SurvNET Introduction

Key Features of SurvNET

- SurvNET reduces survey field measurements to coordinates in assumed, UTM, SPC83 SPC27, and a variety of other coordinate systems. SurvNET calculates the minimum necessary corrections to measured horizontal angles, slope distances and vertical angles in order to fit the desired control. **NOTE:** SurvNET can only process raw field measurements, it is not designed to process bearing or azimuth traverses. If you wish to use SurvNET to process your traverses, you must collect the angles and distances.
- In the 2D/1D model in a state plane coordinate system, a grid factor is computed for each individual line during the reduction. The elevation factor is computed for each individual line if there is sufficient elevation data. If the raw data has only 2D data, the user has the option of defining a project elevation to be used to compute the elevation factor.
- SurvNET supports a variety of map projections and coordinate systems including the New Brunswick Survey Control coordinate system, UTM, and user-defined systems consisting of either a pre-defined ellipsoid or a user defined ellipsoid and one of the following projections, Transverse Mercator, 1-Standard Parallel Lambert Conformal, 2-Standard Parallel Lambert Conformal, Oblique Mercator, and the Double Stereographic projection.
- A full statistical report containing the results of the least squares adjustment is produced and written to the report (.RPT) file. An error report (.ERR) file is created and contains any error messages that are generated during the adjustment.
- Coordinates can be stored into a variety of file types including the Carlson (.CRD) file, C&G (.CRD) file, Simplicity file (.ZAK), Carlson SQLITE (.CRDB), or an Autodesk Land Desktop (.MDB) file types. An ASCII coordinate (.NEZ) file is always created that can be imported into most any mapping/surveying/GIS program. The user has the option to compute unadjusted preliminary coordinates.
- There is an option to compute Traverse Closures during the preprocessing of the raw data. Closures can be computed for both GPS and total station traverses. Closure for multiple traverse loops in the same raw file can be computed.
- When processing Angle-Only records for triangulation, if there is a zenith angle and rod height (zero is a valid rod height), a 3D triangulation will be performed, calculating an elevation of the triangulation point. This is true in both the 3D and 2D/1D models.
- SurvNET can combine GPS vectors and total station data in a single adjustment. GPS Vector files from Leica, Thales, Topcon and Trimble can be input, as well as GPS files in the StarNet format. Additionally GPS vectors can be read from NGS G-files. There is also an option to read the G-file section of an OPUS report.
- SurvNET includes a variety of blunder detection routines. One blunder detection method is effective in detecting if the same point number has been used for two different points. Additionally this blunder detection method is effective in detecting if two different point numbers have been used for the same physical position. This method also flags other raw data problems. Another blunder detection method included in SurvNET is effective in isolating a single blunder, distance or angle in a network. This method does not require that there be a lot of redundancy, but is effective if there is only one blunder in the data set. Additionally, SurvNET includes a blunder detection method that can isolate multiple blunders, distances or angles in a network. This method does require that there be a lot of redundancy in the network to effectively isolate the multiple blunders.
- Other key features include: Differential and Trig level networks and loops can be adjusted using the network least squares program. Geoid modeling is used in SurvNET, allowing the users to choose between a variety of geoid models. The user can alternately enter the project geoid separation. There are description codes to identify duplicate points with different point numbers. The user can specify the confidence interval from 50 to 99 percent.

General Rules for Collecting Data for Use in Least Squares Adjustments

Least squares is very flexible in terms of how the survey data needs to be collected. Generally speaking, any combination of angles, and distances combined with a minimal amount of control points and/or azimuths are needed. This data can be collected in any order. There needs to be at least some redundancy in the measurements. Redundant measurements are measurements that are in excess of the minimum number of measurements required to determine the unknown coordinates. Redundancy can be created by including multiple GPS and other control points within a network or traverse. Measuring angles and distances to points in the network that have been located from another setup in the survey creates redundancy. Running additional cut-off traverses or additional traverses to existing control points creates redundancy. Following are some general rules and tips in collecting data for least squares reduction:

- Backsights should be to point numbers. Some data collectors allow the user to backsight an azimuth not associated with a point number. SurvNET requires that all backsights be associated with a point number.
- There has to be at least a minimum amount of control. Control is defined as known points or azimuths. They can be held FIXED or allowed to move a designated amount. The minimum amount of control is either two points or one point and a reference azimuth. You can however have as many control points as you wish. Control points can be entered in either the raw data file or there can be a supplemental control point file containing the control point. Reference azimuths are entered in the raw data file. The control points and reference azimuths do not need to be for the first points in the raw data file. The control points and azimuths can be associated with any point in the network or traverse. The control points do not need to be adjacent to each other. It is permissible, though unusual, to have one control point on one side of the project and a reference azimuth on the other side of the project.
- Some data collectors do not allow the surveyor to shoot the same point twice using the same point number. SurvNET requires that all measurements to the same point use a single point number. The raw data may need to be edited after it has been downloaded to the office computer to insure that points are numbered correctly. An alternative to renumbering the points in the raw data file is to use the 'Pt Number substitution string' feature in the project 'Settings' screen. See the 'Redundant Measurement' section for more details on this feature.
- The majority of all problems in processing raw data are related to point numbering issues. Using the same point number twice for different points, not using the same point number when measuring the same point, misnumbering backsights or foresights, and misnumbering control points are all common problems.
- It is always best to explicitly define the control for the project. A good method is to put all the control for a project into a separate raw (RW5) file. A big source of problems with new users is a misunderstanding in defining their control for a project.
- Some data collectors may have preliminary unadjusted coordinates included with the raw data. These coordinate records should be removed from the raw file. The only coordinate values that should be in the raw file are the control points. Since there is no concept of 'starting coordinates' in least squares there is no way for SurvNET to determine which points are considered control and which points are preliminary unadjusted points. So all coordinates found in a raw data file will be considered control points.
- When a large project is not processing correctly, it is often useful to divide the project into several raw data files and debug and process each file

separately as it is easier to debug small projects. Once the smaller projects are processing separately they can be combined for a final combined adjustment.

Two Mathematical Models, 2D/1D and 3D

SurvNET gives the user the option to choose one of two mathematical model options when adjusting raw data, the **3D model** and the **2D/1D model**.

In the process of developing SurvNET, numerous projects have been adjusted using both the 2D/1D model and the 3D model. There are slight differences in final adjusted coordinates when comparing the results from the same network using the two models. But in all cases, the differences in the results are typically less than the accuracy of measurements used in the project. The main difference in terms of collecting raw data for the two different models is that the 3D model requires that rod heights and instrument heights need to be measured, and there needs to be sufficient elevation control to compute elevations for all points in the survey. When collecting data for the 2D/1D model, the field crews do not need to collect rod heights and instrument heights.

2D/1D Model

In the 2D/1D model, raw distance measurements are first reduced to horizontal distances and then optionally to grid distances. Then, a two dimensional horizontal least squares adjustment is performed on these reduced horizontal distance measurements and horizontal angles. After the horizontal adjustment is performed, an optional one-dimensional vertical least squares adjustment is performed in order to adjust the elevations if there is sufficient data to compute elevations. The 2D/1D model is the model that has been traditionally been used in the past by non-geodetic surveyors in the reduction of field data. There are several advantages to SurvNET 's implementation of the 2D/lD model. One advantage is that an assumed coordinate system can be used. It is not necessary to know geodetic positions for control points. Another advantage is that 3D raw data is not required. It is not necessary to record rod heights and heights of instruments. Elevations are not required for the control points. The primary disadvantage of SurvNET 's implementation of the 2D/1D model is that GPS vector data cannot be used in 2D/1D projects.

In the 2D/1D model, it is allowed to mix 2D and 3D measurements. Elevations will be calculated only if there is enough information in the raw data file to do so. Least squares adjustment is used for elevation adjustment as well as the horizontal adjustment. To compute an elevation for the point, the instrument record must have an HI, and the foresight record must have a rod height, slope distance and vertical angle. If working with .CGR raw data, a 0.0 (zero) HI or rod height is valid. It is only when the field is blank that the record will be considered a 2D measurement. Carlson SurvCE/SurvPC 2.0 or higher allows you to mix 2D and 3D data by inserting a 2D or 3D comment record into the .RW5 file. A 3D traverse must also have adequate elevation control in order to process the elevations. Elevation control can be obtained from the supplemental control file, coordinate records in the raw data file, or elevation records in the raw data file. The "Adjust Elevations" box in the project settings must be checked to adjust the calculated elevations. If it is unchecked, elevations will still be calculated if the 3D data is available, but they will not be adjusted.

3D Model

In the 3D model, raw data is not reduced to a horizontal plane prior to the least squares adjustment. The 3-dimensional data is adjusted in a single least squares process. In SurvNET 's implementation of the 3D model, XYZ geodetic positions are required for control. The raw data must contain full 3D data including rod heights and measured heights of the instrument(s). The user must designate a supported geodetic coordinate system. The main advantage of using the 3D model is that GPS vectors can be incorporated into the adjustment.

SurvNET can also automatically reduce field measurements to State Plane coordinates in either the NAD 83 or NAD 27 coordinate systems. If a grid coordinate system is selected, the grid scale factor is computed for each individual line during the reduction. The elevation factor is also computed for each individual line if there is sufficient elevation data. If the raw data has only 2D data, the user has the option of defining a project elevation to be used to compute the elevation factor.

A full statistical report containing the results of the least squares adjustment is produced and written to the report (.RPT) file. An error report (.ERR) file is created and contains any error messages that are generated during the adjustment.

Output Coordinate File Types

Coordinates can be written to the following formats, including:

- C&G numeric (*.crd)
- C&G alphanumeric (*.cgc)
- Carlson numeric (*.crd)
- Carlson alphanumeric (*.crd)
- Carlson SQLite (*.crdb)
- MS Access Database (Autodesk Land Desktop) (*.mdb)
- Simplicity (*.zak)
- ASCII P,N,E,Z,D,C (*.nez)

A file with the extension .OUT is always created and contains an ASCII formatted coordinate list of the final adjusted coordinates formatted suitable for printing. Additionally, an ASCII file with an extension of .NEZ containing the final adjusted coordinates in a format suitable for input into 3rd party software that is capable of inputting an ASCII coordinate file.

Opening SurvNET

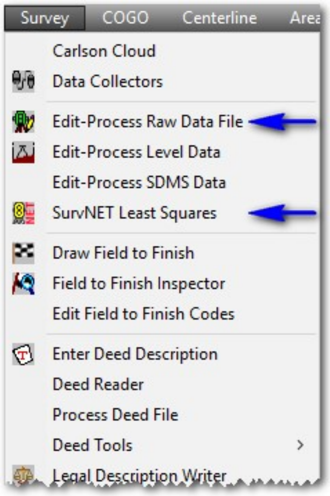
Using SurvNET Dialog Box

The dialog box version of SurvNET offers an interactive graphics user interface which utilizes the CAD drawing editor for graphics while mainlining data entry in a docked dialog box.

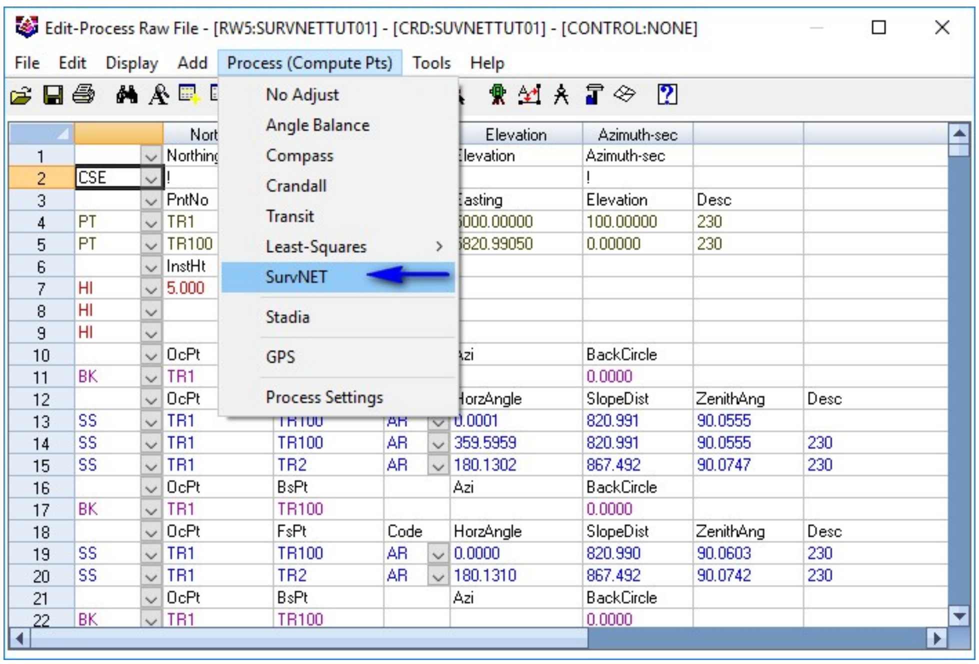
Double-click on the SurvNET icon on the desktop or use the Start menu -- Programs (or All Programs) -- SurvNET

Running From Carlson

Entry into the SurvNET program is easy. It can be accessed in two different ways. The easiest way to start the program is to select **SurvNET** from the **Survey** menu. The other method is to start SurvNET from within the **Raw Data File** editor. To bring up the Raw Data File editor, select **Edit - Process Raw Data File** from the **Survey** menu (see below).



To access SurvNET from within the Carlson Raw Data Editor, choose the **Process (Compute Pts)** menu then the **SurvNET** menu item (see below).

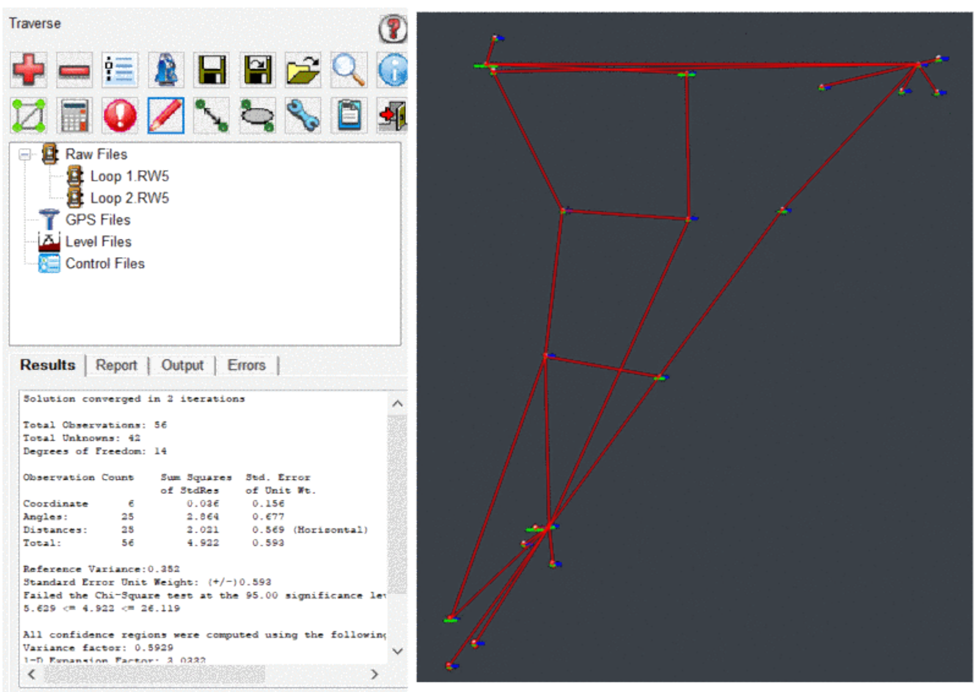


SurvNET Start-up Dialog

The **SurvNET Start-up** dialog is displayed when SurvNET is first started (see below). SurvNET is a project based program. Before performing a least squares adjustment an existing project must be opened or a new project created. This opening dialog box allows the user to open or create a project on start-up.

SurvNET Opening Dialog Box

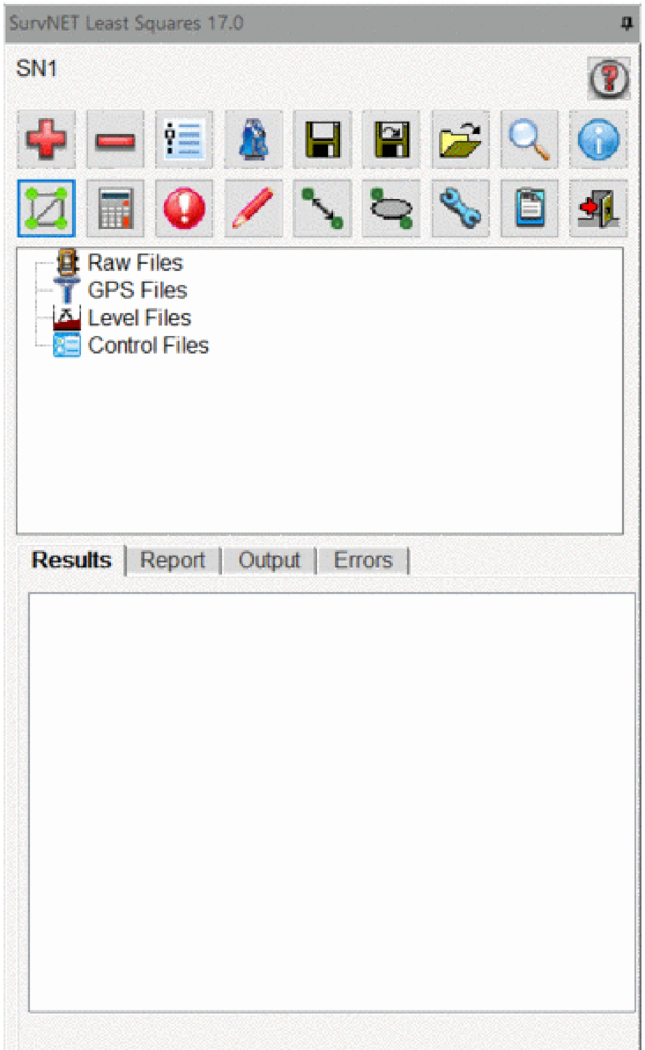
The following is a view of the SurvNET main window after an existing project has been opened and processed:



Note: The various report sub-windows within SurvNET and the SurvNET application itself can all be resized to suit specific screen "real-estate" preferences.

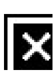
SurvNET Menu System

The following graphic shows the main SurvNET least squares interface.



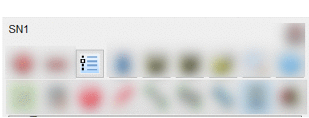
Least squares operations are initiated using the menus summarized below:

[Entering and Editing Raw Files]



- Add and Remove Raw Files
- Review and Edit Control Points and Measurements
- Editing Raw data
- Assigning Standard Errors

[Project Settings]

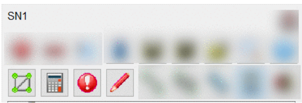


- Coordinate System
- Input File defaults
- Pre-processing
- Default Standard Errors
- Adjustment Standards
- Output Options
- Drawing Settings
- Global Settings

Working with Project Files

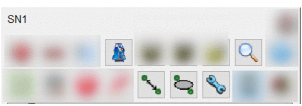
- Open and Create Project Files
- Save Current
- Saveas - copy and create new file

Analyzing and Processing



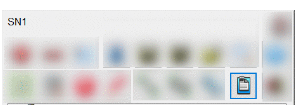
- Process Network
- Pre-process Network
- Blunder Detection
- Draw Network

Tools



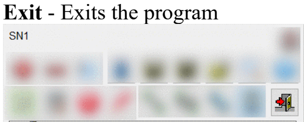
- EDM Calibration
- Point Search
- Inverse
- Error Ellipse
- Conversion Tools

Reports



- Main
- Output
- Errors
- Results

Exit - Exits the program



Help - launches the Carlson Help Menu

File Menu

The **File** menu consists of three main buttons.


SurvNET File Menu

From left to right the are:
Save - saves the current file
Saveas - saves the current file as a new one, essentially making a copy.
Load/New - opens a new dialog box that allows users to select and existing project file or create a new one.

Settings Menu

Selecting the **Settings** menu opens the following menu:

Project Settings

The Project Settings dialog box has six tabbed windows:

Coordinate System Settings

1. Coordinate System
2. Input Files
3. Preprocessing

4. Adjustment
5. Standard Errors
6. Output Options

In addition to the above tabs, there are options to

- Save Project - saves the current project
- Save as Default - saves the current settings as defaults for future projects
- Drawing Settings - opens the Drawing Settings dialog box
- Global Settings - opens the Global Settings dialog box

Coordinate System:

Coordinate System Settings

The Coordinate System tab contains settings that relate to the project coordinate system, the adjustment model and other geodetic settings.

You can select either the 3D model or the 2D/1D mathematical model. If you choose 2D/1D mathematical model, you can choose to only perform a horizontal adjustment, a vertical adjustment or both. In the 3D model, both horizontal and vertical are adjusted simultaneously. The 3D model requires that you choose a geodetic coordinate system. Local, assumed coordinate systems cannot be used with the 3D model. GPS vectors can only be used when using the 3D model.

If using the 2D/1D mathematical model, you can select Local (assumed coordinate system), or a geodetic coordinate system such State Plane NAD83, State Plane NAD27, UTM, or a user-defined coordinate system as the coordinate system. When using the 3D model you cannot use a local system.

Select the "Horizontal Units" for output of coordinate values (Meters, US Feet, or International Feet). In the 3D model, both horizontal and vertical units are assumed to be the same. In the 2D/1D model, horizontal and vertical units can differ if you select "Compute from Project Elevation". The "Horizontal Unit" setting in this screen refers to the output units. It is permissible to have input units in feet and output units in meters. Input units are set in the Input Files tab.

If you choose SPC 1983, SPC 1927, or UTM, the appropriate zone will need to be indicated. The grid scale factor is computed for each measured line using the method described in Section 4.2 in the publication by: Stem, James E., (1990) *State Plane Coordinate System of 1983*. Rockville, MD: NOAA.

If using the 2D/1D model and you select a geodetic coordinate system, you have a choice as to how the elevation factor is computed. You can choose to either enter a project elevation or you can choose to have elevations factors computed for each distance based on computed elevations. In order to use the "Compute Elevation from Raw Data", all HI's and foresight rod heights must be collected for all points.

If you choose a geodetic coordinate system and are using the 2D/1D model, you will want to select "Project Elevation" if any of your raw data measurements are missing any rod heights or instrument heights. There must be enough information to compute elevations for all points in order to compute elevation factors. For most survey projects, it is sufficient to use an approximate elevation, such as can be obtained from a Quad Sheet for the project elevation.

Geoid Modeling

If you are using either the 3D or the 2D/1D adjustment model using non-local coordinate system, you must choose a geoid modeling method. A project geoid separation can be entered or the grid model can be selected from a list of models. The project must fall within the geographic range of the geoid grid files.

Geoid modeling is used as follows. Entering a 0.0 value for the separation is the method to use if you wish to ignore the geoid separation. In the 2D/1D model, it is assumed that elevations entered as control are entered as orthometric heights. Since grid reduction requires the data be reduced to the ellipsoid, the geoid separation is used to compute ellipsoid heights. The difference between using geoid modeling and not using geoid modeling or using a project geoid separation is insignificant for most surveys of limited extents.

In the 3D model, it is also assumed that elevations entered as control are orthometric heights. Since the adjustment is performed on the ellipsoid, the geoid separation is used to compute ellipsoid elevations prior to adjustment. After the adjustment is completed, the adjusted orthometric elevations will be computed from the adjusted ellipsoid elevations and the computed geoid separation for each point.

If you choose one of the geoid models from the list, the geoid separations are computed by interpolation with data points retrieved from geoid separation files. The geoid separation files should be found in the primary the installation directory. Grid files have an extension of .grd. These files can be downloaded from the Carlson website (www.carlsonsw.com). If you pick a geoid model that is not on your computer, SurvNET will automatically connect to the Carlson website and download the specific geoid file.

If you choose to enter a project geoid separation, the best way to determine a project geoid separation is by using the NGS on-line Geodetic Toolkit. Enter a latitude and longitude of the project midpoint and the program will output a project separation.

Working With User-defined Coordinate Systems

SurvNET allows the creation of user-defined geodetic coordinate systems (UDP). The ability to create user-defined coordinate system allows the user to create geodetic coordinate systems based on the supported projections that are not explicitly supported by SurvNET. A SurvNET user-defined coordinate system consists of an ellipsoid, and a map projection. The ellipsoid can be one of the explicitly supported ellipsoids or a user-defined ellipsoid. The supported map projections are:

- Transverse Mercator
- Lambert Conformal Conic with 1 standard parallel
- Lambert Conformal Conic with 2 standard parallels
- Oblique Mercator
- Double Stereographic projection

User-defined coordinate systems are created, edited, and attached to a project from the Project Settings 'Coordinate System' dialog box. To attach an existing UDP file, *.udp, to a project use the 'Select' button. To edit an existing UDP file or create a new UDP file use the 'Edit' button.

Specify User-Defined

The following dialog box is used to create the user-defined coordinate system. The ellipsoid needs to be defined and the appropriate map projection and projection parameters need to be entered. The appropriate parameter fields will be displayed depending on the projection type chosen.

Note: ***Grid Origin*** values for both the Northing and Easting values need to be input in Metric values!

Create/Edit User-Defined

Test - Use the 'Test' button to enter a known latitude and longitude position to check that the UDP is computing correct grid coordinates. Following is the test UDP dialog box. Enter the known lat/long in the top portion of the dialog box then press 'Calculate' and the computed grid coordinates will be displayed in the 'Results' list box:

Test User-Defined

Load - Use the 'Load' to load the coordinate system parameters from an existing .UDP file.

Save - Use the 'Save' button to save the displayed UDP. The 'Save' button prompts the user to enter the .UDP file name.

OK - Use the 'OK' button to save the UDP using the existing file name and return to the 'Coordinate System' dialog box.

Cancel - Use the 'Cancel' button to return to the 'Coordinate System' dialog box without saving any changes to the .UDP file.

If you need to define an ellipsoid, choose the 'User-Defined' ellipsoid option. With the user-defined ellipsoid you will then have the option to enter two of the ellipsoid parameters.

User-defined Ellipsoid

Input Files

Input Files

This dialog box is used to set the default parameters for the **Input Raw** files that will be used for processing the data.

Note that if you are processing Carlson RW5 total station files, you have the option of including GPS vectors that can be collected by SurvCE/SurvPC and stored in the RW5 file. Alternatively, you can select the RW5 file in the GPS vector section. **If the "Include any GPS vectors" option in the Total Station Data Files section is checked, you will have the option to use the Base Point records in the RW5 file as control**. If "Use BP records as control" is NOT checked, or the RW5 file is selected in the GPS vector section, you must define the control in either the RW5 file as POINT records or in a Supplemental Control File.

GPS Vector Files: GPS vector files can be entered and processed. Both GPS vector files and total station raw files can be combined and processed together. **You must have chosen the 3D mathematical model in the Coordinate System tab in order to include GPS vectors in the adjustment.**

A variety of popular GPS vector file formats are supported, including (but not necessarily limited to):

- **ASCII (StarNet)**: See below for more information on StarNet format. These files typically have .GPS extensions.
- **Ashtech/Thales 'O' files**: Typically have .obn extensions and are binary files.
- **Carlson .RW5**: (containing GPS vectors)
- **GeoLab IOB**
- **LandXML (*.xml)**
- **Leica**: Leica files are ASCII files.
- **NGS G-File**
- **NGS G-File from OPUS report**
- **Topcon (.tvf)**: Topcon .tvf files are ASCII files.
- **Topcon (.xml)**: Topcon also can output their GPS vectors in XML format which is in ASCII format.
- **TDS (.raw)**: TDS raw data file with vector information
- **Trimble Data Exchange Format (.asc)**: These files are in ASCII format
- **Trimble data collection (.dc)**: These files are ASCII.
- **Trimble LandXML (*.jxl)**

The following is a typical vector record in the StarNet ASCII format. GPS vectors typically consist of the 'from' and 'to' point number, the delta X, delta Y, delta Z values from the 'from' and 'to' point, with the XYZ deltas being in the geocentric coordinate system. Additionally the variance/covariance values of the delta XYZ's are included in the vector file.

```
.GPS WEIGHT COVARIANCE
C PRS34452 1305780.345005 -4667085.299019 4132689.544939 0.005000 0.005000 0.005000 --MON
C UCNJ 1305780.345005 -4667085.299019 4132689.544939 0.00000100 0.00000100 0.00000100 --MON
G1  UCNJ-1000    8399.71318061   -4742.15645068   -8036.07224424 --MNS
G2   3.939428e-006  2.474560e-005  1.160301e-005
G3   3.924536e-006 -3.360765e-006 -1.028503e-006
G1  UCNJ-1001    8328.15569476   -4796.59445569   -8072.25948922 --MNS
G2   9.596618e-007  1.687749e-005  1.936038e-006
G3   1.176891e-007 -8.668020e-009 -4.798408e-006
```

The first line defines what values are in the G2 and G3 records. It can be either GPS WEIGHT COVARIANCE (G2 is Variance, G3 is Covariance), or GPS WEIGHT STDERRCORRELATION (G2 is standard error, G3 is standard error correlation). This line is optional; the default is COVARIANCE.

