

Carlson SurvNET

The heart and sole of any survey software package is in its data processing and adjustment program. SurvNET is a least squares adjustment program that allows you to perform a mathematically rigorous adjustment and statistical analysis of a network of traverses, GPS vectors and level loops. You can click Survey / Survnet to run the SurvNET routine.

Sample SurvNET Project

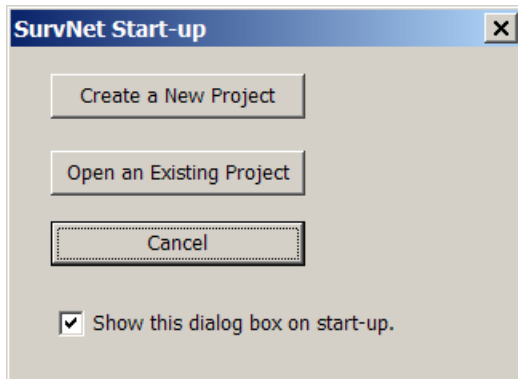
Many of the following steps can be saved as default so when a new project is created, the settings need not be re-entered.

Step 1, Create a Project

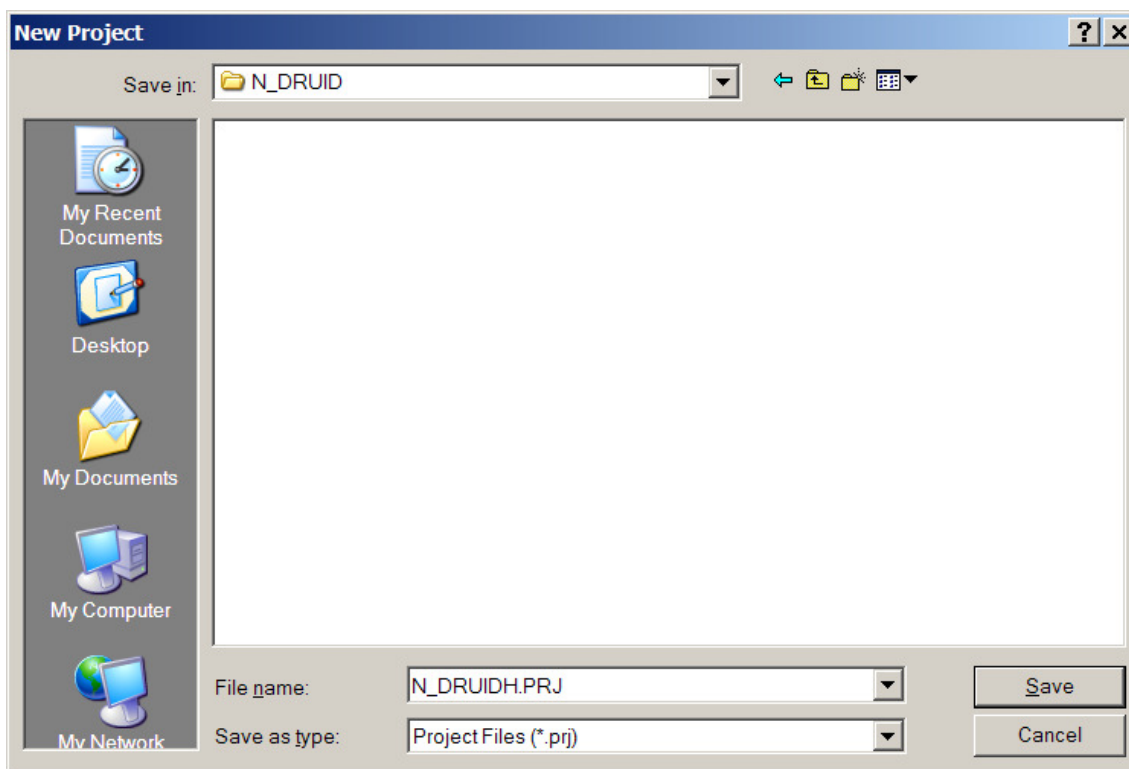
SurvNET is a project-oriented program. Projects can consist of many types of files, each having distinct extensions to identify their content:

File Content	3 Character Extension
Project File	.PRJ
Carlson Total Station Input Data	.RW5
C&G Total Station Input Data	.CGR
Baseline Vector Input Data	.GPS
Differential Level File (Old Format)	.LEV
Trigonometric/Differential Level File	.TLV
Carlson or C&G Coordinate File	.CRD
Closure Point File	.CLS
ALTA Positional Tolerance Report	.ALT
Error Report	.ERR
Adjustment Results Report	.RPT
Error Ellipse information	.ELL
Formatted ASCII Coordinate File	.OUT
ASCII Coordinate File	.NEZ

The project file keeps track of all the supporting files.

