.176	0.019	23536.519	0.026	1[illegible]

Files | Occupations | Sites | Control Sites | Vectors | Repeat Vectors | Loop Closure | Control Tie | Adjustment Analysis | Network Rel. Acc

Number of vectors processed: 6 of 6.

Figure 14.38: Reprocessed Vectors

Review of the vector statistics again demonstrates that the baselines were resolved to the expected precision.

One of the tools available for reviewing unadjusted vectors is the Loop Closures Tab. There are three small loops which include stations MISS. The following table lists the results from the loop tests:

Workbook

	Loop Number	Loop QA	Vectors In Loop	Observed	Loop Length	X Miscl.	Y Miscl.	Z Miscl.	Length Miscl.
1	Loop 1		MISS - PALO	09/30 18:17	51195.627	0.010	-0.006	0.006	0.013
			J886 - PALO	09/30 16:02					
			MISS - J886	09/30 18:17					
4	Loop 2	Fail	MISS - PALO	09/30 18:17	35282.982	-0.043	-0.089	0.076	0.125
			DISC - PALO	09/30 17:09					
			DISC - MISS	09/23 17:06					
▸	Loop 3	Fail	MISS - J886	09/30 18:17	23104.477	0.048	0.064	-0.050	0.095
			DISC - MISS	09/23 17:06					
			DISC - J886	09/30 17:09					

Files | Occupations | Sites | Control Sites | Vectors | Repeat Vectors | Loop Closure | Control Tie | Adjustment Analysis | Network Rel. Acc

Number of vectors processed: 6 of 6.

Figure 14.39: Loop Closure Results

From these we can see that two of the tests show a problem. Unless all loops are checked - a daunting task for large networks - it can be seen that an antenna related problem can easily be propagated into a network.

Now readjust the network, holding DISC fixed as before. After the readjustment set the Adjustment Analysis to display ENU with standard residuals. Also, sort the vectors using the Length Std. Res. Column. This allows us to view the worst fitting vectors first. Note that all of these baselines are not of comparative length. The normalized residuals, which can take into account the varying distances can be a very useful tool for analysis of large networks, but be careful sometimes a value of 4 or more can translate to centimeters or millimeters which may be perfectly acceptable for your project. The following table lists the adjustment output:

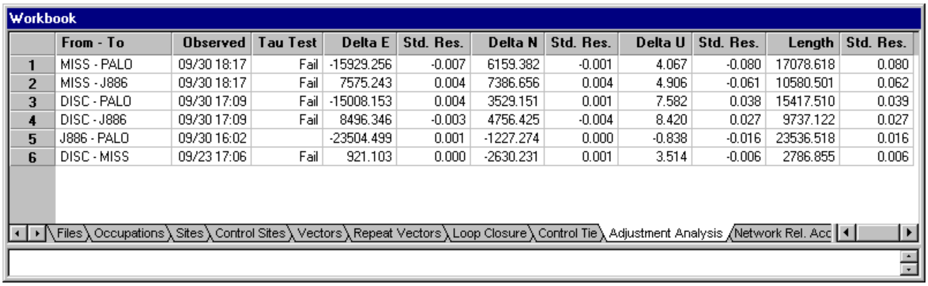
Workbook

	From - To	Observed	Tau Test	Delta E	Std. Res.	Delta N	Std. Res.	Delta U	Std. Res.	Length	Std. Res.
1	MISS - PALO	09/30 18:17	Fail	-15929.256	-0.007	6159.382	-0.001	4.067	-0.080	17078.618	0.080
2	MISS - J886	09/30 18:17	Fail	7575.243	0.004	7386.656	0.004	4.906	-0.061	10580.501	0.062
3	DISC - PALO	09/30 17:09	Fail	-15008.153	0.004	3529.151	0.001	7.582	0.038	15417.510	0.039
4	DISC - J886	09/30 17:09	Fail	8496.346	-0.003	4756.425	-0.004	8.420	0.027	9737.122	0.027
5	J886 - PALO	09/30 16:02		-23504.499	0.001	-1227.274	0.000	-0.838	-0.016	23536.518	0.016
6	DISC - MISS	09/23 17:06	Fail	921.103	0.000	-2630.231	0.001	3.514	-0.006	2786.855	0.006

Files | Occupations | Sites | Control Sites | Vectors | Repeat Vectors | Loop Closure | Control Tie | Adjustment Analysis | Network Rel. Acc

Figure 14.40: New Adjustment Output

The highest residual occurs in the baseline between stations PALO & MISS. Note also that the Up component contains a majority of the distance error, 0.08 meters. Suspecting an H.I. error may be present, sort the adjustment on the Up residual. Figure 14.41 shows the reordered baselines:



	From - To	Observed	Tau Test	Delta E	Std. Res.	Delta N	Std. Res.	Delta U	Std. Res.	Length	Std. Res.
1	MISS - PALO	09/30 18:17	Fail	-15929.256	-0.007	6159.382	-0.001	4.067	-0.080	17078.618	0.080
2	MISS - J886	09/30 18:17	Fail	7575.243	0.004	7386.656	0.004	4.906	-0.061	10580.501	0.062
3	DISC - PALO	09/30 17:09	Fail	-15008.153	0.004	3529.151	0.001	7.582	0.038	15417.510	0.039
4	DISC - J886	09/30 17:09	Fail	8496.346	-0.003	4756.425	-0.004	8.420	0.027	9737.122	0.027
5	J886 - PALO	09/30 16:02		-23504.499	0.001	-1227.274	0.000	-0.838	-0.016	23536.518	0.016
6	DISC - MISS	09/23 17:06	Fail	921.103	0.000	-2630.231	0.001	3.514	-0.006	2786.855	0.006

Figure 14.41: Reordered Baselines

We can see that the first two baselines with the largest Up component residuals include the station MISS. This is a strong pointer that this station is suspect. Another clue is the time associated with the highest Up residual. This points to the second occupation. Hopefully a careful examination of field logs, D-files, and any other available information will result in finding the blunder. If not the next option is to remove the suspect vectors.

Using the right mouse click in the Adjustment Analysis tab, begin by excluding the suspect baseline. The software will automatically readjust the network and output new statistics. Both the Tau Tests and the Variance of Unit Weight indicators fail again. The next highest vector is then excluded and the network readjusts. The results of this adjustment are both passing of the Tau Tests for all baselines and a reasonable Variance of Unit Weight closer to 1. This indicates that the problem has been eliminated. The next step is to begin re-including baselines one at a time, and evaluating their effect. Re-including either of our excluded baselines results in high statistical failures thus the network must be evaluated for acceptance without the excluded vectors. Reviewing my site map I see that without these occupations all stations have only a single occupation thus having no redundant checks. It is advisable to reinforce the network with more field observations or use existing data from another project if possible.

You can see from this example that the Adjustment Analysis tool is an effective way to trouble shoot a network. I believe that for larger projects it may be much easier to use than the Loop Closure testing. I recommend that you experiment with the various display options as each may be more useful under a given set of conditions. You should also review the adjustment statistics presented in the message window, namely the Variance of Unit Weight and Chi-Square test. These values become more useful when analyzing larger networks. For a better understanding of what these values represent, look in the help section and experiment with what happens when you introduce errors into our example networks.

Lets move on to the second example. Remove the H.I. error induced in the preceding example, include the excluded vectors, re-compute the baselines, and readjust the network. This should bring our project back to the base state.

A

Mission Planning

Introduction

This chapter 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 the user 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 maybe 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 *Locus 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 occupation 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 **Mission Planning** from the **Locus Processor** menu.

   The **Mission Planning** main window opens (Figure A.1).

You can access Mission Planning from Locus Processor by selecting Mission Planning from the Tools menu.

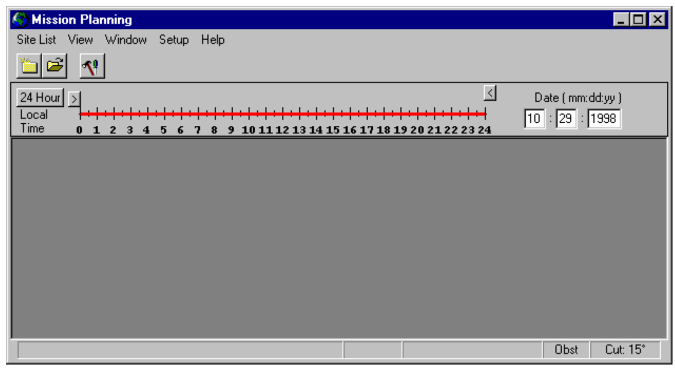


Figure A.1: Mission Planning Main Window

2. Near the top of the screen is a 24-hour time scale (Figure A.2), to specify the time interval for want to determining DOP and satellite availability. You 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 displays in red.

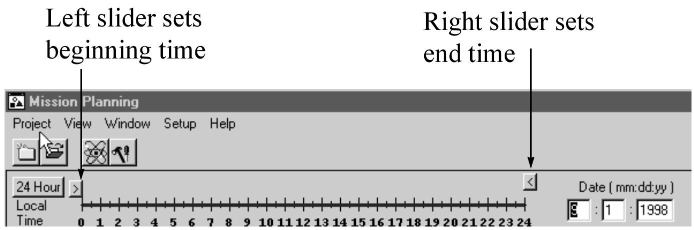


Figure A.2: Time Scale

Loading an Almanac File

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 Locus/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. Select **Options** from the **Setup** menu.
2. In the **Options** dialog box (Figure A.3), click the **Change Dir** button to open the **Change Almanac Directory** dialog box.