The next two lines are coordinate control records. These records are also optional. If used, they must be Geocentric Coordinates (XYZ) in metric units. The format is as follows:

```
    C  PointName  X  Y  Z  StdErrX  StdErrY  StdErrZ  --PointDescription
```

The standard errors and point description are optional.

The GO record is a comment.

The G1 record includes the 'from' and 'to' points and the delta X, delta Y, and delta Z in the geocentric coordinate system and an optional description of the rover point.

The G2 record is the variance (or standard error) of X,Y, and Z. The G3 record contains the covariance (or standard error correlation) of XY, ZX, and ZY. Most all GPS vector files contain the same data fields in different formats.

Use the 'Add' button to insert GPS vector files into the list. Use the 'Remove' button to remove GPS vector files from the list. All the files in this list will be used in the least squares adjustments. All the GPS files in the list must be in the same format. If the GPS file format is ASCII you have the option to edit the GPS vector files. The Edit option allows the editing of any of the ASCII GPS files using Notepad. Typically, only point numbers or point descriptions would be edited. The variance/covariance values are used to determine the weights that the GPS vectors will receive during the adjustment and are not typically edited.

Level Raw Files: Differential and Trig level files can be entered and processed. Differential or Trig Level raw files have a .TLV extension and are created using the Carlson Level Editor. The Carlson Level Editor has several Import options that allow you to bring in levels from different formats (*e.g.* Leica, Trimble, Topcon, *etc*). You can process level data in the same project with the traverse and GPS vector data but the vertical measurements in the traverse/vectors will be part of the adjustment. If you want to use the elevations calculated ONLY from the level data, you must process it in a separate project after your traverse/vector data has been adjusted. The elevations will be written to the Output Coordinate file. Make sure your point numbers in the level data match the points in the traverse/vector data.

Supplemental Control File: The supplemental control file option allows the user to designate an additional coordinate file to be used as Control. The supplemental control file can be from a variety of different file types, including (but not necessarily limited to):

- **C&G or Carlson numeric (.CRD) files**
- **C&G Alphanumeric coordinate files (*.cgc)**
- **Carlson Alphanumeric coordinate files (*.crd)**
- **Autodesk Land Desktop (*.mdb)**
- **Simplicity coordinate files (*.zak)**
- **ASCII (.NEZ) file**
- **ASCII latitude and longitude** (3D model only)
- **CSV ASCII NEZ with std. errors** (only external control file that allows you to assign standard errors to specific points)
- **SDMS (.ctl) control file**
- **ASCII Geocentric (.xyz)** (Geocentric coordinates XYZ in metric units)

Note: For additional information on file format pertaining to the file formats above, refer to the Supplemental Control Files section of the documentation.

Note: You will not be allowed to use the same file for supplemental control points and for final output. Least Squares considers all points to be measurements. If the output file is also used as a supplemental control file, then after the project has been processed all the points in the project would now be in the control file and all the points in the file would now be considered control points if the project was processed again. The simplest and most straight-forward method to define control for a project is to include the control coordinates in a raw data file.

Preprocessing

The Preprocessing tab contains settings that are used in the preprocessing of the raw data.

Preprocessing

Apply Curvature and Refraction Corrections: Check this box if you wish to have the curvature refraction correction applied in the 2D/1D model when reducing the slope distance/vertical angle to horizontal distance and vertical distance. Curvature/refraction primarily impacts vertical distances.

Pt. Number Substitution String: This option is used to automatically renumber point names. Some data collectors do not allow the user to use the same point number twice during data collection. In Least Squares, it is common to collect measurements to the same point from different locations. If the data collector does not allow you to use the correct point number, this option can be used to automatically renumber these points during processing. For example you could enter the string '=' in the Pt. Number Substitution String. Then if you shot point 1 but had to call it something else such as 101, you could enter '=1' in the description field and during preprocessing point 101 would be renumbered as point '1'.

Compute Closures: Traditional traverse closures can be computed for both GPS and total station traverses. This option has no effect on the computation of final least squares adjusted coordinates. This option is useful for surveyors who, due to statutory requirements, are still required to compute traditional traverse closures and for those surveyors who still like to view traverse closures prior to the least squares adjustment. This option is used to specify a previously created Closure File. To use this option the user has to first create a Traverse Closure file.

Tolerances: When sets of angles and/or distances are measured to a point, a single averaged value is calculated for use in the least squares adjustment. You may set the tolerances so that a warning is generated if any differences between the angle sets or distances exceed these tolerances. Tolerance warnings will be shown in the report (.RPT) and the (.ERR) file after processing the data.

If you check the **Extended Angle Sets & Distance Report** option, all the sets will be shown with the difference between the high angle and low angle, and the difference between the high distance and low distance. If this option is not checked ONLY the sets that exceed the tolerances will be shown in the report.

Horz./Slope Dist Tolerance: This value sets the tolerance threshold for the display of warnings if the difference between highest and lowest horizontal distance exceeds this value. In the 2D model it is the horizontal distances that are being compared. In the 3D model it is the slope distances that are being compared.

Vert. Dist Tolerance: This value sets the tolerance threshold for the display of a warning if the difference between highest and lowest vertical difference component exceeds this value (used in 2D model only).

Horz. Angle Tolerance: This value sets the tolerance threshold for the display of a warning if the difference between the highest and lowest horizontal angle exceeds this value.

Vert. Angle Tolerance: This value sets the tolerance threshold for the display a warning if the difference between the highest and lowest vertical angle exceeds this value (used in 3D model only).

Angle Set Spread Display: You can choose to see the splits of individual angles in each set (2 per set), or just the splits of all the sets combined (high / low angle of all the sets combined).

Traverse Closure Files

Some statutes and jurisdictions still require the computation of traditional **Traverse Closures**. SurvNET gives the surveyor the ability to compute the closures of multiple traverses within a project as part of the preprocessing of the project raw data. Closures for single or multiple traverses can be computed for a single project. Additionally, GPS closures can be computed for GPS loops. To compute closures you must first create a "Closure File" (.CLS). Closure Files define the type of traverse loops that are to be computed and an ordered list of the point numbers comprising the traverse. Since the raw data for SurvNET is not expected to be in any particular order, it is required that the user must specify the points and the correct order of the points in the traverse loop. Both GPS and angle/distance traverses can be defined in a single traverse closure file.

There are two options in the **File** menu that are used to create and edit the Closure Files:

1. **Open Traverse Closure File** - This command permits you to browse for and open a previously created Closure File for editing. Once opened, it displays the dialog box below.
2. **New Traverse Closure File** - This command provides you the ability to create a named Closure File in a folder of your choosing. After supplying a file name to create, the following dialog box is displayed.

Traverse Closure Menu

First, enter the point sequence which defines the traverse in the "edit control" portion of the dialog box. Toggle the check boxes to set whether Vertical Closure and/or Angle Closures need to be computed. Then choose what traverse type is being entered. When the values are correct, press the **Save** button and the traverse will be entered into the Traverse Closure file. Add additional traverse information via the "Record" button icon located at the upper left (you may also remove a recorded traverse via the Delete button icon also located in the upper left portion of the dialog box.

If you need to edit one of the traverses, mouse-click the traverse to be edited. Make the appropriate edit(s), then click the **Save** button to save the changes.

As an example of traverse point entry, points can be entered in the form:

```
10,23,30-35,45,23,10
```

A comma separates the point numbers. You can select a range (*e.g.* 30-35) when the points are sequential. **NOTE:** You must start with the first backsight point number and end with the last foresight point number.

For example, if you have a simple loop traverse with angle closure using points 1, 2, 3 and 4, it will be entered as "4,1,2,3,4,1" (or 4,1-4,1) where 1 is the first occupied point and 4 is the initial backsight.

You can turn the "Angle Closure" ON or OFF. If the angle closure is ON, you will be shown the total angular error and error per angle point. If the final closing angle was not collected, you can turn "Angle Closure" OFF and only the linear closure will be computed.

You can turn the "Vertical Closure" ON or OFF. If the vertical closure is ON, you will be shown the total vertical distance closure.

In order to calculate the traverse closure, you must select the **Traverse Type**. It can be:

- **Pt. to Pt. Trav.** - A Point-to-Point Traverse is a traverse that starts at a set of known coordinates and ends at another known coordinate. This option assumes you start from **two** control points and:
  1. tie into one control point if only a linear closure is desired, or,
  2. tie into two control points if an angle closure is desired.

  The first backsight distance and last foresight distance are not used in computing the linear closure. Following is an example:

  ```
  100,101,2-5  (angle closure example collected)
  ```

  In the above Point-to-Point list, Pt 100 is the starting backsight point, Pt. 101 is the starting instrument point. Pt. 4 is (would be) the ending instrument point and the foresight to the angle closure point is point 5. If a closing angle was not collected, the list would look as follows:

  ```
  100,101,2-4
  ```

- **Loop Trav., Int. Az. Ref.** - A closed loop traverse that begins by backsighting the last interior point on the traverse. Following is an example:

```
7,101,2-7,101
```

In the above example, closed loop with angle balance list, point 7 is the backsight point and point 101 is the first occupied point. If the closing angle 6-7-101 was not collected, the list would be entered as follows:

```
7,101,2-7
```

- **Loop Trav., Ext. Az. Ref.** - A closed loop traverse that begins by backsighting an exterior point (point not on the traverse):

```
100,101,2-7,101,100
```

In the above example loop with exterior reference and angle balance list, point 100 is the backsight point and point 101 is the first occupied point. If the closing angle 7-101-101 was not collected, the list would be entered as follows:

```
100,101,2-7,101
```

- **GPS Loop Closure** - GPS loop closures can be computed using this option

```
A,E,F,A
```

In the above example GPS loop, closure will be computed from the GPS loop going from A-E-F-A.

- **GPS Point to Point Closure** - GPS Point to Point closures can be computed using this option:

  ```
  A,E,D,B
  ```

  In the above example the closure will be computed from the GPS traverse going from A-E-D-B. The starting and ending points **MUST** be control points.

After the Closure File has been created, the pre-processing project settings need to be updated to include the Closure File in the project. Following is a view of the Settings screen that defines a Closure File to be used in pre-processing. Notice that the check box 'Compute Traverse Closure' is checked and a Closure File has been entered in the edit box field. Notice that the 'Edit/Create' button can be used to edit an existing Closure File or create a new Closure File.

Updated Pre-Processing

When the data is processed, the Closure reports will appear in the RPT and ERR files. You will notice that two Closures are shown, one with no angle balance and one with angle balance.

Following is an example of a closed loop traverse report:

```
Traverse Closures
=================

Traverse points:
103-118,43-44

Traverse starting and ending on different points;
Compute angle closure.
Compute vertical closure.

BS         IP         FS             Angle          FS H. Dist.    FS V. Dist.
 103        104        105            173-07'48.5"     310.4921     -7.7483
 104        105        106            167-48'21.5"     253.4875      5.6291
 105        106        107            200-52'46.0"     381.4923      8.4877
 106        107        108            149-09'05.5"     410.5476    -16.6830
 107        108        109            080-42'36.5"     245.5731      9.4221
 108        109        110            174-21'17.5"     175.3848     -5.6971
 109        110        111            201-42'21.5"     367.0019    -11.8161
 110        111        112            171-52'54.5"     237.7809      7.5346
 111        112        113            192-32'53.5"     368.8402     -7.0329
 112        113        114            171-30'59.0"     338.0028    -19.1945
 113        114        115            184-54'03.5"     344.5010     16.3157
 114        115        116            149-20'19.5"     353.8460      7.5562
 115        116        117            202-19'01.5"     390.1123     -9.9180
 116        117        118            112-36'32.0"     293.9935      2.0060
 117        118        43             146-06'36.5"     411.3680     -7.7112
 118        43         44             270-04'01.5"

Closing Az:           S 47-39'47.8"W
Computed Closing Az:  S 47-39'51.3"W

Total angular error:      000-00'03.5"
Angular error per point:  000-00'00.2"


Correct Ending Coordinates, North: 1400952.0140 East: 2241884.7010
Ending Coordinates, North: 1400951.7936 East: 2241884.8160
Error, N: -0.2204 E: 0.1150 Total: 0.2486 Brg:  N 27-33'06.7"W
Distance Traversed: 4882.4241 Closure: 1: 19643

Correct Ending Elevation:  948.1710
Ending Elevation:          948.1203
Elevation Error:            -0.0507


Closure After Angle Adjustment

 103        104        105            173-07'48.3"     310.4921     -7.7483
 104        105        106            167-48'21.3"     253.4875      5.6291
 105        106        107            200-52'45.8"     381.4923      8.4877
 106        107        108            149-09'05.3"     410.5476    -16.6830
 107        108        109            080-42'36.3"     245.5731      9.4221
 108        109        110            174-21'17.3"     175.3848     -5.6971
 109        110        111            201-42'21.3"     367.0019    -11.8161
 110        111        112            171-52'54.3"     237.7809      7.5346
 111        112        113            192-32'53.3"     368.8402     -7.0329
 112        113        114            171-30'58.8"     338.0028    -19.1945
 113        114        115            184-54'03.3"     344.5010     16.3157
 114        115        116            149-20'19.3"     353.8460      7.5562
```

```
 115        116        117            202-19'01.3"     390.1123     -9.9180
 116        117        118            112-36'31.8"     293.9935      2.0060
 117        118        43             146-06'36.3"     411.3680     -7.7112
 118        43         44             270-04'01.3"

Closing Az:           S 47-39'47.8"W
Computed Closing Az:  S 47-39'47.8"W

Total angular error:      000-00'00.0"
Angular error per point:  000-00'00.0"


Correct Ending Coordinates, North: 1400952.0140 East: 2241884.7010
Ending Coordinates, North: 1400951.7739 East: 2241884.8363
Error, N: -0.2401 E: 0.1353 Total: 0.2756 Brg:  N 29-24'26.1"W
Distance Traversed: 4882.4241 Closure: 1: 17715
```

Following is an example of a GPS loop closure report:

```
Traverse Closures
=================
GPS Loop Points:
A,E,F,A
GPS Loop Closure;
  Misclosure, X:  -0.0323   Y:  -0.0162   Z:  -0.0105
  Closure error:    0.0376   Perimeter: 20229.3858
  Precision: 1:537594
GPS Loop Points:
C,F,D,B,C
GPS Loop Closure;
  Misclosure, X:  -0.0121   Y:  -0.0101   Z:   0.0002
  Closure error:    0.0158   Perimeter: 41332.9807
  Precision: 1:2622216
GPS Loop Points:
F,D,B,F
GPS Loop Closure;
  Misclosure, X:  -0.0022   Y:  -0.0044   Z:   0.0097
  Closure error:    0.0109   Perimeter: 30814.5047
  Precision: 1:2833226
```

ALTA Tolerance Reports

SurvNET provides the ability to generate reports that give the surveyor the information needed to determine if the survey is within ALTA positional tolerances. It is required that the user define which points are to be included in the ALTA testing. The points to be included for ALTA testing are defined in an .ALT file.

There are two options in the **File** menu that are used to create and edit the ALTA files:

1. **Open ALTA, Rel. Err. Ellipse File** - This command permits you to browse for and open a previously created ALTA File for editing. Once opened, it displays the dialog box below.
2. **New ALTA, Rel. Err. Ellipse File** - This command provides you the ability to create a named ALTA File in a folder of your choosing. After supplying a file name to create, the following dialog box is displayed.

ALTA Points

The above dialog box allows the user to define the points to be included in the ALTA report processing.

Notice that you can enter points based on Descriptions in the left-hand list box. For example, if you wished to check connections between all points with TP, EIP, MON descriptions, enter the descriptions in the edit field and press the **Add by Desc.** button. If TP, EIP, and MON represented Traverse Points, Existing Iron Pipes and Monuments (respectively), then ALTA testing would be performed on those point types.

After you have created the .ALT point file, you need to set some additional **Project Settings**. The Adjustment tab within the Project Settings, has a **Relative Error Ellipses/ALTA Report** section where the ALTA report settings are located. These settings define the ALTA Tolerances, specify the .ALT file to be used, and define the type of reporting to be generated.

Note: The **Rel. Err. Points File** check box must be checked, and an .ALT file must be chosen to get an ALTA report. The .ALT file defines which points will be included in the ALTA reporting. Also note typical ALTA specifications define their positional standard as 0.07 plus 50 PPM.

Sample ALTA Report

There are two sections in the .RPT file created through the ALTA reporting. The following report shows the sections of the ALTA report generated by the data in the dialog box.

The first section of the report displays the *Relative Error Ellipses* between points in the **Specific Connection** list. All the connections will be displayed whether they pass or fail the ALTA certification. The point sequences used in this section come from the list on the right-hand side of the above dialog box.

The second section of the report performs an ALTA tolerance test on the points in the "**Check all Connections**" list. Every possible connection between the points listed will be checked. In this section, only the worst connections will be shown. The number of connections shown is determined by the "**Max. connections to display**" value in the above dialog box. The point sequences used in this section come from the list on the left-hand side of the above dialog box.

An asterisk (*) will be placed beside each connection shown in the report that **does not pass** based on the confidence interval, tolerance and PPM (parts per million) settings in the Adjustment section of the Project Settings.

The following is a sample ALTA report:

```
Relative Error and ALTA Tolerances
==================================
SPECIFIC CONNECTIONS: Tolerance of 0.070 +  50 PPM. at the 95% CI.

                                        Actual       Allowable   Ratio
 Sta.       Sta.           Dist.        Semi Major   Semi Major  Actual/Allowable  Semi Minor  Max. Err. Az.
 27         500          204.5030      0.0793       0.0802      0.9890            0.0588       S 85-06'32.2"E
 500        502           66.8572      0.1132       0.0733      1.5432            0.0842       S 86-05'06.7"E *
 34         36           237.9748      0.0731       0.0819      0.8920            0.0731       N 00-00'00.0"E
ALL CONNECTIONS: Tolerance of 0.070 +  50 PPM. at the 95% CI.
All possible connections between the following points were checked:
505,506,507,508,509,510,511,512,513,514,515,516,517,518,519,520,521,522,523,524,525,550,551,552,553,554,555,556,
557,558,559,560

1225 connections tested, the 10 largest relative error ellipses will be shown:
                                        Actual       Allowable   Ratio
 Sta.       Sta.           Dist.        Semi Major   Semi Major  Actual/Allowable  Semi Minor  Max. Err. Az.
 506        556          806.5402      1.0818       0.1103      9.8054            0.2586       S 86-37'40.4"E
 507        556          827.2364      1.0832       0.1114      9.7268            0.2446       S 86-37'05.9"E
 505        556          818.7994      1.0779       0.1109      9.7158            0.2386       S 86-48'24.5"E
 508        556          854.9436      1.0836       0.1127      9.6108            0.2477       S 86-38'39.4"E
 509        556          880.6338      1.0848       0.1140      9.5129            0.2489       S 86-45'39.4"E
 521        556          798.2729      1.0387       0.1099      9.4500            0.2318       S 87-22'50.2"E
 512        556          793.0518      1.0334       0.1097      9.4245            0.2127       S 87-21'38.9"E
 517        556          907.2084      1.0856       0.1154      9.4106            0.2379       S 87-07'38.4"E
 510        556          918.6572      1.0861       0.1159      9.3682            0.2525       S 86-52'46.5"E
 516        556          935.1194      1.0885       0.1168      9.3228            0.2426       S 87-22'21.7"E
*** All connection combinations passed ***
```

The first part of the report labeled "Specific Connections" will show all selected connections whether they passed or failed. If a connection failed, an asterisk (*) will be placed at the end of the line.

The second part of the report, labeled "All Connections" will only show the connections that "failed" (we chose to see the worst 10).

If all the connections pass in the **Specific Connection** section, you will also see this message in the report:

***** All Specific Connections passed *****

If all the connections pass in the **All Connections** section, you will not see any Error Ellipses. You will see the following message:

***** All connection combinations passed *****

Standard Errors

Standard errors are the expected measurement errors based on the type equipment and field procedures being used. For example, if you are using a 5 second total station, you would expect the angles to be measured within +/- 5 seconds (Reading error).

The Distance Constant, PPM settings, and Angle Reading should be based on the equipment and field procedures being used. These values can be obtained from the published specifications for the total station. Or, the distance PPM and constant can be computed for a specific EDM by performing an EDM calibration using an EDM calibration baseline.

Survey methods should also be taken into account when setting standard errors. For example, you might set the target centering standard error higher when you are sighting a held prism pole than you would if you were sighting a prism set on a tripod.

Standard Error

The settings from this dialog box will be used for the Project Default settings. These default Standard Errors can be overridden for specific measurements by placing SE records directly into the Raw Data File.

If the report generated when you process the data shows that generally you have consistently high standard residuals for a particular measurement value (angles, distances, etc.), then there is the chance that you have selected standard errors that are better than your instrument and methods can obtain. (See explanation of report file). Failing the chi-square test consistently is also an indication that the selected standard errors are not consistent with the field measurements.

You can set the standard errors for the following:

Distance and Angle Standard Errors

Distance Constant: Constant portion of the distance error. This value can be obtained from published EDM specifications, or from an EDM calibration.

Distance PPM: Parts per million component of the distance error. This value can be obtained from published EDM specification, or from an EDM calibration.

Horizontal Angle Pointing: The horizontal angle pointing error is influenced by atmospheric conditions, optics, experience and care taken by instrument operator.

Horizontal Angle Reading: Precision of horizontal angle measurements, obtain from theodolite specifications.

Vertical Angle Pointing: The vertical angle pointing error is influenced by atmospheric conditions, optics, experience and care taken by instrument operator.

Vertical Angle Reading: Precision of vertical angle measurements, obtain from theodolite specifications.

Instrument and Target Standard Errors

Target Centering: This value is the expected amount of error in setting the target or prism over the point.

Instrument Centering: The expected amount of error in setting the total station over the point.

Target Height: The expected amount of error in measuring the height of the target.

Instrument Height: The expected amount of error in measuring the height of the total station.

Control Standard Errors

Direction (Bearing / Azimuth): The estimated amount of error in the bearing / azimuth (direction) found in the azimuth records of the raw data.

North, East, Elev: The estimated amount of error in the control north, east and elevation values. You may want to have different coordinate standard errors for different methods of obtaining control. For example, standard errors of control derived from RTK GPS would be higher than control derived from GPS static measurements.

GPS Standard Errors

Instrument Centering: This option is used to specify the error associated with centering a GPS receiver over a point.

Vector Standard Error Factor: This option is used as a factor to increase GPS vector standard errors as found in the input GPS vector file. Some people think that the GPS vector variances/covariances as found in GPS vector files tend to be overly optimistic. This factor allows the user to globally increase the GPS vector standard errors without having to edit the GPS vector file. A factor of 0 is the default value and results in no change to the GPS vector standard errors as found in the GPS vector file. Acceptable values are 0 through 9. **It is not a linear progression.** The actual multiplication factor is the number 2 raised to the power entered in the factor box. For example, if the value of 4 is entered, the multiplication factor will be 2 to the 4^{th} power or 16.

Differential Leveling Standard Errors

These setting only effect level data and are not used when processing total station or GPS vector files.

Avg. Dist. To BS/FS: This option is used to define the average distance to the backsight and foresight during leveling.

Rod Reading Error per 100 ft./m: This option is used to define the expected level reading error.

Collimation Error: This is the expected differential leveling collimation error in seconds.

Standard Error Definition Files

The Standard error settings can be saved and then later reloaded into an existing or new project. Creating libraries of standard errors for different types of survey equipment or survey procedures is convenient method of creating standards within a survey department that uses a variety of equipment and performs different types of surveys.

Standard error library files (.sef) can be created two ways. From the 'Settings -- Standard Errors' tab, the 'Load' button can be used to import an existing .SEF file into the current project. A .SEF file can also be created from the existing project standard errors by using the 'Save As..' button.

Create .SE

Adjustment

Adjustment

Maximum Iterations: Non-linear least squares is an iterative process. The user must define the maximum number of iterations to make before the program quits trying to find a converging solution. Typically if there are no blunders in the data, the solution will converge in less than 5 iterations.

Convergence Threshold: During each iteration, corrections are computed. When the corrections are less than the threshold value, the solution has converged. This value should be somewhat less than the accuracy of the measurements. For example, if you can only measure distances to the nearest 0.01' then a reasonable convergence threshold value would be 0.005'.

Confidence Interval: This setting is used when calculating the size of error ellipses, and in the Chi^2 (Chi-square) testing. For example, a 95% confidence interval means that there is a 95% chance that the error is within the tolerances shown.

Enable sideshots for relative error ellipses: Check this box if you want to see the error ellipses and relative error ellipses of sideshots. This check-box must be set if you want to use the "relative error ellipse inverse" function with sideshots. When unchecked, this toggle filters out sideshots during the Least Squares processing. Since the sideshots are excluded from the Least Squares processing, error ellipses cannot be computed for these points. When this toggle is off, the sideshots are computed after the network has been adjusted. The final coordinate values of the sideshots will be the same regardless of this setting.

- **Note:** Large numbers of sideshots slow down least squares processing. It is best to uncheck this box while debugging your project to avoid having to wait for the computer to finish processing. After the project processes correctly you may turn on the option for the final processing.
- **Note: Any sideshots that are selected for the ALTA report will automatically be included in the adjustment process in order to calculate the error ellipses - even if this option is turned OFF.** Even if you do not need ALTA report, this is an easy way to get statistics on only selected sideshots which can greatly speed up the adjustment process.

Relative Err. Points File: Any certification specifying "Positional Tolerance", "Positional Accuracy" or "Positional Precision" deal with the relative error between specified points. The ALTA standards require that surveyors certify to the relative positional tolerance between points. Relative error ellipses are an accepted method of determining the relative positional error required by the ALTA standards. The points that are to be included in the relative error checking are specified by the user. These points are defined in an ASCII file with an extension of .ALT. To select an .ALT file for relative error checking use the 'Select' button and then browse to the location of the file. Refer to the Creating ALTA Tolerance Reports for a discussion on creating the .ALT file.

If the Relative Err. Points File box is checked, an ALTA section will be created in the report.

Allowable Tolerance, **PPM**: These fields allow the user to set the allowable error for computations. Typically the user would enter the current ALTA error standards. Many States are adopting similar certifications to the ALTA standards. These certifications may have different tolerances depending on the type of survey (for example rural *vs.* urban). Make sure the appropriate tolerance and PPM (parts per million) values have been defined. The ALTA standards define their positional standard as 0.07' plus 50 PPM and typically require that the computations be performed to a 95% confidence. The confidence interval is set in the *Confidence Interval* edit field.

Refer to the discussion on creating and interpreting the ALTA report.

Output Options

These settings apply to the output of data to the report and coordinate files.

Output

Display Precision

These settings determine the number of decimal places to display in the reports for the following types of data. **The display precision has no effect on any computations, only the display of the reports.**

- Coordinates (North, East, Elevation) - Chose 0-4 decimal places.
- Distances - Chose 0-4 decimal places
- Directions (Azimuths or Bearings) - nearest second, tenth of second, or hundredth of second.

Format

These settings determine the format for the following types of data.

Direction - Choose either bearings or azimuth for direction display. If the angle units are degrees, bearings are entered as QDD.MMSSss and azimuths are entered as DDD.MMSSss. If the angle units are grads, bearings are input as QGGG.ggggg and azimuths are input as GGG.ggggg.

Angles - Choose the units you are working in: degrees or gradians.

Coordinate - Choose the order of coordinate display, either north-east or east-north.

Null Elevation - Choose the value for null elevations in the output ASCII coordinate NEZ file. The Null Elevation field defaults to SurvNET's value for NO ELEVATION. This is used to differentiate between NO ELEVATION (a true 2D point) and ZERO ELEVATION (which is a vaild elevation).

Coordinate File Output

These settings determine the type and format of the output NEZ file. An ASCII .NEZ and .OUT files are always created after processing the raw data. The .OUT file will be a nicely formatted version of the .NEZ file. The .NEZ file will be an ASCII file suitable to be input into other programs. There are a variety of options for the format of the .NEZ file. Following are the different ASCII file output options.

