STAR*NET Students Manual

February 06, 2019

By

James Johnston

B. Ed, Geomatics tech

Contents

STAR*NET Certification Session 1 5

Key Least Squares Concepts 5

STAR*NET Interface "in a nutshell" 9

STAR*NET Certification Session 2 12

Instrument Standard Errors 12

Pre-Analysis 17

Using Convertors to Import Conventional Data 18

Troubleshooting 1: Sort Residuals by Size 20

STAR*NET Certification Session 3 21

Combining Conventional Data from Different Sources Using the Instrument Library 21

Computing Error factors 22

GPS Vectors 25

Troubleshooting 2: Using .data inline entry 29

Modeling Exercise: 30

Custom Coordinate Systems in STAR*NET and other customization files 32

Other types of GPS Data 35

STAR*NET Certification Session 4 36

Leveling Data Conversion Exercise 36

Troubleshooting 3: Using Level Loop Check 38

Combining Data 39

Positional Tolerance: 41

Appendix A 42

Summary of Input Types 42

Appendix B 56

Exchanging Data between MicroSurvey CAD Programs and STAR*NET 56

STAR*NET to MicroSurvey CAD: 56

Exporting Points to a MicroSurvey CAD Program: 56

Exporting Points *and* Graphics to a MicroSurvey CAD Project: 58

MicroSurvey CAD to STAR*NET: 65

Disclaimer and Limited Warranty

This document and the software contained herein may not be reproduced in any fashion or on any media without the explicit written permission of MicroSurvey Software, Inc. MicroSurvey grants permission to attendees of MicroSurvey sanctioned STAR*NET Training to print a copy of this manual for personal use, but requires that electronic copies not be distributed or reproduced.

EXCEPT AS OTHERWISE PROVIDED IN THIS AGREEMENT, MICROSURVEY SOFTWARE, INC. SPECIFICALLY DISCLAIMS ALL WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE., TO DEFECTS IN THE DISKETTE OR OTHER PHYSICAL MEDIA AND DOCUMENTATION, OR TO OPERATION OF THE PROGRAMS AND ANY PARTICULAR APPLICATION OR USE OF THE PROGRAMS. IN NO EVENT SHALL MICROSURVEY SOFTWARE, INC. BE LIABLE FOR ANY LOSS OF PROFIT OR ANY OTHER COMMERCIAL DAMAGE INCLUDING, BUT NOT LIMITED TO, SPECIAL, INCIDENTAL, CONSEQUENTIAL, PUNITIVE OR OTHER DAMAGES.

ALL LIABILITY BY MICROSURVEY SOFTWARE, INC. HEREUNDER IS EXPRESSLY LIMITED TO ANY AMOUNTS PAID TO MICROSURVEY SOFTWARE, INC. PURSUANT TO THIS AGREEMENT.

Notwithstanding any provision of this Agreement, MicroSurvey Software, Inc. owns and retains all title and ownership of all intellectual property, including but not limited to all software and any and all derivative software; all documentation, manuals and related materials; all master diskettes or CD ROM's on which such software may be transferred, and all copies of any such diskettes or CD ROM's, and any and all derivative works of STAR*NET by MicroSurvey. MicroSurvey Software, Inc. does not transfer any portion of such title and ownership, or any goodwill associated therewith; and this Agreement shall not be construed to grant any right or license, whether by implication, estoppel or otherwise, except as expressly provided herein.

STAR*NET Certification Session 1

Key Least Squares Concepts

Objective: Provide students with an understanding of when it is appropriate to use the least squares method, basic concepts of redundancy and special considerations for field data acquisition.