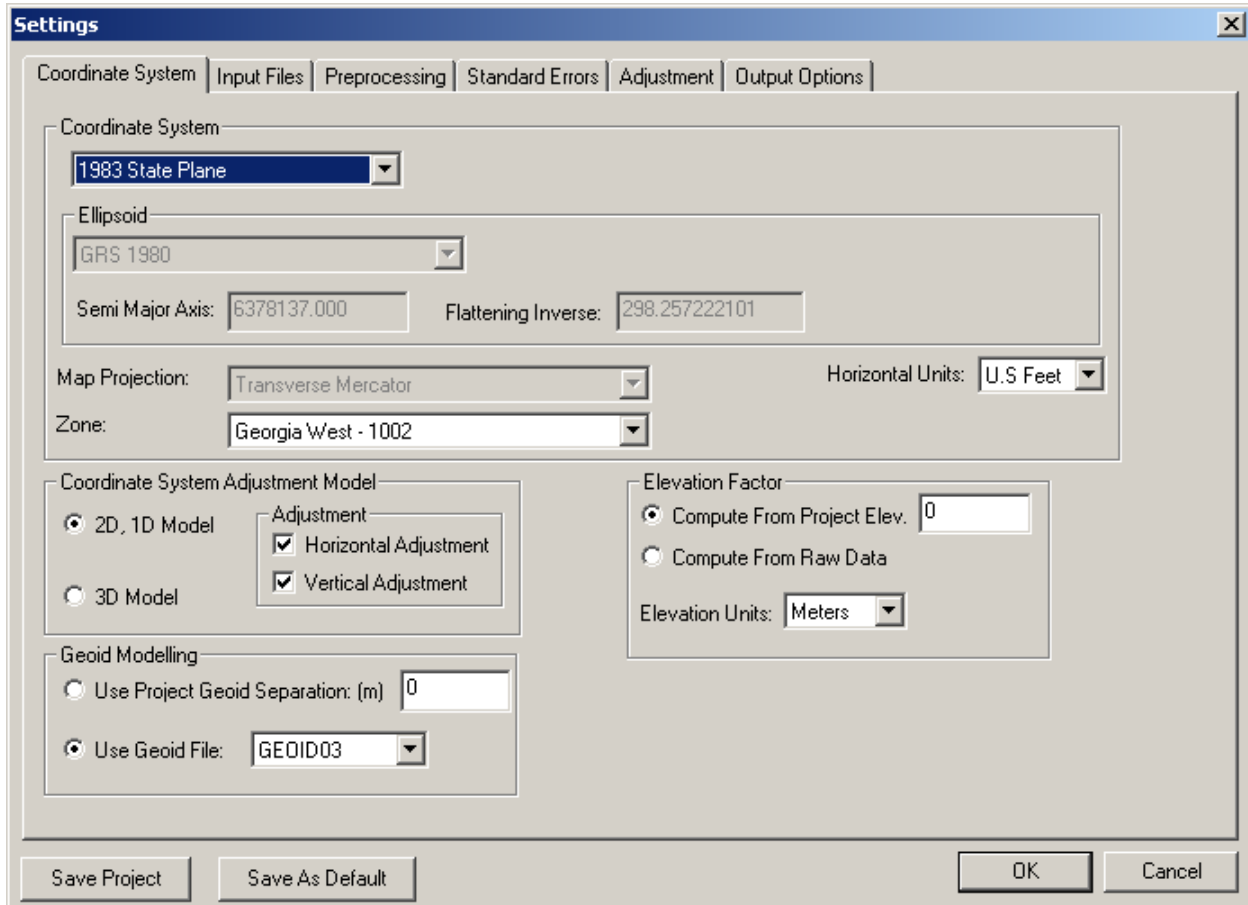


When you first run SurvNET, you will see the above dialog. Select “Create a New Project”. Then create a project file:



Step 2 – Select Project Settings

Select Coordinate System and Adjustment Model



The screenshot shows the 'Settings' dialog box with the following configurations:

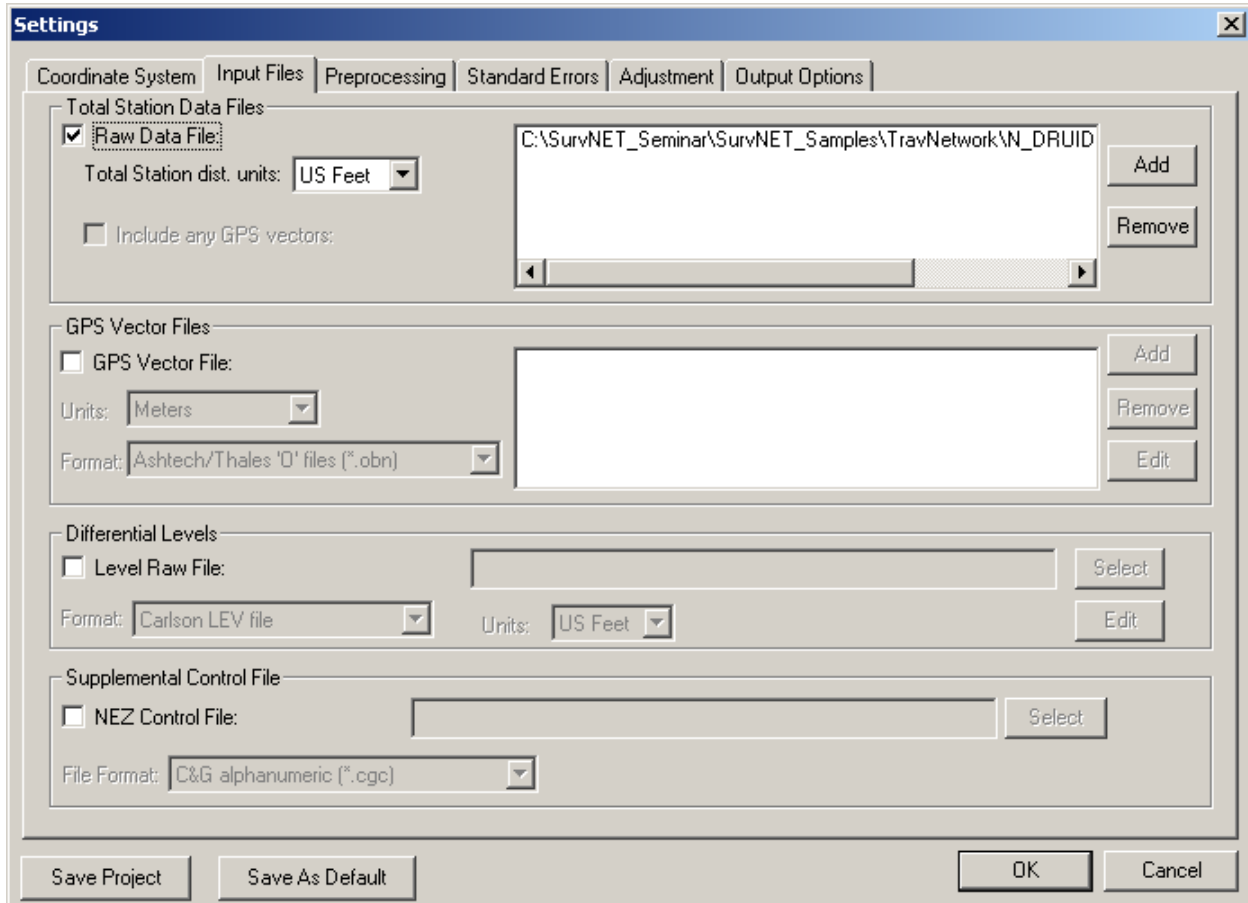
- Coordinate System:** 1983 State Plane
- Ellipsoid:** GRS 1980
- Semi Major Axis:** 6378137.000
- Flattening Inverse:** 298.257222101
- Map Projection:** Transverse Mercator
- Horizontal Units:** U.S Feet
- Zone:** Georgia West - 1002
- Coordinate System Adjustment Model:**
 - 2D, 1D Model
 - Horizontal Adjustment
 - Vertical Adjustment
 - 3D Model
- Elevation Factor:**
 - Compute From Project Elev. (0)
 - Compute From Raw Data
 - Elevation Units:** Meters
- Geoid Modelling:**
 - Use Project Geoid Separation: (m) 0
 - Use Geoid File: GE01D03

Buttons at the bottom: Save Project, Save As Default, OK, Cancel.

SurvNET supports NAD27 and NAD83 state plane coordinate systems. You can also work in a Local coordinates system, or create a user defined system with your choice of Projection system, Ellipsoid and Datum Parameters.

SurvNET has two adjustment models, 2D-1D and 3D. The 2D-1D model allows you to mix 2D and 3D measurements. The 3D model requires 3D data on all measurements and must be selected if you are processing GPS vector files.