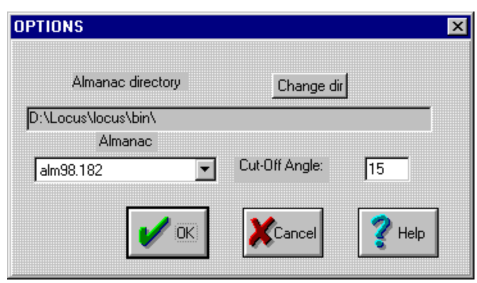


Figure A.3: Satellite Configuration dialog box

3. Navigate to and select the almanac file in the **Change Almanac Directory** dialog box, and click **Open**.
4. Click **OK** in the **Options** dialog box to save the changes and close the **Options** dialog box.

Creating a New Project

Mission Planning Projects are used to store sites, but are independent of Locus Processor projects. In the Locus processor/bin files 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 7.

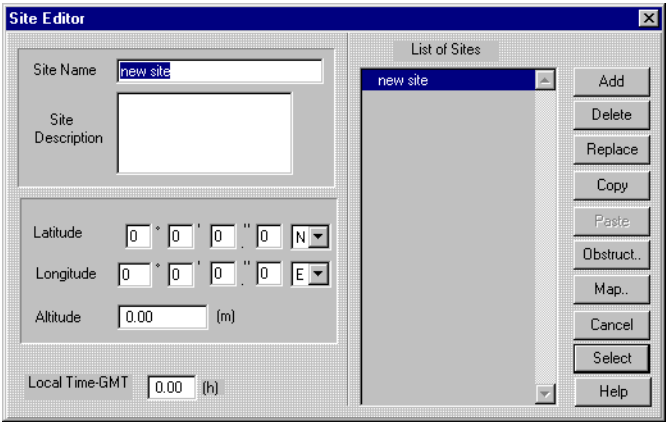


Figure A.4: Site Editor Dialog Box

Opening a Existing Project

1. Select **Open** from the **Site List** menu. The **Open** dialog box, opens (Figure A.5).

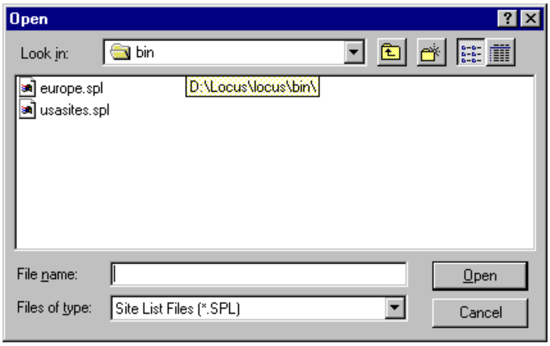


Figure A.5: Open Screen

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.6)

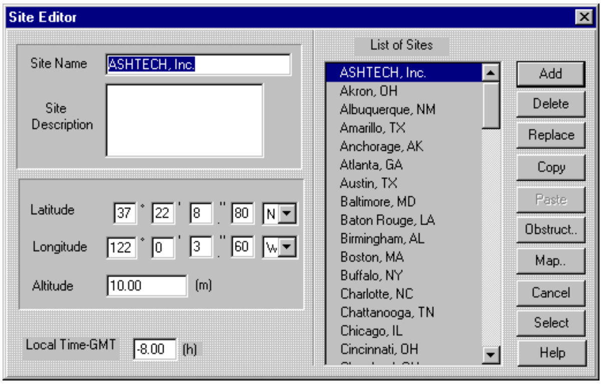


Figure A.6: Site Editor Dialog Box

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 (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 Precisions (DOPs), 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.7), Enter a name for the site in the **Site Name** field.

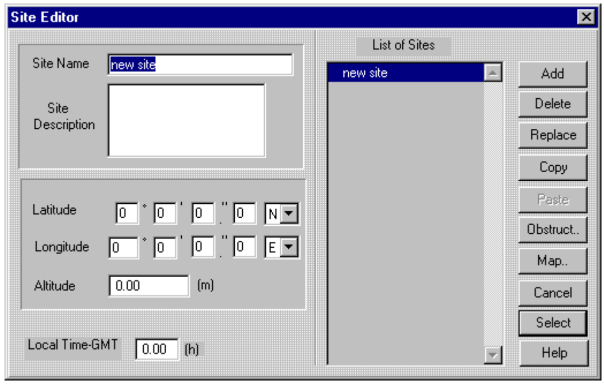


Figure A.7: Site Editor Dialog Box

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.8), and use the mouse to click on the approximate site location. Then click OK to accept the site and close the dialog box.

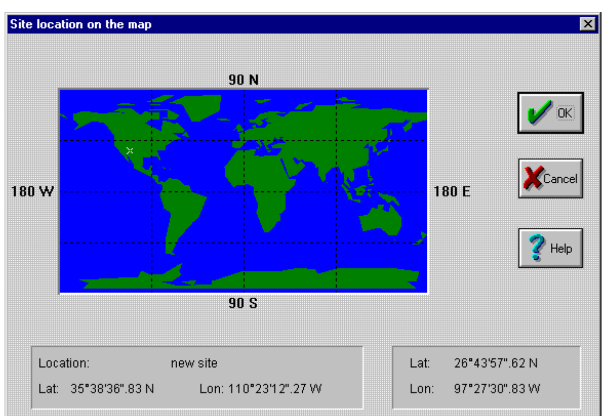


Figure A.8: Site Location on Map Dialog Box

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.

Using the DOP Plot and Sky 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 window (Figure A.9).

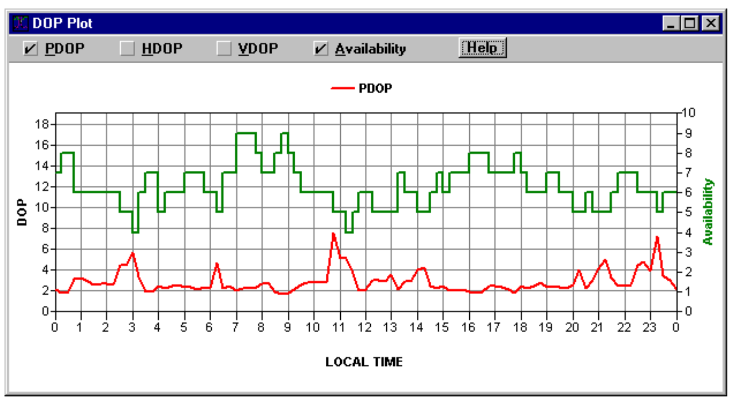


Figure A.9: DOP Plot

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 yet the satellite geometry is poor (e.g., near 21:00 hours).

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

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

4. Select **Sky Plot** from the **View** menu to open the **Sky Plot** window (Figure A.10).

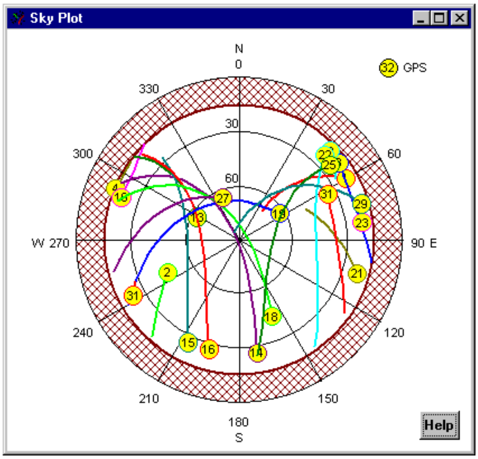


Figure A.10: Sky Plot

This display is an upper 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.

Changing the Cut-Off Angle

The Cut-off Angle (or elevation mask) is the minimum elevation above the horizon that data will be collected. By default the Cut-Off is set to 15°.

To change the Cut-Off Angle:

1. Select **Options** from the **Setup** Menu.

   The **Options** dialog box opens (Figure A.11).

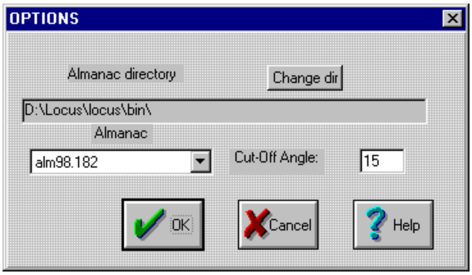


Figure A.11: Satellite Configuration Dialog

2. Enter a new Cut-Off Angle and click **OK**. The Options dialog box closes and the **Sky Plot** and DOP Plot windows updates after clicking in them.

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 **Site Editor** dialog box) to open the **Obstruction Editor** dialog box (Figure A.12).

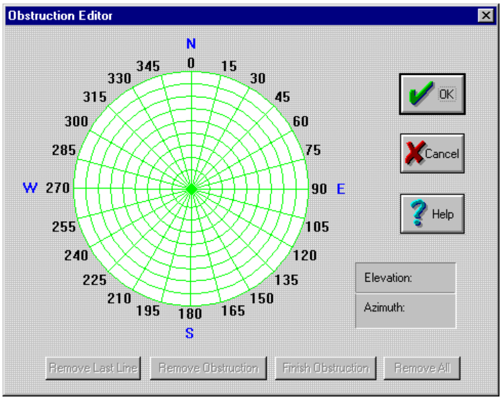


Figure A.12: Obstruction Editor Dialog Box

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.
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 .

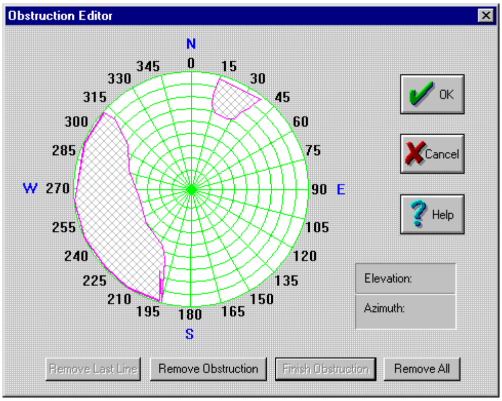


Figure A.13: Drawing the Obstruction

- 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.