- P,N,E,Z,CD,DESC (fixed columns); - Point,north,east,elev.,code,desc in fixed columns separated by commas.
- P,N,E,Z,CD,DESC; Point,north,east,elev.,code,desc separated by commas.
- P N E Z CD DESC (fixed columns); Point,north,east,elev.,code,desc in fixed columns with no commas.
- P N E Z CD DESC; Point,north,east,elev.,code,desc in fixed columns with no commas.
- P,N,E,Z,DESC (fixed columns); Point,north,east,elev., desc in fixed columns separated by commas.
- P,N,E,Z,DESC; Point,north,east,elev., desc separated by commas.
- P N E Z DESC (fixed columns); Point,north,east,elev., desc in fixed columns with no commas.
- P N E Z DESC; Point,north,east,elev.,code,desc separated by spaces.
- P,E,N,Z,CD,DESC (fixed columns); - Point,east,north,elev.,code,desc in fixed columns separated by commas.
- P,E,N,Z,CD,DESC; Point,east,north,elev.,code,desc separated by commas.
- P E N Z CD DESC (fixed columns); Point,east,north,elev.,code,desc in fixed columns with no commas.
- P E N Z CD DESC; Point,east,north,elev.,code,desc in fixed columns with no commas.
- P,E,N,Z,DESC (fixed columns); Point,east,north,elev., desc in fixed columns separated by commas.
- P,E,N,Z,DESC; Point,east,north,elev., desc separated by commas.
- P E N Z DESC (fixed columns); Point,east,north,elev., desc in fixed columns with no commas.
- P E N Z DESC; Point,east,north,elev.,code,desc separated by spaces.
- CSV ASCII with Standard Errors

You can also set the output precision of the coordinates for the ASCII output file. This setting only applies to ASCII files, not to the C&G or Carlson binary coordinate files which are stored to full double precision.

* N/E Precision: number of places after the decimal to use for North and East values (0 -- 8) in the output NEZ ASCII file.

* Elevation Precision: number of places after the decimal to use for Elevation values (0 -- 8) in the output NEZ ASCII file.

Write to Coordinate File: If you want to write the calculated coordinates directly to a Carlson-supported coordinate file, check the "Write to Coordinate File" box and select the file. You can choose the type of Carlson/C&G file to be created when you 'select' the file to be created. You may wish to leave this box unchecked until you are satisfied with the adjustment. Specifying the File Extension will govern the type of file being created.

There are two check-boxes below the Output File edit box:

1. **Do not overwrite elevations** - If this is checked the existing elevations in the coordinate file will not be changed.
2. **Do not overwrite descriptions** - If this is checked the existing point descriptions in the coordinate file will not be changed.

Overwriting exiting points:

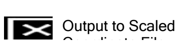
* NOTE: After the adjustment the coordinates will be written to the selected output file. If coordinate points already exist in the coordinate file, before a point is written, you will see the following "Point Protection" dialog box:

Cancel: Cancel the present operation. No more points will be written to the coordinate file.

Overwrite: Overwrite the existing point. Notice that if you check the 'Do Not Ask Again' box, all further duplicate points will be overwritten without prompting.

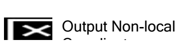
Do not Overwrite: The existing point will not be overwritten. Notice that if you check the 'Do Not Ask Again' box, all further duplicate points will automatically not be overwritten - only new points will be written.

Scaled Coordinate File: You are also allowed to output coordinates to a second, scaled or ground, coordinate file. Check the "Create Scaled/Ground NEZ file" box (see below):



If you are working with a **Local** coordinate system as defined in the Coordinate System tab, you will only be allowed to manually enter a scale factor. You can select the output file format and the output file.

If you are working in a non-local coordinate system (*i.e.* 1983 State Plane), you will have the following scaling options:



You can either enter a scale factor or use the computed grid to ground scale factor. If you select to use the computed scale factor, SurvNET will use the "average combined scale factor" as shown in the project report file.

You will also be required to enter the point number of the point you will be scaling around. This function can also be used as a translation tool. You can either "Use the Current NE values" (no translation), "Enter the new NE values" (desired N and E values for the scaling point), or "Enter Translation Values" (enter the actual delta-north and delta-east values).

If the Scaled Coordinate file exists when you process the project, you will see the following warning dialog box:

Overwrite Existing Scaled Coordinate

If you pick OK the points in the Scaled File will be overwritten. If you Cancel no point will be written to the Scaled File.

Global Settings

The menu option "Settings -- Global Settings" displays the following dialog box. If the 'Use Carlson Utilities' is chosen then the .RW5 editor will be the default raw editor and Carlson SurvCom will be the default data collection transfer program. If the 'Use C&G Utilities' is chosen then the C&G .CGR editor will be the default raw editor and C&G's data collection transfer program will be the default data collection transfer program. For additional information, refer to the Raw Data Files and Raw Data Editor Functions section of this manual.

Global

User-Interface (for CAD versions of SurvNET) - Indicate the desired graphical user interface (*gui*, "gooey") you wish to use.

Drawing Settings

If you are running SurvNET from inside Carlson Survey, you can draw the network into the active drawing file. These are the settings for the Draw Network function.

Drawing Settings

NOTE: As a reference, the following is the suggested *National CAD Standards* layer list for the Drawing Settings dialong box:

- V-CTRL-TRAV
- V-CTRL-NODE-SHOT
- V-CTRL-NODE-KNOW
- V-CTRL-HVPT
- V-CTRL-GRID
- V-CTRL-GRID-SHOT
- V-CTRL-LINE-NETW
- V-CTRL-LINE-SHOT
- V-CTRL-LINE-DIRC
- V-CTRL-LINE-SHOT
- V-CTRL-TRAV-ERRO

Check the type points and lines you want to draw. If you want to draw the error ellipse at each point check the "Draw Error Ellipses" box. You can choose a layer for all the points and lines and a symbol for all the points.

Process Menu

The Processing buttons from left to right are:

Network Adjustment - adjusts the network and creates a results report
Preprocess, compute unadjusted coordinates - processes the network, calculates positions and creates an error and coordinate report
Blunder Detection - processes the network based on three user selected parameters and creates an error report
Draw Network - draws the network in an open CAD drawing based on the Drawing Settings set in the Project Settings

Network Adjustment

When you select Process -- *Network Adjustment* from the menu, the raw data will be processed and adjusted using least squares based on the Project Settings. If there is a problem with the reduction, you will be shown error messages that will help you track down the problem. Additionally a .ERR file is created that will log and display error and warning messages.

The data is first preprocessed to calculate averaged angles and distances for sets of angles and multiple distances. For a given setup, all multiple angles and distances to a point will be averaged prior to the adjustment. The standard error as set in the Project Settings dialog box is the standard error for a single measurement. Since the average of multiple measurements is more precise than a single measurement, the standard error for the averaged measurement is computed using the standard deviation of the mean formula.

Non-linear network least squares solutions require that initial approximations of all the coordinates be known before the least squares processing can be performed. So, during the preprocessing approximate coordinate values for each point are calculated using basic coordinate geometry functions. If there is inadequate control or an odd geometric situation, SurvNET may generate a message indicating that the initial coordinate approximations could not be computed. The most common cause of this problem is that control has not been adequately defined or there are point numbering issues.

Side-shots are separated from the raw data and computed after the adjustment (unless the "Enable sideshots for relative error ellipses" toggle is checked in the Adjustment dialog box). If side shots are filtered out of the least squares process and processed after the network is adjusted, processing is greatly sped up, especially for a large project with a lot of side shots.

If the raw data processes completely, a report file, .RPT, a .NEZ file, an .OUT file, and an .ERR file will be created in the project directory. The file names will consist of the project name plus the above file extensions. These different files are shown in separate windows after processing. Additionally, a graphic display of the network can be generated.

.RPT file: This is an ASCII file that contains the statistical and computational results of the least squares processing.

.NEZ file: This file is an ASCII file containing the final adjusted coordinates. This file can be imported into any program that can read ASCII coordinate files. The format of the file is determined by the ASCII NEZ setting in the Project Settings dialog box.

.OUT file: The .OUT file is a formatted ASCII file of the final adjusted coordinates suitable for display or printing.

.ERR file: The .ERR file contains any warning or error messages that were generated during processing. Though some warning messages may be innocuous it is always prudent to review and understand the meaning of the messages.

If you have "Write to Coordinate File" checked in the Output options dialog, the coordinates will also be written to a coordinate file (.CRD by default).

The following is an example of the initial report displayed in the dialog box showing the calculation results.

Users can see immediately the results of the Chi Square test along with other pertinent information. you can also toggle each tab to see additional information. To review and print a complete report, use the Report button.

Processing a GPS Vector Network

GPS vector networks can be adjusted with SurvNET. This chapter will describe the processing of a simple GPS network. Following is a graphic view of the GPS network that is to be adjusted. Points A and B are control points. The magenta lines represent measured GPS vectors. Most GPS vendor's software can output GPS vectors to a file as part of the post-processing of GPS data.

When processing GPS vectors, certain project settings are important. In the following settings dialog box, notice that the 3D-model has been chosen and SPC 1983 with the appropriate zone has been chosen. The 3-D model and a geodetic coordinate are required when processing GPS vectors. Though it is not required for GPS processing, it is in most cases appropriate to choose to do geoid modeling.

Sample GPS Processing

The following settings dialog box shows the raw files used in processing GPS files. A GPS vector file must be chosen. GPS vector files from various GPS vendors are supported. Select the vector files to be processed:

Coordinate control for the network can be in one of several files. The control can be located in the GPS vector file itself. More typically, the control points can be regular coordinate records in the .RW5 or the .CGR file. They also can be entered as 'Supplemental Control' in one of the available formats.

When the control coordinates are in the raw data file they are expected to be grid coordinates with orthometric heights.

The supplemental control file formats support grid coordinates with orthometric heights, geographic coordinates with orthometric heights, or geocentric coordinates with ellipsoid heights.

If the control coordinates are found in the GPS vector file, they are assumed to be Geocentric ECEF (earth-centered-earth-fixed) XYZ coordinates. As shown in the dialog above, it is not unusual to have different distance units for GPS, total station data, and control data. GPS vector data is usually in metric units but the total station raw file can be in US Feet. So, the distance units must be specified for the different raw data types.

In the Preprocessing Settings dialog box, the only important setting is the **Compute Closures** option. If GPS loop or point-to-point closures need to be computed, the point numbers defining the loops need to be entered into a Closure File. See the discussion on traverse closures to see how to create Closure Files.

GPS Preprocessing

There are two GPS standard errors fields in the Standard Errors Settings dialog box. The GPS vector XYZ standard errors and covariances do not need to be defined as project settings since they are found in the GPS vector data files.

GPS Standard Error

For more information, see the discussion on GPS Standard Errors.

Processing a Total Station and a GPS Vector Network

Processing a GPS vector network together with conventional total station data is similar to processing a GPS network by itself. The only difference in regards to project settings is that a raw data file containing the total station data needs to be chosen as well as a GPS vector file. The project must be set up for the 3D model and a geodetic coordinate system needs to be chosen. **The total station data must be 3D, all rod heights and instrument heights must be measured.**

Following is a view of the Input Files Settings dialog box showing both a GPS vector file and a total station raw data file chosen in a single project. It is not uncommon to have different distance units for GPS data and total station data, so make sure the correct units are set for data types.

One of the most common problems for new users in combining GPS and total station data is not collecting HI's and rod heights when collecting the total station data. Since the 3D model is being used complete 3D data needs to be collected. If you only have 2D traverse data, you can adjust the GPS vectors first and then use the adjusted coordinates as control for the Traverse data project.

Preprocess, Compute Unadjusted Coordinates

The 'Preprocess, Compute Unadjusted Coordinates' option allows the computation of unadjusted coordinates. If there are redundant measurements in the raw data, the first angle and distance found in the raw data is used to compute the coordinates. If a State Plane grid system has been designated the measurements are reduced to grid prior to the computation of the unadjusted coordinates. If the point is located from two different points the initial computation of the point will be the value stored.

Blunder Detection

A variety of blunder detection tools are available that gives the user additional tools in analyzing the survey data and detecting blunders. The standard least squares adjustment processing and its resulting report can often be used to determine blunders. No blunder detection method can be guaranteed to find all blunders. So much depends on the nature of the network geometry, the nature of the measurements, and the intuition of the analyst. Generally, the more redundancy there is in a network the easier it is to detect blunders.

There are three different methods that can be used to track down blunders in a network or traverse:

1. Preprocess the raw data
2. Float one observation
3. Reweight based on residuals

Option 1) Preprocess the raw data:

Preprocess the Raw

The **Preprocess the raw data** option validates the raw data. It displays angle and distance spreads as well as checks the validity of the raw data. Traverse Closures are computed if specified. It also performs a "K-Matrix" analysis. The "K-Matrix" analysis compares the unadjusted, averaged measurements with the computed preliminary measurements (measurements calculated from the preliminary computed coordinates). This method will catch blunders such as using the same point number twice for two different points. The report will be sent to the .ERR file. The .ERR file will contain the tolerance checks, closures and the K-Matrix analysis. Following is an example of the report created using the 'Preprocess the raw data' option. Notice that the first section of the report shows the angle and distance spreads from the multiple angle and distance measurements. The second part of the report shows the 'K-matrix' analyses.

Additionally there is a 'Point Proximity Report' section that reports pairs of different points that are in close proximity to each other which may indicate where the same point was collected multiple times using different point numbers.

The 'Preprocess the raw data' option is one of the simplest and effective tools in finding blunders. Time spent learning how this function works will be well spent. If the project is not converging due to an unknown blunder in the raw data, this tool is one of the most effective tools in finding the blunder. Many blunders are due to point numbering errors during data collections, and the 'K-matrix' analysis and 'Point Proximity' search are great tools for finding this type blunders.

```
     =====================================
     LEAST SQUARES ADJUSTMENT ERROR REPORT
     =====================================

Tue Mar 21 16:04:00
Input Raw Files:
    C:\Carlson Projects\cgstar\CGSTAR.CGR
Output File: C:\Carlson Projects\cgstar\cgstar.RPT

Checking raw data syntax and angle & distance spreads.

Warning: Missing Vert. Angle. Assumption made as to whether it is direct or reverse.
  1                                    5.00  180.00050                             4
Warning: Missing Vert. Angle. Assumption made as to whether it is direct or reverse.
  1                                    5.00  180.00070                             5
Warning: Missing Vert. Angle. Assumption made as to whether it is direct or reverse.
  1                                    5.00  180.00100                            10
Warning: Missing Vert. Angle. Assumption made as to whether it is direct or reverse.
  1                                    5.00  180.00020                            11
Warning: Missing Vert. Angle. Assumption made as to whether it is direct or reverse.
  1                                    5.00  325.54320                             2     H&T
Warning: Missing Vert. Angle. Assumption made as to whether it is direct or reverse.
  1                                    5.01  145.54300                             2     H&T
Warning: Missing Vert. Angle. Assumption made as to whether it is direct or reverse.
  1                                    5.01  180.00020                            12
Horizontal Angle spread exceeds tolerance:
  IP: 1,  BS: 5,  FS: 2
  Low: 109-19'10.0" ,  High: 109-19'17.0" ,  Diff: 000-00'07.0"

Horizontal Angle spread exceeds tolerance:
  IP: 2,  BS: 1,  FS: 6
  Low: 190-32'02.0" ,  High: 190-32'10.0" ,  Diff: 000-00'08.0"

Horizontal Angle spread exceeds tolerance:
  IP: 2,  BS: 1,  FS: 3
  Low: 096-03'48.0" ,  High: 096-03'56.0" ,  Diff: 000-00'08.0"

Horizontal Angle spread exceeds tolerance:
  IP: 3,  BS: 2,  FS: 4
  Low: 124-03'50.0" ,  High: 124-03'56.0" ,  Diff: 000-00'06.0"

Horizontal Angle spread exceeds tolerance:
  IP: 5,  BS: 4,  FS: 10
  Low: 039-26'35.0" ,  High: 039-26'45.0" ,  Diff: 000-00'10.0"

Horizontal Angle spread exceeds tolerance:
  IP: 10,  BS: 5,  FS: 11
  Low: 241-56'23.0" ,  High: 241-56'35.0" ,  Diff: 000-00'12.0"

Horizontal Angle spread exceeds tolerance:
  IP: 11,  BS: 10,  FS: 12
  Low: 114-56'20.0" ,  High: 114-56'34.0" ,  Diff: 000-00'14.0"
```

```
Horizontal Angle spread exceeds tolerance:
  IP: 12,  BS: 11,  FS: 3
  Low: 140-39'18.0" ,  High: 140-39'31.0" ,  Diff: 000-00'13.0"

Horizontal Angle spread exceeds tolerance:
  IP: 5,  BS: 4,  FS: 1
  Low: 117-30'35.0" ,  High: 117-30'50.0" ,  Diff: 000-00'15.0"

Horizontal Distance from 2 to 3 exceeds tolerance:
  Low: 324.15,  High: 324.20,  Diff: 0.04

Vertical Distance from 2 to 3 exceeds tolerance:
  Low: 6.62,  High: 8.36,  Diff: 1.74

Vertical Distance from 3 to 4 exceeds tolerance:
  Low: 11.46,  High: 11.51,  Diff: 0.05

Horizontal Distance from 12 to 3 exceeds tolerance:
  Low: 144.64,  High: 144.66,  Diff: 0.02


K-Matrix Analysis.

Distance: From pt.: 4  To pt.: 5
   Measured distance:    309.61  Initial computed distance:    309.65
   Difference:     -0.04

Distance: From pt.: 12  To pt.: 3
   Measured distance:    144.63  Initial computed distance:    144.66
   Difference:     -0.03

Distance: From pt.: 5  To pt.: 6
   Measured distance:    348.51  Initial computed distance:    523.29
   Difference:   -174.79

Angle: IP: 4  BS: 3  FS: 5
   Measured angle:          093-02'11.5"
   Initial computed angle:  093-01'45.1"
   Difference:  000-00'26.4"

Angle: IP: 12  BS: 11  FS: 3
   Measured angle:          140-39'24.5"
   Initial computed angle:  140-40'32.6"
   Difference: -000-01'08.1"

Angle: IP: 5  BS: 4  FS: 1
   Measured angle:          117-30'42.5"
   Initial computed angle:  117-31'16.4"
   Difference: -000-00'33.9"

Angle: IP: 5  BS: 4  FS: 6
   Measured angle:          145-30'34.0"
   Initial computed angle:  079-39'46.4"
   Difference:  065-50'47.6"

Point Proximity Report:

  Points  3  and 30 are within      0.05 of each other.
```

The problem with the above project was that point 6 was accidentally used twice for two separate side shots. Because of the point numbering problem the project would not converge, using the regular least squares processing. The 'Preprocess the raw data' option was then used. Notice in the K-matrix section the distance from 5 to 6 shows a difference of 174.79' and the angle 4-5-6 shows a difference of 065-50'47.6". Then notice that the other listed differences are in the range of .02' for the distances and less than a minute for the angles. This report is clearly pointing out a problem to point 6.

Note the point proximity report section. During data collection, point number 30 was used as the point number when the point was previously collected as point 3.

In the first section of the report, notice that there are several warnings concerning whether a horizontal angle reading was collected in direct or reverse reading. The preprocessing software uses the vertical angle reading to determine the angle face of the horizontal angle reading. If the vertical angle is missing, the program makes its best guess as to whether the angle was collected in direct or reverse face. Since all horizontal angle spreads in the report are reasonable, the preprocessing software must have made the correct determination.

Option 2) Float one observation:

This option is useful in finding a single blunder, either an angle or distance, within a network or traverse. If there is more than a single blunder in the network then it is less likely that this method will be able to isolate the blunders. **If the standard least squares processing results in a network that will not converge, then this blunder detection method will not work**. Use the Preprocess the raw data blunder detection method if the solution is not converging. Also this method will only work on small and moderately sized networks. This method performs a least squares adjustment once for every non-trivial measurement in the network. So for large networks this method may take so long to process that it is not feasible to use this method.

With this method, an adjustment is computed for each non-trivial individual angle and distance measurement. Consecutively, a single angle or distance is allowed to float during each adjustment. The selected angle or distance does not "constrain" the adjustment in any way. If there is a single bad angle or distance, one of the adjustment possibilities will place most of the error in the "float" measurement, and the other measurements should have small residuals. The potentially bad angle or distance is flagged with a double asterisk (**). Since an adjustment is computed for each measurement, this method may take a long time when analyzing large data files.

The adjustments with the lowest reference variances are selected as the most likely adjustments that have isolated the blunder. You have the choice to view the best adjustment, or the top adjustments with a maximum of ten. In the above example, we asked to see the top 5 choices for potential blunders. The results are shown in the .ERR file. Following is a section of the report generated where an angular blunder was introduced into a small traverse. Notice the '**' characters beside the angle measurements. In this report the two most likely adjustments were displayed. The blunder was introduced to angle 101-2-3. Angle 101-2-3 was chosen as the 2nd most likely source of the blunder, showing that these blunder detection methods though not perfect, can be a useful tool in the analysis of survey measurements. Notice how much higher the standard residuals are on the suspected blunders than the standard residuals of the other measurements.

```
Adjusted Observations
=====================

Adjusted Distances
 From Sta.  To Sta.        Distance      Residual     StdRes.   StdDev
 101          2              68.780    -0.006         0.608    0.008
 2            3              22.592    -0.006         0.573    0.008
 3            4              47.694    -0.002         0.213    0.008
 4            5              44.954    -0.001         0.069    0.008
 5            6              62.604     0.005         0.472    0.009
 6            7              35.512     0.006         0.539    0.008
 7            101            61.704     0.003         0.314    0.009
            Root Mean Square (RMS)      0.005

Adjusted Angles
 BS Sta. Occ. Sta.  FS Sta.    Angle       Residual      StdRes    StdDev(Sec.)
 7          101      2        048-05'06"       -5          0          21
 101        2        3        172-14'33"       -2          0          27
 2          3        4        129-27'44"     -222    *     7          56   **
 3          4        5        166-09'59"       11          0          25
 4          5        6        043-12'26"       22          1          21
 5          6        7        192-11'52"       12          0          25
 6          7        101      148-38'19"        8          0          25
                               Root Mean Square (RMS)      85

Adjusted Azimuths
 Occ. Sta.  FS Sta.      Bearing           Residual    StdRes   StdDev(Sec.)
 101          7          N 00-00'00"
E             0              0            4
                Root Mean Square
 (RMS)          0

Statistics
==========

 Solution converged in 2 iterations
 Degrees of freedom:3
 Error Factors... (not shown)
 Standard error unit Weight: +/-0.88
 Reference variance:0.78
 Passed the Chi-Square test at the 95.00 significance level
 0.216 <= 2.347 <= 9.348


Adjusted Observations
=====================

Adjusted Distances
 From Sta.  To Sta.        Distance      Residual     StdRes.   StdDev
 101          2              68.781    -0.005         0.473    0.009
 2            3              22.592    -0.005         0.512    0.009
 3            4              47.690    -0.006         0.586    0.009
 4            5              44.950    -0.005         0.523    0.009
 5            6              62.605     0.006         0.607    0.009
 6            7              35.512     0.006         0.560    0.009
 7            101            61.708     0.006         0.614    0.009
            Root Mean Square (RMS)      0.006

Adjusted Angles
 BS Sta.  Occ. Sta.   FS Sta.    Angle        Residual      StdRes   StdDev(Sec.)
 7         101         2        048-05'22"       11           0        24
 101       2           3        172-11'03"     -213    *      7        58    **
 2         3           4        129-31'23"       -3           0        29
 3         4           5        166-09'48"        1           0        26
 4         5           6        043-12'11"        6           0        21
 5         6           7        192-11'50"       10           0        27
 6         7           101      148-38'24"       13           0        27
                               Root Mean Square (RMS)       81
```

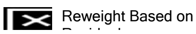
```
Adjusted Azimuths
 Occ. Sta.  FS Sta.      Bearing           Residual    StdRes   StdDev(Sec.)
 101         7          N-00-00'00"E          -0            0             5
                Root Mean Square (RMS)          0

Statistics
==========

 Solution converged in 2 iterations
 Degrees of freedom:3
 Error Factors... (not shown)
 Standard error unit Weight: +/-0.94
 Reference variance:0.89
 Passed the Chi-Square test at the 95.00 significance level
 0.216 <= 2.675 <= 9.348
```

The blunder is most likely in the measurement containing the largest residual and standard residual. The observation marked with ** is the observation that floated. It is also most likely the measurement containing the blunder.

Option 3) Reweight based on residuals:



This method is capable of detecting multiple blunders but one is more likely to find the blunders if there is a high degree of redundancy (network of interconnected traverses). The higher the degree of freedom the more likely this method will find the blunders. **This method will not work if the standard least squares processing will not converge**. Use the Preprocess the raw data blunder detection method if the network is not converging.

First, select the number of adjustments or passes you wish to make. Each time an adjustment is completed, the measurements will be re-weighted based on the residuals and standard errors. Hopefully, after three or four passes, the blunders will become obvious. The results are shown in the .ERR file, look for the measurements with the highest standard residuals. These measurements are more likely to contain blunders.

The theory behind this method is that after processing, the measurements with blunders are more likely to have higher residuals and computed standard errors. So, in the next pass the measurements are re-weighted based on the computed residuals, with less weight being assigned to the measurements with high residuals. After several passes it is likely that the measurements with the blunders have been reweighed such that they have little effect on the network.

As a rule of thumb, three or four passes are usually sufficient. Following is a section of the report showing the results of the 'Reweight based on residuals'. This report was generated using the same data used in the earlier example. Notice that it has flagged the same two angle measurements.

The 'Reweight based on residuals' method performs a new adjustment for each pass. So, this method will take longer than the standard least squares adjustment, but does not take near as long to complete processing as the Float one Observation method for larger networks.

```
Adjusted Observations
=====================

Adjusted Distances
 From Sta.  To Sta.        Distance      Residual     StdRes.   StdDev
 101          2              68.778    -0.009         0.827    0.014
 2            3              22.588    -0.010         0.942    0.015
 3            4              47.694    -0.002         0.208    0.009
 4            5              44.954    -0.001         0.077    0.006
 5            6              62.608     0.010         0.919    0.016
 6            7              35.517     0.011         1.040    0.016
 7            101            61.705     0.004         0.398    0.011
            Root Mean Square (RMS)      0.008

Adjusted Angles
 BS Sta.   Occ. Sta.   FS Sta.       Angle          Residual     StdRes   StdDev(Sec.)
 7          101         2          048-05'07"        -4            0       21
 101        2           3          172-13'19"       -77     *      2       65
 2          3           4          129-29'56"       -91     *      3       64
 3          4           5          166-09'44"        -3            0       24
 4          5           6          043-12'05"         0            0        9
 5          6           7          192-11'40"        -0            0       19
 6          7           101        148-38'10"        -1            0       20
                               Root Mean Square (RMS)          45

Adjusted Azimuths
 Occ. Sta.  FS Sta.      Bearing           Residual    StdRes   StdDev(Sec.)
 101         7          N 00-00'00"E           0            0             2
                Root Mean Square (RMS)          0


Statistics
==========

 Solution converged in 1 iterations
 Degrees of freedom:3
 Error Factors... (not shown)
```

```
Standard error unit Weight: +/-1.33
Reference variance:1.77
Passed the Chi-Square test at the 95.00 significance level
0.216 <= 5.322 <= 9.348
```

The blunders are most likely in the measurements containing the largest residuals and standard residuals.

Draw Network

If you are running SurvNET from inside Carlson Survey with AutoCAD or IntelliCAD, you can draw the network in the DWG file. The Drawing Settings option located in the Settings Menu will determine the layers and symbols used for each point and line entity.

The Draw Network option will not be available until the network has been adjusted. After the adjustment, you can select Draw Network.

Your project will be drawn in the drawing (.DWG) file. Put focus back in the CAD program to view the network.

Draw

Once the network is drawn in CAD, you are able to use the CAD entities themselves interactively with the raw files. This allows you to make edits to data such as adding specific standard errors to points and measurements with greater ease. See Raw Data Files and Raw Data Editor Functions for more on editing raw data.

Tools Menu

There are a variety of **Tools** for working within the SurvNET project manager.

From left to right/top to bottom, the tools are:
EDM Calibration - offers an option to enter field measurements and calibrate to a published base line.
Point Search - Searches for points by name
Inverse - calculates the direction and horizontal distance between two points
Relative Error Ellipses - calculates the error ellipse between two points
Conversion Tools - converts data formats of raw input files

- Convert GPS/Total Station File
- Convert Level Files

EDM Calibration

The EDM Calibration program allows a surveyor to enter and process the raw data collected on an EDM calibration baseline. The purpose of an EDM calibration is to determine if the EDM is measuring within standards. The program performs a statistical analysis of that data as outlined in "*Use of Calibration Base Lines*", by Charles J. Fronczek, NOAA Technical Memorandum NOS NGS-10. The NGS document can be downloaded from the NGS website. NGS maintains a webpage on EDM Calibration Base Lines. The manual and other information on EDM calibrations can be found at https://www.ngs.noaa.gov/CBLINES/calibration.shtml. Following is the main EDM Calibration dialog box. NGS publishes the EDM calibration data in metric units. SurvNET's EDM calibration program currently expects the data to be collected in meters.

The basic flow of this program is to first fill out the lower portion of the dialog box which contains different text fields, EDM constant values, and the optional Atmospheric Corrections settings. Next, fill out the grid in the upper portion of the dialog box. This grid contains the field data collected and also the published distances between monuments of the baseline. After this information has been filled out use the 'Compute' button The program will then display the result of the calibration in the window in the lower portion of the dialog box as follows.