Select Input Files



Three types of raw data files can be selected and processed simultaneously:

Traverse raw data files – CGR (C&G), RW5 (Carlson) or PRJ (SDMS)

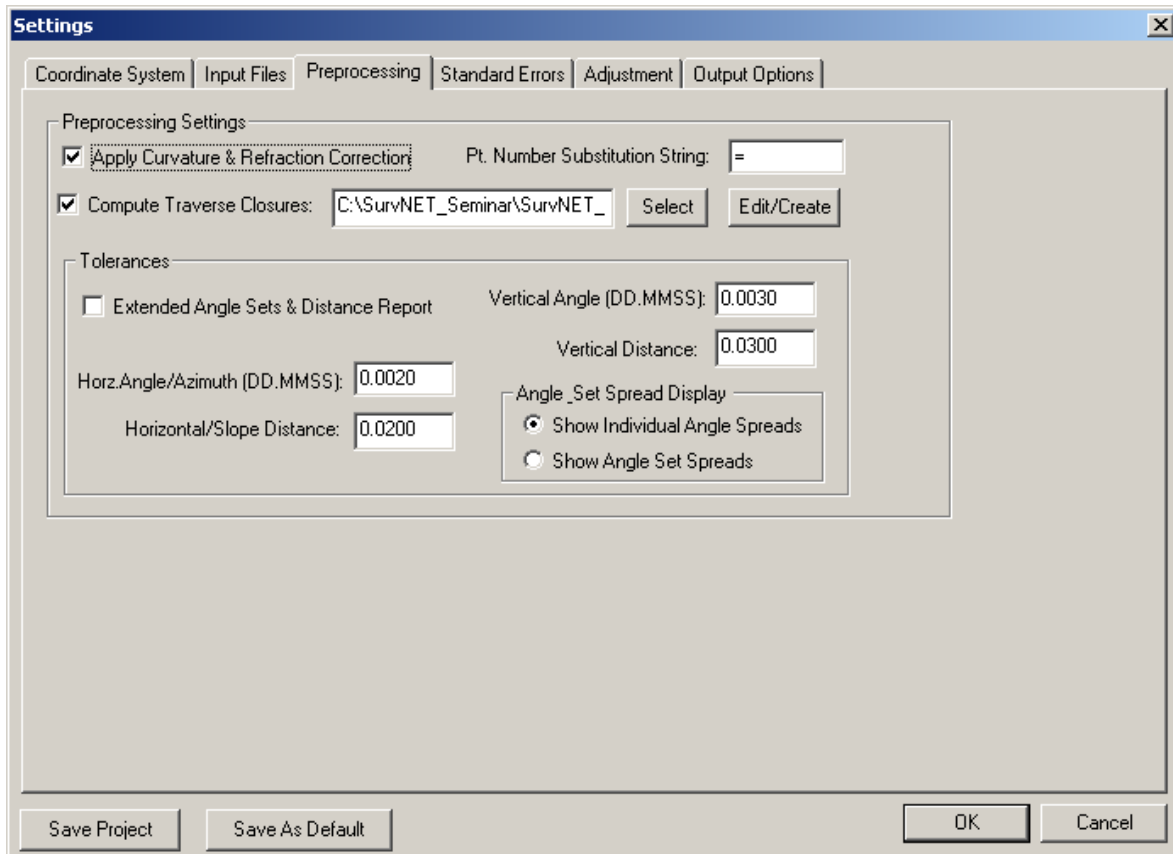
GPS Vector files – Supports several types

Level Files – Carlson LEV, and TLV files

You can select as many RAW and GPS files as you wish. Currently you can only select one level file. Currently, if you select multiple raw data files, they must be of the same type (cannot select a CGR and a RW5).

You can also select a supplemental control file. This file should only have Control Points and should not be used for output.

Select Preprocessing Options



Choose whether you want C&R corrections.

Some data collectors do not allow you to reuse point numbers. Using the “Point Substitution String” allows you to let SurvNET know what the REAL point number is. For example, if you locate a point assigned the point number 211, but it is really point 11, you can enter the following for the description of point 211:

=11

SurvNET will then treat all points assigned the number 211 as if it were point 11. It is VERY important that you call a point by its real name or you will lose the benefits of redundant measurements.

If you want to calculate Closures, you must create a Closure file. This file includes the points that define the traverses. You can define as many traverses as you wish. Unless the points define a LOOP, they must start and end on control points. When defining a traverse, always start with your first BS point, and end with your last FS point,

Example of Loop Traverse:

1,2-5,1,2

Also set up your desired tolerance settings. When SETS of angles and distances are averaged, you will be warned if a particular measurement falls outside the selected tolerance value.

Horizontal Angle Tolerances: When horizontal angle tolerances are checked, you have the choice of comparing ALL the angles (Direct and Reverse comprise two angles), or just the individual SETS (a SET is comprised of one Direct and one Reverse angle that are averaged and treated as a SINGLE angle).

You can select the "Extended Angle Sets and Distance Report" if you wish. The extended report takes up more space in the report file. It shows all angle and distance measurements and notes the ones that fall outside the accepted tolerance. The Normal Report will only show measurements outside the accepted tolerance.

Below are samples of the Normal Report and the Extended Report:

Normal Tolerance Report:

Horizontal Angle spread exceeds tolerance:

IP: 104, BS: 103, FS: 105
Low: 173-07'46.0" , High: 173-07'51.0" , Diff: 000-00'05.0"

Vertical Distance from 104 to 103 exceeds tolerance:

Low: 4.359, High: 4.409, Diff: 0.050

Horizontal Distance from 105 to 106 exceeds tolerance:

Low: 253.512, High: 253.540, Diff: 0.028

Extended Tolerance Report:

=====
Horizontal Angle: IP: 104, BS: 103, FS: 105
173-07'51.0"
173-07'46.0"
Average: 173-07'48.5"

Horizontal Angle spread exceeds tolerance:

IP: 104, BS: 103, FS: 105
Low: 173-07'46.0" , High: 173-07'51.0" , Diff: 000-00'05.0"

=====
Distance: From: 104, To: 103

Horiz. Dist.	Vert. Dist.
324.871	-4.372
324.871	-4.364
324.869	4.403
324.868	4.409
324.871	-4.359
324.871	-4.370