RINEX Converter

Introduction

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.

When **RINEX Converter** converts a RINEX file to Ashtech format, the conversion can produce up to four types of data:

Obs	Observation data
Nav	Navigation data
Nav G	GLONASS navigation data if available
Met	Meteorological data if available

In addition, the observation data is separated into three files:

B-file	GPS measurement data
E-file	Satellite ephemeris data
S-file	Site information, if recorded in receiver at time of observation

J-files not collected by Locus Receiver.

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

1. Select the **Rinex Converter** application in the **Locus Processor** in the **Programs** menu from the **Start** Bar.

   -or-

   Select **RINEX Converter** from the **Tools** menu in **Locus Processor**.
2. The **RINEX to Ashtech** window opens (Figure B.1).

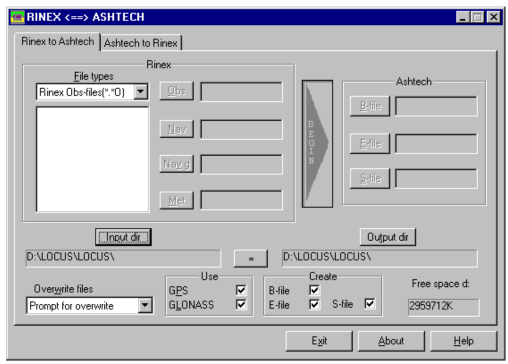


Figure B.1 RINEX-to-Ashtech Dialog

This dialog lets you select the files you want to convert, and defines the conversion options. Table B.1 describes the fields in the **RINEX to Ashtech** dialog.

Table B.1 RINEX to Ashtech Dialog 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 displayed 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.
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 .

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

Item	Description
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. See next entry in this table.
Set input directory	This dialog 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	This dialog lets you 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 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). 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 easily 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, click **Input dir** to open the **Set input directory** dialog, similar to Figure B.2.

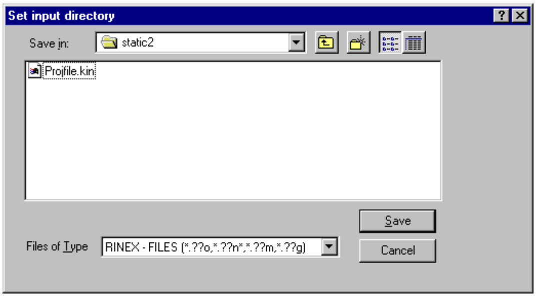


Figure B.2 Set Input Directory Dialog

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 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.

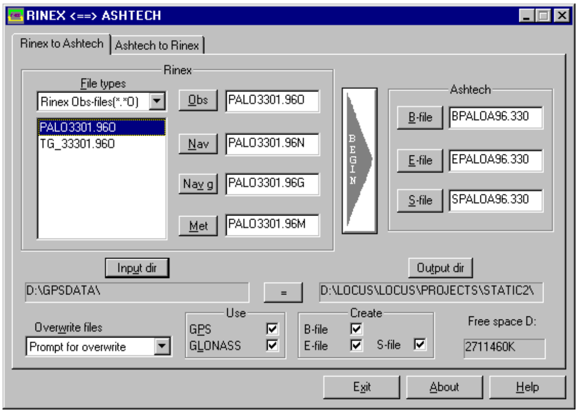


Figure B.3 Rinex-to-Ashtech Dialog with Suggested Output File Names

4. Click **Output dir** to open the **Set Output directory** dialog, Figure B.4.

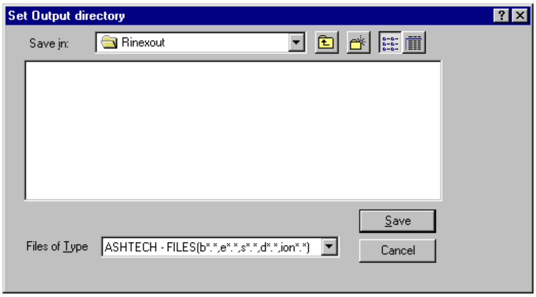


Figure B.4 Set Output Directory Dialog

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 presented. 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 opens, asking 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 will not be 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 opens (Figure B.5).

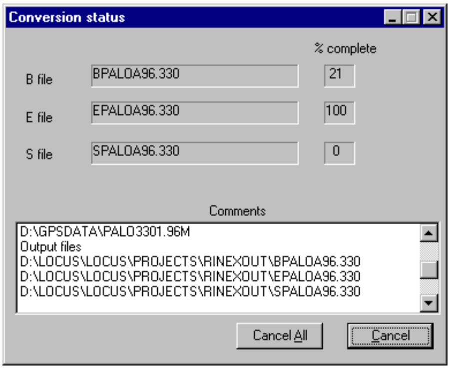


Figure B.5 Conversion Status Dialog

8. The **Conversion status** dialog shows the status of each file as it converts. 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).

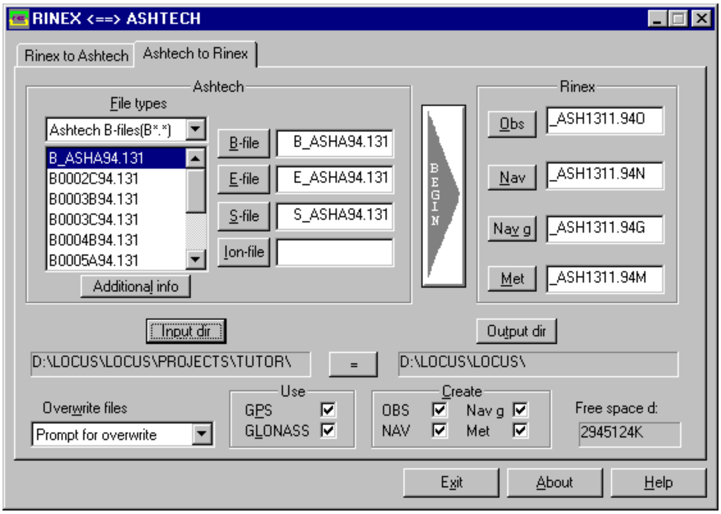


Figure B.6 Ashtech to Rinex Dialog

RINEX Converter

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

Table B.2 Ashtech to RINEX Dialog 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 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. See next entry in this table.
Set input directory	This dialog 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. See next entry in this table.
Set output directory	This dialog displays the directory path where converted RINEX files are stored.

Table B.2 Ashtech to RINEX Dialog 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 which displays the software version number.
Help	Opens the on-line help system.

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

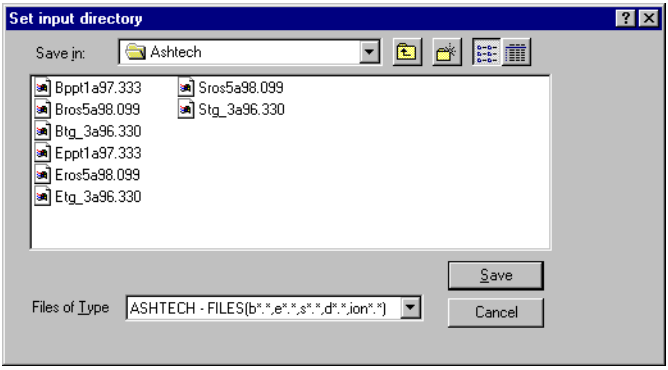


Figure B.7 Set Input Directory Dialog

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.

   The **Input Directory** lists the directory path, and **Available Files** list lists the Rinex files in the input directory (Figure B.8).

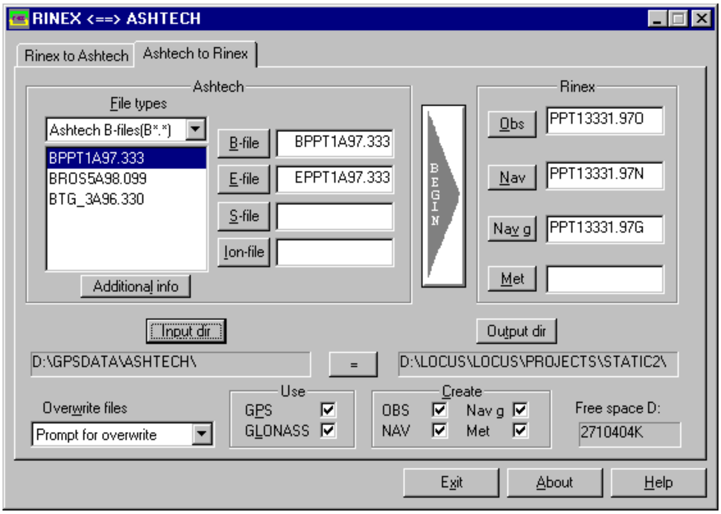


Figure B.8 Ashtech Files in Selected Ashtech Input Directory

5. 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.

6. Click **Output dir** to open the **Set output directory** dialog, Figure B.9.

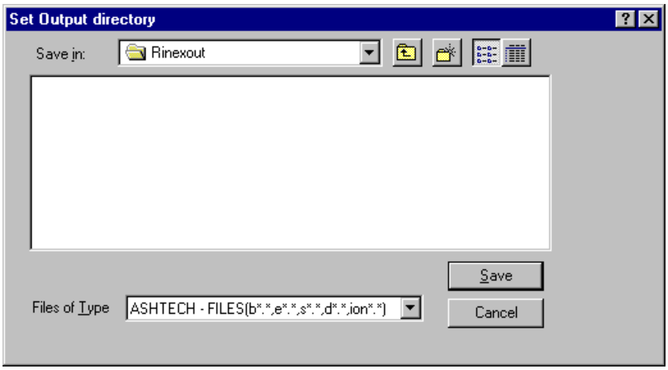


Figure B.9 Set Output Directory Dialog

7. 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.