After the file is processed, the results can be stored as an ASCII text file. Use the **Save Output** or the menu option "File/Save Results File As..." to save the results. First, you will be prompted for an output file name. The input data can also be stored. Once stored it can be opened and processed again.

Following is the entire output with a brief explanation of the results. Comments about the results are inserted in **bold**:

EDM Calibration Report

Observed Data

EDM Type:
Date: Time:
Prism description:
Weather description:
Comment:
Atmosphere Correction: OFF
Constants: Refrector: 0.000 EDM: 0.000

From Sta.	From Elev.	From HI	To Sta.	To Elev.	To HI	Temp.	Pressure	Observed Slope Dist.	Published Dist.
STA_0	47.494	1.576	STA_150	44.631	1.552	0.0	0.0	150.0326	150.0008
STA_0	47.494	1.576	STA_400	41.497	1.537	0.0	0.0	400.0229	399.9772
STA_0	47.494	1.576	STA_1100	41.431	1.519	0.0	0.0	1100.0203	1100.0001
STA_150	44.631	1.570	STA_1100	41.431	1.519	0.0	0.0	950.0081	949.9991
STA_400	41.497	1.583	STA_1100	41.431	1.519	0.0	0.0	700.0265	700.0226
STA_400	41.497	1.580	STA_150	44.631	1.480	0.0	0.0	249.9946	249.9764
STA_400	41.497	1.580	STA_0	47.494	1.526	0.0	0.0	400.0260	399.9722

The above section shows the input. The input consists of the observed slope distances and the measured HI's. The from and To elevations are published data from the data sheet from NGS on the particular baseline being observed. The published distances are also published data from the data sheet from NGS. In this example atmospheric pressure was turned off so the Temperature and Pressure fields are irrelevant.

Results

```
Null Hypothesis, HO: EDM scale error and EDM constant error = 0.0
```

If the scale error and the EDM constant are 0.0, then the EDM is without error. So the purpose of the statistical test is to test how close to 0.0 are the results.

```
Scale Error (ppm): -0.00000044
Constant Error: -0.0032
```

The two above lines show the values for the computed scale error and constant error.

```
Scale Standard Error: 0.00000403
Constant Standard Error: 0.0026
```

The two above lines show the values for the computed standard errors of the scale error and constant error.

```
Reference Variance: 0.0000126
Scale t-Value: -0.1096
Constant t-Value: -1.2110
Degrees of Freedom: 5
Critical t-Value at the 1 percent confidence level: 4.0320
Cannot reject the H0 for the scale error. (The scale factor is 0.0)
Cannot reject the H0 for the constant error. (The constant is 0.0)
```

The above lines show the final results of the statistical test. Since the test determined that we cannot reject the null hypothesis, this EDM is in good working order.

EDM Calibrations and Atmospheric Corrections

The atmospheric correction algorithms used in the EDM calibration are from the NGS manual. To use this method both dry-bulb and wet-bulb temperature needs to be measured, or the vapor pressure, e, and the dry bulb temperature needs to be measured. Refer to the NGS documentation for a detailed explanation of the atmospheric corrections that they use.

It is probably most common to turn atmospheric correction off in the calibration program, and turn atmospheric correction ON on the EDM (total station). When atmospheric correction is turned off in the calibration program, the user does not need to enter the temperature into the grid or any of the other atmospheric values. If atmospheric corrections are turned OFF then the grid input columns 'Temp. (dry bulb)', 'Pressure, (mm of Hg)', and 'Temp. (wet bulb)' will not be displayed since they are not needed.

Constants can be entered for both the EDM and the reflector. These values are added to the observed distances during processing. Typically they are set to 0.0.

The following text fields have no effect on any computations and are simply comments that can be used to document the calibration.

Entering Data Into the EDM Calibration Grid

Blank data records are inserted into or deleted from the grid using the following tool bar.

The first button deletes the current highlighted record. The second button inserts a new blank record before the current highlighted record. The third button inserts a new blank record after the current highlighted record. Alternately the 'Edit' menu options could be used to delete and insert new data records.

Following is a brief explanation of the fields that make up the grid.

- **From Sta.** - This field represents the station name where the EDM is located. Any name can be used, but you must be consistent and used the same name whenever you occupy or measure a distance to the station.
- **From HI.** - This field represents the height of instrument of the from station. It should be in the same units as the measurements. If horizontal distances are being entered into the grid then all the HI fields should be set to a constant value such as 0.0.
- **From Elev.** - This field represents the elevation of the station. This value is published as part of the baseline calibration sheets obtained from NGS. If horizontal distances, then all the Elevation fields should be set to a constant.
- **To Sta.** - This field represents the station name where the prism is located. Any name can be used, but you must be consistent and used the same name whenever you occupy or measure a distance to the station.
- **To HI.** - This field represents the height of instrument of the to station. It should be in the same units as the distance measurements. If horizontal distances are being entered into the grid, then all the HI fields can be set to a constant value such as 0.0.
- **To Elev.** - This field represents the elevation of the station where the prism is located. This value is published as part of the baseline calibration sheets obtained from NGS. If horizontal distances, then all the Elevation fields should be set to a constant.
- **Observed S. Dist.** - This is the measured slope distance. This can be a measured horizontal distance. If it is a horizontal distance then all the HI's and elevations should be set to a constant value.
- **Published Dist.** - This field represents the published distance between the From and To station. This value is published as part of the baseline calibration data obtained from NGS for the particular baseline being observed.
- **Temp. C. (dry bulb)** - This field is only present if atmospheric corrections are turned on. Provide the dry bulb temperature in degrees Centrigrade.
- **Pressure. (mm of Hg)** - This field is only present if atmospheric corrections are turned on. Provide the atmospheric pressure in millimeters of Mercury.
- **Temp. (wet bulb)** - This field is only present if atmospheric corrections are turned on. Provide the wet bulb temperature in degrees Centrigrade.

Search Point

Searches and indicates the location of a point in the drawing file.

Inverse

The 'Inverse' command is only active after a network has been processed successfully. This option can be used to obtain the bearing and distance between any two points in the network. Additionally the standard deviation of the bearing and distance between the two points is displayed.

Relative Error Ellipse

The 'Relative Error Ellipse' command is only active after a network has been processed successfully. This option can be used to obtain the relative error ellipse between two points. It shows the semi-major and semi-minor axis and the azimuth of the error ellipse, computed to a user-define confidence interval. This information can also be used to determine the relative precision between any two points in the network. It is the relative error ellipse calculation that is the basis for the ALTA tolerance reporting. If the Enable sideshots for relative error ellipses toggle is enabled, then all points in the project can be used to compute relative error ellipses. The trade-off is that with large projects, processing time will be increased.

If you need to certify as to the "Positional Tolerances" of your monuments, as per the ALTA Standards, use the **Relative Error Ellipse** inverse routine to determine these values, or use the specific ALTA tolerance reporting as you desire.

For example, if you must certify that all monuments have a positional tolerance of no more than 0.07 feet with 50 PPM at a 95 percent confidence interval. First set the confidence interval to 95 percent in the Settings/Adjustment screen. Then process the raw data. Then you may inverse between points in as many combinations as you deem necessary and make note of the semi-major axis error values. If none of them are larger than 0.07 feet + (50PPM*distance), you have met the standards. It is however more convenient to create a Relative Error Points File containing the points you wish to check and include the ALTA tolerance report. This report takes into account the PPM and directly tells you if the positional tolerance between the selected points meets the ALTA standards.

Conversion Tools

Convert GPS/Total Station Files

The purpose of this option is to convert GPS vector files that are in the manufacturers' binary or ASCII format into the StarNet ASCII file format. The advantage of creating an ASCII file is that the ASCII file can be edited using a standard text editor. Being able to edit the vector file may be necessary in order to edit point numbers so that the point numbers in the GPS file match the point numbers in the total station file.

There is also a tool to convert Trimble Data Exchange total station data to either the Carlson RW5 format or the C&G CGR format. The following dialog box is displayed after choosing this option.

GPS

First choose the file format of the GPS vector file to be converted. Next use the 'Select' button to navigate to the vector file to be converted. If you are converting a Thales file you have the option to remove the leading 0's from Thales point numbers. Next, use the second 'Select' button to select the name of the new ASCII GPS vector file to be created. Choose the 'Convert' button to initiate the file conversion. Press the 'Cancel' button when you have completed the conversions. The file created will have an extension of .GPS. Following are examples of different GPS formats that can be converted to ASCII:

- **Ashtech/Thales 'O' files:** - Typically have .obn extensions and are binary files. Notice that you have the option to remove the leading 0's from Thales point numbers, by checking the "Remove leading 0's from Thales point numbers" check box.
- **Carlson .RW5** - (containing GPS vectors)
- **GeoLab IOB**
- **LandXML (.XML):** - The LandXML format is an industry standard format. Currently SurvNET will only import LandXML survey point records. The conversion will not import LandXML vectors.
- **Leica:** - The Leica vector file is an ASCII format typically created with the Leica SKI software. This format is created by Leica when baseline vectors are required for input into 3rd party adjustment software such as SurvNET. The SKI ASCII Baseline Vector format is an extension of the SKI ASCII Point Coordinate format.
- **NGS G-File:** - National Geodetic Survey format.
- **NGS G-File from OPUS report:** - National Geodetic Survey format as used in the OPUS report
- **TDS (.RAW):** - Import vector records from a TDS raw data file.
- **Topcon (.TVF):** - The Topcon Vector File is in ASCII format and typically has an extension of .TVF
- **Topcon (.XML):** - The Topcon XML file is an ASCII file. It contains the GPS vectors in an XML format. This format is not equivalent to LandXML format.
- **Trimble Data Exchange Format (.ASC):** - The Trimble TDEF format is an ASCII file. It is typically output by Trimble's office software as a means to output GPS vectors for use by 3rd party software.
- **Trimble Data Collection (.dc):** - The Trimble .dc format is an ASCII file. It is typically output by Trimble's data collector. It contains a variety of measurements including GPS vectors. This option only converts GPS vectors found in the .DC file.

- **Trimble LandXML (*.jxl):** This is Trimble's Land XML format.

  NOTE: The Trimble Data Collection (.dc) and Trimble LandXML (.jxl) formats allow you to bring in both GPS vectors (creating a .GPS file) and Total Station data (creating a .RW5 file) at the same time.

Convert Level Files

The purpose of this option is to convert differential level files from digital levels into C&G/Carlson differential level file format. At present the only level file format that can be converted are the level files downloaded from the Topcon digital levels.

Level Conversion

View Menu

Graphics

SurvNET provides a window that graphically displays the survey network. Additionally the user is able to display Error Ellipses, and GPS vectors. The user has much control over how the network is displayed. The graphic tool is a useful tool in debugging networks since the raw data can be displayed prior to adjustment. If there are problems with the raw data the graphics often reflect the problem. The actual graphics cannot be output or saved. The graphics can be shown independent of whether the project has been processed.

The following snapshot shows a view of the graphic window. The graphic window can be accessed using the "eye" icon on the main tool bar. A project must be opened before the graphic window can be displayed. The graphics window will only display Error Ellipses after the project has been processed.

Display

The tool bar in the graphics window contains buttons that allow the user to pan, zoom in, zoom out, zoom extents, and zoom to a window. Additionally there is a button that allows the user to navigate to points in the .CGR raw data editor. Also, there are buttons that will refresh the graphic, and change the graphic settings.

Display Controls

Icon	Friendly Name	Action
Pan	Pan	Use this button to position the graphics to a different position on the display.
Zoom In	Zoom In	Use this button to increase the magnification of the graphics.
Zoom Out	Zoom Out	Use this button to decrease the magnification of the graphics.
Zoom Extents	Zoom Extents	Use this button to fit the content of the entire project into the limits of the available display.
Zoom Window	Zoom Window	Use this button to display the content of the project within the rectangular confines defined by two corner "pick-points".
Pick Point	Pick Point	This button allows the user to navigate within the (.CGR) Raw File Editor from the graphics window. It also allows you to pick points when creating a Traverse Closure file.
Graphics Settings	Graphics Settings	This buttons is used to change the graphic display settings.
Refresh	Refresh	This button will refresh the graphic view. Graphics are generated from the saved raw data file. If you make changes to the raw file in the raw editor you must save the project before the changes will be reflected in the refreshed graphic screen.

Graphics Settings

Following is a description of the options in the Graphics Setting dialog box.

Points Options

These settings determine how the different type control points are displayed in the graphics window. Different graphic settings can be applied to standard control points, fixed control points and floating control points. The symbol node display can be controlled as to symbol type, symbol color, symbol size. The control point name can be displayed and its size set from this setting dialog box.

The graphic pick radius defines a search radius. This radius is used when navigating the .CGR editor using the graphic window. You can pick a point graphically and the cursor in the editor will go to the next field containing that point number. The radius is defined in terms of the distance units of the raw data file.

Graphics

Trav/SS's Options

These settings determine how the network line work will be displayed for total station raw data. There are settings for traverse data, side shot data, and azimuth control. The program considers any point that has only a single angle and distance to it a side shot. The user can control the color of the traverse lines. The symbol node display can be controlled as to symbol type, symbol color, symbol size. The point name can be displayed and its size set from this setting dialog box.

Trav/SS

Error Ellipses Options

These settings determine how the error ellipses will be displayed in the graphic window. Error ellipses will only be displayed if there is a successful least squares adjustment. The display of the error ellipses is relative. The program automatically determines a default relative error ellipse size. The user can modify the visual size of the error ellipses using the track bar in the following dialog box. The user can also control the color of the error ellipse from the following dialog box.

Error Ellipse

GPS Options

The settings in the following dialog box determine how GPS vectors will be displayed in the graphic window. The user can control the color of the GPS vector lines. The symbol node display can be controlled as to symbol type, symbol color, symbol size. The GPS point names can be displayed and their size set from this setting dialog box. GPS side-shots (points defined by a single vector) can be controlled separately.

GPS Graphics

Toolbar Short-cuts

Many of the more commonly used functions can be accessed using the toolbar:

SurvNET

SurvNET Toolbar Short-cuts

Icon	Menu Location	Action
New	File -- New Project	Creates a New Project.
Open	File -- Open Project	Opens an Existing Project.
Save	File -- Save Project	Saves the Current Project.
Print	File -- Print	Prints the Specified Output.
Standard	Settings -- Project Settings -- Standard Errors	This icon initiates the **Project Settings** -- Standard Errors tab.
Data Collector	Tools -- Data Collector Transfer	[Legacy Application] - This icon will initiate either the specified "handshaking" program designed to communicate with numerous field collection data collection devices thus permitting the user to directly transfer data from the field device into SurvNET (and vice versa).
Edit	Tools -- Edit Raw Files	This icon can be used to review or edit your raw data file(s). If your project has multiple raw data files, you will be shown a list and asked to select the file you wish to edit.
Process	Process -- Network Adjustment	This icon will process the available data against the specified Project Settings and displays any pertinent results or alerts.
Inv	Tools -- Inverse	This icon will provide the ability to inverse between a pair of specified points (once the network has been adjusted) to get the angle and distance information between the specified points.
Relative Error	Tools -- Relative Error Ellipse	This icon will provide the ability to generate the Relative Error Ellipse information between a pair of specified points (once the network has been adjusted).
Gra	Window -- Graphics	This icon is active once a project has been opened and displays the graphical results (if any) of the traverse, sideshot(s) and GPS points.
	Help -- SurvNET Help	This icon will take you to the SurvNET Help/on-line documentation.

Raw Data Files and Raw Data Editor Functions

SurvNET works equally well for both Carlson users and C&G users. The primary difference between the two users is that a Carlson user will typically be using an .RW5 file for raw data and a C&G user will typically be using a .CGR file.

SurvNET is capable of processing either C&G (.CGR) raw data files, Carlson (.RW5) raw data files or SDMS (.PRJ) raw data files. If the raw data is in another format, you can use our conversion tools to create one of the supported formats. Select the desired type of raw file editor as described under Settings -- Global Settings.

Measurement, coordinate, elevation and direction (Brg/Az) records are all recognized. Scale factor records in the .CGR file are not processed since SurvNET calculates the State Plane scale factors automatically.

Once raw data is entered, the network can be processed. Often it is desired to apply a standard error for a particular measurement or control point that is different than those set in the Project Settings. This can be accomplished by editing the Standard Errors of specific or groups of points or measurements.

Entering Raw Data Files:

There are four types of Raw Data Files files you can add and process as part of a single network:
Raw Data File - traditional total station files (usually ground measurements)
GPS Vector File - GPS observations in the form of vector data
Differential Levels - standard differential level or Trig observations for vertical control
Control File - point records to be used as control for the network.

Raw Data File

To process traverse raw data, click the **Add** (red + button) and select the **Raw Data File** to insert raw total station files into the list. Use **Remove** (red - button) to remove raw files from the list. All the files in this list are included in the Least Squares adjustments. Having the ability to choose multiple files allows one to keep Control in one file and measurements in another file. Or, different files collected at different times can be processed all at one time. If you have multiple crews working on the same project using different equipment, you can have "crew-specific" raw data files with standard error settings for their particular equipment. Having separate data files is also a convenient method of working with large projects. It is often easier to debug and process individual raw files. Once the individual files are processing correctly, all the files can be included for a final adjustment. You can either enter C&G (.CGR) raw files or Carlson (.RW5) files into the list for processing. You cannot have both .CGR and .RW5 files in the same project to be processed at the same time. Notice that you have the ability to highlight multiple files when removing files from the project.

Note that if you are processing Carlson RW5 total station files, you have the option of including GPS vectors that can be collected by SurvCE/SurvPC and stored in the RW5 file. Alternatively, you can select the RW5 file in the GPS vector section. **If the "Include any GPS vectors" option in the Total Station Data Files section is checked, you will have the option to use the Base Point records in the RW5 file as control**. If "Use BP records as control" is NOT checked, or the RW5 file is selected in the GPS vector section, you must define the control in either the RW5 file as POINT records or in a Supplemental Control File.

To set these options, select the **Settings** option from the main menu.

GPS Vector Files

GPS vector files can be entered and processed. Both GPS vector files and total station raw files can be combined and processed together. **You must have chosen the 3D mathematical model in the Coordinate System tab in order to include GPS vectors in the adjustment.**

A variety of popular GPS vector file formats are supported, including (but not necessarily limited to):

- **ASCII (StarNet)**: See below for more information on StarNet format. These files typically have .GPS extensions.
- **Ashtech/Thales 'O' files**: Typically have .obn extensions and are binary files.
- **Carlson .RW5**: (containing GPS vectors)
- **GeoLab IOB**
- **LandXML (*.xml)**
- **Leica**: Leica files are ASCII files.
- **NGS G-File**
- **NGS G-File from OPUS report**
- **Topcon (.tvf)**: Topcon .tvf files are ASCII files.
- **Topcon (.xml)**: Topcon also can output their GPS vectors in XML format which is in ASCII format.
- **TDS (.raw)**: TDS raw data file with vector information
- **Trimble Data Exchange Format (.asc)**: These files are in ASCII format
- **Trimble data collection (.dc)**: These files are ASCII.
- **Trimble LandXML (*.jxl)**

The following is a typical vector record in the StarNet ASCII format. GPS vectors typically consist of the 'from' and 'to' point number, the delta X, delta Y, delta Z values from the 'from' and 'to' point, with the XYZ deltas being in the geocentric coordinate system. Additionally the variance/covariance values of the delta XYZ's are included in the vector file.

```
.GPS WEIGHT COVARIANCE
C PRS34452 1305780.345005 -4667085.299019 4132689.544939 0.005000 0.005000 0.005000 --MON
C UCNJ 1305780.345005 -4667085.299019 4132689.544939 0.00000100 0.00000100 0.00000100 --MON
G1  UCNJ-1000    8399.71318061   -4742.15645068   -8036.07224424 --MNS
G2   3.939428e-006  2.474560e-005  1.160301e-005
G3   3.924536e-006 -3.360765e-006 -1.028503e-006
G1  UCNJ-1001    8328.15569476   -4796.59445569   -8072.25948922 --MNS
G2   9.596618e-007  1.687749e-005  1.936038e-006
G3   1.176891e-007 -8.668020e-009 -4.798408e-006
```

The first line defines what values are in the G2 and G3 records. It can be either GPS WEIGHT COVARIANCE (G2 is Variance, G3 is Covariance), or GPS WEIGHT STDERRCORRELATION (G2 is standard error, G3 is standard error correlation). This line is optional; the default is COVARIANCE.

The next two lines are coordinate control records. These records are also optional. If used, they must be Geocentric Coordinates (XYZ) in metric units. The format is as follows:

```
C  PointName  X  Y  Z  StdErrX  StdErrY  StdErrZ  --PointDescription
```

The standard errors and point description are optional.

The GO record is a comment.

The G1 record includes the 'from' and 'to' points and the delta X, delta Y, and delta Z in the geocentric coordinate system and an optional description of the rover point.

The G2 record is the variance (or standard error) of X,Y, and Z. The G3 record contains the covariance (or standard error correlation) of XY, ZX, and ZY. Most all GPS vector files contain the same data fields in different formats.

Use the 'Add' button to insert GPS vector files into the list. Use the 'Remove' button to remove GPS vector files from the list. All the files in this list will be used in the least squares adjustments. All the GPS files in the list must be in the same format. If the GPS file format is ASCII you have the option to edit the GPS vector files. The Edit option allows the editing of any of the ASCII GPS files using Notepad. Typically, only point numbers or point descriptions would be edited. The variance/covariance values are used to determine the weights that the GPS vectors will receive during the adjustment and are not typically edited.

Differential Levels

Differential and Trig level files can be entered and processed. Differential or Trig Level raw files have a .TLV extension and are created using the Carlson Level Editor. The Carlson Level Editor has several Import options that allow you to bring in levels from different formats (*e.g.* Leica, Trimble, Topcon, *etc*). You can process level data in the same project with the traverse and GPS vector data but the vertical measurements in the traverse/vectors will be part of the adjustment. If you want to use the elevations calculated ONLY from the level data, you must process it in a separate project after your traverse/vector data has been adjusted. The elevations will be written to the Output Coordinate file. Make sure your point numbers in the level data match the points in the traverse/vector data.

Supplemental Control File: The supplemental control file option allows the user to designate an additional coordinate file to be used as Control. The supplemental control file can be from a variety of different file types, including (but not necessarily limited to):

- **C&G or Carlson numeric (.CRD) files**
- **C&G Alphanumeric coordinate files (*.cgc)**
- **Carlson Alphanumeric coordinate files (*.crd)**

- **Autodesk Land Desktop (*.mdb)**
- **Simplicity coordinate files (*.zak)**
- **ASCII (.NEZ) file**
- **ASCII latitude and longitude** (3D model only)
- **CSV ASCII NEZ with std. errors** (only external control file that allows you to assign standard errors to specific points)
- **SDMS (.ctl) control file**
- **ASCII Geocentric (.xyz)** (Geocentric coordinates XYZ in metric units)

Note: For additional information on file format pertaining to the file formats above, refer to the Supplemental Control Files section of the documentation.

Note: You will not be allowed to use the same file for supplemental control points and for final output. Least Squares considers all points to be measurements. If the output file is also used as a supplemental control file, then after the project has been processed all the points in the project would now be in the control file and all the points in the file would now be considered control points if the project was processed again. The simplest and most straight-forward method to define control for a project is to include the control coordinates in a raw data file.

Supplemental Control Files

In order to process a raw data file, you must have (as a minimum) a control point and a control azimuth, or two control points. Control points can be inserted into the raw data file or alternately control points can be read from a coordinate file as linked via the Input Files portion of the program.

The major advantage of putting coordinate control points in the actual raw data file is that specific standard errors can be assigned to each control point (as described in the Control Standard Errors section above). If you do not include an SE record, the standard error will be assigned from the NORTH, EAST, and ELEVATION standard errors from the Control Standard Error project default values dialog box.

The standard errors for the control points from a supplemental control file will be assigned the NORTH and EAST standard errors from the project settings dialog box.

In the ASCII .NEZ file, the coordinate records need to be in the following format:

Pt. No., Northing, Easting, Elevation, Description<cr><lf>
103, 123233.23491, 238477.28654, 923.456, Mon 56-7B<CR><LF>

Each line is terminated with the "non-printing" carriage-return <CR> and line-feed <LF> characters. When viewed in a simple ASCII file editor such as Windows Notepad, the file snippet above would resemble:

Pt. No., Northing, Easting, Elevation, Description
103, 123233.23491, 238477.28654, 923.456, Mon 56-7B

In the ASCII latitude and longitude file, the records need to be in the following format:

Pt. No., Latitude (NDDD.mmssssss), Longitude (WDDD.mmssssss), Elevation (Orthometric), Description<cr><lf>
FRKN,N35.113068642,W083.234174724,649.27<CR><LF>

Each line is terminated with the "non-printing" carriage-return <CR> and line-feed <LF> characters. When viewed in a simple ASCII file editor such as Windows Notepad, the file snippet above would resemble:

Pt. No., Latitude (NDDD.mmssssss), Longitude (WDDD.mmssssss), Elevation (Orthometric), Description
FRKN,N35.113068642,W083.234174724,649.27

In the ASCII XYZ Geocentric file, the records need to be in the following format:

Pt. No. X Y Z Descriptions<cr><lf>
105 1413426.6020 -4537671.2000 4239299.9360 MON<CR><LF>

Each line is terminated with the "non-printing" carriage-return <CR> and line-feed <LF> characters. When viewed in a simple ASCII file editor such as Windows Notepad, the file snippet above would resemble:

Pt. No. X Y Z Descriptions
105 1413426.6020 -4537671.2000 4239299.9360 MON

NOTE: It is not allowed for the supplemental control file and the final output file to be the same file. Since Least Squares considers all points to be control points, only control points should be in a supplemental control file.

Standard Error Records in the Raw Data File

Once raw data files are added to the network it can be adjusted using the parameters as set in the Project Settings. In many instances, there will be a need to assign specific standard errors for particular measurements or control points. This can be accomplished by editing individual points or measurements or by assigning a standard error to a particular raw data file.

Standard errors are estimated errors that are assigned to measurements or coordinates. A standard error is an estimate of the standard deviation of a sample. A higher standard error indicates a less accurate measurement. The higher the standard error of a measurement, the less weight it will have in the adjustment process.

Although you can set default standard errors for the various types of measurements in the Project Settings of SurvNET, standard errors can also be placed directly into the raw data file. A standard error record inserted into a raw data file applies to all the measurements following the **SE** record. The standard error does not change until another SE record is inserted that either changes the specific standard error, or sets the standard errors back to the project defaults. The advantage of entering standard errors into the raw file is that you can have different standard errors for the same type measurement in the same job.

For example, if you used a 1" total station with fixed backsights and foresights for a portion of a traverse and a 10" total station with backsights and foresights to hand-held prisms on the other portion of the traverse, you would want to assign different standard errors to reflect the different methods used to collect the data.

Make sure the SE record is placed before the measurements for which it applies. If you do not have standard errors defined in the raw data file, the default standard errors in the project settings will be applied to the entire file.

Editing Standard Errors

The dialog box option allows users to edit raw field data directly through a the typical Carlson data Editor by selecting a raw file and *right-clicking:*

Carlson Raw Data Editor

Note, editing standard errors in the Carlson Data Editor is described more fully in the **Standalone** version of this help menu.

Graphic CAD Editor

With the dialog box editor, users can review and edit information for points, vectors and measurement lines by selecting the information button or by double-clicking any entity.

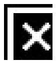
Select any a graphic entity such as a traverse line or control point and *double-click* on it.

CSE - Control Standard Errors

You can insert or add Control Standard Error records for a specific point by double-clicking on a control point and selecting **Control Standard Error**

Add Standard Error records

You can set standard errors for Northing, Easting, Elevation, and Azimuth selecting the **Edit Control Errors** option. Azimuth standard errors are entered in seconds. The North, East and Elevation standard errors affect the PT (coordinate) and EL (elevation) records.



You can hold the North, East and Elevation fixed by entering an exclamation "!" symbol. You can allow the North, East and Elevation to FLOAT by entering a hash (or "pound") "#" symbol. You can also assign the North, East and Elevation actual values. If you use an asterix "*" symbol, the current standard error value will return to the control standard error project defaults.

North	East	Elevation	Azim	
!	!	!		(Fix all values)
#	#	#	30.0	(Allow the N., E. & Elevation to Float)
0.01	0.01	0.03	5.0	(assign values)
*	*	*	*	(return the control standard errors back to project defaults)

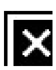
When you fix a coordinate point, the original value does not change during the adjustment and all measurements will be adjusted to fit the fixed point. If you allow a value to float, it will not be used in the actual adjustment, it will just be used to help calculate the initial coordinate values required for the adjustment process. Placing a very high or low standard error on a coordinate point accomplishes almost the same thing as setting the standard error as float or fixed. The primary purpose of using a float point is if SurvNET cannot compute preliminary values, a preliminary float value can be computed and entered for the point.

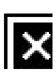
Direction records cannot be FIXED or FLOAT. You can assign a low standard error (or zero to fix) if you want to weight it heavily, or a high standard error to allow it to float.