Average 324.872 -4.380

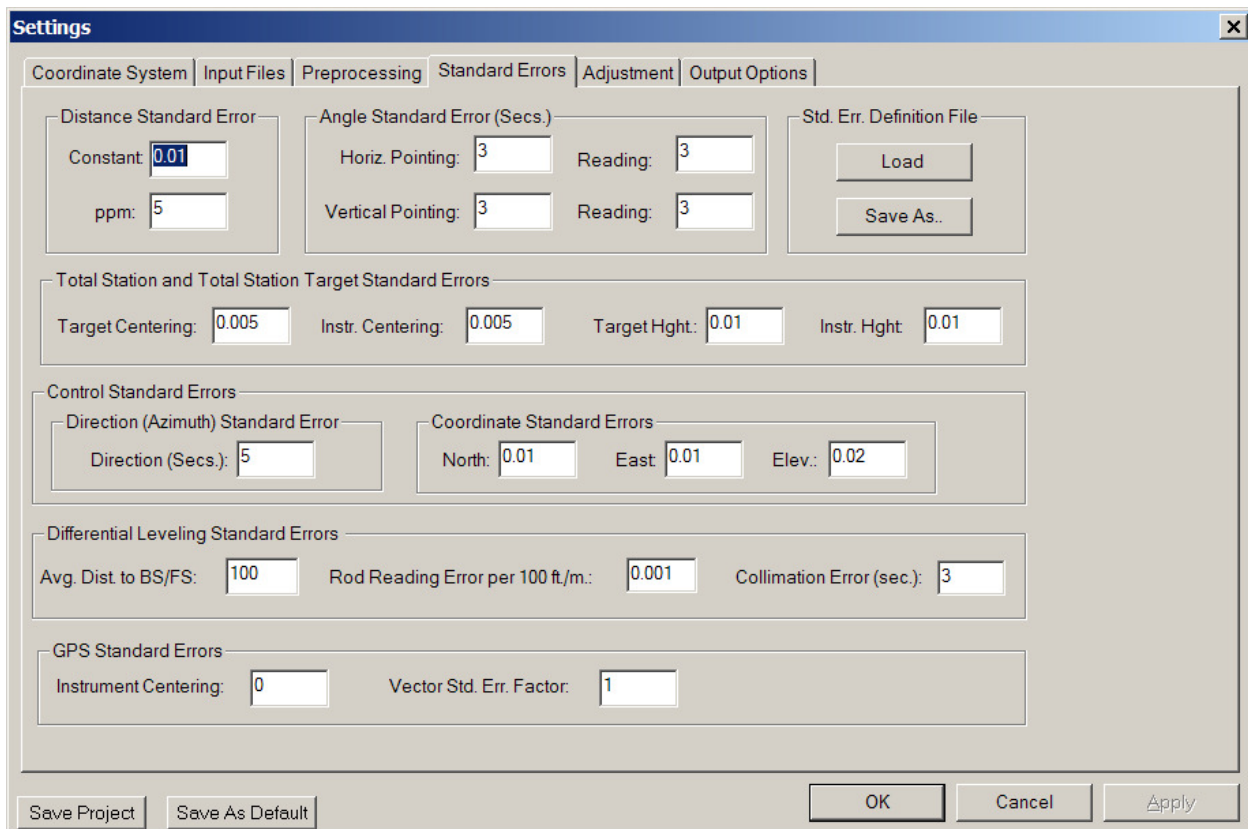
Vertical Distance from 104 to 103 exceeds tolerance:

Low: 4.359, High: 4.409, Diff: 0.050
=====

Set your Standard Errors

Standard errors are basically realistic errors you would expect to obtain based on the type equipment and field procedures you are using when taking your measurements. For example, if you are using a 5 second theodolite, you could expect the angles to be measured within +/- 5 seconds (Reading error).

You can save the SE settings for a particular instrument (Save As Button). This allows you to LOAD standard errors by equipment.



Settings

Coordinate System | Input Files | Preprocessing | **Standard Errors** | Adjustment | Output Options

Distance Standard Error
Constant:
ppm:

Angle Standard Error (Secs.)
Horiz. Pointing: Reading:
Vertical Pointing: Reading:

Std. Err. Definition File

Total Station and Total Station Target Standard Errors
Target Centering: Instr. Centering: Target Hght: Instr. Hght:

Control Standard Errors
Direction (Azimuth) Standard Error
Direction (Secs.):

Coordinate Standard Errors
North: East: Elev.:

Differential Leveling Standard Errors
Avg. Dist. to BS/FS: Rod Reading Error per 100 ft./m.: Collimation Error (sec.):

GPS Standard Errors
Instrument Centering: Vector Std. Err. Factor:

The Distance, Angle Reading and PPM settings should be based on the equipment being used. Check the published specifications for the total station being used.

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.

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.

You can set the standard errors for the following

Measurement Standard Errors:

Distance

PPM

Horizontal Angle Pointing

Horizontal Angle Reading

Vertical Angle Pointing

Vertical Angle Reading

Distance – Precision of distance measurements, obtain from EDM specs.

PPM – Parts per Million, Obtain from EDM specs.

Horizontal Reading – Precision of horizontal angle measurements, obtain from theodolite specs.

Horizontal Pointing – How close can I point horizontally? Determined by atmospheric conditions, optics, experience and care taken by instrument operator.

Vertical Reading – Precision of vertical angle measurements, obtain from theodolite specs.

Vertical Pointing – How close can I point vertically? Determined by atmospheric conditions, optics, experience and care taken by instrument operator.

Instrument and Target Standard errors:

Target Centering

Instrument Centering

Target Height

Instrument Height

Instrument Centering – How close can you set the instrument over the point?

Target Centering – How close can you set the target (prism) over the point?

Instrument Height – How close can you measure the height of the instrument?

Target Centering – How close can you measure the height of the target?

Control Standard Errors:

Direction (Bearing / Azimuth)

North

East

Direction – How precise are your bearing / azimuth (direction) records?

North, East, Elevation – How precise are your coordinate records?

Differential Level Standard Errors:

Average Dist to BS/FS
Rod Reading per 100 ft/meter
Collimation Error (SEC)

Average distance to BS/FS – pick an average distance.

Rod Reading per 100 ft/meter – how close can you read the level rod.

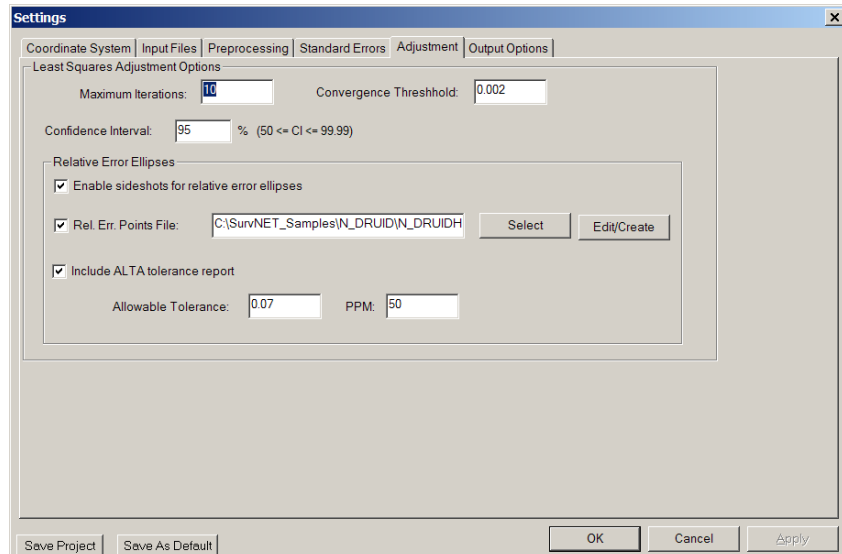
Collimation error (sec) – enter collimation error in seconds.

GPS Standard Errors:

Instrument Centering
Vertical Standard Error Multiplication Factor

Instrument Centering – How close can I set the antenna over the point.

Vertical Standard Error Factor – if your variance/covariance values are too optimistic, you can use this factor to bring them more in line. The value can be zero (no factor applied) to 10. The higher the number the lower the precision assigned your GPS vectors.

Choose adjustment settings

Maximum Iterations: A non-linear least squares adjustment 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: Corrections are computed with each iteration. 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 .01' then a reasonable convergence threshold value would be .005'.

Confidence Interval: This is a statistical term and is used when calculating the size of error ellipses, and in the 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 checkbox must be set if you want to use the "relative error ellipse inverse" function with sideshots. When turned off 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.