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

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

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

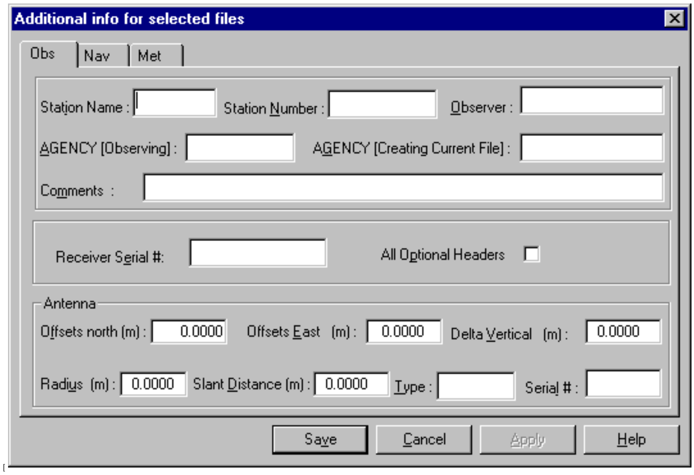


Figure B.10 Additional Info for Selected Files Dialog - OBS Tab

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.

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

Table B.3 Additional Info for Selected Files Dialog - 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 - 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 overwrites the values in the S-file.
Type	Type of antenna used in data collection.
Serial #	Serial number of antenna used for data collection.

11. 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 dat ausing 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.

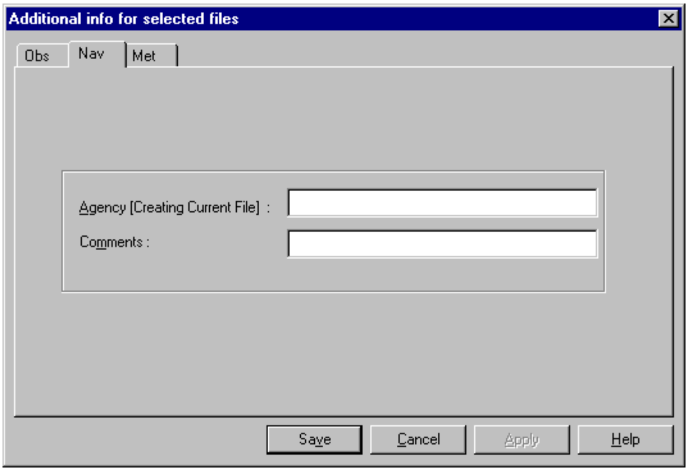


Figure B.11 Additional Info for Selected Files Dialog - NAV Tab

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

Table B.4 Additional Info for Selected Files Dialog - 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.

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

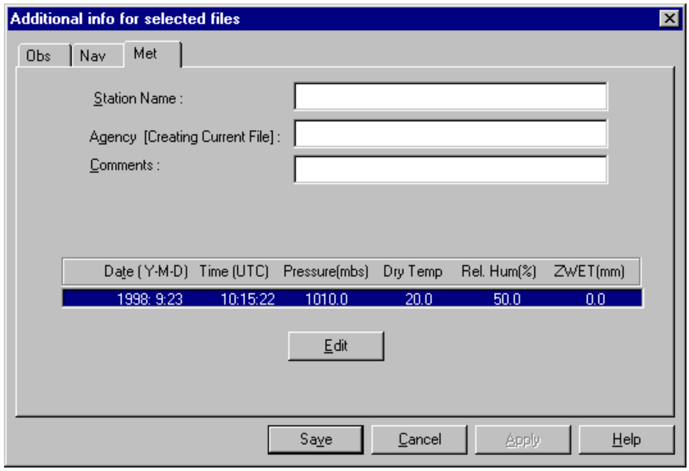


Figure B.12 Additional Info for Selected Files Dialog - MET Tab

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

Table B.5 Additional Info for Selected Files Dialog - 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 and edit the selected meteorological data line.

15. Click **Edit** to open the **Edit** dialog and inspect or change the meteorological data.

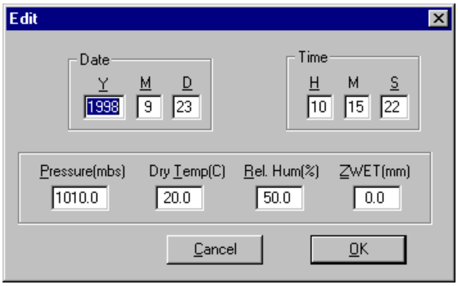


Figure B.13 Edit Dialog

16. 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.

Table B.6 Edit Dialog 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)

17. Click **OK** to accept the meteorological data and close the **Edit** dialog.
18. Click **Save** to save the changes made to the **Met** tab and close the **Additional info for selected files** dialog.
    - The **Apply** button saves any changes made to the active tab, and does not close the **Additional info for selected files** dialog.
    - The **Save** button saves any changes made any tab, and closes the **Additional info for selected files** dialog.
19. Click **Begin** to convert the selected Ashtech files to RINEX format. The **Conversion Status** dialog opens (Figure B.14), showing the status of the

conversion process. Upon completion, the dialog indicates 100% for each file.

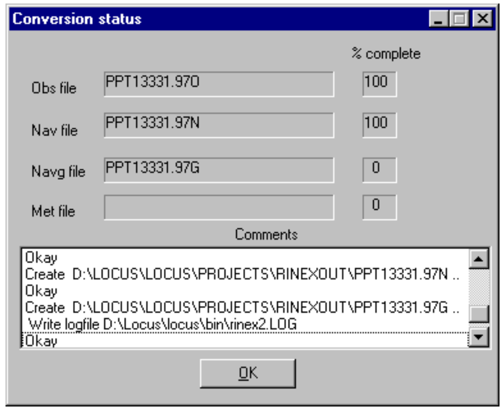


Figure B.14 Conversion Status Dialog

20. 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.

Post-Adjustment Analysis

Introduction

Performing a least-squares adjustment of survey observations is one of the most important steps in performing a GPS survey. The actual performance of a least-squares adjustment is very easy in Locus Processor. The user simply pushes a button and the adjustment is performed. There really isn't anything complicated or new in this process. Many adjustment packages exist today that support this level of adjustment. The actual performance of the least-squares adjustment has never really been tricky. The tricky part, and where most improvement has been needed, has been in the analysis of the results of a least-squares adjustment.

A great deal of effort has gone into the adjustment module of Locus Processor to supply the user with tools to assist in the process of analyzing the results of an adjustment. Some of the tools are classical tools used for some time for this purpose. Others are new and innovative.

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 the user must remember when analyzing an adjustment with this tool set.

1. Many of the analysis tools presented by Locus Processor 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 of Locus Processor 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 under the pertinent tools 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 occupation of each point being established. Unfortunately, this is not practical and really not necessary. Select a certain percentage of points to receive multiple occupations. 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 supplied 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 supplied in the adjustment module of Locus Processor are designed to assist the user 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, let's examine 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

In least-squares adjustments, there are two Variance of Unit Weight values. They are termed A-priori Variance of Unit Weight and A-posteriori Variance of Unit Weight. A-priori means before the adjustment and a-posteriori means after the adjustment. The a-priori variance of unit weight is an assigned value. The a-posteriori variance of unit weight is a calculated value. Examining the mathematics of least-squares, it can be proven that the expected value of the calculated a-posteriori variance of unit weight is the a-priori variance of unit weight.

The a-posteriori variance of unit weight can be used as a test of the quality of an adjustment since it's expected value is known. Locus Processor outputs the a-posteriori variance of unit weight for this purpose. Analysis of the a-posteriori variance of unit weight will reveal one of three things.

1. A value close or equal to the expected value is a good indication that the adjustment contains no blunders and the uncertainties assigned to the observations going into the adjustment were valid (not too optimistic or pessimistic). Unfortunately, this is not a definitive indication of a good adjustment. Manipulation of observation uncertainties could cause this test to be fooled. Therefore, this tool, like all others, cannot be used alone. All analysis tools must be used in conjunction with each other to determine the quality of an adjustment.
2. A value significantly larger than the expected value is an indication that either a blunder or blunders exist in the data adjusted, or the uncertainties assigned to the observations going into the adjustment are too optimistic, i.e. smaller than the true uncertainties). Other analysis tools must be used to determine which of these conditions exist. If blunders are found, they must be removed and the adjustment run again. If it is found that the uncertainties are too optimistic, they must be scaled up to more realistic values and the adjustment run again.
3. A value significantly smaller than the expected value is an indication that the observation uncertainties are too pessimistic, i.e. larger than the true uncertainties. There still may be blunders in the data set but they will be difficult to find using the statistical analysis tools due to the pessimistic uncertainties. The uncertainties must be scaled down to more realistic values and the adjustment run again. The scaling process of uncertainties is

facilitated by a scaling tool. With the scaling tool, the user can scale all observation uncertainties by a specified amount. Trial and error will result in the ability to scale the uncertainties to a level that are more realistic.

At the start of any adjustment, Locus Processor automatically assigns a value of 1 to the a-priori variance of unit weight. At the end of each adjustment, the a-posteriori variance of unit weight is calculated and output. As stated earlier, the expected value of the a-posteriori variance of unit weight is the a-priori variance of unit weight. This means that the calculated a-posteriori variance of unit weight should equal 1.