In the example below, the first CSE record containing the '!' character and sets points 103, 204, and 306 to be fixed. The last CSE record contains the '*' character. It sets the standard errors for point 478 and any other points that follow to the project settings. The Azimuth standard error was left blank.

MSE - Measurement Standard Errors

You can set the standard errors for various types of measurements for a specific measurement by *double-clicking* on a drawing entity (line or point) and selecting **Edit Measurement Errors**





Example:

	Distance	Point	Read	V.Point	V.Read	PPM
MSE	0.01	3	3	3	3	5

You can enter any combination of the above values. If you do not want to change the standard error for a particular measurement type, leave it blank.

If you use an "*" symbol, the standard error for that measurement type will return to the standard measurement error project defaults.

SSE - Setup Standard Errors

These standard errors are a measure of how accurately the instrument and target can be set up over the points as discussed in the Instrument and Target Standard Errors section. You can edit a particular setup by double-clicking on that point or measurement line and selecting **Edit Setup Errors**

Example:

	Rod Ctr	Inst Ctr	Inst Ht	Rod Hgt
SSE	0.005	0.005	0.01	0.01

You can enter any combination of the above values. If you do not want to change the standard error for a particular measurement type, leave it blank.

If you use an "*" symbol, it will return the standard error to the Instrument and Target Standard Errors project default values.

Redundant Measurements

One of the benefits of SurvNET is the ability to process redundant measurements. In terms of total station data, redundant measurement is defined as measuring angles and/or distances to the same point from two or more different setups.

It is required that the **same point number** be used when locating a point that was previously recorded. However, since some data collectors will not allow you to use the same point number if the point already exists, SurvNET also uses the following convention for collecting redundant points while collecting the data in the field:

If the point description contains a user-defined string, for example an "=" (equal sign) followed by the original point number, SurvNET will treat that measurement as a redundant measurement to the point defined in the description field. The user-defined character or string is set in the Project Settings dialog. For example, if point number 56 has the description "=12", we will treat it as a measurement to point 12 and point 56 will not exist. Make sure the *Preprocessing Settings* dialog box has the **Pt. Number Substitution String** set to the appropriate value.

Point Substitution

Alternately, the point numbers can be edited after the raw data has been downloaded from the data collector.

SurvNET Editor

Please refer to topic on Carlson or CGEditor raw editor.

Data Collector Transfer

Please refer to the Carlson or CG data collector transfer topic.

Example Projects

On the installation disk there are a variety of different least squares projects one can use to become familiar with least squares and SurvNET. These projects are located in the SurvNET Examples folder under the Carlson Projects folder (*e.g.* C:\Carlson Projects\SurvNET Examples).

NOTE: When you open a project for review, you will need to check the project settings, input data files to see if the paths are correct. If they do not, you will have to re-select them.

Simple Traverse with Traverse Closure

This project is located in \Carlson Projects\SurvNET Examples\2DTraverse. The name of the project is Traverse. This project illustrated a basic loop traverse with two control points and a known azimuth for control. This project also illustrates how to obtain traditional closure information as part of the least squares report. The program uses the 2D/1D model and uses a local coordinate system.

Traverse using State Plane Coordinates

This project is located in \Carlson Projects\SurvNET Examples\SPCTraverse. The name of the project is Trav01SPCUSFt. This project illustrated a basic network with three GPS control points for control. This project is computed using the **SPC83 NC Grid** coordinate system. The project is set up to generate traditional loop closure data. The program uses the 2D/1D model. No elevations are computed or adjusted as there were no HI's or rod readings collected. Notice, that the project uses two raw data files. One file contains the raw angle & distance data. The other raw data file contains the control for the project.

Network with ALTA Reporting

The ALTA reporting project is located in \Carlson Projects\SurvNET Examples\ALTARpt. The name of the project is ALTARpt. This project illustrates how to perform ALTA tolerance testing on points within a network.

GPS Network with GPS Loop Closures

The GPS network project is located in \Carlson Projects\SurvNET Examples\GPSNetwork. The name of the project is GPSOnly. This project is a simple GPS network. In addition to the least squares computation and report, GPS loop closures were generated for various GPS loops for this project.

Level Network

The differential leveling project is located in \Carlson Projects\SurvNET Examples\LevelNetwork. The name of the project is network1. This project is a simple differential leveling network.

Basic 3D Project

The basic 3D adjustment project is located in \Carlson Projects\SurvNET Examples\3DNetwork. The name of the project is pg08. This project is a simple four point example network. Notice in the raw data that all set up records have an HI and all FS readings have valid rod heights. Also note that there are valid vertical angles for every slope distance. Since the 3D model is a true one process 3-dimensional adjustment, you must enter all valid slope distances and vertical angles. Be aware that you cannot just enter a horizontal distance and a vertical angle of 90 from reduced field notes when adjusting using the 3D model.

3D Project Combining Total Station and GPS Vectors

The total station raw data combined with GPS vectors example is located in \Carlson Projects\SurvNET Examples\GPSandTtlSta. The name of the project is GPSandTS. This project illustrates a 3D model adjustment that combines both GPS vectors and data from a total station. Since there is GPS data the 3D model must be used. Notice that the GPS vectors are in meters but the total station data is in US feet and the output coordinates are in US feet. Always make sure your units are correct for each data type, especially when using the 3D model.

Resection

The total station raw data combined with GPS vectors example is located in \Carlson Projects\SurvNET Examples\Resection. The name of the project is ResectRaw. This project illustrates an angle and distance resection. There is no real difference in a resection project than any other angle and distance network in terms of how the data is collected or how the project is set up.

Network Processing Reports

Report File: A report file consisting of the project name with an .RPT extension is generated after successfully processing the raw data. The report file will be shown in a text window so you can analyze the data.

By clicking on the **Report** button, you will see several options for available reports.

Main Report

This report contains essentially all of the data analysis of the network, errors, horizontal and vertical adjustments, data statistics, the optional ALTA report and the results of the chi square test are all included.

Output Report

This report contains final adjusted coordinates from the network based on the options made in the Project Settings.

Error Report

This report contains essential information about measurements that exceed the tolerances of standard errors set in the Project Settings. It also contains information such as Point Aliases.

Results Report

This report displays just the essential pass/fail Chi square test along with the contributing data statistics.

Sample 2D/1D, Local Coordinate System Report File

The following explanations should be used in conjunction with the report at the end of the explanatory text. The report is shown in a tabbed window.

Pre-Process:

Project Settings

The first section of the report displays the project settings at the time the project was processed.

Tolerances

The second section of the report displays warning and error messages generated during the preprocessing of the raw data. The primary messages displayed will be warnings when multiple angles, horizontal distances, and vertical differences exceed the tolerance settings as set in the project settings. The low and high measurement and the difference are displayed. It is prudent to pay attention to any messages generated in this section of the report. Some warnings may be innocuous but it is prudent to check and understand all warning messages.

Unadjusted Observations:

The next four sections list the reduced and averaged, but unadjusted measurements that make up the network. Multiple measurements of the same angle or distance are averaged to a single measurement. The standard error of multiple averaged measurements is less than the standard error of a single measurement. When multiple measurements are used, the standard error for the averaged measurement will be computed using the average of the mean formula.

The first of the four sections lists the control coordinates used in the network adjustment. These coordinates could have been read from the .CGR raw data file, or from the .CRD or .NEZ supplemental coordinate file. Notice that the standard errors for the control points are displayed.

The second of the four measurement sections shows the control reference azimuths and azimuth standard errors used in the adjustment. Azimuths are defined in the .CGR or RW5 files (Add->Reference Azimuth).

The third of the four measurement sections shows the distances and distance standard errors used in the adjustment. These distances are horizontal distances computed from all slope distance and vertical angles for that distance, including all foresight and backsight distances. The standard error settings used to calculate the final distance standard error include the distance standard error, the PPM standard error, the target centering standard error and the instrument centering standard errors. The techniques and formulas used to calculate the final distance standard error are found in section 6.12 of the textbook "Adjustment Computations, Statistics and Least Squares in Surveying and GIS", by Paul Wolf and Charles Ghilani (Wolf, Paul, and Charles Ghilani. *Adjustment Computations, Statistics and Least Squares in Surveying and GIS*. John Wiley & Sons, 1997).

The fourth of the four measurement sections shows the angles and angle standard errors used in the adjustment. These angles are the averaged angle value for all the multiple angles collected. The standard error settings used to calculate the final angle standard error include the pointing standard error, the reading standard error, the target centering standard error and the instrument centering standard errors. The techniques and formulas used to calculate the final angle standard error are found in section 6.2 of the textbook "Adjustment Computations, Statistics and Least Squares in Surveying and GIS", by Paul Wolf and Charles Ghilani (Wolf, Paul, and Charles Ghilani. *Adjustment Computations, Statistics and Least Squares in Surveying and GIS*. John Wiley & Sons, 1997).

If you have a Traverse Closure file selected, there will be a fifth section in the Unadjusted Observations section which shows the error of closure report.

Adjusted Coordinates:

If the adjustment of the network converges the next section displays a list of the final adjusted coordinates and the computed standard X, Y standard error. An interpretation of the meaning of the X, Y standard error, is that there is a 68% probability that the adjusted X, Y is within plus or minus the standard error of the X, Y of its true value.

Also shown are the Delta N, Delta E and Delta EL values of the non-fixed control points (how much the control points moved).

The next section displays the error ellipses for the adjusted coordinates. The error ellipse is a truer representation of the error of the point than the X, Y standard error. The error ellipses are calculated to the confidence interval as defined in the settings screen. In this report the error ellipse axis is larger than the X, Y standard errors since the error ellipses in this report are calculated at a 95% probability level as set in the Settings screens. The maximum error axis direction is along the axis of the semi-major axis. The direction of the minimum error axis direction is along the semi-minor axis and is perpendicular to the semi-major axis. If a point is located from a variety of stations, you will most likely see that the error ellipse will approach a circle, which is the strongest geometric shape.

Adjusted Observations:

The next three sections list the adjusted horizontal distance, horizontal angle, and azimuth measurements. In addition to the adjusted measurement the, residual, the standard residual and the standard deviation of the adjusted measurement is displayed.

The ***residual*** is defined as the difference between the unadjusted measurement and the adjusted measurement. The residual is one of the most useful and intuitive measures displayed in the report. Large residuals in relation to the standards of the survey are indications of problems with the data.

The standard residual is the *a priori* standard error divided by the residual of a measurement. The *a priori* standard errors are the standard errors of the measurements as displayed in the unadjusted measurement section. A standard residual of 1 indicates that the adjustment applied to the measurement is consistent with the expected adjustment to the measurement. One or a few measurements having high standard residuals, in relation to the rest of the standard residuals, may be an indication of a blunder in the survey. When all standard residuals are consistently large there is likely an inconsistency in the a priori standard errors and the adjustments being made to the measurements. In other words the standard errors defined for the project are too small, in relation to the survey methods used.

The standard deviation of the measurement means that there is a 68% probability that the adjusted measurement is within plus or minus the standard deviation of the measurement's true value.

Additionally, the root mean square of each measurement type is displayed. The root mean square is defined as the square root of the average of the squares of a set of numbers. Loosely defined, it is as an average residual for that measurement type.

Statistics

The next section displays some statistical measures of the adjustment including the number of iterations needed for the solution to converge, the degrees of freedom of the network, the Error Factor for each type of measurement, the standard error of unit weight, the reference variance and the results of a Chi² (Chi-square) test.

- **Degrees of Freedom** - The degree of freedom is an indication of how many redundant measurements are in the survey. Degree of freedom is defined as the number of measurements in excess of the number of measurements necessary to solve the network. The higher the DOF the more meaningful the statistics are.
- **Standard Error** - The possible measurement types are:
  - Coordinates (control points - in the 2D/1D model each point counts as 2 measurements (N & E); in the 3D model each point counts as 3 measurements (N, E, & EL))
  - Elevations (elevation control - from elevation records in the raw data file)
  - Azimuths (azimuth control - from reference azimuth records in the raw data file)
  - Angles (horizontal angles)
  - Distances (horizontal in 2D/1D model and mark-to-mark in 3D model)
  - Vertical Angles (mark-to-mark, 3D model only)
  - GPS Vectors (3D model only)

  The total standard error of unit weight relates to the overall adjustment and not an individual measurement. A value of one indicates that the results of the adjustment are consistent with *a priori* standard errors. The total standard error of unit weight equals the sum of all the measurement standard errors of unit weight.
- **Reference Variance** - The reference variance is the standard error of unit weight squared.
- **Chi² Test** - The Chi² (Chi-square) test is a test of the "goodness" of fit of the adjustment. It is not an absolute test of the accuracy of the survey. The a priori standard errors which are defined in the project settings dialog box or with the SE record in the raw data (.RW5 or .CGR) file are used to determine the weights of the measurements. These standard errors can also be looked at as an estimate of how accurately the measurements were made. The chi-square test merely tests whether the results of the adjusted measurements are consistent with the a priori standard errors. **Notice that if you change the project standard errors and then reprocess the survey, the results of the chi-square test change... even though the final adjusted coordinates may change very little.**

If the project passes the Chi Square test, the expansion factor used to calculate the confidence regions (error ellipses at say 95% confidence) will be taken from the normal distribution table. If the project fails the Chi Square test, the expansion factors will be taken from the F-Distribution table:

```
All confidence regions were computed using the following factors:
Variance factor: 1.0000
1-D Expansion Factor: 1.9600
2-D Expansion Factor: 2.4477
Expansion factors for 95.00 confidence regions taken from normal distribution table
```

Sideshots:

The next section displays the computed sideshots of the network. Sideshots are filtered out of the network adjustment as part of the preprocessing process if the Enable Sideshots for Relative Error Ellipses toggle is off. Least squares adjustment requires a lot of computer resources. Sideshots are filtered out to minimize the computer resources needed in a large network adjustment. The sideshots are computed from the final adjusted network points. The results of the side shot computations are the same whether they are reduced as part of the least squares adjustment or from the final adjusted coordinates.

Elevation Report:

The next part of the report displays the results of the vertical adjustment. In the 2D/1D model the horizontal and the vertical adjustments are separate least squares adjustment processes. As long as there are redundant vertical measurements the vertical component of the network will also be reduced and adjusted using least squares.

The first section displays the vertical benchmarks used in the vertical adjustment. Next, is listed the points that will be adjusted as part of the vertical adjustment. The following section displays the measurements used in the adjustment. The measurements consist of the vertical elevation difference between points in vertical adjustment. The lengths between these points are used to determine the weights in the vertical adjustment. Longer length lines are weighted less in the vertical adjustment than shorter length lines.

The next section displays some statistics about the vertical control: Number of unknown elevations, number of routes, number of fixed and non-fixed benchmarks, and degrees of freedom.

The next section displays the adjusted elevations and the computed standard deviations of the computed elevations. Following the adjusted elevation section is a section displaying the final adjusted elevation difference measurements and their residuals. Finally, the computed side shot elevations are displayed.

```
     ===============================
     LEAST SQUARES ADJUSTMENT REPORT
     ===============================

Wed Oct 12 09:54:00
2D Geodetic Model.
Input Raw Files:
    C:\Carlson Projects\cgstar.cgr
Output File: C:\Carlson Projects\cgstar.RPT
Traverse File: C:\Carlson Projects\cgstar.cls
Curvature, refraction correction: ON
Maximum iterations: 10 , Convergence Limit: 0.002000
Local Coordinate System, Scale Factor: 1.000000
Horizontal Units: US Feet
Confidence Interval: 95.00
Default Standard Errors:
  Distance: Constant 0.010 ,PPM: 5.000
  Horiz. Angle: Pointing 0.0" ,Reading: 5.0"
  Vert. Angle: Pointing 0.0" ,Reading: 20.0"
  Total Station: Centering 0.010 ,Height: 0.010
  Target: Centering 0.010 ,Height: 0.010
  Azimuth: 5"
  Coordinate Control: N:0.010, E:0.010, Z:0.020,

Horizontal Distance from 2 to 3 exceeds tolerance:
  Low: 324.153,  High: 324.196,  Diff: 0.042

Vertical Distance from 2 to 3 exceeds tolerance:
  Low: 6.617,  High: 8.362,  Diff: 1.745

Vertical Distance from 3 to 4 exceeds tolerance:
  Low: 11.463,  High: 11.512,  Diff: 0.050

Horizontal Distance from 12 to 3 exceeds tolerance:
  Low: 144.641,  High: 144.661,  Diff: 0.020


     HORIZONTAL ADJUSTMENT REPORT
     ============================


Unadjusted Observations
```

=======================

Control Coordinates: 2 Observed Points, 0 Fixed Points, 0 Approx. Points

Sta.	N:	E:	StErr N:	StErr E:
1	658428.2600	2150182.7000	0.0200	0.0200
4	658863.5500	2149911.0300	0.0200	0.0200

Azimuths: 1 Observations

Occ. Sta.	FS Sta.	Bearing	StErr (Sec.)
1	2	N 45-00'00.0"E	05.0

Distances: 14 Observations

From Sta.	To Sta.	Dist.	StErr
1	5	290.450	0.015
1	2	292.213	0.015
2	6	52.388	0.016
2	3	324.186	0.015
3	4	275.603	0.015
3	20	134.663	0.018
20	21	116.073	0.018
21	22	50.115	0.017
4	5	309.647	0.015
5	10	129.985	0.016
10	11	126.010	0.016
10	15	10.000	0.017
11	12	129.426	0.016
12	3	144.651	0.016

Angles: 17 Observations

BS Sta.	Occ. Sta.	FS Sta.	Angle	StErr (Sec.)
5	1	2	109-19'13.0"	13.9
1	2	6	190-32'06.0"	51.9
1	2	3	096-03'52.0"	12.9
2	3	30	350-57'34.0"	07.1
2	3	4	124-03'53.0"	14.0
2	3	20	185-23'56.0"	23.7
3	20	21	180-15'26.0"	33.9
20	21	22	183-26'45.0"	61.6
3	4	5	093-02'11.5"	13.3
4	5	10	039-26'40.0"	19.7
5	10	11	241-56'29.0"	30.4
5	10	15	056-23'10.0"	249.9
10	11	12	114-56'27.0"	30.3
11	12	3	140-39'24.5"	29.8
12	3	2	325-54'30.0"	17.8
4	5	30	079-39'33.0"	07.1
4	5	1	117-30'42.5"	13.8

Traverse Closures
=================

Traverse points:
5,1-5,1

Loop Traverse; Interior direction reference;
Compute angle closure.
Compute vertical closure.

BS	IP	FS	Angle	FS H. Dist.	FS V. Dist.
5	1	2	109-19'13.0"	292.213	7.566
1	2	3	096-03'52.0"	324.186	6.984
2	3	4	124-03'53.0"	275.603	-11.491
3	4	5	093-02'11.5"	309.647	4.356
4	5	1	117-30'42.5"	290.450	-7.504

Closing Az: S 64-19'13.0"E
Computed Closing Az: S 64-19'21.0"E

Total angular error: 000-00'08.0"
Angular error per point: 000-00'01.6"

Correct Ending Coordinates, North: 658428.260 East: 2150182.700
Ending Coordinates, North: 658428.312 East: 2150182.664
Error, N: 0.052 E: -0.036 Total: 0.064 Brg: S 34-49'32.1"E
Distance Traversed: 1492.100 Closure: 1: 23369

Correct Ending Elevation: 569.850
Ending Elevation: 569.761
Elevation Error: -0.089

Closure After Angle Adjustment

5	1	2	109-19'14.6"	292.213	7.566

1	2	3	096-03'53.6"	324.186	6.984
2	3	4	124-03'54.6"	275.603	-11.491
3	4	5	093-02'13.1"	309.647	4.356
4	5	1	117-30'44.1"	290.450	-7.504

```
Closing Az:           S 64-19'13.0"E
Computed Closing Az:  S 64-19'13.0"E

Total angular error:      000-00'00.0"
Angular error per point:  000-00'00.0"


Correct Ending Coordinates, North: 658428.260 East: 2150182.700
Ending Coordinates, North: 658428.310 East: 2150182.654
Error, N: 0.050 E: -0.046 Total: 0.068 Brg:  S 42-39'20.9"E
Distance Traversed:  1492.100 Closure: 1: 21990


Traverse points:
5,1-5

Loop Traverse; Interior direction reference;
Do not compute angle closure.
Compute vertical closure.
```

BS	IP	FS	Angle	FS H. Dist.	FS V. Dist.
5	1	2	109-19'13.0"	292.213	7.566
1	2	3	096-03'52.0"	324.186	6.984
2	3	4	124-03'53.0"	275.603	-11.491
3	4	5	093-02'11.5"	309.647	4.356

```
Correct Ending Coordinates, North: 658554.124 East: 2149920.937
Ending Coordinates, North: 658554.166 East: 2149920.896
Error, N: 0.042 E: -0.041 Total: 0.059 Brg:  S 44-22'19.4"E
Distance Traversed:  1492.100 Closure: 1: 25238

Correct Ending Elevation:   577.354
Ending Elevation:           577.265
Elevation Error:             -0.089
```

Adjusted Coordinates
====================

Adjusted Local Coordinates

Sta.	N:	E:	StErr N:	StErr E:	DN	DE
1	658428.2359	2150182.7169	0.0163	0.0164	-0.0241	0.0169
4	658863.5741	2149911.0131	0.0163	0.0164	0.0241	-0.0169
2	658634.8584	2150389.3399	0.0192	0.0178		
5	658554.0894	2149920.9457	0.0178	0.0177		
3	658887.0003	2150185.6059	0.0177	0.0189		
20	658999.2418	2150111.2028	0.0246	0.0268		
21	659096.2758	2150047.5057	0.0336	0.0401		
10	658657.0743	2150000.2697	0.0203	0.0194		
11	658636.1774	2150124.5368	0.0221	0.0217		
12	658742.8596	2150197.8311	0.0224	0.0191		

Adjusted Coordinates Error Ellipses, 95% CI

Sta.	Semi Major Axis	Semi Minor Axis	Max. Error Az.
1	0.0420	0.0379	N 47-22'19.9"E
4	0.0420	0.0379	N 47-22'19.9"E
2	0.0502	0.0399	N 35-00'21.0"E
5	0.0458	0.0408	S 44-05'12.1"E
3	0.0466	0.0430	S 70-27'40.9"E
20	0.0658	0.0600	S 80-49'45.3"E
21	0.1032	0.0758	N 62-59'30.6"E
10	0.0512	0.0459	N 32-30'51.3"E
11	0.0560	0.0512	N 39-41'54.3"E
12	0.0549	0.0467	S 01-01'01.0"E

Adjusted Observations
=====================

Adjusted Distances

From Sta.	To Sta.	Distance	Residual	StdRes.	StdDev
1	5	290.454	0.003	0.2	0.013
1	2	292.209	-0.005	0.3	0.013
2	3	324.165	-0.021	1.4	0.013
3	4	275.590	-0.013	0.9	0.013
3	20	134.663	0.000	0.0	0.018
20	21	116.073	0.000	0.0	0.018
4	5	309.644	-0.003	0.2	0.012
5	10	129.993	0.008	0.5	0.014
10	11	126.012	0.002	0.1	0.014

11	12	129.434	0.008	0.5	0.014
12	3	144.658	0.007	0.5	0.015
	Root Mean Square (RMS)		0.009		

Adjusted Angles

BS Sta.	Occ. Sta.	FS Sta.	Angle	Residual	StdRes	StdDev(Sec.)
5	1	2	109-19'22.5"	09.5	0.7	09.1
1	2	3	096-03'40.6"	-11.4	0.9	08.8
2	3	4	124-03'44.8"	-08.2	0.6	10.5
2	3	20	185-23'56.0"	-00.0	0.0	23.7
3	20	21	180-15'26.0"	-00.0	0.0	33.9
3	4	5	093-02'16.8"	05.3	0.4	09.5
4	5	10	039-26'36.3"	-03.7	0.2	15.8
5	10	11	241-56'25.5"	-03.5	0.1	24.0
10	11	12	114-56'41.1"	14.1	0.5	24.8
11	12	3	140-39'42.2"	17.7	0.6	22.8
12	3	2	325-54'33.2"	03.2	0.2	14.3
4	5	1	117-30'55.4"	12.9	0.9	10.3
			Root Mean Square (RMS)	09.3		

Adjusted Azimuths

Occ. Sta.	FS Sta.	Bearing	Residual	StdRes	StdDev(Sec.)
1	2	N 45-00'00.2"E	00.2	0.0	04.7
		Root Mean Square (RMS)	00.2		

Statistics
==========

Solution converged in 2 iterations

Total Observations:28
Total Unknowns:20
Degrees of Freedom:8

Observation	Count	Sum Squares of StdRes	Std. Error of Unit Wt.	
Coordinate	4	4.335	1.948	
Azimuths:	1	0.002	0.091	
Angles:	12	3.291	0.980	
Distances:	11	3.567	1.065	(Horizontal)
Total:	28	11.194	1.183	

Reference Variance:1.399
Standard Error Unit Weight: (+/-)1.183
Passed the Chi-Square test at the 95.00 significance level
2.180 <= 11.194 <= 17.535

All confidence regions were computed using the following factors:
Variance factor: 1.0000
1-D Expansion Factor: 1.9600
2-D Expansion Factor: 2.4477
Expansion factors for 95.00 confidence regions taken from normal distribution table

Sideshots
=========

From	To	Bearing	Dist.	N	E	StdDev. N	StdDev. E
2	6	N 55-32'06.2"E	52.388	658664.5046	2150432.5320	0.0239	0.0233
21	22	N 29-50'12.2"W	50.115	659139.7480	2150022.5719	0.0376	0.0430
10	15	N 86-00'31.2"W	10.000	658657.7704	2149990.2940	0.0237	0.0260

From	Bearing	From	Bearing	To	N	E	StdDev. N	StdDev. E		
5	N 77-49'15.4"E	3	S 47-58'45.2"E	30	658664.5029	2150432.5341	0.0398	0.0261	0.040	0.026

LEAST SQUARES VERTICAL ADJUSTMENT REPORT

Wed Oct 12 09:54:00
2D Geodetic Model.
Input Raw Files:
C:\Carlson Projects\cgstar.cgr
Output File: C:\Carlson Projects\cgstar.RPT
Traverse File: C:\Carlson Projects\cgstar.cls
Curvature, refraction correction: ON

VERTICAL BENCHMARKS

Station	Elevation	Std. Error
1	569.8500	0.040
4	572.9500	0.040

POINTS TO BE ADJUSTED

Station
2,5,3,10,11,12,30

MEASUREMENT SUMMARY

From	To	Elev. Diff. (unadjusted)	StdErr
1	5	7.5037	0.0200
1	2	7.5659	0.0201
2	3	6.9843	0.0200
3	4	-11.4907	0.0196
4	5	4.3557	0.0206
5	10	2.2639	0.0168
10	11	1.0931	0.0166
11	12	0.3828	0.0167
12	3	3.3590	0.0174
3	30	-7.3186	0.0354
5	30	-0.0334	0.0527

STATISTICAL SUMMARY

Total Unknown Elevations:7
Total Elev. Routes:11
Total Fixed BM's:0
Total non-fixed BM's:2
Degrees of freedom:4

ADJUSTED ELEVATIONS

Station	Adjusted Elev	Standard Dev.	Error Ellipse at 95% CI
1	569.8432	0.05007	0.09814
4	572.9568	0.05007	0.09814
2	577.4359	0.05819	0.11405
5	577.3168	0.05389	0.10562
3	584.4468	0.05591	0.10958
10	579.5885	0.06295	0.12339
11	580.6892	0.06601	0.12937
12	581.0797	0.06400	0.12544
30	577.1905	0.06953	0.13628

ADJUSTED MEASUREMENT SUMMARY

From	To	Elev. Diff. (adjusted)	Residuals	Std. Dev.
1	5	7.4736	-0.0301	0.037
1	2	7.5926	0.0268	0.038
2	3	7.0109	0.0267	0.038
3	4	-11.4900	0.0007	0.036
4	5	4.3600	0.0043	0.036
5	10	2.2717	0.0078	0.037
10	11	1.1008	0.0077	0.037
11	12	0.3905	0.0077	0.037
12	3	3.3670	0.0081	0.038
3	30	-7.2563	0.0624	0.049
5	30	-0.1262	-0.0928	0.052

Vertical Sideshots

Station	Elevation
6	577.135
20	571.777
21	581.262
22	580.151
15	579.588

Sample 2D/1D, State Plane Coordinate System Report File

Note: Highlighted explanatory text is found within the report text.

```
===============================
LEAST SQUARES ADJUSTMENT REPORT
===============================
```

```
Wed Oct 12 10:15:00
2D Geodetic Model.
Input Raw Files:
    C:\Carlson Projects\cgstar.cgr
Output File: C:\Carlson Projects\cgstar.RPT
Traverse File: C:\Carlson Projects\cgstar.cls
Curvature, refraction correction: ON
Maximum iterations: 10 , Convergence Limit: 0.002000
1983 State Plane Coordinates, zone:Georgia West - 1002
Elevation factor computed from raw data elevations.
Elevation Units: US Feet
Horizontal Units: US Feet
Confidence Interval: 95.00
Project Geoid Height:     0.000
Default Standard Errors:
  Distance: Constant 0.010 ,PPM: 5.000
  Horiz. Angle: Pointing 0.0" ,Reading: 5.0"
  Vert. Angle: Pointing 0.0" ,Reading: 20.0"
  Total Station: Centering 0.010 ,Height: 0.010
  Target: Centering 0.010 ,Height: 0.010
  Azimuth: 5"
  Coordinate Control: N:0.010, E:0.010, Z:0.020,

Horizontal Distance from 2 to 3 exceeds tolerance:
  Low: 324.153,  High: 324.196,  Diff: 0.042

Vertical Distance from 2 to 3 exceeds tolerance:
  Low: 6.617,  High: 8.362,  Diff: 1.745

Vertical Distance from 3 to 4 exceeds tolerance:
  Low: 11.463,  High: 11.512,  Diff: 0.050

Horizontal Distance from 12 to 3 exceeds tolerance:
  Low: 144.641,  High: 144.661,  Diff: 0.020

     HORIZONTAL ADJUSTMENT REPORT
     ============================

Unadjusted Observations
=======================
```

The control coordinates and azimuths are shown:

```
Control Coordinates:     2 Observed  Points,    0 Fixed Points,    0  Approx. Points
 Sta.             N:             E:            StErr N:   StErr  E:

 1             658428.2600  2150182.7000      0.0200      0.0200
 4             658863.5500  2149911.0300      0.0200      0.0200

Grid Azimuths:    1 Observations
 Occ. Sta.   FS  Sta.        Bearing        StErr (Sec.)
 1            2          N  45-00'00.0"E     05.0
```

The first distance listing in the Unadjusted Observation section of the report shows the unadjusted horizontal ground distances

```
Distances:   14 Observations
 From Sta.   To  Sta.       Ground  Dist.     StErr
 1             5                 290.450       0.015
 1             2                 292.213       0.015
 2             6                  52.388       0.016
 2             3                 324.186       0.015
 3             4                 275.603       0.015
 3             20                134.663       0.018
 20            21                116.073       0.018
 21            22                 50.115       0.017
 4             5                 309.647       0.015
 5             10                129.985       0.016
 10            11                126.010       0.016
 10            15                 10.000       0.017
 11            12                129.426       0.016
 12            3                 144.651       0.016

Angles:   17 Observations
 BS Sta.    Occ. Sta.    FS  Sta.          Angle          StErr  (Sec.)
 5            1            2           109-19'13.0"       13.9
 1            2            6           190-32'06.0"       51.9
 1            2            3           096-03'52.0"       12.9
 2            3            30          350-57'34.0"       07.1
 2            3            4           124-03'53.0"       14.0
 2            3            20          185-23'56.0"       23.7
 3            20           21          180-15'26.0"       33.9
 20           21           22          183-26'45.0"       61.6
 3            4            5           093-02'11.5"       13.3
```

4	5	10	039-26'40.0"	19.7
5	10	11	241-56'29.0"	30.4
5	10	15	056-23'10.0"	249.9
10	11	12	114-56'27.0"	30.3
11	12	3	140-39'24.5"	29.8
12	3	2	325-54'30.0"	17.8
4	5	30	079-39'33.0"	07.1
4	5	1	117-30'42.5"	13.8

Closure Report if a project closure file has been created and selected:

Traverse Closures
=================

Traverse points:
5,1-5,1

Loop Traverse; Interior direction reference;
Compute angle closure.
Compute vertical closure.