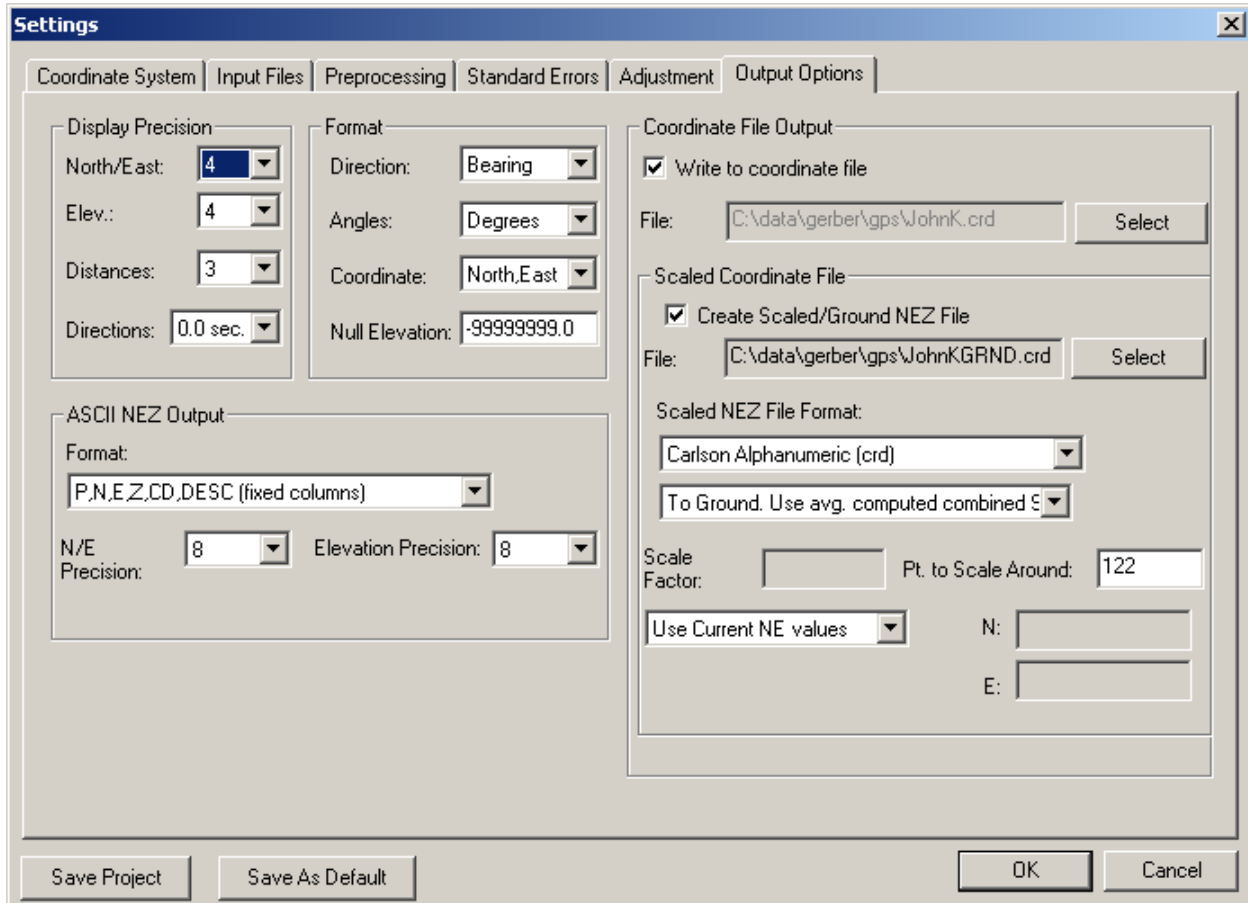
NOTE: If you do not want to slow down the processing by including ALL your sideshots in the adjustment, but you do want to include a few of them, you can leave the “Enable Sideshots” box unchecked and create a Relative Error Points File (see below) that includes the desired points.

Relative Err. Points File: The new ALTA standards require that surveyors certify to the relative positional error 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 file's location.

Include ALTA tolerance report: Turn this toggle on if you wish to include the ALTA tolerance section of 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, i.e. 0.07' & 50 PPM.

Choose Output Settings



The screenshot shows the 'Settings' dialog box with the 'Output Options' tab selected. The dialog is divided into several sections:

- Display Precision:** North/East: 4, Elev.: 4, Distances: 3, Directions: 0.0 sec.
- Format:** Direction: Bearing, Angles: Degrees, Coordinate: North,East, Null Elevation: -99999999.0
- Coordinate File Output:** Write to coordinate file. File: C:\data\gerber\gps\JohnK.crd (Select button).
- Scaled Coordinate File:** Create Scaled/Ground NEZ File. File: C:\data\gerber\gps\JohnKGRND.crd (Select button).
- Scaled NEZ File Format:** Carlson Alphanumeric (crd), To Ground. Use avg. computed combined S.
- Scale:** Scale Factor: (empty), Pt. to Scale Around: 122. Use Current NE values (dropdown), N: (empty), E: (empty).
- ASCII NEZ Output:** Format: P,N,E,Z,CD,DESC (fixed columns) (dropdown), N/E Precision: 8, Elevation Precision: 8.

Buttons at the bottom: Save Project, Save As Default, OK, Cancel.

Select the rounding options output formats and output coordinate file/s. The rounding settings are just for reports; all calculations are done in double-precision math. You may want to hold off selecting an output coordinate file until you have processed the data and reviewed the reports.

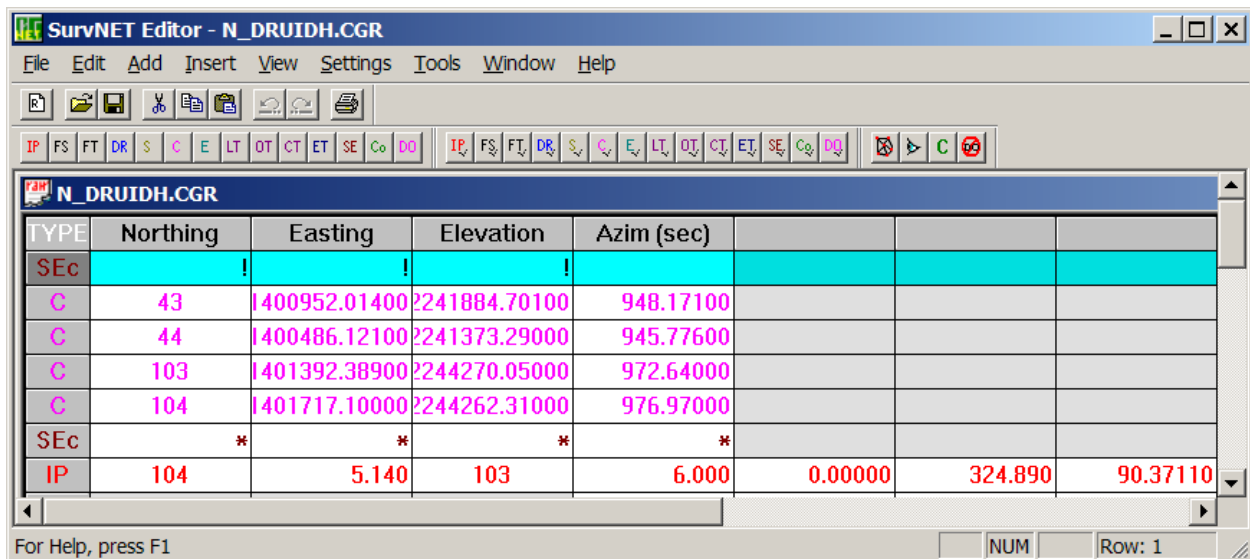
If your project is set to a State Plane Coordinate System, you are allowed to select a second coordinate output file for coordinates that are scaled to ground.