It is seldom that the a-posteriori variance of unit weight will equal exactly 1, due to the fact that it is simply an estimate of the a-priori variance of unit weight, and this estimate contains uncertainty. Due to this, the calculated a-posteriori variance of unit weight could deviate from 1 yet the adjustment could be good. Unfortunately, it is not possible to say exactly where the cutoff is for a good or bad adjustment. A value of 0.5 may be calculated from a good adjustment. A value of 5 may also be calculated from a good adjustment. Unfortunately, at times a value of 0.5 or 5 may also be calculated from an adjustment with a problem. Large deviations from 1 though are virtually always an indication of a problem.

In summary, utilize the a-posteriori variance of unit weight (shortened to variance of unit weight in the software) as an indicator of the overall quality of the least-squares adjustment.

- If the variance of unit weight is close to 1, consider this a good indication that the adjustment is good. Look at other quality tools to confirm this.
- If the variance of unit weight is significantly smaller than 1, this is an indication that the uncertainties of the observations are too large and need to be scaled down and the adjustment rerun.
- If the variance of unit weight is significantly larger than 1, use other analysis tools to determine if the cause is due to blunders or uncertainties that are too small. Either remove the blunders or scale the uncertainties up and rerun the adjustment.

Chi-Square Test

Comparing the equivalence of the a-posteriori variance of unit weight and a-priori variance of unit weight is a good indicator of the quality of an adjustment. In the section Variance of Unit Weight, we discuss how the two variance factors are compared to determine if they are numerically equivalent. But, as discussed in that section, due to the fact that the a-posteriori variance of unit weight is an estimate of the a-priori variance of unit weight and the estimate contains uncertainties, the two values do not have to be numerically equal to indicate a good adjustment. There is a gray area where sometimes it is difficult to determine if the a-posteriori variance factor is indicating a good or bad adjustment.

The Chi-Square test examines the a-posteriori variance of unit weight to determine if the computed value is statistically equivalent to the a-priori variance of unit weight. Statistical equivalence takes into account that the a-posteriori variance of unit weight is an estimate, and that the estimate has uncertainty. The test is conducted by computing a chi-square test value using the two variance of unit weight values. This test value is compared to a range defined by a lower limit value and an upper limit value. There are two possible outcomes to the test:

1. If the test value falls within the range, the chi-square test passes indicating statistical equivalence of the two variance of unit weight values. As stated in the description of Variance of Unit Weight, equivalence of the two variance factors is a good indicator that the adjustment is good.
2. If the test value falls outside of the range, the chi-square test fails indicating that the two variance of unit weight values are not statistically equivalent. This non-equivalent is a good indication of there being a problem with the adjustment. The a-posteriori variance of unit weight should be examined. It's value should give a clue to what the problem may be, as discussed in the description of Variance of Unit Weight.

The chi-square test is automatically performed by the adjustment module of Locus Processor. The results of the test are output for the user to examine. Like the variance of unit weight, the chi-square test is an overall quality check of the adjustment.

In summary, utilize the chi-square test to help determine the overall quality of the least-squares adjustment by testing the statistical equivalent of the two variance of unit weight values.

- If the test passes, it is a good indication that the adjustment is good. Look at other quality tools to confirm this.
- If the test fails, examine the a-posteriori variance of unit weight. The value should give clues to the cause of the failure as discussed in the description of Variance 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. Locus Processor 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.

Locus Processor presents residuals in two forms. The user can examine the size of the residual in linear units (meters or feet) as discussed above, or the user 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:

1. 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.
2. 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 Locus Processor. Each residual is tested and the outcome of the test is presented to the user 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.

Locus Processor supplies the tools for the user to perform a loop closure analysis of the survey network to assist in isolating blunders. By selecting vectors, the user 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 the user 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.

Locus Processor 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 did his/her job by conducting 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 he/she still wants these control points 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, the user would have to compute the relative accuracy between all control points in the survey.

The control tie analysis feature of Locus Processor 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 of Locus Processor are designed to assist the user in determining the overall quality of an adjustment. The tools assist in qualifying the attained accuracy of the survey network. Each tool is presented 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 the user an indication as to the level of uncertainty in the relationship between the two points estimated by the adjustment. The adjustment module of Locus Processor 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 of Locus Processor 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.

Let us 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 the user 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, let us look at 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 was 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 on this.

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 was 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.

Locus Processor allows for the user to 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.

Locus Processor 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 need to be collected to get 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.

Locus Processor computes and presents 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 some areas 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.

Global Product Support

If you have any problems or require further assistance, Ashtech Precision Products Customer Support can be reached through the following:

- telephone
- email
- 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:

Sunnyvale, California, USA

800 Number: 800-229-2400

Direct Dial: (408) 615-3980

Local Voice Line: (408) 615-5100

Fax Line: (408) 615-5200

Email: support@ashtech.com

Ashtech Europe Ltd. Oxfordshire UK

Tel: 44 1 753 835 700

Fax: 44 1 753 835 710

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

Table D.1: GPS/GIS Product Information

Information Category	Your actual numbers
Receiver serial #	
Software version #	
Software key serial #	

Table D.1: GPS/GIS Product Information (continued)

Information Category	Your actual numbers
Firmware version #	
A clear, concise description of the problem.	

Glossary

3D
Three dimensional

95% error
The goal of any measurement is to find the true value. Since all measurements contain error, the true value is never observed. In order to qualify measurements, an error estimate is statistically derived for each measurement. A 95% error estimate indicates there is a 95% probability that the true value of a measurement falls within the range generated by subtracting and adding the error estimate to the measured value. For example, if a measurement of 50.5 meters has a 95% error of 0.1 meters, then there is a 95% probability that the true value is between 50.4 – 50.6 meters

A

Acquisition
The process a GPS receiver goes through to find and lock onto a GPS satellite. Once a GPS receiver has acquired 4 or more satellites, it can begin to compute positions.

Adjusted position
The final position of a survey point derived from a least squares adjustment of the measurements used to derive the position.

Adjustment
The adjustment of survey observations is the process of correcting observations to produce the best final values for the unknowns. An adjustment cannot be performed unless the set of observations being adjusted contains redundancy. The adjustment process also assists in finding and eliminating blunders in observations, and produces statistical uncertainties that can be used to estimate the final precision of the survey performed.

Almanac
Data transmitted by a GPS satellite which includes orbit information on all the satellites, clock correction, and atmospheric delay parameters. These data are used to facilitate rapid satellite acquisition. The orbit information is a subset of the ephemeris data with reduced accuracy.

AmbigDOP
A calculated quantity used to determine the ability of the post-processing software to compute integer ambiguities.

Ambiguity
The unknown integer number of cycles of the reconstructed carrier phase contained in an unbroken set of data from a single satellite collected by a single receiver. Also known as integer ambiguity and integer bias.

Antenna
The antenna is the component of a GPS system that collects the analog signal from the GPS satellite and sends this signal to the GPS receiver for processing. There are a variety of GPS antennas ranging from simpler microstrip devices to complex choke ring antennas that mitigate the effects of multipath scattering.

ASCII
American Standard Code for Information Interchange. A set of characters (letters, numbers, symbols) used to display and transfer digital data in standard English format.

Autonomous position
Also known as a point, position or raw position.

The position derived from a single receiver without using any differential correction. This is the least accurate method of positioning.

B

Baseline

The three-dimensional vector distance between a pair of stations for which simultaneous GPS data has been collected and processed with differential techniques. The most accurate GPS result.

Base Station

In differential positioning, the end of the baseline that is assumed known and its position fixed. Used as the basis for differential correction of unknown points.

B-file

Raw data binary 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.

Blunder

A mistake or error caused by confusion, carelessness, or ignorance, including, but not limited to: transposing numbers when writing down the HI or reading the HI incorrectly, occupying the wrong point.

Blunder detection

A method, or series of methods, which automatically detect blunders.

C

C/A code

The Coarse/Acquisition (or Clear/Acquisition) code modulated onto the GPS Ll signal. This code is a sequence of 1023 pseudorandom binary biphase modulations on the GPS carrier at a chipping rate of 1.023 MHz, thus having a code repetition period of one millisecond. This code was selected to provide good acquisition properties.

Carrier frequency

The hardware in a receiver that allows the receiver to detect, lock-on, and continuously track the signal from a single satellite. The more receiver channels available, the greater number of satellite signals a receiver can simultaneously lock-on and track.

Carrier phase

The phase of either the L1 or L2 carrier of a GPS signal, measured by a receiver while locked-onto the signal (also known as integrated Doppler).

Cartesian coordinates

Values representing the location of a point in a plane in relation to three mutually perpendicular coordinate axes which intersect at a common point or origin. The point is located by measuring its distance from each axis along a plane parallel to the axis.

Channel

The hardware in a receiver that allows the receiver to detect, lock-on and continuously track the signal from a single satellite. The more receiver channels available, the greater number of satellite signals a receiver can simultaneously lock-on and track.

Code phase

Term used in reference to C/A or P-code data.

Confidence level

The goal of any measurement is to find the true value. Since all measurements contain error, the true value is never observed. In order to qualify measurements, an error estimate is statistically derived for each measurement. An error estimate has a confidence level associated with it which gives the probability that the true value of a measurement falls within the range generated by subtracting and adding the error estimate to the measured value. For example, if a measurement of 50.5 meters has an error estimate of 0.1 meters at the 95% confidence level, then there is a 95% probability that the true value is between 50.4 – 50.6 meters.

Constellation

The collection of orbiting GPS satellites. The GPS constellation consists of 24 satellites in 12-hour circular orbits at an altitude of 20,200 kilometers. In the nominal constellation, four satellites are spaced in each of six orbital planes. The constellation design was selected to provoke a very high probability of satellite coverage even in the event of satellite outages.