BS	IP	FS	Angle	FS H. Dist.	FS V. Dist.
5	1	2	109-19'13.0"	292.183	7.566
1	2	3	096-03'52.0"	324.153	6.984
2	3	4	124-03'53.0"	275.575	-11.491
3	4	5	093-02'11.5"	309.615	4.356
4	5	1	117-30'42.5"	290.420	-7.504

Closing Az: S 64-19'13.0"E
Computed Closing Az: S 64-19'21.0"E

Total angular error: 000-00'08.0"
Angular error per point: 000-00'01.6"

Correct Ending Coordinates, North: 658428.260 East: 2150182.700
Ending Coordinates, North: 658428.312 East: 2150182.664
Error, N: 0.052 E: -0.036 Total: 0.064 Brg: S 34-48'25.3"E
Distance Traversed: 1491.946 Closure: 1: 23446

Correct Ending Elevation: 569.850
Ending Elevation: 569.761
Elevation Error: -0.089

Closure After Angle Adjustment

5	1	2	109-19'14.6"	292.183	7.566
1	2	3	096-03'53.6"	324.153	6.984
2	3	4	124-03'54.6"	275.575	-11.491
3	4	5	093-02'13.1"	309.615	4.356
4	5	1	117-30'44.1"	290.420	-7.504

Closing Az: S 64-19'13.0"E
Computed Closing Az: S 64-19'13.0"E

Total angular error: 000-00'00.0"
Angular error per point: 000-00'00.0"

Correct Ending Coordinates, North: 658428.260 East: 2150182.700
Ending Coordinates, North: 658428.310 East: 2150182.654
Error, N: 0.050 E: -0.046 Total: 0.068 Brg: S 42-39'45.7"E
Distance Traversed: 1491.946 Closure: 1: 22059

The reduced, unadjusted grid distances are shown. The grid factor, the elevation factor, and the combined factor used to reduce the ground distance to a grid distance are included in the listing:

Grid Distances: 14 Observations

From Sta.	To Sta.	Grid Dist.	Grid Factor	Z Factor	Combined Factor
1	5	290.420	0.99992459	0.99997256	0.99989716
1	2	292.183	0.99992452	0.99997256	0.99989708
2	6	52.382	0.99992447	0.99997239	0.99989686
2	3	324.153	0.99992451	0.99997221	0.99989673
3	4	275.575	0.99992459	0.99997232	0.99989692
3	20	134.649	0.99992456	0.99997235	0.99989691
20	21	116.061	0.99992458	0.99997243	0.99989701
21	22	50.110	0.99992460	0.99997223	0.99989683
4	5	309.615	0.99992464	0.99997249	0.99989713
5	10	129.972	0.99992462	0.99997233	0.99989696
10	11	125.997	0.99992459	0.99997225	0.99989684
10	15	9.999	0.99992461	0.99997228	0.99989689
11	12	129.413	0.99992456	0.99997221	0.99989677
12	3	144.636	0.99992455	0.99997213	0.99989667

The reduced, unadjusted horizontal angles with the t-T correction applied are shown. The t-T correction is generally a small correction. For most surveys of limited size the correction is negligible. The t-T correction is displayed in seconds.

Grid Horizontal Angles: 17 Observations

BS Sta.	Occ. Sta.	FS Sta.	Angle	StErr (Sec.)	t-T
5	1	2	109-19'13.0"	13.9	0.0
1	2	6	190-32'06.0"	51.9	0.0
1	2	3	096-03'52.0"	12.9	0.0
2	3	30	350-57'34.0"	7.1	0.0
2	3	4	124-03'53.0"	14.0	0.0
2	3	20	185-23'56.0"	23.7	0.0
3	20	21	180-15'26.0"	33.9	0.0
20	21	22	183-26'45.0"	61.6	0.0
3	4	5	093-02'11.5"	13.3	-0.0
4	5	10	039-26'40.0"	19.7	-0.0
5	10	11	241-56'29.0"	30.4	0.0
5	10	15	056-23'10.0"	249.9	0.0
10	11	12	114-56'27.0"	30.3	0.0
11	12	3	140-39'24.5"	29.8	0.0
12	3	2	325-54'30.0"	17.8	-0.0
4	5	30	079-39'33.0"	7.1	-0.0
4	5	1	117-30'42.5"	13.8	-0.0

Adjusted Coordinates
====================

The adjusted GRID coordinates are show along with the Delta N and Delta E values of the non-fixed control points:

Adjusted Grid Coordinates

Sta.	N:	E:	StErr N:	StErr E:	DN	DE
1	658428.2529	2150182.7047	0.0163	0.0164	-0.0071	0.0047
4	658863.5571	2149911.0253	0.0163	0.0164	0.0071	-0.0047
2	658634.8548	2150389.3067	0.0192	0.0178		
5	658554.0988	2149920.9564	0.0178	0.0177		
3	658886.9763	2150185.5926	0.0177	0.0189		
20	658999.2069	2150111.1980	0.0246	0.0268		
21	659096.2313	2150047.5082	0.0336	0.0401		
10	658657.0735	2150000.2729	0.0203	0.0194		
11	658636.1786	2150124.5275	0.0221	0.0217		
12	658742.8499	2150197.8152	0.0224	0.0191		

In the Adjusted Coordinates section of the report there is a section displaying the latitude and longitude of the final adjusted points. Additionally the convergence angle, the grid factor, the elevation factor, and the combined factor are displayed for each point. Also calculated is the Average Combined Scale Factor for the project which is useful if you want to scale the grid coordinates to ground.

Adjusted Geographic Coordinates

Sta.	Latitude	Longitude	Conv. Ang.	Grid Factor	Z Factor	Combined Factor
1	31-48'34.11031"N	84-38'16.70951"W	-000-14'54.3"	0.99992455	0.99997274	0.99989729
4	31-48'38.40662"N	84-38'19.87996"W	-000-14'56.0"	0.99992464	0.99997259	0.99989724
2	31-48'36.16380"N	84-38'14.32554"W	-000-14'53.1"	0.99992448	0.99997238	0.99989686
5	31-48'35.34450"N	84-38'19.74929"W	-000-14'56.0"	0.99992464	0.99997238	0.99989702
3	31-48'38.65018"N	84-38'16.69910"W	-000-14'54.4"	0.99992455	0.99997205	0.99989660
20	31-48'39.75767"N	84-38'17.56692"W	-000-14'54.8"	0.99992457	0.99997265	0.99989723
21	31-48'40.71513"N	84-38'18.30993"W	-000-14'55.2"	0.99992459	0.99997220	0.99989680
10	31-48'36.36700"N	84-38'18.83526"W	-000-14'55.5"	0.99992461	0.99997228	0.99989689
11	31-48'36.16555"N	84-38'17.39419"W	-000-14'54.7"	0.99992457	0.99997222	0.99989679
12	31-48'37.22436"N	84-38'16.55020"W	-000-14'54.3"	0.99992454	0.99997221	0.99989675

Average Combined Scale Factor: 0.99989695

Error ellipses shown at 95% confidence interval:

Adjusted Coordinates Error Ellipses, 95% CI

Sta.	Semi Major Axis	Semi Minor Axis	Max. Error Az.
1	0.0420	0.0379	N 47-22'21.7"E
4	0.0420	0.0379	N 47-22'21.7"E
2	0.0502	0.0399	N 35-00'26.0"E
5	0.0458	0.0408	S 44-05'10.1"E
3	0.0466	0.0430	S 70-27'45.8"E
20	0.0658	0.0600	S 80-48'51.3"E
21	0.1031	0.0758	N 62-59'38.9"E
10	0.0512	0.0459	N 32-30'53.2"E
11	0.0560	0.0512	N 39-41'57.3"E
12	0.0549	0.0467	S 01-00'56.8"E

The adjusted distances, angles and reference azimuths are shown:

Adjusted Observations
=====================

Adjusted Distances

From Sta.	To Sta.	Distance	Residual	StdRes.	StdDev
1	5	290.430	0.009	0.6	0.013
1	2	292.179	-0.004	0.3	0.013
2	3	324.137	-0.016	1.0	0.013
3	4	275.564	-0.011	0.7	0.013
3	20	134.649	-0.000	0.0	0.018
20	21	116.061	0.000	0.0	0.018
4	5	309.618	0.003	0.2	0.012
5	10	129.980	0.009	0.5	0.014
10	11	125.999	0.002	0.1	0.014
11	12	129.421	0.009	0.5	0.014
12	3	144.644	0.008	0.5	0.015
	Root Mean Square (RMS)		0.008		

Adjusted Angles

BS Sta.	Occ. Sta.	FS Sta.	Angle	Residual	StdRes	StdDev(Sec.)
5	1	2	109-19'20.1"	07.1	0.5	09.1
1	2	3	096-03'42.4"	-09.6	0.7	08.8
2	3	4	124-03'46.7"	-06.3	0.4	10.5
2	3	20	185-23'56.0"	00.0	0.0	23.7
3	20	21	180-15'26.0"	-00.0	0.0	33.9
3	4	5	093-02'13.7"	02.2	0.2	09.5
4	5	10	039-26'36.3"	-03.7	0.2	15.8
5	10	11	241-56'25.3"	-03.7	0.1	24.0
10	11	12	114-56'42.1"	15.1	0.5	24.8
11	12	3	140-39'42.9"	18.4	0.6	22.8
12	3	2	325-54'33.0"	03.0	0.2	14.3
4	5	1	117-30'57.1"	14.6	1.1	10.3
		Root Mean Square (RMS)		09.1		

Adjusted Azimuths

Occ. Sta.	FS Sta.	Bearing	Residual	StdRes	StdDev(Sec.)
1	2	N 45-00'00.0"E	00.0	0.0	04.7
	Root Mean Square (RMS)		00.0		

Project Statistics are shown:

Statistics
==========

Solution converged in 2 iterations

Total Observations:28
Total Unknowns:20
Degrees of Freedom:8

Observation	Count	Sum Squares of StdRes	Std. Error of Unit Wt.
Coordinate	4	0.364	0.564
Azimuths:	1	0.000	0.014
Angles:	12	2.878	0.916
Distances:	11	2.923	0.964 (Horizontal)
Total:	28	6.165	0.878

Reference Variance:0.771
Standard Error Unit Weight: (+/-)0.878
Passed the Chi-Square test at the 95.00 significance level
2.180 <= 6.165 <= 17.535

All confidence regions were computed using the following factors:
Variance factor: 1.0000
1-D Expansion Factor: 1.9600
2-D Expansion Factor: 2.4477
Expansion factors for 95.00 confidence regions taken from normal distribution table

Sideshots are shown:

Sideshots
=========

From	To	Bearing	Dist.	N	E	StDev. N	StDev. E

```
 2          6          N  55-32'06.0"E     52.382  658664.4980  2150432.4944  0.0239  0.0233
 21         22         N  29-50'10.6"W     50.110  659139.6992  2150022.5773  0.0376  0.0430
 10         15         N  86-00'30.8"W      9.999  658657.7695  2149990.2981  0.0237  0.0260
```

Elevation adjustment report is shown:

```
                  LEAST SQUARES VERTICAL ADJUSTMENT REPORT

Wed Oct 12 10:15:00
2D Geodetic Model.
Input Raw Files:
    C:\Carlson Projects\cgstar.cgr
Output File: C:\Carlson Projects\cgstar.RPT
Traverse File: C:\Carlson Projects\cgstar.cls
Curvature, refraction correction: ON


                                VERTICAL BENCHMARKS

        Station             Elevation             Std. Error
      1                    569.8500              0.040
      4                    572.9500              0.040

                             POINTS TO BE ADJUSTED

       Station
     2,5,3,10,11,12,30

                                 MEASUREMENT SUMMARY

        From           To            Elev. Diff.    StdErr
                                   (unadjusted)
      1              5                  7.5037      0.0200
      1              2                  7.5659      0.0201
      2              3                  6.9843      0.0200
      3              4                -11.4907      0.0196
      4              5                  4.3557      0.0206
      5              10                 2.2639      0.0168
      10             11                 1.0931      0.0166
      11             12                 0.3828      0.0167
      12             3                  3.3590      0.0174
      3              30                -7.3173      0.0354
      5              30                -0.0329      0.0527

                          STATISTICAL SUMMARY

                               Total Unknown Elevations:7
                               Total Elev. Routes:11
                               Total Fixed BM's:0
                               Total non-fixed BM's:2
                               Degrees of freedom:4

                               ADJUSTED ELEVATIONS

        Station     Adjusted Elev   Standard  Dev.  Error Ellipse at 95% CI
      1                569.8432         0.04991        0.09782
      4                572.9568         0.04991        0.09782
      2                577.4358         0.05800        0.11368
      5                577.3168         0.05372        0.10528
      3                584.4467         0.05573        0.10923
      10               579.5885         0.06275        0.12299
      11               580.6892         0.06579        0.12895
      12               581.0797         0.06379        0.12503
      30               577.1915         0.06931        0.13584

                         ADJUSTED MEASUREMENT SUMMARY

     From           To            Elev.  Diff.       Residuals       Std. Dev.
                                  (adjusted)
      1              5                 7.4736        -0.0301          0.037
      1              2                 7.5926         0.0267          0.038
      2              3                 7.0109         0.0266          0.038
      3              4               -11.4899         0.0008          0.036
      4              5                 4.3600         0.0043          0.036
      5              10                2.2717         0.0077          0.037
      10             11                1.1007         0.0077          0.037
      11             12                0.3905         0.0077          0.037
      12             3                 3.3670         0.0080          0.037
      3              30               -7.2552         0.0621          0.049
      5              30               -0.1253        -0.0924          0.052

Vertical Sideshots
 Station                 Elevation
```

```
 6                         577.135
 20                        571.777
 21                        581.262
 22                        580.151
 15                        579.588
```

GPS Network report

Note: The following section shows the report generated by the least squares adjustment of the GPS network. The 3D adjustment model MUST be used when processing GPS vectors. **Explanations of the report are included in the report section and are in bold text.**

```
     ===============================
     LEAST SQUARES ADJUSTMENT REPORT
     ===============================

Wed Oct 12 10:59:00
3D Geodetic Model.
Input Raw Files:
    C:\Carlson Projects\gpsonly\control.cgr
    C:\Carlson Projects\gpsonly\chapt16.gps
Output File: C:\Carlson Projects\gpsonly\gpsOnly.RPT
Traverse File: C:\Carlson Projects\gpsonly\gpsLoops.cls
Curvature, refraction correction: OFF
Maximum iterations: 10 , Convergence Limit: 0.002000
1983 State Plane Coordinates, zone:Wisconsin South - 4803
Horizontal Units: Meters
Confidence Interval: 95.00
Geoid Height computed from geoid grid files using the GEOID99 model.
Default Standard Errors:
  Distance: Constant 0.010 ,PPM: 5.000
  Horiz. Angle: Pointing 10.0" ,Reading: 3.0"
  Vert. Angle: Pointing 3.0" ,Reading: 3.0"
  Total Station: Centering 0.005 ,Height: 0.010
  Target: Centering 0.010 ,Height: 0.010
  Azimuth: 5"
  Coordinate Control: N:0.001, E:0.001, Z:0.030,
  GPS: Centering:0.003, Vector Err. Factor:7.0


     3-DIMENSIONAL ADJUSTMENT REPORT
     ===============================
```

The following section shows the unadjusted measurements that make up the network. The control coordinates are displayed first followed by the GPS vectors. The control coordinates are displayed as latitude/longitude, SPC Grid XYZ, and geocentric XYZ. If geoid modeling is set both ellipsoid and orthometric elevations are displayed, ellipsoid elevation in the latitude/longitude section and orthometric elevation in the SPC section. The GPS vector section shows the unadjusted delta XYZ, variances and covariances of the vectors.

```
Unadjusted Observations
=======================

Control Coordinates:     0 Observed Points,    2 Fixed Points,    0 Approx. Points
 Sta.         Latitude          Longitude          Z (Ellip.)     StErr N:   StErr E:   StErr Z:NE
 A          43-15'46.28901"N  89-59'42.16399"W      1348.23       FIXED      FIXED      FIXED
 B          43-23'46.36261"N  89-54'00.75701"W      1200.63       FIXED      FIXED      FIXED

Grid XYZ
 Sta.             N:            E:             Z (Geoid): StErr N:   StErr E: StErr Z:
 A            140291.2060   600402.2380       1382.62      FIXED       FIXED     FIXED
 B            155110.5390   608083.9250       1235.46      FIXED       FIXED     FIXED

Geocentric XYZ
 Sta.            X:            Y:              Z:        StErr X(m): StErr Y(m): StErr Z(m):
 A               402.3489  -4652970.2600 4349737.2110       FIXED       FIXED     FIXED
 B              8085.9876  -4642687.5392 4360415.1538       FIXED       FIXED     FIXED
```

The GPS vectors are shown (Delta X, Delta Y and Delta Z values). Also shown are the bearing, horizontal distance and vertical difference of each vector:

```
GPS Vectors:   13 Observations (Meters)
Multiplication factor applied to Variance and Covariance values:  128 (2 to  7 power)

 From Sta.        Delta X   Variance Delta X   Covariance XY   Bearing
 To   Sta.        Delta Y   Variance Delta Y   Covariance XZ   H.Distance
                  Delta Z   Variance Delta Z   Covariance YZ   V.Distance

 A              11644.223          0.126        -0.001226   N 67-00'00.4"E
```

```
 C              3601.217          0.12        0.001219    12650.1512
                3399.255        0.1258       -0.001219     -292.0672

 A             -5321.716       0.02764      -0.0002688   N 47-56'12.9"W
 E              3634.075       0.02458       0.0002765     7167.7644
                3173.665       0.02568      -0.0002688     -471.6711

 B              3960.544       0.02952      -0.0002854   S 21-46'39.9"E
 C             -6681.247       0.03261        0.000265    10643.7341
               -7279.015       0.02884      -0.0002854     -141.2376

 B            -11167.608       0.03458       -0.000352   S 85-18'14.1"W
 D              -394.520       0.03485       0.0003648    11205.8960
                -907.959       0.03419      -0.0003482     -351.2707

 D             15128.165       0.01872       -0.000183   S 59-25'16.9"E
 C             -6286.705       0.02068       0.0001715    17576.6958
               -6371.058       0.01676      -0.0001843      184.8828

 D             -1837.746       0.01577      -0.0001523   S 11-24'12.6"W
 E             -6253.853       0.01636       0.0001562     9273.8256
               -6596.670       0.01644      -0.0001549       14.2116

 F             -1116.452      0.009586      -0.0001011   S 10-01'41.1"W
 A             -4596.161      0.008457       0.0001126     6420.1982
               -4355.906      0.009766      -0.0001037      355.1552

 F             10527.785       0.03288       -0.000288   S 82-31'36.9"E
 C              -994.938        0.0277       0.0003072    10617.6451
                -956.625        0.0307      -0.0002906       70.0452

 F             -6438.136        0.0121      -0.0001178   S 76-43'39.1"W
 E              -962.069       0.01277       0.0001331     6615.1455
               -1182.230       0.01132      -0.0001139     -112.6820

 F             -4600.379       0.01196      -0.0001267   N 31-16'31.7"W
 D              5291.779       0.01266       0.0001152     8857.9833
                5414.431       0.01543      -0.0001267     -136.3798

 F              6567.231      0.008521       -8.32E-005   N 37-41'59.1"E
 B              5686.293      0.009573       8.832E-005   10742.1697
                6322.392      0.007759      -8.192E-005     202.1754

 B             -6567.231      0.007073      -8.064E-005   S 37-45'19.5"W
 F             -5686.303      0.009582       7.808E-005   10741.8133
               -6322.381      0.008503      -8.064E-005    -220.2601

 A              1116.458       0.00849      -0.0001024   N 10-01'07.3"E
 F              4596.155        0.0104       0.0001152     6419.8396
                4355.914       0.01202       -0.000105     -361.6188
```

The optional Traverse Closure shows the GPS loop closures for the GPS loops defined in the closure file.

```
Traverse Closures
=================

GPS Loop Points:
A,E,F,A

GPS Loop Closure;

 Misclosure, X:   -0.0323   Y:   -0.0162   Z:   -0.0105
  Closure error:    0.0376   Perimeter: 20229.3858
  Precision: 1: 537594

GPS Loop Points:
C,F,D,B,C

GPS Loop Closure;

 Misclosure, X:   -0.0121   Y:   -0.0101   Z:    0.0002
  Closure error:    0.0158   Perimeter: 41332.9807
  Precision: 1: 2622216

GPS Loop Points:
F,D,B,F

GPS Loop Closure;

 Misclosure, X:   -0.0022   Y:   -0.0044   Z:    0.0097
  Closure error:    0.0109   Perimeter: 30814.5047
  Precision: 1: 2833226
```

Following are the final adjusted coordinates. Included in the report are point grid factor, elev. factor and the combined factor. Following the

adjusted coordinates are the error ellipses, followed by the adjusted measurements section.

```
Adjusted Geographic Coordinates
 Sta.         Latitude          Longitude          Z (Ellip.)   Conv. Ang.    Grid Factor   Z Factor   Combined Factor
 C          43-18'26.10221"N  89-51'05.56799"W       1068.43   000-06'07.2"   0.99993389   0.99983235   0.99976625
 E          43-18'21.80297"N  90-03'38.24477"W        880.40  -000-02'30.0"   0.99993392   0.99986185   0.99979578
 D          43-23'16.34105"N  90-02'16.89840"W        859.36  -000-01'34.1"   0.99993257   0.99986515   0.99979774
 F          43-19'11.10720"N  89-58'52.60718"W        989.61   000-00'46.3"   0.99993355   0.99984472   0.99977828

                                                   Average Combined Scale Factor: 0.99978451

Adjusted Grid Coordinates, (Meters)
 Sta.            N:            E:             Z (Geoid): StErr N:   StErr E: StErr Z:     DN          DE          DZ
 C            145233.5291   612043.7357         1103.09  0.0962     0.0972   0.0973
 E            145091.9273   595081.6287          914.80  0.0831     0.0837   0.0840
 D            154179.9652   596918.9980          894.01  0.0812     0.0791   0.0819
 F            146611.7765   601518.4253         1024.16  0.0447     0.0427   0.0452


Adjusted Geocentric Coordinates, (Metric)
 Sta.           X:            Y:              Z:         StErr X(m): StErr Y(m): StErr Z(m):
 C             12046.5393  -4649368.8693      4353136.26  0.0962      0.0966   0.0979
 E             -4919.3737  -4649336.0614      4352910.73  0.0831      0.0833   0.0844
 D             -3081.6241  -4643082.1683      4359507.34  0.0812      0.0801   0.0810
 F              1518.7615  -4648373.9615      4354092.93  0.0447      0.0437   0.0442


Adjusted Grid Coordinates (N,E) Error Ellipses, 95% CI
 Sta.               Semi Major     Semi Minor      Max. Error Az.        Elev.
                       Axis           Axis
 C                   0.2380         0.2355          N 89-13'58.4"E       0.1919
 E                   0.2050         0.2033          N 86-52'01.5"E       0.1655
 D                   0.1989         0.1937          N 00-18'30.1"E       0.1588
 F                   0.1094         0.1046          N 00-33'33.6"E       0.0867
```

The adjusted observations are shown:

```
Adjusted Observations
=====================

GPS Vectors:   13 Observations (Meters)
 From Sta.          Delta X    Residual    StdRes    StdDev
 To   Sta.          Delta Y    Residual    StdRes    StdDev
                    Delta Z    Residual    StdRes    StdDev

 A                 11644.3130    0.0898        0.3     0.0972
 C                  3601.4692    0.2527        0.7     0.0962
                    3399.2263   -0.0287        0.1     0.0973

 A                 -5321.6362    0.0802        0.5     0.0837
 E                  3634.2495    0.1741        1.1     0.0831
                    3173.6413   -0.0239        0.1     0.0840

 B                  3960.4857   -0.0585        0.3     0.0972
 C                 -6681.3803   -0.1336        0.7     0.0962
                   -7278.9822    0.0326        0.2     0.0973

 B                -11167.6912   -0.0836        0.4     0.0791
 D                  -394.6781   -0.1577        0.8     0.0812
                    -907.9287    0.0306        0.2     0.0819

 D                 15128.1635   -0.0012        0.0     0.0989
 C                 -6286.7011    0.0043        0.0     0.0981
                   -6371.0766   -0.0183        0.1     0.0993

 D                 -1837.7496   -0.0037        0.0     0.0883
 E                 -6253.8932   -0.0398        0.3     0.0892
                   -6596.6118    0.0579        0.5     0.0900

 F                 -1116.4126    0.0397        0.4     0.0427
 A                 -4596.2985   -0.1375        1.5     0.0447
                   -4355.7192    0.1870        1.9     0.0452

 F                 10527.7779   -0.0073        0.0     0.0966
 C                  -994.9079    0.0298        0.2     0.0954
                    -956.6675   -0.0429        0.2     0.0964

 F                 -6438.1351    0.0013        0.0     0.0795
 E                  -962.1000   -0.0306        0.3     0.0789
                   -1182.2028    0.0277        0.3     0.0797

 F                 -4600.3856   -0.0069        0.1     0.0749
 D                  5291.7932    0.0147        0.1     0.0773
                    5414.4090   -0.0221        0.2     0.0779
```

```
 F                  6567.2261   -0.0050        0.1     0.0427
 B                  5686.4222    0.1296        1.3     0.0447
                    6322.2236   -0.1681        1.9     0.0452

 B                 -6567.2263    0.0048        0.1     0.0427
 F                 -5686.4224   -0.1191        1.2     0.0447
                   -6322.2237    0.1570        1.7     0.0452

 A                  1116.4126   -0.0451        0.5     0.0427
 F                  4596.2983    0.1430        1.4     0.0447
                    4355.7191   -0.1950        1.8     0.0452
```