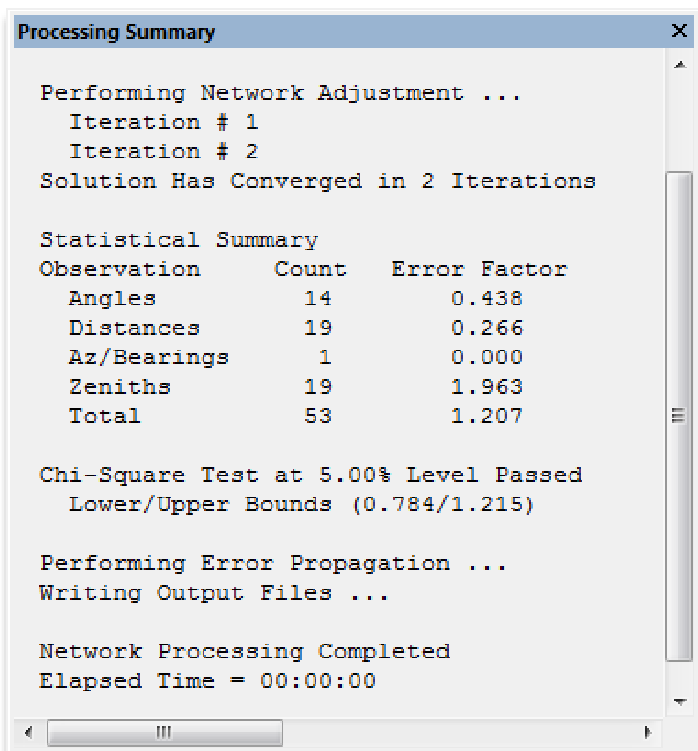
Resource: Help file entry for .alias
Resource: Least Squares the Great Arbiter.pdf
Resource: Comparing a "Traditional" closed traverse with Least Squares network on following pages
Resource: FGTPS project in "1 Key Least Squares Concepts" folder
Resource: Template.dat (uncomment different sections of the template file to illustrate concepts)
Resource: Kelso UTM project in "1 Key Least Squares Concepts" folder is great to show cluster detection

Least Squares vs. Traverse adjustment: Compare least squares to a balanced closed traverse. With least Squares, cross ties add strength to the network rather than function simply as "checks."

Redundancy/Degrees of Freedom: "Degrees of Freedom" of the network, is equal to *the number of observations in the network minus the number of unknowns*. This is also sometimes called the redundancy of a network.

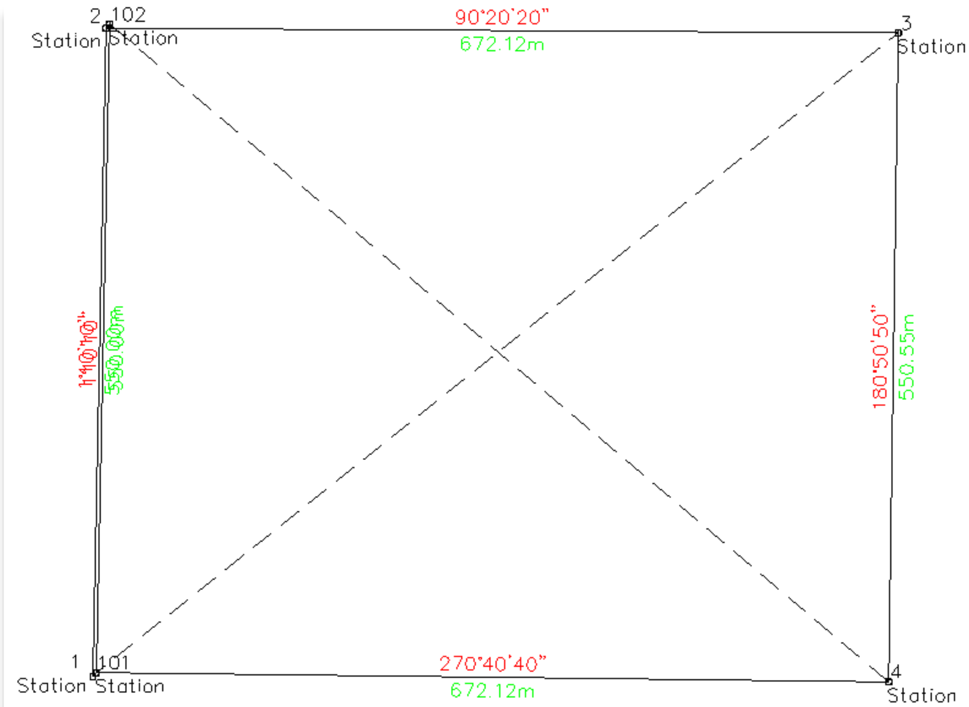
Network Summary/ Chi Square test:

While a closed traverse is judged by the error ratio (1:5000 is typical as the minimum acceptable), a least squares adjustment is judged by the Chi-square test (1 is perfect)



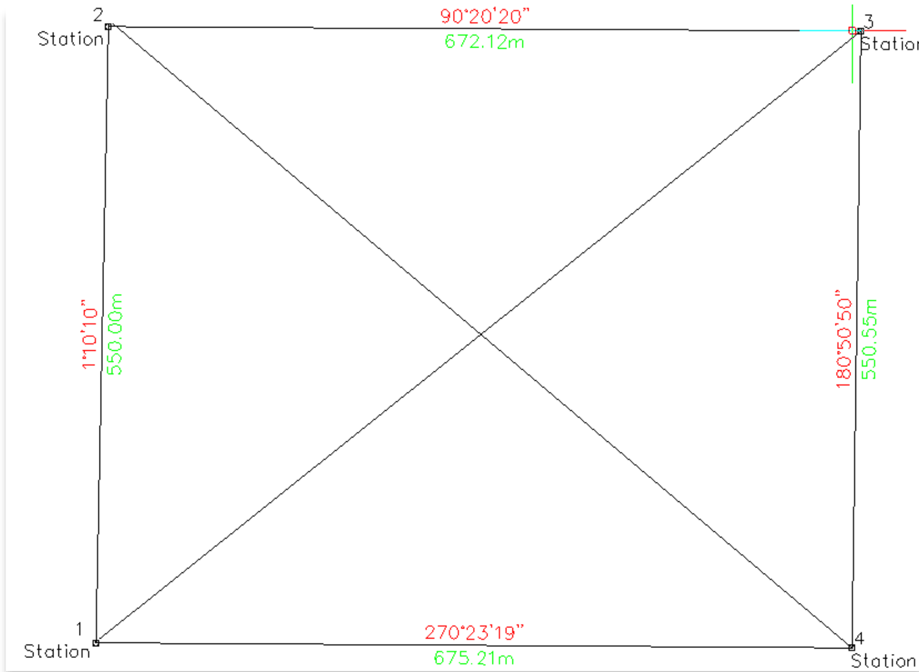
Comparing a "traditional" Closed Traverse with Least Squares Network:

Closed Traverse:



Characteristics:	• Measurements start and finish at known stations • Computations must proceed sequentially (you can't "jump around")
Quality Check:	• *Misclosure:* difference between measured and known coordinates • *Misclosure Ratio:* length of misclosure divided by total length (ie: 1:5000)
Point Identifiers:	• Each point must have a unique name, • Redundant measurements need to be identified in the office.
Redundant Measurements:	• Cross ties can be used as checks • Cross ties can't be included in the "balanced" solution.
Adjust (*balance*) by:	• Compass rule, Bowditch rule, angular balance etc. seek to distribute error evenly over each station to simulate a "perfect" closure.
Advantages:	• Simple to compute by hand or spreadsheet • Misclosure ratio is easy to understand
Disadvantages:	• "Balancing" assumes that error is evenly distributed. • Closure ratio does not take into account expected accuracies. • No easy way to find errors, it's "all or nothing." • Redundant measurements can't be used.