Constraints

A limitation placed on a position in an adjustment. An unknown may have a constraint that does not allow its value to be adjusted. If one of the survey points contained in the data is a control point, it’s coordinates should not be adjusted since they are already known. In order to stop the adjustment from computing new coordinates for this control point, the coordinates are constrained or fixed to their known values.

Control tie

When performing a survey where the newly established network of points must be tied to a local, regional, or national network, control points from this network must be incorporated into the survey. The goal is to constrain the known coordinates of these control points in the adjustment in order to determine the position of the new points in reference to the control network. If for some reason the coordinates for one of the control points is incorrect (blunder in entry or disturbed monument), the adjustment will be distorted by constraining this point. To avoid this, the relative accuracy of control points should be checked prior to constraining them in the adjustment. A control tie is the process used to check the relative accuracy of control points.

Cycle slip

A loss of count of carrier cycles as they are being measured by a GPS receiver. Loss of signal, ionospheric interference, obstructions, and other forms of interference cause cycle slips to occur (see carrier phase). To properly compute a vector between data collected from two GPS receivers, all cycle slips must be corrected. This task is normally performed automatically by the software.

D

Datum

See Geodetic datum

Datum bias parameters

The relationship between two datums is defined by a set of 7 transformation parameters. These parameters define how the coordinates of a point in one datum change to the coordinates of the same point in another datum. When performing a least-squares adjustment, these parameters can be estimated as part of the adjustment process. This comes into play if the control points held fixed in the adjustment are on a different datum than the observations being adjusted. Datum bias parameters is the term usually used to refer to transformation parameters estimated through a least-squares process.

D-file

ASCII descriptor file containing feature and attribute data downloaded from the receiver. This file gives time in seconds of the week (measured from midnight Saturday).

Differential GPS (DGPS)

A technique whereby data from a receiver at a known location is used to correct the data from a receiver at an unknown location. Differential corrections can be applied in real-time or by post-processing. Since most of the errors in GPS are common to users in a wide area, the DGPS-corrected solution is significantly more accurate than a normal autonomous solution.

Differential positioning
Determination of relative coordinates of two or more receivers which are simultaneously tracking the same satellites. Dynamic differential positioning is a real-time calibration technique achieved by sending corrections to the roving receiver from one or more reference stations. Static differential GPS involves determining baseline vectors between pairs of receivers.

Differential processing
GPS measurements can be differenced between receivers, satellites, and epochs. Although many combinations are possible, the present convention for differential processing of GPS phase measurements is to subtract differences between receivers (single difference), then between satellites (double difference), then between measurement epochs (triple difference).

A single-difference measurement between receivers is the instantaneous difference in phase of the signal from the same satellite, measured by two receivers simultaneously.

A double-difference measurement is obtained by differencing the single difference for one satellite with respect to the corresponding single difference for a chosen reference satellite.

A triple-difference measurement is the difference between a double difference at one epoch of time and the same double difference at the previous epoch of time.

Dilution of Precision (DOP)
The geometry of the visible satellites is an important factor in achieving high quality results. The geometry changes with time due to the relative motion of the satellites. A measure for the geometry is the Dilution of Precision (DOP) factor.

DOP is a description of the effect of satellite geometry on position and time computations. Values considered 'good' are less than three. Values greater than seven are considered poor. Thus, small DOP is associated with widely separated satellites

Standard DOP terms for GPS include:

Table Gloss.1: DOP Terms

GDOP Geometric Dilution of Precision	GDOP is a composite measure reflecting the effects of satellite geometry on position and time computations.
PDOP Position Dilution of Precision	PDOP reflects the effects of satellite geometry on 3-D position computation.
HDOP Horizontal Dilution of Precision	HDOP reflects the effects of satellite geometry on the horizontal component of the position computation.
VDOP Vertical Dilution of Precision	VDOP reflects the effects of satellite geometry on the vertical component of the position computation.
TDOP Time Dilution of Precision	TDOP reflects the effects of satellite geometry on the time computation.

E

Earth-centered earth-fixed (ECEF)
(ECEF) Right-handed cartesian coordinate system where the X-axis passes through the intersection of the prime meridian (Greenwich) with the equator, the Z-axis is coincident with the mean position of the earth's rotational axis, and the Y-axis is orthogonal to both the X and Z-axes.

Easting
The distance eastward from the north-south grid line that passes through the origin of a grid system.

Eccentricity
The ratio of the distance from the center of an ellipse to its focus to the semimajor axis.

E-file
Binary ephemeris file downloaded from a receiver. Unlike an almanac file, which gives information on all satellites, an ephemeris file applies only to the satellite which sent ephemeris data. The file is a record of the broadcast message comprising accurate orbit parameters and time corrections for all tracked satellites during the data recording period. This information is used for computing the satellite position. The ephemeris data are deciphered and configured into a readable structure.

EGM96
The EGM96 geoid model is a global model on a 0.25 x 0.25 degree grid. It was created from the EGM96 spherical harmonic model completed to degree and order 360.

Elevation
Height above a reference datum. The reference datum may be an ellipsoid (ellipsoidal elevation), a geoid (orthometric elevation), above mean-sea-level, or above a locally defined reference plane.

Elevation factor (sea-level 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 grid factor to produce a grid distance.

Elevation mask angle
An adjustable feature of GPS receivers that specifies that a satellite must be at least a specified number of degrees above the horizon before the signals from the satellite are to be used. Satellites at low elevation angles (five degrees or less) have lower signal strengths and are more prone to loss of lock thus causing noisy solutions.

Ellipsoid
In geodesy, unless otherwise specified, a mathematical figure formed by revolving an ellipse about its minor axis. It is often used interchangeably with spheroid. Two quantities define an ellipsoid; these are usually given as the length of the semi-major axis, a, and the flattening, $f = (a - b)/a$, where b is the length of the semi-minor axis. Prolate and triaxial ellipsoids are invariably described as such.

Ellipsoid height (elevation)
The vertical distance above a reference ellipsoid for a specific point. GPS receivers compute ellipsoid heights above the WGS-84 reference ellipsoid.

Ephemeris
A list of (accurate) positions or locations of a celestial object as a function of time. Available as "broadcast ephemeris" or as post-processed "precise ephemeris"

Epoch
Time stamp for a measurement interval or data frequency, e.g., 15 seconds, 30 seconds.

Equatorial Mercator
Map projection in which meridians appear as equally spaced vertical lines, and parallels as horizontal lines drawn farther apart as latitude increases, such that the correct relationship between latitude and longitude scales at any point is maintained. The Mercator map is widely used in navigation since directions can be easily measured.

Error ellipse (absolute and relative)

All measurements contain error. The computed position of a point is never the true position because the measurements used to determine the position contain error. An error ellipse is a statistical estimate of the precision of a point position. More specifically, it is an elliptical shaped region around a point representing the area within which there is a certain probability that the true position of the point is located.

Error of closure (misclosure)

Whenever closing a traverse or level loop onto the starting point, error in the observations will always produce two different positions for that point: the original position and the position computed using the measurements from the survey. For example, if the elevation of the starting point for a level run is 100.000 meters, the end elevation of the loop should be 100.000 meters if the loop ends on the starting point. But due to measurement error, the final elevation may be 100.060 meters. The difference between the two elevations is the error of closure. This error is also often referred to a misclosure

F

Firmware

The electronic heart of a receiver, where coded instructions relating to receiver function, and (sometimes) data processing algorithms, are embedded as integral portions of the internal circuitry.

Fixed solution

Processing of GPS vectors produces many solutions for the vector at different stages of the processing. One of the parameters being solved for during the processing is the integer ambiguity. A fixed solution is a vector solution where the integer ambiguities have been correctly determined and held fix. The fixed solution for a vector is most often the best solution. If for some reason the ambiguities could not be solved, the final solution for the vector will be a float solution.

Flattening

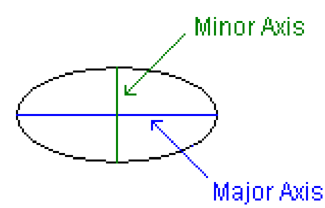
The ratio of the difference in lengths of the major and minor axes, respectively, of an ellipse, to the length of the major axis of the ellipse.

f = (a- b)/a = 1 -(1 - e2)

a = Semimajor axis

b = Semiminor axis

e = Eccentricity



Float solution

Processing of GPS vectors produces many solutions for the vector at different stages of the processing. One of the parameters being solved for during the processing is the integer ambiguities. A float solution is a vector solution where the integer values for the ambiguities could not be determined, therefore they are not fixed to a specific integer value (left to float as a real number.

Fully constrained adjustment

An adjustment is fully constrained when sufficient control has been constrained to allow the solving of all unknown parameters. If all seven datum bias parameters are being solved, 2 horizontal control points and 3 vertical control points are sufficient to produce a fully constrained adjustment.

G

Geocentric cartesian coordinates
x, y , and z coordinates that define the position of a point with respect to the center of the earth.

Geodetic coordinates
A coordinate system where the position of a point is defined using the components of latitude, longitude and geodetic height.

Geodetic datum
Any numerical or geometrical quantity or set of quantities that serves as a reference or base for other quantities. In surveying, two types of datums are considered: a horizontal datum, which forms the basis for the computations of horizontal positions that consider the curvature of the earth, and a vertical datum, to which elevations refer. Historically, horizontal datums were defined by an ellipsoid and the relationship between the ellipsoid and a point on the topographic surface established as the origin of datum. This relationship can be defined by six quantities, generally (but not necessarily): the geodetic latitude, longitude, and the height of the origin, the two components of the deflection of the vertical at the origin, and the geodetic azimuth of a line from the origin to some other point. GPS uses WGS-84 which, as in the newer datums, is earth-centered-earth-fixed (ECEF).