The final section displays a variety statistical measures, followed by sideshots if there are any. Side shots would be a point that has only a single GPS vector going to or from the point.

```
Statistics
==========

 Solution converged in 2 iterations

 Total Observations:39
 Total Unknowns:12
 Degrees of Freedom:27

  Observation Count    Sum Squares  Std. Error
                       of StdRes    of Unit Wt.
  Vectors:       39       25.231     0.967

  Total:         39       25.231     0.967

 Reference Variance:0.934
 Standard Error Unit Weight: (+/-)0.967
 Passed the Chi-Square test at the 95.00 significance level
 14.573 <= 24.955 <= 43.195

  All confidence regions were computed using the following factors:
  Variance factor: 1.0000
  1-D Expansion Factor: 1.9600
  2-D Expansion Factor: 2.4477
  Expansion factors for 95.00 confidence regions taken from normal distribution table


Sideshots
=========
```

GPS Vectors and Total Station Sample Report

The following is a report generated from a project that combined GPS vectors and total station data. The 3D adjustment model MUST be used when processing GPS vectors. Notice that the report is very similar to the GPS vector only project report. Explanations of the report are included in the report and are in **bold, normal text**.

```
     ===============================
     LEAST SQUARES ADJUSTMENT REPORT
     ===============================
Wed Oct 12 11:11:00
3D Geodetic Model.
Input Raw Files:
    C:\Carlson Projects\GPSandTS\Orginal_M07052.RW5
    C:\Carlson Projects\GPSandTS\OM07052A.GPS
Output File: C:\Carlson Projects\GPSandTS\m07052.RPT
Traverse File: C:\Carlson Projects\GPSandTS\m07052.cls
Curvature, refraction correction: ON
Maximum iterations: 10 , Convergence Limit: 1.000000
1983 State Plane Coordinates, zone:Texas North Central -  4202
Horizontal Units: US Feet
Confidence Interval: 95.00
Geoid Height computed from geoid grid files using the  GEOID03 model.
Default Standard Errors:
  Distance: Constant 0.003 ,PPM: 3.000
  Horiz. Angle: Pointing 3.0" ,Reading: 3.0"
  Vert. Angle: Pointing 3.0" ,Reading: 3.0"
  Total Station: Centering 0.003 ,Height: 0.005
  Target: Centering 0.003 ,Height: 0.005
  Azimuth: 10"
  Coordinate Control: N:0.010, E:0.010, Z:0.020,
  GPS: Centering:0.005, Vector Err. Factor:1.0

Horizontal Distance from 2004 to 2002 exceeds tolerance:
  Low: 425.153,  High: 425.184,  Diff: 0.031

Vertical Distance from 2001 to 2028 exceeds tolerance:
```

Low: 2.227, High: 2.292, Diff: 0.065

Mark to Mark Vertical Angle from 2003 to 2004 exceeds tolerance:
Low: 088-39'31.4" , High: 088-39'41.1" , Diff: 000-00'09.7"

Mark to Mark distance from 2004 to 2002 exceeds tolerance:
Low: 425.172, High: 425.203, Diff: 0.031

Mark to Mark Vertical Angle from 2001 to 2028 exceeds tolerance:
Low: 090-15'26.8" , High: 090-15'58.8" , Diff: 000-00'32.0"

Mark to Mark Vertical Angle from 2028 to 2046 exceeds tolerance:
Low: 089-57'54.2" , High: 089-58'07.9" , Diff: 000-00'13.7"

Mark to Mark Vertical Angle from 2028 to 2061 exceeds tolerance:
Low: 091-00'27.8" , High: 091-00'41.1" , Diff: 000-00'13.3"

Mark to Mark Vertical Angle from 2046 to 2083 exceeds tolerance:
Low: 089-21'42.6" , High: 089-21'49.0" , Diff: 000-00'06.4"

Mark to Mark Vertical Angle from 2083 to 2002 exceeds tolerance:
Low: 088-48'02.7" , High: 088-48'14.1" , Diff: 000-00'11.3"

3-DIMENSIONAL ADJUSTMENT REPORT
===============================

The control coordinates are shown in Geodetic, Grid and Geocentric coordinate systems. Notice that in this example, geoid modeling was used. Notice that the ellipsoid elevation is displayed with the latitudes and longitudes. Orthometric elevations are displayed with the SPC83 grid coordinates.

Unadjusted Observations
=======================

Control Coordinates: 1 Observed Points, 2 Fixed Points, 0 Approx. Points

Sta.	Latitude	Longitude	Z (Ellip.)	StErr N:	StErr E:	StErr Z:NE
5	32-24'35.39394"N	94-49'52.08763"W	253.817	FIXED	FIXED	FIXED
1	32-24'55.19534"N	94-49'33.44142"W	248.060	FIXED	FIXED	FIXED
2003	32-24'42.93765"N	94-49'22.76059"W	255.704	FLOAT	FLOAT	0.000

Grid XYZ

Sta.	N:	E:	Z (Geoid):	StErr N:	StErr E:	StErr Z:
5	6851811.008	3100515.417	340.442	FIXED	FIXED	FIXED
1	6853866.683	3102042.915	334.692	FIXED	FIXED	FIXED
2003	6852660.757	3103001.258	342.330	FLOAT	FLOAT	0.000

Geocentric XYZ

Sta.	X:	Y:	Z:	StErr X(m):	StErr Y(m):	StErr Z(m):
5	-453934.078	-5370753.946	3398927.169	FIXED	FIXED	FIXED
1	-453420.933	-5370467.692	3399441.169	FIXED	FIXED	FIXED
2003	-453160.021	-5370694.806	3399123.657	99747.776	54068.184	84421.637

Notice that in the 3-D model, distances are not reduced to horizontal or grid. Slope distances are reduced to mark to mark distances. A Mark to mark distance is the computed slope distance from the monument to monument.

Mark to Mark Slope Distances: 101 Observations

From Sta.	To Sta.	Dist.	StErr
2003	2001	713.020	0.008
2003	2004	454.830	0.007
2003	2005	95.942	0.006
2004	2002	425.188	0.007
2004	2007	276.272	0.007
2004	2008	291.021	0.007
2004	2009	272.204	0.007
2004	2010	281.020	0.007
2004	2011	307.650	0.007
2004	2012	318.715	0.007
2001	2014	427.579	0.008
2001	2015	426.947	0.008
2001	2017	396.702	0.008
2001	2018	422.118	0.008
2001	2019	236.372	0.007
2001	2020	127.451	0.006
2001	2021	120.691	0.006
2001	2022	116.666	0.006
2001	2023	114.515	0.006
2001	2024	94.819	0.006
2001	2025	124.650	0.006
2001	2026	161.794	0.006
2001	2027	140.828	0.006
2001	2028	494.273	0.007
2001	2029	307.380	0.007
2001	2030	245.443	0.007

2001	2031	247.078	0.007
2001	2032	288.191	0.007
2001	2033	132.091	0.006
2001	2034	327.524	0.008
2001	2035	316.236	0.007
2001	2036	355.847	0.008
2001	2037	194.246	0.006
2001	2038	254.679	0.007
2001	2039	467.332	0.009
2001	2040	533.896	0.009
2001	2041	729.607	0.011
2001	2042	196.157	0.007
2001	2043	225.061	0.007
2001	2044	439.031	0.008
2028	2046	1243.938	0.012
2028	2047	361.901	0.008
2028	2048	513.032	0.009
2028	2049	361.805	0.008
2028	2050	361.250	0.008
2028	2051	703.162	0.011
2028	2052	652.990	0.010
2028	2053	618.889	0.010
2028	2054	643.429	0.010
2028	2055	498.669	0.009
2028	2056	483.619	0.009
2028	2057	511.066	0.009
2028	2058	513.548	0.009
2028	2059	525.440	0.009
2028	2060	11.009	0.005
2028	2061	509.379	0.007
2028	2062	23.319	0.005
2028	2063	35.409	0.005
2028	2064	9.151	0.005
2061	2066	297.764	0.007
2061	2067	200.923	0.007
2061	2068	163.679	0.006
2061	2069	51.856	0.006
2061	2070	26.490	0.005
2061	2071	79.182	0.006
2061	2072	103.125	0.006
2061	2073	186.018	0.006
2061	2074	304.536	0.006
2061	2075	279.157	0.007
2061	2076	277.273	0.007
2046	2078	475.616	0.007
2046	2079	89.991	0.006
2046	2080	20.232	0.005
2046	2081	61.170	0.006
2046	2082	58.911	0.006
2046	2083	814.805	0.009
2078	2085	53.677	0.006
2078	2086	70.701	0.006
2078	2087	90.911	0.006
2083	2002	334.150	0.006
2083	2090	241.764	0.007
2083	2091	133.283	0.006
2002	2094	334.831	0.008
2002	2095	196.403	0.007
2002	2096	192.984	0.006
2002	2097	334.947	0.008
2002	2098	188.679	0.006
2002	2099	114.068	0.006
2002	2100	185.073	0.006
2002	2101	131.057	0.006
2002	2102	120.385	0.006
2002	2103	175.168	0.006
2002	2104	148.159	0.006
2002	2105	119.767	0.006
2002	2106	280.762	0.007
2002	2107	158.649	0.006
2002	2108	153.766	0.006
2002	2109	158.381	0.006
2002	2110	155.574	0.006
2002	2111	167.254	0.006
2074	1	418.772	0.008

Notice that in the 3-D model, vertical angles are considered as separate measurements. Vertical angles have also been converted to mark to mark vertical angles.

Mark to Mark Vertical Angles: 101 Observations

From Sta.	To Sta.	Vertical Ang.	StErr (Sec.)
2003	2001	089-59'14.5"	03.0
2003	2004	088-39'36.2"	03.0
2003	2005	090-52'55.3"	04.2
2004	2002	089-27'12.5"	03.0

2004	2007	089-20'18.1"	04.2
2004	2008	088-24'41.6"	04.2
2004	2009	088-20'22.6"	04.2
2004	2010	089-56'09.3"	04.2
2004	2011	085-01'15.4"	04.2
2004	2012	085-07'02.5"	04.2
2001	2014	089-45'31.0"	04.2
2001	2015	089-46'23.6"	04.2
2001	2017	089-43'33.3"	04.2
2001	2018	090-08'56.5"	04.2
2001	2019	090-40'55.0"	04.2
2001	2020	088-57'10.4"	04.2
2001	2021	088-47'57.4"	04.2
2001	2022	088-42'22.7"	04.2
2001	2023	088-39'17.3"	04.2
2001	2024	092-32'27.5"	04.2
2001	2025	093-33'19.2"	04.2
2001	2026	092-05'05.6"	04.2
2001	2027	091-40'35.1"	04.2
2001	2028	090-15'42.8"	03.0
2001	2029	090-56'04.2"	04.2
2001	2030	091-09'38.1"	04.2
2001	2031	091-09'32.2"	04.2
2001	2032	090-54'51.6"	04.2
2001	2033	089-45'41.3"	04.2
2001	2034	090-44'21.7"	04.2
2001	2035	085-04'16.4"	04.2
2001	2036	088-48'17.8"	04.2
2001	2037	084-26'58.6"	04.2
2001	2038	086-11'06.8"	04.2
2001	2039	087-27'14.1"	04.2
2001	2040	088-19'39.1"	04.2
2001	2041	089-03'57.7"	04.2
2001	2042	090-47'01.9"	04.2
2001	2043	090-49'09.2"	04.2
2001	2044	089-17'51.9"	04.2
2028	2046	089-58'01.1"	03.0
2028	2047	089-48'39.4"	04.2
2028	2048	089-44'04.4"	04.2
2028	2049	089-18'31.3"	04.2
2028	2050	089-19'58.9"	04.2
2028	2051	089-01'11.1"	04.2
2028	2052	089-37'02.7"	04.2
2028	2053	089-38'14.5"	04.2
2028	2054	089-52'42.1"	04.2
2028	2055	089-37'17.0"	04.2
2028	2056	089-36'08.6"	04.2
2028	2057	089-38'13.9"	04.2
2028	2058	089-47'46.7"	04.2
2028	2059	089-48'39.4"	04.2
2028	2060	089-30'16.3"	04.2
2028	2061	091-00'34.4"	03.0
2028	2062	091-58'59.1"	04.2
2028	2063	091-30'44.0"	04.2
2028	2064	093-54'55.9"	04.2
2061	2066	089-28'19.4"	04.2
2061	2067	089-33'11.5"	04.2
2061	2068	090-01'30.6"	04.2
2061	2069	092-49'51.7"	04.2
2061	2070	090-48'22.6"	04.2
2061	2071	088-59'08.0"	04.2
2061	2072	088-34'19.3"	04.2
2061	2073	088-53'32.3"	04.2
2061	2074	089-19'34.5"	03.0
2061	2075	089-02'34.1"	04.2
2061	2076	088-52'41.9"	04.2
2046	2078	091-41'56.5"	03.0
2046	2079	092-56'27.2"	04.2
2046	2080	092-31'47.5"	04.2
2046	2081	090-34'48.1"	04.2
2046	2082	090-25'54.8"	04.2
2046	2083	089-21'45.8"	03.0
2078	2085	091-59'10.6"	04.2
2078	2086	094-33'42.0"	04.2
2078	2087	092-14'47.8"	04.2
2083	2002	088-48'08.4"	03.0
2083	2090	091-45'04.2"	04.2
2083	2091	089-25'09.0"	04.2
2002	2094	089-35'07.6"	04.2
2002	2095	087-20'52.8"	04.2
2002	2096	087-45'48.7"	04.2
2002	2097	086-49'13.5"	04.2
2002	2098	090-03'17.3"	04.2
2002	2099	090-19'24.7"	04.2
2002	2100	087-28'27.3"	04.2
2002	2101	090-26'33.7"	04.2
2002	2102	090-00'15.2"	04.2

2002	2103	089-16'44.7"	04.2
2002	2104	089-08'12.4"	04.2
2002	2105	089-33'50.7"	04.2
2002	2106	090-44'21.2"	04.2
2002	2107	089-04'40.1"	04.2
2002	2108	088-43'52.2"	04.2
2002	2109	088-43'43.5"	04.2
2002	2110	089-04'44.7"	04.2
2002	2111	089-07'46.5"	04.2
2074	1	090-01'27.6"	04.2

Horizontal Angles: 101 Observations

BS Sta.	Occ. Sta.	FS Sta.	Angle	StErr (Sec.)
2001	2003	2004	168-34'02.0"	06.4
2001	2003	2005	059-32'00.0"	09.8
2003	2004	2002	161-02'16.0"	06.6
2003	2004	2007	182-26'35.0"	07.0
2003	2004	2008	157-56'12.0"	06.9
2003	2004	2009	154-18'53.0"	07.0
2003	2004	2010	157-59'26.0"	07.0
2003	2004	2011	146-45'42.0"	06.9
2003	2004	2012	146-45'43.0"	06.8
2003	2001	2014	201-59'12.0"	06.4
2003	2001	2015	202-08'04.0"	06.4
2003	2001	2017	203-41'20.0"	06.5
2003	2001	2018	211-05'58.0"	06.4
2003	2001	2019	030-08'11.0"	06.7
2003	2001	2020	026-31'26.0"	08.3
2003	2001	2021	019-53'03.0"	08.5
2003	2001	2022	012-46'09.0"	08.7
2003	2001	2023	005-13'38.0"	08.7
2003	2001	2024	354-47'10.0"	09.8
2003	2001	2025	042-03'50.0"	08.4
2003	2001	2026	030-58'40.0"	07.5
2003	2001	2027	356-54'03.0"	07.9
2003	2001	2028	097-51'17.0"	06.3
2003	2001	2029	001-21'06.0"	06.4
2003	2001	2030	001-19'07.0"	06.7
2003	2001	2031	009-34'48.0"	06.7
2003	2001	2032	008-21'35.0"	06.5
2003	2001	2033	269-04'45.0"	08.4
2003	2001	2034	016-18'26.0"	06.4
2003	2001	2035	004-12'03.0"	06.4
2003	2001	2036	332-05'53.0"	06.4
2003	2001	2037	291-53'36.0"	07.2
2003	2001	2038	228-39'25.0"	06.9
2003	2001	2039	205-53'14.0"	06.4
2003	2001	2040	169-11'06.0"	06.3
2003	2001	2041	148-15'59.0"	06.2
2003	2001	2042	321-52'43.0"	07.1
2003	2001	2043	346-51'27.0"	06.8
2003	2001	2044	159-49'11.0"	06.4
2001	2028	2046	093-37'03.0"	06.2
2001	2028	2047	270-14'38.0"	06.5
2001	2028	2048	266-14'44.0"	06.4
2001	2028	2049	269-37'27.0"	06.5
2001	2028	2050	267-24'53.0"	06.5
2001	2028	2051	243-22'42.0"	06.3
2001	2028	2052	243-42'14.0"	06.3
2001	2028	2053	238-35'14.0"	06.4
2001	2028	2054	237-25'22.0"	06.4
2001	2028	2055	225-23'07.0"	06.5
2001	2028	2056	223-50'19.0"	06.5
2001	2028	2057	220-23'28.0"	06.5
2001	2028	2058	219-49'11.0"	06.5
2001	2028	2059	218-34'59.0"	06.4
2001	2028	2060	195-53'28.0"	69.6
2001	2028	2061	132-38'59.0"	06.4
2001	2028	2062	185-30'42.0"	33.6
2001	2028	2063	184-05'46.0"	22.8
2001	2028	2064	202-20'41.0"	83.7
2028	2061	2066	062-05'00.0"	06.6
2028	2061	2067	064-50'44.0"	07.1
2028	2061	2068	065-32'29.0"	07.6
2028	2061	2069	081-34'37.0"	15.8
2028	2061	2070	140-10'23.0"	29.6
2028	2061	2071	167-45'04.0"	11.8
2028	2061	2072	182-53'28.0"	10.0
2028	2061	2073	201-26'16.0"	07.7
2028	2061	2074	278-54'20.0"	06.6
2028	2061	2075	277-42'49.0"	06.7
2028	2061	2076	278-40'33.0"	06.7
2028	2046	2078	000-42'06.0"	06.2
2028	2046	2079	344-41'17.0"	10.2
2028	2046	2080	145-10'41.0"	38.1
2028	2046	2081	278-14'36.0"	13.8
2028	2046	2082	119-21'31.0"	14.3

```
2028          2046         2083         108-00'05.0"       06.1
2046          2078         2085         040-56'15.0"       15.1
2046          2078         2086         030-52'34.0"       12.0
2046          2078         2087         022-46'29.0"       10.0
2046          2083         2002         145-53'36.0"       06.6
2046          2083         2090         356-22'59.0"       06.7
2046          2083         2091         186-44'57.0"       08.5
2083          2002         2004         064-14'35.0"       06.6
2083          2002         2094         252-05'26.0"       06.9
2083          2002         2095         142-56'46.0"       07.8
2083          2002         2096         168-34'25.0"       07.9
2083          2002         2097         100-03'00.0"       06.8
2083          2002         2098         224-51'23.0"       07.8
2083          2002         2099         069-34'02.0"       09.0
2083          2002         2100         196-45'31.0"       08.0
2083          2002         2101         113-49'02.0"       08.8
2083          2002         2102         118-25'07.0"       09.2
2083          2002         2103         159-27'09.0"       08.1
2083          2002         2104         148-55'00.0"       08.6
2083          2002         2105         118-24'58.0"       09.3
2083          2002         2106         091-49'18.0"       07.0
2083          2002         2107         172-11'19.0"       08.4
2083          2002         2108         184-15'44.0"       08.5
2083          2002         2109         192-14'20.0"       08.4
2083          2002         2110         202-13'25.0"       08.5
2083          2002         2111         213-52'09.0"       08.2
2061          2074         1            210-25'35.0"       06.9
```

Unadjusted vector data is shown:

```
GPS Vectors:    6 Observations (Meters)
Multiplication factor applied to Variance and Covariance  values:    2 (2 to  1 power)

 From Sta.         Delta X   Variance Delta X   Covariance  XY   Bearing
 To    Sta.        Delta Y    Variance Delta Y   Covariance XZ   H.Distance

  Delta Z   Variance Delta Z   Covariance  YZ   V.Distance

 1
  315.769       5.28E-005        8.497E-007   S 28-38'43.2"E
 2002
  -373.192      5.485E-005         9.31E-009       721.852

  -531.162      5.601E-005       -3.512E-006         6.769

 2001
  22.748      5.131E-005        4.072E-007   S 05-23'03.0"E
 2002
  -259.604      5.233E-005       -4.792E-008       474.172

  -396.166      5.287E-005       -1.689E-006         4.409

 1
  293.021      5.091E-005        2.949E-007   S 61-50'19.5"E
 2001
  -113.588      5.179E-005        2.886E-009       342.026

  -134.997       5.23E-005        -1.32E-006         2.373

 5
  806.171      5.339E-005        1.024E-006   N 60-22'21.5"E
 2001
  172.665      5.533E-005       -5.993E-009       907.399

  379.011      5.618E-005       -3.755E-006         0.568

 5
  828.920      5.363E-005        1.144E-006   S 88-23'05.3"E
 2002
  -86.940      5.632E-005       -1.107E-009       833.628

  -17.154      5.752E-005       -4.498E-006         5.006

 1
  -513.151      5.357E-005        1.147E-006   S 38-37'06.7"W
 5
  -286.253      5.649E-005       -3.598E-009       780.683

  -514.008      5.783E-005       -4.666E-006         1.702
```

Option traverse and GPS closures are shown if a Closure File is specified:

Traverse Closures
=================

Traverse points:
2003,2004,2002,2083,2046,2028,2001,2003,2004

Loop Traverse; Interior direction reference;
Compute angle closure.
Compute vertical closure.

BS	IP	FS	Angle	FS H. Dist.	FS V. Dist.
2003	2004	2002	161-02'16.0"	425.135	4.056
2004	2002	2083	295-45'25.0"	334.052	-6.984
2002	2083	2046	214-06'24.0"	814.691	-9.063
2083	2046	2028	251-59'55.0"	1243.841	-0.717
2046	2028	2001	266-22'57.0"	494.229	2.259
2028	2001	2003	262-08'43.0"	712.964	-0.157
2001	2003	2004	168-34'02.0"	454.670	10.636

Closing Az: S 07-30'32.0"E
Computed Closing Az: S 07-30'50.0"E

Total angular error: 000-00'18.0"
Angular error per point: 000-00'02.6"

Correct Ending Coordinates, North: 6852209.986 East: 3103060.674
Ending Coordinates, North: 6852209.966 East: 3103060.633
Error, N: -0.020 E: -0.041 Total: 0.046 Brg: N 63-58'04.2"E
Distance Traversed: 4479.583 Closure: 1: 97122

Correct Ending Elevation: 352.964
Ending Elevation: 352.993
Elevation Error: 0.029

Closure After Angle Adjustment

2003	2004	2002	161-02'18.6"	425.135	4.056
2004	2002	2083	295-45'27.6"	334.052	-6.984
2002	2083	2046	214-06'26.6"	814.691	-9.063
2083	2046	2028	251-59'57.6"	1243.841	-0.717
2046	2028	2001	266-22'59.6"	494.229	2.259
2028	2001	2003	262-08'45.6"	712.964	-0.157
2001	2003	2004	168-34'04.6"	454.670	10.636

Closing Az: S 07-30'32.0"E
Computed Closing Az: S 07-30'32.0"E

Total angular error: 000-00'00.0"
Angular error per point: 000-00'00.0"

Correct Ending Coordinates, North: 6852209.986 East: 3103060.674
Ending Coordinates, North: 6852209.949 East: 3103060.606
Error, N: -0.037 E: -0.069 Total: 0.078 Brg: N 61-38'31.8"E
Distance Traversed: 4479.583 Closure: 1: 57506

Adjusted coordinates are shown in Geographic, Grid and Geocentric formats, as well as Grid Factor, Elevation Factor and Combined Factors.

Adjusted Geographic Coordinates

Sta.	Latitude	Longitude	Z (Ellip.)	Conv. Ang.	Grid Factor	Z Factor	Combined Factor
2003	32-24'42.93768"N	94-49'22.76059"W	255.704	002-00'19.5"	0.99993450	0.99998777	0.99992227
2001	32-24'49.95503"N	94-49'21.90114"W	255.874	002-00'20.0"	0.99993412	0.99998776	0.99992188
2004	32-24'38.45922"N	94-49'22.25214"W	266.347	002-00'19.8"	0.99993474	0.99998726	0.99992200
2002	32-24'34.62991"N	94-49'20.19858"W	270.409	002-00'20.9"	0.99993494	0.99998707	0.99992201
2028	32-24'51.12045"N	94-49'27.50058"W	253.618	002-00'16.9"	0.99993406	0.99998787	0.99992193
2046	32-24'39.37540"N	94-49'31.84052"W	254.353	002-00'14.6"	0.99993469	0.99998783	0.99992252
2061	32-24'48.33434"N	94-49'32.45093"W	244.650	002-00'14.2"	0.99993421	0.99998830	0.99992251
2074	32-24'51.07272"N	94-49'33.93275"W	248.233	002-00'13.4"	0.99993406	0.99998813	0.99992219
2078	32-24'43.84653"N	94-49'30.11725"W	240.257	002-00'15.5"	0.99993445	0.99998851	0.99992296
2083	32-24'34.70477"N	94-49'24.09435"W	263.423	002-00'18.8"	0.99993494	0.99998740	0.99992234

Average Combined Scale Factor: 0.99992226

Adjusted Grid Coordinates, (US Feet)

Sta.	N:	E:	Z (Geoid):	StErr N:	StErr E:	StErr Z:	DN	DE	DZ
2003	6852660.757	3103001.258	342.330	0.015	0.012	0.000	0.000	-0.000	0.000
2001	6853372.046	3103050.070	342.503	0.013	0.012	0.007			
2004	6852209.985	3103060.655	352.971	0.015	0.012	0.006			
2002	6851829.410	3103250.131	357.031	0.014	0.012	0.007			
2028	6853472.952	3102566.255	340.248	0.014	0.011	0.008			
2046	6852273.760	3102235.966	340.978	0.016	0.016	0.012			
2061	6853176.730	3102152.013	331.279	0.017	0.009	0.008			

2074	6853448.848	3102015.391	334.863	0.012	0.008	0.007
2078	6852730.484	3102367.798	326.884	0.019	0.017	0.014
2083	6851825.283	3102916.106	350.046	0.015	0.013	0.009

Adjusted Geocentric Coordinates, (Metric)

Sta.	X:	Y:	Z:	StErr X(m):	StErr Y(m):	StErr Z(m):
2003	-453160.021	-5370694.805	3399123.658	0.005	0.002	0.003
2001	-453127.904	-5370581.279	3399306.173	0.004	0.003	0.003
2004	-453153.229	-5370772.333	3399008.931	0.005	0.003	0.003
2002	-453105.160	-5370840.885	3398910.010	0.004	0.003	0.003
2028	-453272.031	-5370549.223	3399336.111	0.004	0.003	0.003
2046	-453401.361	-5370733.113	3399030.798	0.005	0.004	0.005
2061	-453404.600	-5370581.884	3399262.193	0.005	0.002	0.003
2074	-453439.457	-5370534.490	3399333.990	0.004	0.002	0.002
2078	-453349.975	-5370659.726	3399144.769	0.006	0.005	0.005
2083	-453206.345	-5370829.304	3398910.815	0.005	0.003	0.004

Error ellipses are shown:

Adjusted Grid Coordinates (N,E) Error Ellipses, 95% CI

Sta.	Semi Major Axis	Semi Minor Axis	Max. Error Az.	Elev.
2003	0.038	0.030	N 16-10'14.4"E	0.021
2001	0.032	0.028	N 20-45'50.0"E	0.021
2004	0.037	0.030	N 14-44'50.6"E	0.021
2002	0.035	0.028	N 21-39'49.4"E	0.021
2028	0.035	0.025	N 18-55'31.6"E	0.020
2046	0.039	0.038	S 53-41'52.7"E	0.029
2061	0.041	0.022	S 00-10'19.3"E	0.017
2074	0.030	0.019	S 12-01'00.7"E	0.015
2078	0.047	0.042	S 05-10'11.3"E	0.032
2083	0.037	0.031	N 01-23'07.4"E	0.023

Adjusted observations are shown:

Adjusted Observations
=====================

Adjusted Mark to Mark Distances

From Sta.	To Sta.	Distance	Residual	StdRes.	StdDev
2003	2001	713.017	-0.003	0.3	0.007
2003	2004	454.828	-0.001	0.2	0.006
2004	2002	425.187	-0.001	0.1	0.006
2001	2028	494.269	-0.003	0.5	0.007
2028	2046	1243.943	0.005	0.4	0.011
2028	2061	509.377	-0.003	0.4	0.007
2061	2074	304.534	-0.002	0.3	0.006
2046	2078	475.616	0.000	0.0	0.007
2046	2083	814.805	0.000	0.0	0.009
2083	2002	334.150	-0.001	0.1	0.006
2074	1	418.771	-0.001	0.1	0.008
	Root Mean Square (RMS)		0.002		