Step 3, Define Control

Control is defined as KNOWN coordinates, elevations and directions (azimuths/bearings) that constrain the adjustment. These are values that will either be held fixed, or allowed to change only slightly.

Control can be placed directly in the raw data file as coordinate, azimuth and/or elevation records. Standard errors can be assigned directly to each control point.

NOTE: ALL coordinate records in a raw data file will be considered control. If the raw data file contains calculated coordinate points that you do not wish to be used as control, you must remove them prior to processing.



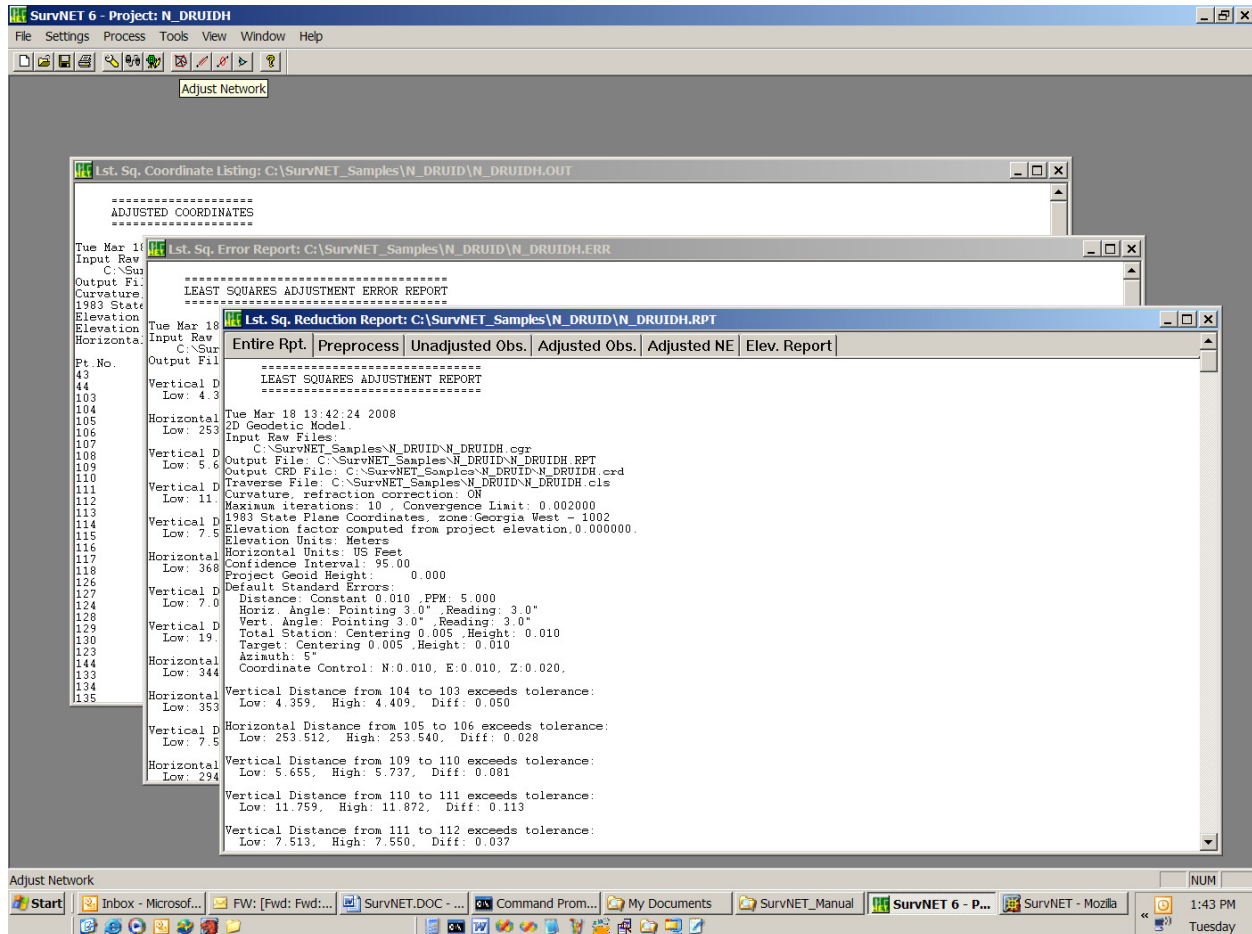
TYPE	Northing	Easting	Elevation	Azim (sec)			
SEc	!	!	!				
C	43	1400952.01400	2241884.70100	948.17100			
C	44	1400486.12100	2241373.29000	945.77600			
C	103	1401392.38900	2244270.05000	972.64000			
C	104	1401717.10000	2244262.31000	976.97000			
SEc	*	*	*	*			
IP	104	5.140	103	6.000	0.00000	324.890	90.37110

In the above example, 4 control points are placed in the raw data file. This is shown in the C&G CGR editor but it is the same for the Carlson RW5 editor.

The SEc record (Control Standard Errors) inserted prior to the points sets the points as FIXED (explanation point means FIXED). The Sec record following the points sets the control standard errors back to the project defaults, as defined in the project settings.

The minimal control is either two coordinate points, or a single coordinate point and an azimuth. It is not necessary to enter “starting coordinates”. The control can be any point/s in the traverse.

Step 4, Process data



The screenshot shows the SurvNET 6 software interface. The main window displays a list of points (Pt. No. 43-135) with their respective vertical and horizontal coordinates. Three separate windows are open, showing the results of the adjustment process:

- Lst. Sq. Coordinate Listing:** C:\SurvNET_Samples\N_DRUID\N_DRUIDH.OUT
- Lst. Sq. Error Report:** C:\SurvNET_Samples\N_DRUID\N_DRUIDH.ERR
- Lst. Sq. Reduction Report:** C:\SurvNET_Samples\N_DRUID\N_DRUIDH.RPT

The Reduction Report window shows detailed statistical data and warnings, such as "Vertical Distance from 104 to 103 exceeds tolerance".

Press the “Adjust Network” icon to process the data. If the adjustment converges, three files will be created with the project name and shown in three separate windows.