Least Squares Network:



Characteristics:	• Measurements can be entered in any order • Requires at least one known station and one known direction • "Degrees of freedom" must be > 1
Quality Check:	• Chi-square test compares overall expected level of error to actual level of error. • Error ratios compare expected level of error for one type of measurement to actual level of error. • Standardized Errors compare expected level of error for one measurement to actual residual • With all of the above, 1 is perfect
Point Identifiers:	• Each station has one Point ID • STAR*NET "aliasing" feature allows for multiple names for one station
Redundant Measurements:	• Can be included in the adjusted solution. • Strengthen the network so give you greater accuracy • Easy to exclude in STAR*NET
Adjust by:	• Least Square adjustment seeks to adjust the network while changing the field measurements the minimum amount.
Advantages:	• More sophisticated way of distributing error • More sophisticated way of judging the quality • Redundant measurements make it possible to find errors and outliers • Measurements can be input in any order as long as Degrees of freedom are greater than 1
Disadvantages:	• Operator must be knowledgeable: ○ results will not be accurate unless correct a priori values (instrument settings) are input ○ Chi-Square test and error ratios require careful inspection. • Complicated computations usually require a computer.

Field Data acquisition procedures (aliases, /# options in FG): Normally, point Ids need to be the same in STAR*NET no matter how many times you observe the point. This can cause conflicts during fieldwork because user is prompted to overwrite the point every time it is observed. Various strategies can be applied to deal with this:

- **Overwrite:** Overwrite the point every time
- **Use /## in description and use converter:** Use /Point ID in description FG,TDS or Carlson software (i.e. if you are overwriting point 1, call it Point 101 and give it the description /1) and the convertor will substitute the correct Point ID
- **Use .alias:** Use .alias inline option to state alias substitutions or prefixes
- **Cluster Detection:** Store points with any Point ID and use the "Run once with Cluster Detection" option which will group points with similar locations. *This strategy requires that the data is free of blunders so might be best used as a secondary solution.*

Assessment: Test 1 STARNET Key Least Squares Concepts

STAR*NET Interface "in a nutshell"

Objective: Introduce the main components of the main STAR*NET Interface and basic input methods. Lesson will prepare students for manual input activity.
Resource: Interesting Examples: "Mumbai Tunnel Authority" and "DuPont Complex Conventional network" in "2 STARNET in a Nutshell" folder **Resource:** "Nutshell" project in "2 STARNET in a Nutshell" folder **Resource:** Notepad and Windows keyboard shortcuts: **Resource:** "Summary of Input Types" in this document **Resource:** Manual Entry Exercise

Notepad and Windows keyboard shortcuts:

Ctrl c	Copy highlighted
Ctrl x	Cut highlighted
Ctrl v	Paste in cursor location
Ctrl z	Undo previous action
Ctrl h	Replace
Move:	Highlight text, left click and drag to new location
Make a new line:	Click at left margin and enter
Column Edits:	Alt –click-click-Alt

Lesson:

- View Interesting examples
- Brief overview of the control panels of STAR*NET
  - **Workflow:** Import->set options->process->summary->listing, rinse and repeat
  - **Processing Summary:** Iterations, Error Factors, Chi-Square Test
  - **Pop up Help and Error Linking**
  - **Output:** Listing, Errors, Coordinates, Lat/Long, Ground file
  - **Project Options**: Adjustment, Instrument, Listing options
- Introduction to basic input types, comments and inline options *(Start doing the manual input exercise to demonstrate each input type below)*
  - C,P and E Records
  - B Records assign bearing/azimuth
  - D Records assign distance
  - DV includes a vertical component
  - M Record: From-at-to
  - Fixity: !,*,&,.0#s

Activity: Manual Input Exercise 1: 2D Conventional Traverse

Use the following record types to complete this exercise. See below for examples of record types you will require:

"C" Record: (Stored Coordinate)
C 101 1000.00 1000.00 ! ! 'CONTROL
C Station North East [Std Errors] [Description]

"B" Record: (Bearing or Azimuth)
B 1-2 0 !
B From-To Azimuth [Standard Error]

"D" Record: (Distance)
D 1-2 100.01
D From-To Horizontal Distance [Std Error]

"D" Record: (Distance)
D 1-2 100.01
D From-To Horizontal Distance [Std Error]

"DV" Record: (Distance with a vertical component)
DV 1-2 100.01 90-00-05 5.12/4.97
DV From-To Slope Distance Zenith [Std Error] HI/HT