Adjusted Horizontal Angles

BS Sta.	Occ. Sta.	FS Sta.	Angle	Residual	StdRes	StdDev(Sec.)
2001	2003	2004	168-34'03.9"	01.9	0.3	05.7
2003	2004	2002	161-02'21.1"	05.1	0.8	05.8
2003	2001	2028	097-51'18.5"	01.5	0.2	04.1
2001	2028	2046	093-37'04.9"	01.9	0.3	03.6
2001	2028	2061	132-39'02.9"	03.9	0.6	05.6
2028	2061	2074	278-54'30.8"	10.8	1.6	05.1
2028	2046	2078	000-42'06.0"	-00.0	0.0	06.2
2028	2046	2083	108-00'05.4"	00.4	0.1	03.8
2046	2083	2002	145-53'29.9"	-06.1	0.9	05.4
2083	2002	2004	064-14'26.4"	-08.6	1.3	04.9
2061	2074	1	210-25'42.6"	07.6	1.1	06.1
			Root Mean Square (RMS)	05.5		

Adjusted Mark to Mark Vertical Angles

From Sta.	To Sta.	Vertical Ang.	Residual	StdRes	StdDev(Sec.)
2003	2001	089-59'14.3"	00.2	0.1	02.1
2003	2004	088-39'35.2"	01.0	0.3	02.7
2004	2002	089-27'11.5"	00.9	0.3	02.8
2001	2028	090-15'43.9"	-01.1	0.4	02.7
2028	2046	089-58'04.3"	-03.2	1.1	02.0
2028	2061	091-00'34.2"	00.2	0.1	02.7
2061	2074	089-19'34.3"	00.1	0.0	02.9
2046	2078	091-41'56.5"	00.0	0.0	03.0
2046	2083	089-21'47.9"	-02.1	0.7	02.6
2083	2002	088-48'09.3"	-00.9	0.3	02.9
2074	1	090-01'27.2"	00.4	0.1	03.6

Root Mean Square (RMS) 01.3

GPS Vectors: 6 Observations (Meters)

From Sta. / To Sta.	Delta X / Delta Y / Delta Z	Residual	StdRes	StdDev
1	315.7728	0.0038	0.5	0.0037
2002	-373.1927	-0.0003	0.0	0.0043
	-531.1593	0.0028	0.4	0.0022
2001	22.7442	-0.0036	0.5	0.0031
2002	-259.6057	-0.0018	0.3	0.0046
	-396.1633	0.0025	0.3	0.0029
1	293.0285	0.0078	1.1	0.0036
2001	-113.5870	0.0009	0.1	0.0039
	-134.9961	0.0006	0.1	0.0022
5	806.1738	0.0033	0.5	0.0036
2001	172.6667	0.0022	0.3	0.0039
	379.0044	-0.0066	0.9	0.0022
5	828.9181	-0.0021	0.3	0.0037
2002	-86.9390	0.0009	0.1	0.0043
	-17.1589	-0.0048	0.6	0.0022
1	-513.1453	0.0057	0.8	0.0000
5	-286.2538	-0.0010	0.1	0.0000
	-514.0005	0.0075	1.0	0.0000

Statistics are shown:

Statistics
==========

Solution converged in 1 iterations

Total Observations:54
Total Unknowns:30
Degrees of Freedom:24

Observation	Count	Sum Squares of StdRes	Std. Error of Unit Wt.
Coordinate	3	0.000	0.005
Angles:	11	7.641	1.250
Distances:	11	0.874	0.423 (Mark-to-Mark)
VertAngles	11	2.079	0.652 (Mark-to-Mark)
Vectors:	18	5.298	0.814
Total:	54	15.892	0.814

Reference Variance:0.662
Standard Error Unit Weight: (+/-)0.814
Passed the Chi-Square test at the 95.00 significance level
12.401 <= 15.873 <= 39.364

All confidence regions were computed using the following factors:
Variance factor: 1.0000
1-D Expansion Factor: 1.9600
2-D Expansion Factor: 2.4477
Expansion factors for 95.00 confidence regions taken from normal distribution table

Sideshots are shown:

Sideshots
=========

From	To	Bearing	Dist.	N	E	StDev. N	StDev. E
2003	2005	N 63-27'32.8"E	95.923	6852703.619	3103087.072	0.002	0.005
2004	2007	S 05-03'48.2"E	276.232	6851934.831	3103085.034	0.003	0.005
2004	2008	S 29-34'11.2"E	290.887	6851956.985	3103204.202	0.003	0.005
2004	2009	S 33-11'30.2"E	272.068	6851982.307	3103209.596	0.003	0.005
2004	2010	S 29-30'57.2"E	280.998	6851965.455	3103199.093	0.003	0.005
2004	2011	S 40-44'41.2"E	306.465	6851977.800	3103260.681	0.004	0.005
2004	2012	S 40-44'40.2"E	317.533	6851969.414	3103267.904	0.004	0.005
2001	2014	N 25-54'44.8"E	427.542	6853756.604	3103236.905	0.004	0.005
2001	2015	N 26-03'36.8"E	426.910	6853755.553	3103237.618	0.004	0.005
2001	2017	N 27-36'52.8"E	396.667	6853723.526	3103233.934	0.004	0.005
2001	2018	N 35-01'30.8"E	422.084	6853717.690	3103292.320	0.004	0.005
2001	2019	S 34-03'43.8"W	236.337	6853176.257	3102917.700	0.003	0.004
2001	2020	S 30-26'58.8"W	127.420	6853262.200	3102985.496	0.003	0.004

2001	2021	S 23-48'35.8"W	120.655	6853261.660	3103001.361	0.003	0.004
2001	2022	S 16-41'41.8"W	116.627	6853260.335	3103016.566	0.003	0.004
2001	2023	S 09-09'10.8"W	114.475	6853259.029	3103031.860	0.003	0.004
2001	2024	S 01-17'17.2"E	94.718	6853277.351	3103052.199	0.003	0.004
2001	2025	S 45-59'22.8"W	124.400	6853285.614	3102960.600	0.003	0.004
2001	2026	S 34-54'12.8"W	161.674	6853239.454	3102957.561	0.003	0.004
2001	2027	S 00-49'35.8"W	140.757	6853231.304	3103048.039	0.003	0.004
2001	2029	S 05-16'38.8"W	307.316	6853066.033	3103021.804	0.003	0.005
2001	2030	S 05-14'39.8"W	245.374	6853127.699	3103027.642	0.003	0.005
2001	2031	S 13-30'20.8"W	247.009	6853131.868	3102992.383	0.003	0.005
2001	2032	S 12-17'07.8"W	288.132	6853090.512	3102988.761	0.003	0.005
2001	2033	S 86-59'42.2"E	132.080	6853365.122	3103181.968	0.003	0.004
2001	2034	S 20-13'58.8"W	327.472	6853064.781	3102936.818	0.004	0.005
2001	2035	S 08-07'35.8"W	315.040	6853060.169	3103005.536	0.003	0.005
2001	2036	S 23-58'34.2"E	355.742	6853046.999	3103194.628	0.004	0.005
2001	2037	S 64-10'51.2"E	193.319	6853287.849	3103224.091	0.003	0.004
2001	2038	N 52-34'57.8"E	254.094	6853526.437	3103251.880	0.004	0.005
2001	2039	N 29-48'46.8"E	466.833	6853777.095	3103282.166	0.004	0.006
2001	2040	N 06-53'21.2"W	533.626	6853901.819	3102986.062	0.004	0.006
2001	2041	N 27-48'28.2"W	729.453	6854017.259	3102709.775	0.005	0.007
2001	2042	S 34-11'44.2"E	196.123	6853209.828	3103160.295	0.003	0.004
2001	2043	S 09-13'00.2"E	225.021	6853149.930	3103086.112	0.003	0.004
2001	2044	N 16-15'16.2"W	438.964	6853793.463	3102927.202	0.004	0.006
2028	2047	N 12-01'29.3"E	361.871	6853826.882	3102641.646	0.004	0.006
2028	2048	N 08-01'35.3"E	512.986	6853980.913	3102637.884	0.004	0.006
2028	2049	N 11-24'18.3"E	361.751	6853827.559	3102637.789	0.004	0.006
2028	2050	N 09-11'44.3"E	361.197	6853829.507	3102623.977	0.004	0.006
2028	2051	N 14-50'26.7"W	703.004	6854152.505	3102386.192	0.004	0.008
2028	2052	N 14-30'54.7"W	652.924	6854105.035	3102402.608	0.004	0.007
2028	2053	N 19-37'54.7"W	618.829	6854055.808	3102358.344	0.004	0.007
2028	2054	N 20-47'46.7"W	643.378	6854074.413	3102337.826	0.004	0.007
2028	2055	N 32-50'01.7"W	498.619	6853891.915	3102295.902	0.004	0.006
2028	2056	N 34-22'49.7"W	483.570	6853872.045	3102293.190	0.004	0.006
2028	2057	N 37-49'40.7"W	511.016	6853876.581	3102252.853	0.005	0.006
2028	2058	N 38-23'57.7"W	513.505	6853875.386	3102247.297	0.005	0.006
2028	2059	N 39-38'09.7"W	525.396	6853877.566	3102231.101	0.005	0.006
2028	2060	N 62-19'40.7"W	11.008	6853478.064	3102556.506	0.003	0.005
2028	2062	N 72-42'26.7"W	23.303	6853479.879	3102544.005	0.003	0.005
2028	2063	N 74-07'22.7"W	35.394	6853482.635	3102532.211	0.003	0.005
2028	2064	N 55-52'27.7"W	9.129	6853478.073	3102558.698	0.003	0.005
2061	2066	S 63-29'05.8"E	297.728	6853043.815	3102418.425	0.004	0.006
2061	2067	S 60-43'21.8"E	200.901	6853078.482	3102327.251	0.003	0.006
2061	2068	S 60-01'36.8"E	163.667	6853094.964	3102293.790	0.003	0.005
2061	2069	S 43-59'28.8"E	51.789	6853139.471	3102187.983	0.003	0.005
2061	2070	S 14-36'17.2"W	26.485	6853151.101	3102145.334	0.003	0.005
2061	2071	S 42-10'58.2"W	79.163	6853118.070	3102098.855	0.003	0.005
2061	2072	S 57-19'22.2"W	103.085	6853121.074	3102065.243	0.003	0.005
2061	2073	S 75-52'10.2"W	185.969	6853131.330	3101971.671	0.003	0.005
2061	2075	N 27-51'16.8"W	279.096	6853423.489	3102021.610	0.003	0.006
2061	2076	N 26-53'32.8"W	277.199	6853423.952	3102026.631	0.003	0.006
2046	2079	N 00-05'13.2"E	89.866	6852363.626	3102236.103	0.004	0.005
2046	2080	S 19-25'22.8"E	20.210	6852254.700	3102242.687	0.004	0.005
2046	2081	N 66-21'27.8"W	61.163	6852298.288	3102179.937	0.004	0.005
2046	2082	S 45-14'32.8"E	58.905	6852232.284	3102277.794	0.004	0.005
2078	2085	S 57-02'17.3"W	53.640	6852701.299	3102322.792	0.005	0.006
2078	2086	S 46-58'36.3"W	70.472	6852682.401	3102316.278	0.005	0.006
2078	2087	S 38-52'31.3"W	90.834	6852659.769	3102310.788	0.005	0.006
2083	2090	N 60-12'59.4"W	241.632	6851945.307	3102706.391	0.004	0.005
2083	2091	S 49-51'01.4"E	133.266	6851739.355	3103017.970	0.004	0.005
2002	2094	S 18-37'02.6"E	334.796	6851512.133	3103357.014	0.004	0.005
2002	2095	N 52-14'17.4"E	196.177	6851949.545	3103405.221	0.003	0.005
2002	2096	N 77-51'56.4"E	192.822	6851869.942	3103438.645	0.004	0.005
2002	2097	N 09-20'31.4"E	334.404	6852159.379	3103304.414	0.004	0.005
2002	2098	S 45-51'05.6"E	188.665	6851698.001	3103385.505	0.003	0.005
2002	2099	N 21-08'26.6"W	114.057	6851935.791	3103208.995	0.003	0.005
2002	2100	S 73-56'57.6"E	184.878	6851778.293	3103427.802	0.003	0.005
2002	2101	N 23-06'33.4"E	131.043	6851949.938	3103301.564	0.003	0.005
2002	2102	N 27-42'38.4"E	120.375	6851935.979	3103306.106	0.003	0.005
2002	2103	N 68-44'40.4"E	175.141	6851892.903	3103413.358	0.003	0.005
2002	2104	N 58-12'31.4"E	148.131	6851907.449	3103376.038	0.003	0.005
2002	2105	N 27-42'29.4"E	119.754	6851935.431	3103305.813	0.003	0.005
2002	2106	N 01-06'49.4"E	280.717	6852110.074	3103255.587	0.003	0.005
2002	2107	N 81-28'50.4"E	158.616	6851852.908	3103406.997	0.003	0.005
2002	2108	S 86-26'44.6"E	153.716	6851819.880	3103403.552	0.003	0.005
2002	2109	S 78-28'08.6"E	158.330	6851797.760	3103405.265	0.003	0.005
2002	2110	S 68-29'03.6"E	155.542	6851772.364	3103394.835	0.003	0.005
2002	2111	S 56-50'19.6"E	167.222	6851737.940	3103390.118	0.003	0.005

Vertical Adjustment Report

This is the vertical adjustment report for the 2D/1D model adjustment:

```
LEAST SQUARES VERTICAL ADJUSTMENT REPORT
```

```
Fri Apr 5 12:00:00
2D Geodetic Model.
Input Raw Files:
    C:\Carlson Projects\SurvNetTut01.rw5
Output File: C:\Carlson Projects\SurvNet\SurvNetTut01.RPT
Output CRD File: C:\Carlson Projects\SurvNet\SurvNetTut01.crd
Curvature, refraction correction: ON
```

VERTICAL BENCHMARKS

Station	Elevation	Std. Error
TR1	100.0000	FIXED
TR100	0.0000	FIXED

POINTS TO BE ADJUSTED

Station
TR2,TR3,TR4,TR5,TR6,TR7,TR7B,TR7C

MEASUREMENT SUMMARY

From	To	Elev. Diff. (unadjusted)	StdErr
TR1	TR100	-2.4904	0.0147
TR1	TR2	-2.2258	0.0147
TR2	TR3	-4.0634	0.0147
TR3	TR4	-1.5208	0.0143
TR4	TR5	7.2363	0.0152
TR5	TR6	-2.1809	0.0151
TR6	TR7	0.1132	0.0145
TR7	TR7B	5.1236	0.0151
TR7	TR100	1.6154	0.0151
TR7	TR7C	3.3496	0.0163
TR7B	TR1	-2.3590	0.0157
TR7B	TR3	-8.5867	0.0228
TR7B	TR5	-3.0523	0.0174
TR7C	TR100	2.5981	0.0145

STATISTICAL SUMMARY

Total Unknown Elevations:8
Total Elev. Routes:14
Total Fixed BM's:2
Total non-fixed BM's:0
Degrees of freedom:6

ADJUSTED ELEVATIONS

Station	Adjusted Elev	Standard Dev.	Error Ellipse at 95% CI
TR1	100.0000	FIXED	0.00000
TR100	0.0000	FIXED	0.00000
TR2	84.5686	41.14026	80.63343
TR3	67.3188	45.22845	88.64613
TR4	58.3139	52.40847	102.71870
TR5	57.5924	46.54994	91.23621
TR6	41.6824	48.31011	94.68608
TR7	28.6393	33.33185	65.32922
TR7B	67.3621	35.07818	68.75197
TR7C	13.6980	38.41413	75.29031

ADJUSTED MEASUREMENT SUMMARY

From	To	Elev. Diff. (adjusted)	Residuals	Std. Dev.
TR1	TR100	-100.0000	-97.5096	0.000
TR1	TR2	-15.4314	-13.2056	41.140
TR2	TR3	-17.2498	-13.1864	41.122
TR3	TR4	-9.0049	-7.4841	41.178
TR4	TR5	-0.7215	-7.9578	41.980
TR5	TR6	-15.9099	-13.7290	41.104
TR6	TR7	-13.0431	-13.1563	40.602
TR7	TR7B	38.7229	33.5992	34.757
TR7	TR100	-28.6393	-30.2547	33.332
TR7	TR7C	-14.9413	-18.2909	39.239
TR7B	TR1	32.6379	34.9968	35.078
TR7B	TR3	-0.0433	8.5433	41.824
TR7B	TR5	-9.7698	-6.7175	39.342
TR7C	TR100	-13.6980	-16.2961	38.414

Vertical Sideshots

Station	Elevation

TR1B	98.0007
100	105.4404
101	105.4607
102	108.9285
103	104.9080
104	105.7794
105	105.3716
106	106.9132
TR2C	80.7241
CC1	81.0316
TR2B	82.4713
125	91.8345
126	91.1025
127	91.4001
128	88.7827
129	89.2359
130	89.7661
131	89.1042
132	89.2006
133	88.9114
150	73.7072
151	75.1551
152	75.3588
153	75.9565
154	76.0468
155	75.3200
156	74.6387
157	75.2392
158	74.5438
159	73.2178
160	67.3246
161	67.9606
162	69.2969
200	64.3422
201	62.2583
202	63.0329
203	63.3425
204	65.8137
205	62.8474
MN2	37.7423
CC200	39.9471
CC201	40.0756
225	49.5442
226	47.5001
227	47.9010
228	47.3816
229	47.5252
230	45.7544
231	45.6291
232	44.9244
233	45.0296
234	49.3004
235	48.8310
236	51.1671
237	50.9847
238	48.0367
239	50.4217
240	47.6531
241	48.1279
242	48.5686
300	30.4839
301	33.9766
302	33.5054
303	33.9313
304	33.1538
305	33.6198
306	27.7555
307	28.5585
308	29.1737
CC300	34.4190
CC301	33.9808
GPS1	31.1822
CC400	64.5606
CC500	59.4460
TR1BCK	63.1440
CC600	67.3962
500	64.7735
501	67.3561
502	71.5196
503	71.5325
504	72.8553
505	72.7991
506	72.5789
507	72.5883
508	74.6496
509	74.5704
510	74.6176

```
 511                    76.0482
 512                    72.7430
 513                    73.4538
 1000                  116.6556
 1001                  117.9243
 1002                  120.3538
 1003                  116.8152
 1004                  104.9979
 1005                  105.7780
 1006                  105.4189
 1007                  106.1852
 1008                  103.5893
 1009                  103.5550
 1010                  105.2201
 1011                  119.9053
 1012                  116.3988
 1013                  105.0764
 1014                  106.2287
 1015                  106.4953
 1016                  105.6196
 1017                  106.2795
 1018                  105.5693
 1019                  105.3773
 1020                  104.2048
 1021                  108.0350
 1022                  106.9444
 1023                  107.2728
 1024                  107.4679
 1025                  109.0913
 1026                  109.3273
 1100                   34.7236
 1101                   33.1876
 1102                   23.4532
 1103                   23.6922
 1104                   20.4123
 1105                   30.4324
 1106                   29.3272
 1107                   30.9160
 1108                   20.5319
 1109                   22.5550
 1110                   22.4347
 1111                   21.7911
 1112                   21.2860
 1113                   21.7111
 1114                   34.2394
 1115                   33.5384
 1116                   34.0657
 1117                   34.0688
 1118                   40.6604
 1200                    6.1629
 1201                    5.1502
 1202                    6.9316
 1203                   16.0098
 1204                   16.4797
 1205                    8.7831
 1206                    8.9042
 1207                    6.3770
 1208                    8.4799
 1209                    7.3919
 1210                   19.2004
 1211                    6.7228
 1212                    7.0911
 1213                    7.0724
```

Differential Level Network

This is a sample report of a differential level network adjustment:

```
     ===============================
     LEAST SQUARES ADJUSTMENT REPORT
     ===============================

Fri Apr 5 12:00:00
Output File: C:\SurvNET_Seminar\SurvNetExamples1\LevelNetwork\network1.RPT
Curvature, refraction correction: ON
Maximum iterations: 10 , Convergence Limit: 0.002000
Local Coordinate System, Scale Factor: 1.000000
Horizontal Units: US Feet
Confidence Interval: 95.00
Default Standard Errors:
  Distance: Constant 0.003 ,PPM: 5.000
  Horiz. Angle: Pointing 1.0" ,Reading: 1.0"
  Vert. Angle: Pointing 3.0" ,Reading: 3.0"
  Total Station: Centering 0.003 ,Height: 0.010
```

```
  Target: Centering 0.003 ,Height: 0.010
  Azimuth: 5"
  Coordinate Control: N:0.010, E:0.010, Z:0.010,


     HORIZONTAL ADJUSTMENT REPORT
     ============================


Unadjusted Observations
=======================

Control Coordinates:     0 Observed Points,    2 Fixed Points,    0 Approx. Points
 Sta.            N:             E:           StErr N:   StErr E:
 BMY             1000.000      1000.000      FIXED      FIXED
 BMX             1000.000      1000.000      FIXED      FIXED



                 LEAST SQUARES VERTICAL ADJUSTMENT REPORT


Fri Apr 5 12:00:00
Level File:  DiffLevel.tlv
Output File: C:\SurvNET_Seminar\SurvNetExamples1\LevelNetwork\network1.RPT
Curvature, refraction correction: ON
Differential Leveling Standard Errors
    Avg. Dist. to BS/FS:50.0
    Rod Reading Err. per 100'/m:0.000
    Collimation Err. (sec.) 3.0:

Unadjusted Trigonometric Level Report

 Header1:    Operator:  loop Name:   Project Name:
 Header2:    date:  pressure: 1630170  temperature: time:
 Benchmark:  Name: BMX         El:    100.000  Desc: BMX

Differential Level Loop:

 Rod:        Rod Ht.      0.000
 Backsight:  Name: BMX          VD:    5.300 HD:  100.000 HI:   105.300 Desc: BMX
                                                                          Average HI:   105.300

 Foresight:  Name: 1            VD:    6.000 HD:  100.000 EL:    99.300
                                                                          Average EL:    99.300

 Backsight:  Name: 1            VD:    0.700 HD:  100.000 HI:   100.000
                                                                          Average HI:   100.000

 Foresight:  Name: SS1          VD:    3.500 HD:  100.000 EL:    96.500
                                                                          Average EL:    96.500

 Foresight:  Name: SS2          VD:    4.500 HD:  100.000 EL:    95.500
                                                                          Average EL:    95.500

 Foresight:  Name: 2            VD:    1.000 HD:  100.000 EL:    99.000
                                                                          Average EL:    99.000

 Backsight:  Name: 2            VD:   15.000 HD:  100.000 HI:   114.000
                                                                          Average HI:   114.000

 Foresight:  Name: A            VD:    8.900 HD:  100.000 EL:   105.100
                                                                          Average EL:   105.100

 Backsight:  Name: A            VD:    6.800 HD:  100.000 HI:   111.900
                                                                          Average HI:   111.900

 Foresight:  Name: 3            VD:    5.100 HD:  100.000 EL:   106.800
                                                                          Average EL:   106.800

 Backsight:  Name: 3            VD:    2.300 HD:  100.000 HI:   109.100
                                                                          Average HI:   109.100

 Foresight:  Name: 4            VD:    6.200 HD:  100.000 EL:   102.900
                                                                          Average EL:   102.900

 Backsight:  Name: 4            VD:   16.300 HD:  100.000 HI:   119.200
                                                                          Average HI:   119.200

 Foresight:  Name: BMY          VD:   11.760 HD:  100.000 EL:   107.440
                                                                          Average EL:   107.440

 Benchmark:  Name: BMY         El:    107.500  Desc: BMY
 Backsight:  Name: BMY          VD:    6.500 HD:  100.000 HI:   114.000 Desc: BMY
                                                                          Average HI:   114.000

 Foresight:  Name: 5            VD:    5.800 HD:  100.000 EL:   108.200
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                                                                          Average EL:   108.200

Backsight:  Name: 5           VD:   10.000 HD:  100.000 HI:   118.200
                                                                          Average HI:   118.200

Foresight:  Name: C           VD:   11.950 HD:  100.000 EL:   106.250
                                                                          Average EL:   106.250

Backsight:  Name: C           VD:   10.500 HD:  100.000 HI:   116.750
                                                                          Average HI:   116.750

Foresight:  Name: 6           VD:    5.300 HD:  100.000 EL:   111.450
                                                                          Average EL:   111.450

Backsight:  Name: 6           VD:    4.800 HD:  100.000 HI:   116.250
                                                                          Average HI:   116.250

Foresight:  Name: BMX         VD:   16.130 HD:  100.000 EL:   100.120
                                                                          Average EL:   100.120

Benchmark:  Name: BMX        El:    100.000
Benchmark:  Name: BMY        El:    107.500
Backsight:  Name: BMY         VD:    8.400 HD:  100.000 HI:   115.900
                                                                          Average HI:   115.900

Foresight:  Name: 7           VD:    3.800 HD:  100.000 EL:   112.100
                                                                          Average EL:   112.100

Backsight:  Name: 7           VD:    1.500 HD:  100.000 HI:   113.600
                                                                          Average HI:   113.600

Foresight:  Name: B           VD:    9.100 HD:  100.000 EL:   104.500
                                                                          Average EL:   104.500

Backsight:  Name: B           VD:    6.900 HD:  100.000 HI:   111.400
                                                                          Average HI:   111.400

Foresight:  Name: 8           VD:    5.210 HD:  100.000 EL:   106.190
                                                                          Average EL:   106.190

Backsight:  Name: 8           VD:    5.000 HD:  100.000 HI:   111.190
                                                                          Average HI:   111.190

Foresight:  Name: C           VD:    4.990 HD:  100.000 EL:   106.200 Desc: TBM
                                                                          Average EL:   106.200

Backsight:  Name: A           VD:    6.300 HD:  100.000 HI:   111.400 Desc: TBM1
                                                                          Average HI:   111.400

Foresight:  Name: B           VD:    6.980 HD:  100.000 EL:   104.420 Desc: TBM3
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VERTICAL BENCHMARKS

Station	Elevation	Std. Error
BMY	107.5000	FIXED
BMX	100.0000	FIXED

POINTS TO BE ADJUSTED

Station
1,2,A,3,4,5,C,6,7,B,8

MEASUREMENT SUMMARY

From	To	Elev. Diff. (unadjusted)	StdErr
BMX	1	-0.7000	0.0015
1	2	-0.3000	0.0029
2	A	6.1000	0.0033
A	3	1.7000	0.0036
3	4	-3.9000	0.0039
4	BMY	4.5400	0.0041
BMY	5	0.7000	0.0015
5	C	-1.9500	0.0021
C	6	5.2000	0.0025
6	BMX	-11.3300	0.0029
BMY	7	4.6000	0.0015
7	B	-7.6000	0.0021
B	8	1.6900	0.0025
8	C	0.0100	0.0029
A	B	-0.6800	0.0033

STATISTICAL SUMMARY

Total Unknown Elevations:11
Total Elev. Routes:15
Total Fixed BM's:4
Total non-fixed BM's:0
Degrees of freedom:4

ADJUSTED ELEVATIONS

Station	Adjusted Elev	Standard Dev.	Error Ellipse at 95% CI
BMY	107.5000	FIXED	0.00000
BMX	100.0000	FIXED	0.00000
1	99.3094	0.02592	0.09659
2	99.0283	0.03777	0.14074
A	105.1494	0.03661	0.13642
3	106.8527	0.04407	0.16425
4	102.9562	0.03964	0.14772
5	108.1787	0.02456	0.09154
C	106.1985	0.02979	0.11103
6	111.3667	0.03114	0.11604
7	112.0948	0.02486	0.09263
B	104.4875	0.03118	0.11618
8	106.1827	0.03635	0.13547

ADJUSTED MEASUREMENT SUMMARY

From	To	Elev. Diff. (adjusted)	Residuals	Std. Dev.
BMX	1	-0.6906	0.0094	0.026
1	2	-0.2811	0.0189	0.034
2	A	6.1211	0.0211	0.035
A	3	1.7033	0.0033	0.038
3	4	-3.8965	0.0035	0.039
4	BMY	4.5438	0.0038	0.040
BMY	5	0.6787	-0.0213	0.025
5	C	-1.9801	-0.0301	0.027
C	6	5.1682	-0.0318	0.030
6	BMX	-11.3667	-0.0367	0.031
BMY	7	4.5948	-0.0052	0.025
7	B	-7.6073	-0.0073	0.028
B	8	1.6951	0.0051	0.032
8	C	0.0159	0.0059	0.033
A	B	-0.6619	0.0181	0.034

Vertical Sideshots

Station	Elevation
SS1	96.509
SS2	95.509