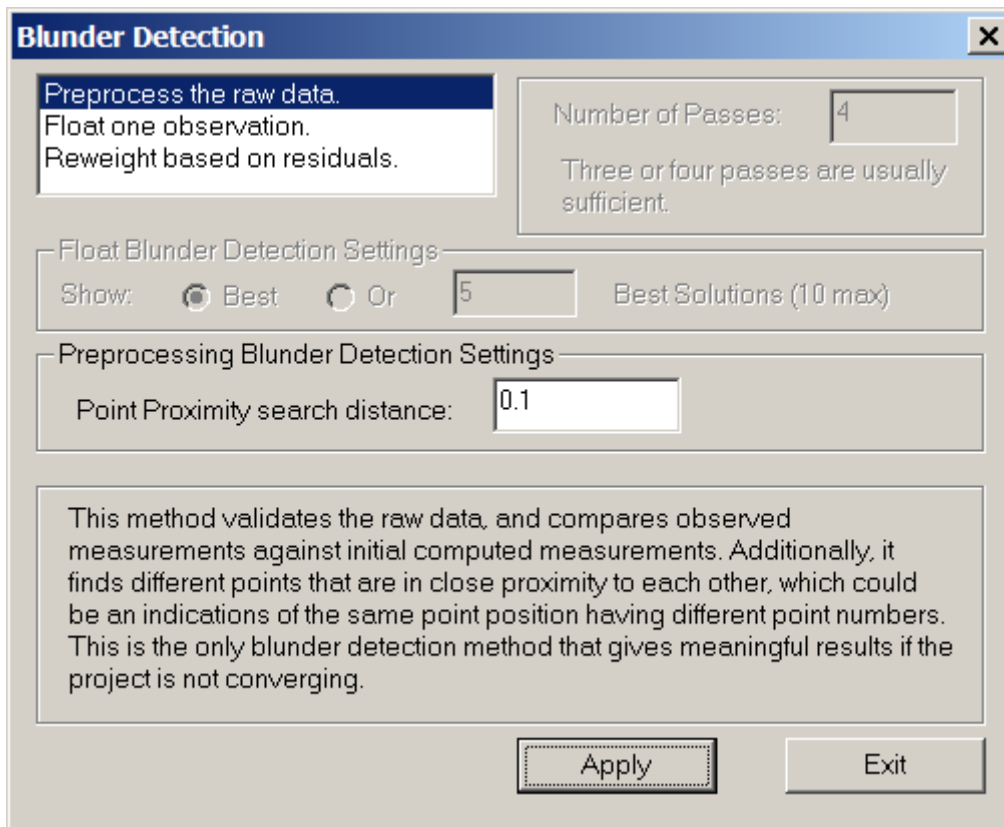
Error file (.ERR): - this file will contain any errors or warnings encountered during the processing.

Output file (.OUT) – this file will contain the calculated coordinates.

Report File (.RPT) – this file will contain the statistical report.

Blunders – Blunders are usually caused by bad measurements or incorrect assignment of point numbers. Blunders cannot be adjusted because they are not predictable errors. If there is a problem with processing the project, review the Error report for clues. If the project will not converge, or the residuals are extremely high, you will need to track down the problem. SurvNET has three “blunder detection” functions that will help you find the problem:

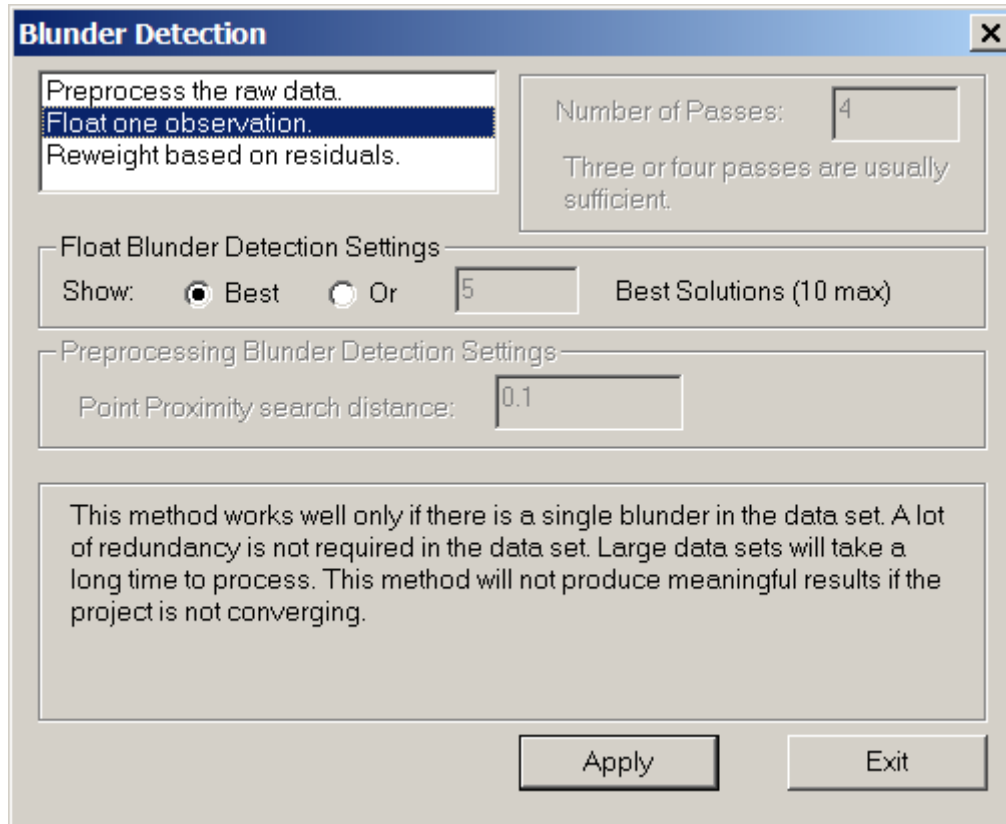
Under the PROCESS menu option, you will see a “Blunder Detection” option:



The first option is “Preprocess the raw data”. This option is the only blunder-detection option that will work if the project does not converge. This option is particularly good at finding problems with point numbering. For example, if you use the same point number for two different points, there is a good chance the project will not converge. The “blunder” report will tell you which points potentially cause the problem.

This blunder-detection option will also tell you which point numbers may actually be assigned to the same point. For example, it may tell you that points 5 and 45 are 0.02 feet apart and may actually be the same point.

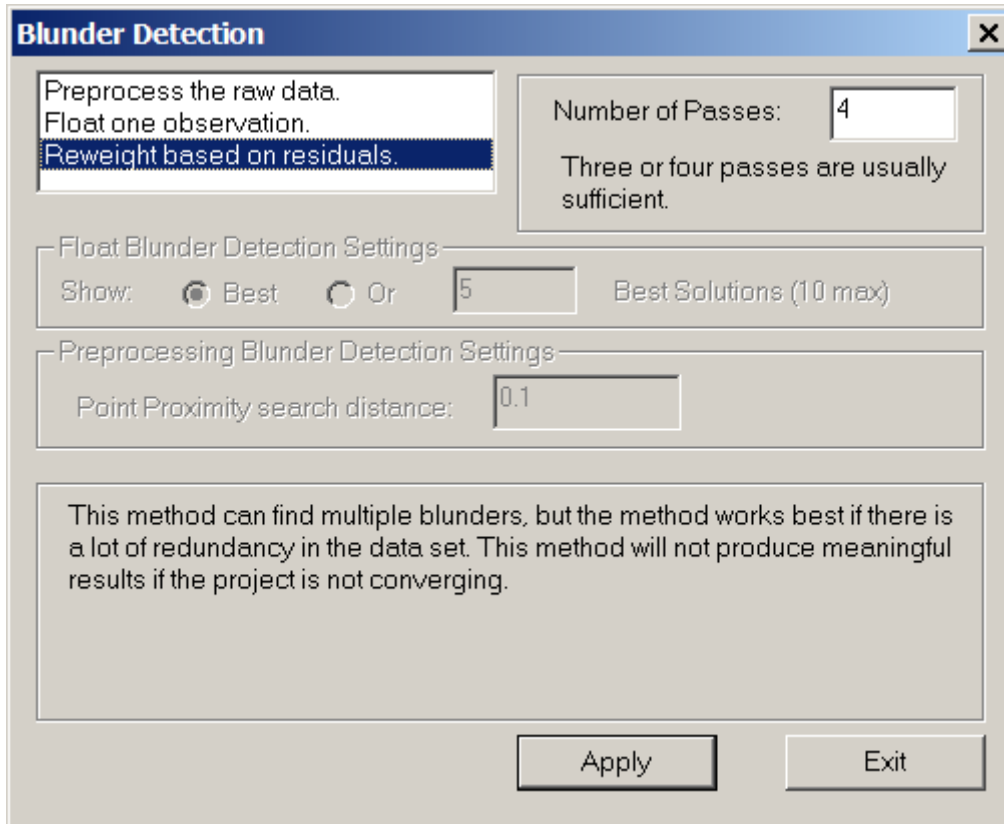
The next option is Float one observation:



If there is a single blunder in either a distance or an angle, this function will point you in the right direction. Basically it will process the project for each observation, allowing a different one to “float” each time. Since there are many solutions, you need to decide how many you wish to view. It is usually best to view the top two or three solutions because the error is not always in the BEST.

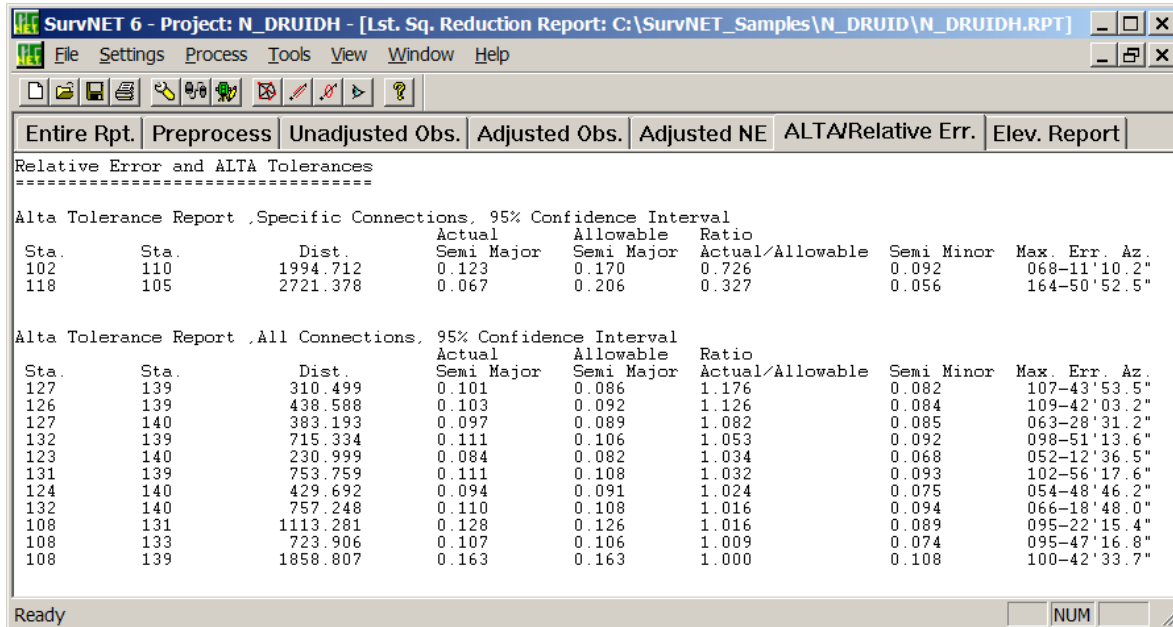
The report will show you the residuals for each measurement. When all residuals are small except for the one measurement, you have potentially found your error. There may be two or three solutions that meet these criteria.

The last blunder option is “re-weight based” on residuals:



This option can be useful if there are more than one blunder. It makes a selected number of passes and after each pass re-weights the measurements based on previous residuals. This tends to make errors stand out as having the largest corrections.

Step 5, Review Report



Relative Error and ALTA Tolerances							
=====							
Alta Tolerance Report .Specific Connections, 95% Confidence Interval							
Sta.	Sta.	Dist.	Actual Semi Major	Allowable Semi Major	Ratio Actual/Allowable	Semi Minor	Max. Err. Az.
102	110	1994.712	0.123	0.170	0.726	0.092	068-11'10.2"
118	105	2721.378	0.067	0.206	0.327	0.056	164-50'52.5"

Alta Tolerance Report .All Connections, 95% Confidence Interval							
Sta.	Sta.	Dist.	Actual Semi Major	Allowable Semi Major	Ratio Actual/Allowable	Semi Minor	Max. Err. Az.
127	139	310.499	0.101	0.086	1.176	0.082	107-43'53.5"
126	139	438.588	0.103	0.092	1.126	0.084	109-42'03.2"
127	140	383.193	0.097	0.089	1.082	0.085	063-28'31.2"
132	139	715.334	0.111	0.106	1.053	0.092	098-51'13.6"
123	140	230.999	0.084	0.082	1.034	0.068	052-12'36.5"
131	139	753.759	0.111	0.108	1.032	0.093	102-56'17.6"
124	140	429.692	0.094	0.091	1.024	0.075	054-48'46.2"
132	140	757.248	0.110	0.108	1.016	0.094	066-18'48.0"
108	131	1113.281	0.128	0.126	1.016	0.089	095-22'15.4"
108	133	723.906	0.107	0.106	1.009	0.074	095-47'16.8"
108	139	1858.807	0.163	0.163	1.000	0.108	100-42'33.7"

The Report File Window is divided into “tabs” that separate the report into logical categories. This makes it easier to go directly to certain areas of the report.

The tabs are:

Entire Report – view the entire report from this tab.

Preprocess – shows initial settings and tolerance warnings.

Preprocess – shows tolerance warnings when averaging sets of angles and distances.

Unadjusted Observations – shows control, all measurements and the standard errors assigned to each. It also shows the closure reports if a Closure File has been used.

Adjusted Observations – Shows each observation, the calculated standard deviations, the residuals, the standard residuals, and adjustment statistics.

Adjusted NE – Shows the adjusted coordinates, the calculated standard errors, and the error ellipses for each point.

ALTA/Relative Err. – This part of the report is optional. If you wish to have an ALTA report, you must create an ALT file defining the pairs of points for which you want the positional tolerances calculated (relative error ellipses). This file is created/selected in the Adjustment Settings.

Side Shots – Shows all side shots. Side shots are always calculated from adjusted points.

Elevation Report – In the 2D/1D model, elevations are calculated separately.

Step 6 – Make necessary changes and reprocess

After reviewing the report, make any necessary changes to the input files and/or project settings and re-process. When everything is to your liking, check the “Write to Coordinate File” box in the OUTPUT settings and press the PROCESS icon one more time.