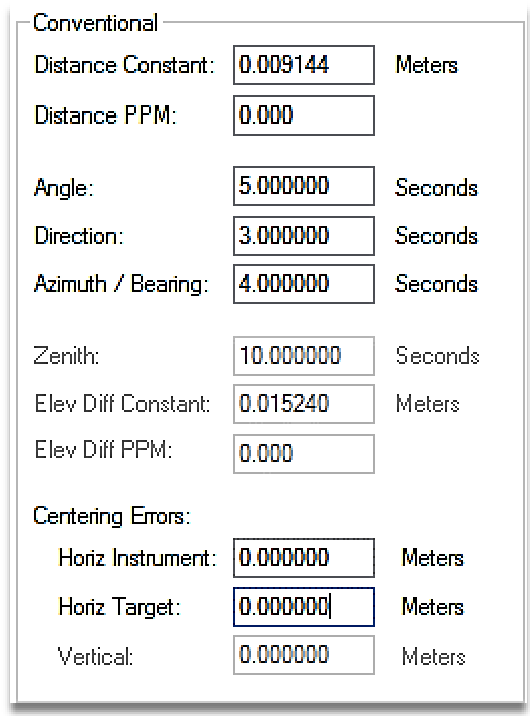
"M" Record (Backsight, Foresight and Distance)
M 1-2-3 90-00-06 100.00
M At-From-To Angle Distance [Std Errs]

"A" Record (Backsight, Foresight and Distance)
A 1-2-3 90-00-06
A At-From-To Angle [Std Errs]

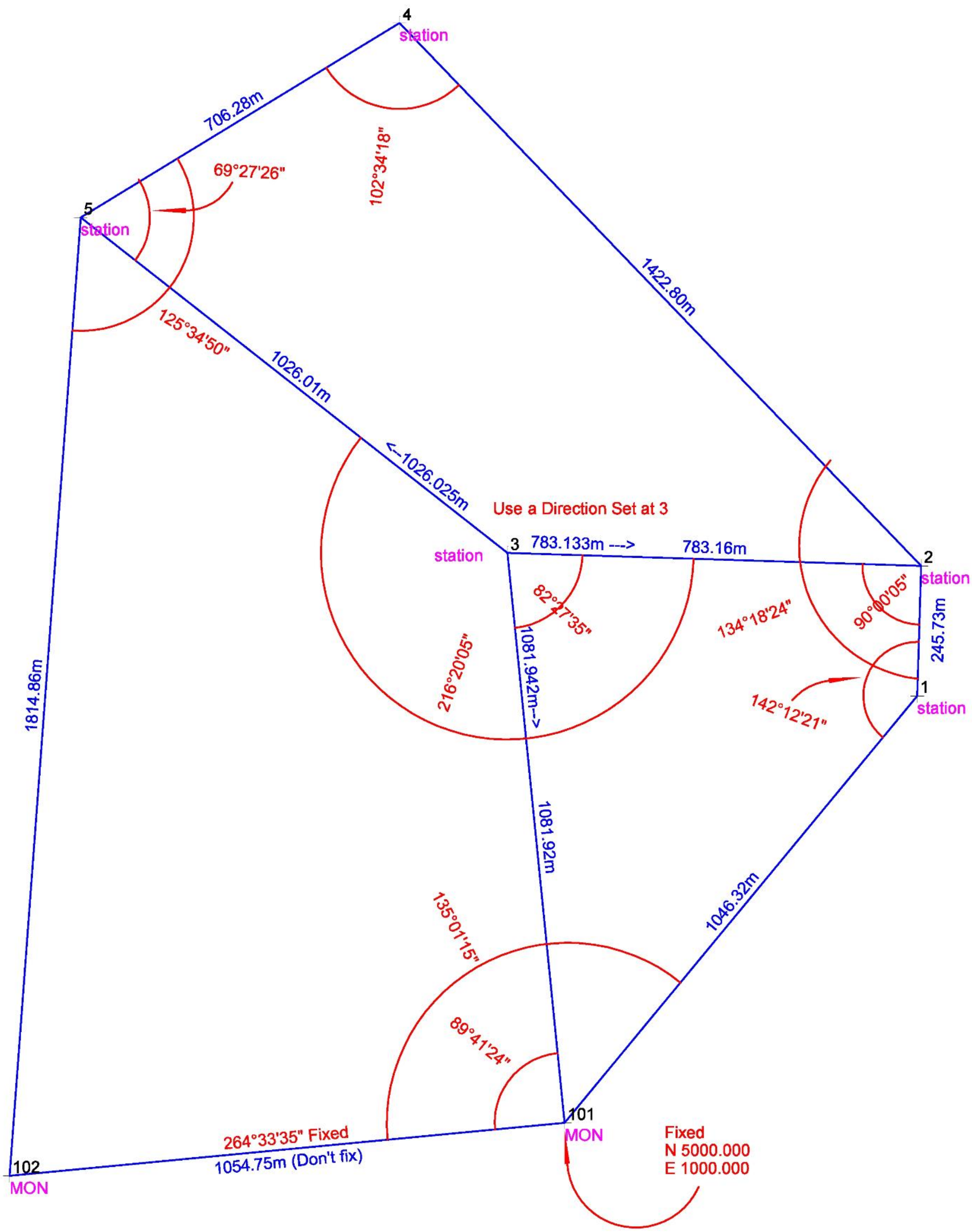
"Direction Set" (Directions or plate readings and distances to a series of stations)
DB 1
DM 2 0.0000 50.00
DM 3 45.0000 75
DE