Geodetic height (ellipsoidal height)
The height of a point above an ellipsoidal surface. The difference between a point's geodetic height and its orthometric height (height above ellipsoid) equals the geoidal separation.

Geoid
A gravity based surface used to best represent the physical surface of the earth. The center of the geoid coincides with the true center of the earth. Its surface is an equipotential surface, meaning that at any point the geoid is perpendicular to the direction of gravity. The geoid can be visualized by imagining that the earth were completely covered by water. This water surface is an equipotential surface since the water flows to compensate for any height difference that occurs.

Geoid height

See Geoidal separation

Geoidal separation
The height difference between the ellipsoidal height and orthometric height at any given point on the earth's surface. Worded differently, it is the separation between the geoid surface and ellipsoid surface at a given point on the earth's surface.

Geoid96
The current geoid model covering the United States, Puerto Rico, and the Virgin Islands. The GEOID96 model was computed in October, 1996 using over 1.8 million terrestrial and marine gravity values. The result is a gravimetric geoid height grid with 2‘ x 2‘ spacing in latitude and longitude. The GEOID96 model was developed to support direct conversion between NAD83 GPS ellipsoidal heights and NAVD88 orthometric heights.

Geometric Dilution of Precision (GDOP)
See Dilution of Precision

Global Positioning System (GPS)
Passive, satellite-based navigation system operated by the Department of Defense. It's primary mission is to provide passive global positioning/navigation for land-, sea-, and air-based operations.
GPS consists of-

- a space segment (up to 24 NAVSTAR satellites in 6 different orbits)
- the control segment (5 monitor stations, 1

master control station and 3 upload stations) the user segment (GPS receivers) NAVSTAR satellites carry extremely accurate atomic clocks and broadcast coherent simultaneous signals.

GPS time
The time system upon which GPS is based. GPS time is an atomic time system and is related to International Atomic Time in the following manner:
International Atomic Time (IAT) = GPS + 19.000 sec

GPS week
GPS time started at Saturday/Sunday midnight, January 6, 1980. The GPS week is the number of whole weeks since GPS time zero.

Greenwich mean time (GMT)
Time based on the Greenwich Meridian as a reference. In distinction from time based on a local meridian or the meridian of a time zone.

Grid coordinates
Coordinates of a point on the physical earth based on a defined two dimensional grid system. These coordinates are normally referred to as Easting and Northing.

Grid system
A grid system is a defined set of parameters that, along with a map projection, are used to convert geodetic coordinates (curved surface) to grid coordinates (flat surface).

GSD-95
GSD95 is the newest Canadian geoid model. It is a refinement to the previous model, GSD91, but continues to use the same format, grid spacing, and GRS80 reference ellipsoid (as used to define the NAD83 datum. The GSD95 model was develop to support the direct conversion between NAD83 GPS ellipsoidal heights and CVD28 orthometric heights.

H

HARN
High Accuracy Reference Network

HI
Height of Instrument

Horizontal Dilution of Precision (HDOP)
See Dilution of Precision

Horizontal relative accuracy
The horizontal component of the relative accuracy between two points. See Relative Accuracy.

I

Integer Ambiguities (Integer bias)
See Ambiguity

Integer Bias
See Ambiguity

Ionosphere
The layers of ionized air in the atmosphere extending from 70 kilometers to 700 kilometers and higher. Depending on frequency, the ionosphere can either block radio signals completely or change the propagation speed. GPS signals penetrate the ionosphere but are delayed. This delay induces error in the GPS measurements that can result in poor survey results. Most GPS receivers/processing software model the ionosphere to minimize its affects. Also, the effects of ionosphere can be nearly eliminated by using dual frequency receivers which can calculate the delay due to ionosphere.

Ionospheric delay
A wave propagating through the ionosphere [which is a non-homogeneous (in space and time) and dispersive medium] experiences delay. Phase delay depends on electron content and affects carrier signals. Group delay depends on dispersion in the ionosphere as well, and affects

signal modulation (codes). The phase and group delay are of the same magnitude but opposite sign.

J

Julian date
The number of days that have elapsed since 1 January 4713 B.C. in the Julian calendar. GPS time zero is defined to be midnight UTC, Saturday/Sunday, 6 January 1980 at Greenwich. The Julian date for GPS time zero is 2,444,244.5.

K

Kinematic initialization bar
A metal attachment of fixed length (0.2 meters) used to expedite the initialization process of a kinematic survey. Two Locus receivers are attached to the kinematic initialization bar, one over a known location. They act as a fixed baseline and allow the receivers to initialize (accurate position/ambiguity resolution) more rapidly than if the receivers were to initialize across a baseline of unknown length.

Kinematic surveying
A form of continuous differential carrier-phase surveying requiring only short periods of data observations. Operational constraints include starting from or determining a known baseline, and tracking a minimum of four satellites. One receiver is statically located at a control point, while others are moved between points to be measured.

L

L1
The primary L-band signal radiated by each NAVSTAR satellite at 1575.42 MHz. The Ll beacon is modulated with the C/A and P codes, and with the NAV message.

L2
The secondary L-band signal radiated by each NAVSTAR satellite at 1227.60 MHz and is modulated with the P code and the NAV message.

Lambert Conformal Conic
A conformal conic map projection on which all meridians are represented by equally spaced straight lines that radiate from a common point outside the map limits, and the parallels are represented by circular arcs with this common point for a center and intersect the meridians at right angles. Smallest distortion for middle latitudes. In the United States, the Lambert Conformal Conic projection is the basis of State Plane Coordinate System (SPCS) for states with predominant east-west orientation.

Latitude
Angle generated by the intersection of the semi-major axis of the datum reference ellipsoid and the ellipsoid normal (line running perpendicular to the ellipsoid surface) at the point of interest. Latitude is one of the positional elements when defining the geodetic coordinates of a point.

Local grid coordinates
Coordinates of a point on the physical earth, based on an arbitrarily defined two dimensional grid system. These coordinates are normally referred to as Easting and Northing.

Local grid system
A local plane coordinate system usually defined for use on a small survey project. The defining parameters for the system are usually an origin with arbitrarily determined horizontal coordinates (such as 0,0 or 1000,1000) and an arbitrary direction (boundary line or backsight to another point). The local system usually stands on it's own, with no known relationship with any other defined coordinate system. This relation may be

determined though if the coordinates of a sufficient number of points can be determined in both coordinates systems between which a relationship is sought.

Longitude
The length of the arc or portion of the Earth's equator between the meridian of a given place and the prime meridian expressed in degrees west or east of the prime meridian to a maximum of 180 degrees.

M

Map projection
Any systematic method of representing the whole or a part of the curved surface of the Earth upon another surface.

Minimally constrained adjustment
When performing a least-squares adjustment on GPS data, the mathematics require that the horizontal coordinates of at least one point and the vertical coordinates of at least one point (may or may not be the same point) be held fixed (constrained) to known or arbitrarily selected values. One horizontal position and one vertical position is the minimum set of constraints. An adjustment performed holding fixed the minimum set of constraints is referred to as a minimally constrained adjustment.

Misclosure
See Error of Closure

Multipath
The reception of a satellite signal both along a direct path and along one or more reflected paths. The reflected signals are caused by reflecting surfaces near the GPS antenna. The resulting signal results in an incorrect pseudorange measurement. The classical example of multipath is the ghosting that appears on television when an airplane passes overhead.

Multipath error
A GPS positioning error resulting from the use of reflected satellite signals (multipath) in the position computation.

N

NAD27
North American Datum, 1927.

NAD83
North American Datum, 1983.

Navstar
The name of GPS satellites, built by Rockwell International, which is an acronym formed from Navigation System with Time And Ranging.

Normalized residual (Standardized Residual)
The residual of an adjusted GPS vector divided by it's estimated error. By normalizing a residual, it's position within a normal distribution can be determined. A normalized residual of 1 indicates the residual falls in the middle of the normal distribution. A normalized residual of 3 or greater indicates that the residual falls out at the tail of the distribution. Since only a very small percentage of residuals normally fall out at the tails, it is often likely that a normalized residual of this magnitude could belong to a measurement containing a blunder.

Northing
The distance northward from an east-west line that passes through the origin of a grid.

O

Oblique Mercator - verify

Oblique Stereographic - verify

Observable
In GPS surveying, the observable is another name

for the raw data being collected (observed) by the GPS receiver.

Observation
The act of recording (GPS) data at a site. An example usage of the term would be, 'The observation at point 0001 lasted 1 hour'. Observation is usually interchangeable with the term occupation.

Obstruction
Physical feature that blocks the satellite direct line of site from the point of observation. GPS signals are very weak. They can be blocked from reaching the GPS antenna by objects between the antenna and the satellites. Classic examples of obstructions are trees and buildings.

Occupation
The period of recorded data for a site. For example, a 1-hour period of data collection on a survey point is considered an occupation. Occupation is usually interchangeable with the term observation.

Orthometric elevation (orthometric height)
The height of a point above the geoid. Orthometric elevation is often equated with mean-sea-level elevation.

OSU91A
OSU91A is a global geoid model. Technically, it is a high resolution spherical harmonic model (degree 360). The errors in the geoid defined by this model are estimated at 28 cm RMS over the oceans and 46 cm RMS over the continents. This model was developed by Richard Rapp and his colleagues at Ohio State University.

P

Partially constrained adjustment
In a partially constrained adjustment, the number of constraints applied are greater than what is required for a minimally constrained adjustment, and less than what is needed for a fully constrained adjustment. An example would be a network containing two known horizontal control points and only one vertical control point. Constraining these points would result in a partially constrained adjustment where the datum bias parameters could not fully be determined.