DB From Occupied Station Name [Direction Set Description]
DN To Station Name Direction [Standard Error]
DE

Instrument Settings for this exercise:



NOTES:
-Coordinate Order is N,E
-Project is 2D
-Use a direction set to enter measurements from 3
-Options | Editor to enable help tips for help with entry



Assessment: Test: 2 STAR*NET Least Squares "in a nutshell"

-be sure that “DV” record type has been covered

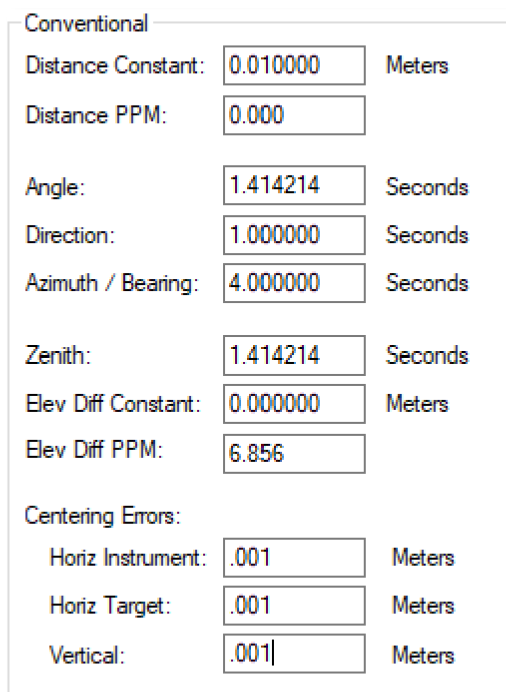
STAR*NET Certification Session 2

Instrument Standard Errors

Objective: Establish the importance of Instrument settings and GPS Standard Errors and their effect on the Chi-square test. *Misunderstanding this concept is the main path by which least squares can be misused by novices.*
Resource: “Instrument Options” and “GPS Options” in Chapter 4 of Help Files.
Resource: “Instrument Settings” Project in “3 Instrument Standard Errors” folder
Resource: “Din18723.pdf” in “3 Instrument Standard Errors” folder
Resource: “Peter Messier's Discussion of a priori instrument SEs.pdf” in “3 Instrument Standard Errors” folder
Resource: “Error_Theory_Related_to_Surveying _Measurements.pdf” in “3 Instrument Standard Errors” folder
Resource: “White_Paper_Surveying_Reflectors_en[marked up].pdf” in “3 Instrument Standard Errors” folder
Resource: “Leica Viva TS15 Datasheet_en [marked up].pdf” in “3 Instrument Standard Errors” folder
Resource: Centering Errors article from RPLS.pdf in “3 Instrument Standard Errors” folder