P-Code
The protected or precise code used on both LIE and L2 GPIs beacons. This code will be made available by the DOD only to authorized users. The P code is a very long (about 1014 bits) sequence of pseudorandom binary biphase modulations on the GPS carrier at a chipping rate of 10.23 MHz which does not repeat itself for about 38 weeks. Each satellite uses a one-week segment of this code which is unique to each GPS satellite, and is reset each week.

Phase center
The phase center of a GPS antenna is the physical location on the antenna where the raw GPS signals are observed. This is the physical location where the computed position will be determined. GPS antennas are manufactured to place the phase center as closely as possible to the physical center of the antenna housing. To determine the position of a survey marker on the ground, the GPS antenna (and thus the phase center) is centered over the marker and the HI is measured to the survey marker for use during processing.

Point positioning
See Autonomous position.

Polar Stereographic - verify
Projection of points on the surface of a sphere to a plane tangent at its pole. Most common map projection used for polar areas of the earth.

Position Dilution of Precision (PDOP)
See Dilution of Precision.

Post-processed position
The position of a survey point obtained from the processing of GPS raw data observed simultaneously between this point an another point of known position.

Post-processing
The reduction and processing of GPS data after the data were collected in the field. Postprocessing is usually accomplished on a computer in an office environment where appropriate software is employed to achieve optimum position solutions.

PPM
Part per million

PRN number
Satellite identification number

Pseudorange
A measure of the apparent propagation time from the satellite to the receiver antenna, expressed as a distance. Pseudorange is obtained by multiplying the apparent signal-propagation time by the speed of light. Pseudorange differs from the actual range by the amount that the satellite and user clocks are offset, by propagation delays, and other errors. The apparent propagation time is determined from the time shift required to align (correlate) a replica of the GPS code generated in the receiver with the received GPS code. The time shift is the difference between the time of signal reception (measured in the receiver time frame) and the time of emission (measured in the satellite time frame).

Q

QA
Quality Assurance. GPS post-processing software often has a number of different QA tests to ensure quality data is being used.

R

Random errors
Small, unpredictable errors caused by imperfections in the surveying equipment or operator procedures.

Raw data
GPS data which has not been processed or differentially corrected.

Recording interval
The time interval between the recording of GPS raw data to the GPS receiver memory. For example, a recording interval of 10 seconds indicates that GPS raw data will be stored to the GPS receiver memory once every 10 seconds.

Reference Station
A point (site) where crustal stability, or tidal current constraints, have been determined through accurate observations, and which is then used as a standard for the comparison of simultaneous observations at one or more subordinate stations. Certain of these are known as Continuous Operating Reference Stations (CORS), and transmit reference data on a 24-hour basis. Data from these sites are available for public use and can be retrieved in one hour increments from the internet at: http://www.ngs.noaa.gov/cors/cors-data.html .

Relative accuracy
Estimated accuracy of a point's position in relation to another point. The accuracy of survey measurements is often determined by examining the relative accuracy of points established by the measurements. For instance, an accuracy specification of 1 part in 100,000 is a relative accuracy specification. This accuracy specification defines the allowable error between two points based on the distance between them.

Relative positioning
The process of determining the relative difference

in position between two marks with greater precision than that to which the position of a single point can be determined. Here, a receiver (antenna) is placed over each spot and measurements are made by observing the same satellite at the same time. This technique allows cancellation (during computations) of all errors which are common to both observers, such as satellite clock errors, propagation delays, etc.

Residual

The difference between the observed value and the computed value. In a least-squares adjustment of GPS data, GPS vectors are adjusted in order to find the best fit for all vectors. The adjustment of each vector produces a residual(s) for the vector. The residual is the amount the vector was adjusted to make it fit in with all other vectors. The residual values are analyzed to determine if there is a potential problem with a vector(s) in the adjustment.

RINEX

Receiver INdependent EXchange format. A set of standard definitions and formats to promote the free exchange of GPS data and facilitate the use of data from any GPS receiver with any software package. The format includes definitions for three fundamental GPS observables: time, phase, and range. A complete description of the RINEX format is found in the Commission VIII International Coordination of Space Techniques for Geodesy and Geodynamics "GPSBULLETIN" May-June,1989.

Root-Mean-Square (RMS)

A statistical measure of the scatter of computed positions about a "best fit" position solution. RMS can be applied to any random variable.

Rover

The GPS receiver that moves from site to site during a kinematics GPS survey.

S

Scale factor

Scale factor is a scale adjustment applied to ellipsoidal distances in order to reduce the distances to grid distances. This is the second and last step to converting measured distances to grid distances. The first step is to reduce measured distances to ellipsoidal distances by applying the elevation factor.

Seed coordinate

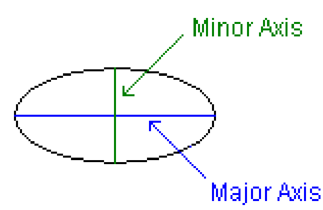
When processing GPS raw data collected simultaneously between two points, the processing requires that the coordinates of one of the two points be held fixed. Normally, these are the known coordinates for one of the points. These coordinates are referred to as seed coordinates.

Selective Availability (SA)

A Department of Defense program to control the accuracy of pseudorange measurements, whereby the user receives a false pseudorange which is in error by a controlled amount. Differential GPS techniques can reduce these effects for local applications.

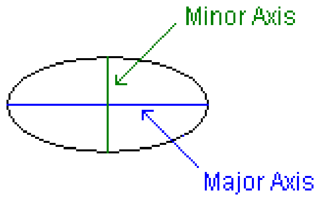
Semi-major axis

One half of the major axis of an ellipse.



Semi-minor axis

One half the minor axis of an ellipse.



Session

A session is a group of simultaneously collected GPS raw data. For example, if 4 GPS receivers collected data simultaneously on 4 points, the entire data set is considered a session. Within a session, GPS vectors can be computed between all points.

Singularity

Singularity is a condition that causes the inverse operation of a matrix to fail. Matrix inversion is an important operation in a least-squares adjustment. If a matrix inversion cannot be performed due to a singularity, there will be no adjustment. One situation that will cause a singularity is attempting to adjust GPS vectors in a network in which parts of the network are not connected to other parts, i.e. two or more sets of points that do not have connectivity to each other.

Site

A location or survey point where GPS data is collected.

Site ID

A four character alpha-numeric identifier for s 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 pair

Two survey points between which exists a GPS vector. The term site pairs is used when analyzing the quality and accuracy of measurements between survey points.

Slant height

The distance from the survey marker to the edge of the antenna ground plane. Using the slant height and radius of the GPS antenna, the true vertical height or HI of the antenna can be determined. The HI is used in the processing to determine the location of the survey marker on the ground.

Add picture?

Spheroid

See ellipsoid.

Standard Error (standard deviation)

The goal of any measurement is to find the true value. Since all measurements contain error, the true value is never observed. In order to qualify measurements, an error estimate is statistically derived for each measurement. A standard error estimate indicates there is a 66% probability that the true value of a measurement falls within the range generated by subtracting and adding the error estimate to the measured value. For example, if a measurement of 50.5 meters has a 95% error of 0.1 meters, then there is a 95% probability that the true value is between 50.4 – 50.6 meters. The 66% value is derived from a normal distribution. For a normally distributed variable, the standard error is the bound within which 66% of the samples of the variable fall.

Static surveying

A method of GPS surveying that involves simultaneous observations between stationary receivers. Post-processing computes the vector between points.

SV

Satellite vehicle or space vehicle.

T

Tau test

The Tau test is a blunder detection QA test performed on adjusted survey measurements (GPS vectors). The test examines the size of the measurement residuals and compares it statistically to an expected distribution. If the residual is larger than expected, the observation is flagged as a potential blunder.

Time Dilution of Precision (TDOP)

See Dilution of Precision.

Transverse Mercator

Mercator projection turned 90^0 in azimuth. The central meridian is represented by a straight line, corresponding to the line which represents the equator on the regular Mercator map projection. In the United States, the Transverse Mercator is the base used in the State Plane Coordinate System (SPCS) for states with predominant north-south extent.

U

UTC

Time as maintained by the U.S. Naval Observatory. Because of variations in the Earth's rotation, UTC is sometimes adjusted by an integer second. The accumulation of these adjustments compared to GPS time, which runs continuously, has resulted in an 11 second offset between GPS time and UTC at the start of 1996. After accounting for leap seconds and using adjustments contained in the navigation message, GPS time can be related to UTC within 20 nanoseconds or better.

UTM

Universal Transverse Mercator Map Projection. A special case of the Transverse Mercator projection. Abbreviated as the UTM Grid, it consists of 60 north-south zones, each 6 degrees wide in longitude.

V

Variance of unit weight

A statistical quality indicator of a least-squares adjusted network. The expected value of the variance of unit weight is 1. A value below 1 is an indication that the uncertainties assigned to the measurements are too optimistic. A value greater than 1 is an indication that the either the uncertainties assigned to the measurements are too pessimistic or that there is one or more blunders in the data set adjusted.

Vector

The spatial line, described by 3D components, between two points. In GPS surveying, a vector is the product of processing raw data collected on two points simultaneously.

Vertical Dilution of Precision (VDOP)

See Dilution of Precision.

Vertical relative accuracy

The vertical component of the relative accuracy between two points. See Relative Accuracy.

W

WGS84

WGS84 is the datum that GPS positions and vectors are referenced to. This datum is basically equivalent to the NAD83 datum used in the United States. The difference is too small to have any impact on GPS positions and vectors.

Index

O

P

Q

R

S

T

U

V

W

Z