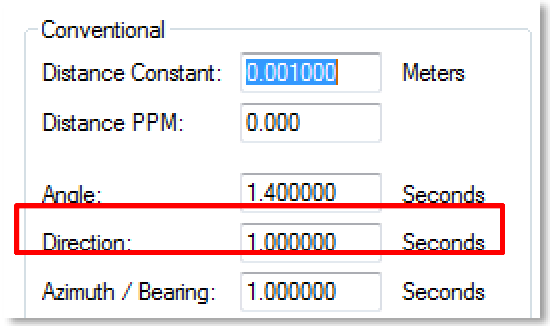
Lesson: Discuss contents of Instrument and GPS Tab in project options.

- **Important Points:**
  - Direction Setting weights direction sets (DB, DN, DE combinations) and DV
  - Direction Setting can be determined several ways:
    - Determine by field testing
    - Use the Manufacturer’s DIN 18723 Specification for Direction Accuracy
    - Use the Manufacturer’s ISO 17123-3 Specification for Direction Accuracy
  - Angle Setting affects M, SS, A measurements.
    - Angular settings can be determined from field testing
    - Angular settings can be calculated as shown below
  - Azimuth/Bearing affects B and BM measurements
  - Distance and constant settings D, DV or any distance component
  - Zenith and Vertical Difference settings are derived from direction setting
  - Centering affects most measurements
  - GPS Centering (*see GPS tab*) error important unless using "forced centering"

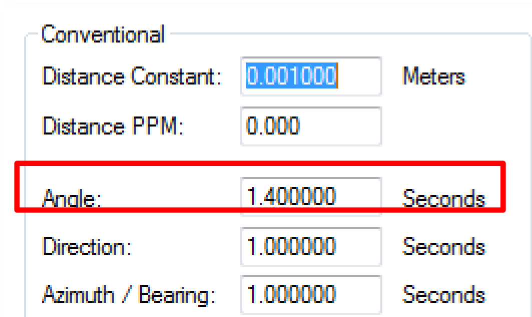


<table>
<tr>
<td>
<u>Direction Accuracy:</u>
DIN 18723 Specification for Theodolite Accuracy (i.e. a “1 second instrument”) applies to a repeated F1 and F2 “Pointing” or target sighting (ISO 17123 Specification is the same for practical purposes.)

Direction Std Err = DIN 18723 (or ISO 17123)
Or if direction is averaged from N observations:
Std Error = DIN 18723 / √ N

Eg: 2 observations with a 1 second instrument:
1”/ √ 2 = .71”
Eg: 6 observations with a 2 second instrument:
2”/ √ 6 = .82”
</td>
<td>
Apply this setting to


</td>
</tr>
<tr>
<td>
<u>Angular Accuracy:</u>
Angular Std Err = 2 x (DIN 18723) / √Number of “Pointings”

E.g.: 1 sets (1 FS + 1 BS) with a 1 second instrument: 2(1”) / √2 = 1.414”
E.g.: 3 sets (3 FS + 3 BS) with a 5 second instrument: 2(5”) / √6 = 4.082”
</td>
<td>
Apply this setting to:


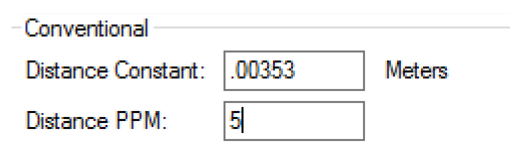
</td>
</tr>
<tr>
<td>
<u>Distance Accuracy</u>
Given as the Constant and PPM values generated when the EDM was calibrated. When multiple observations are averaged the constant must be calculated:

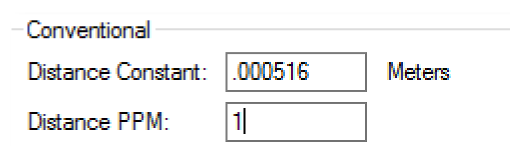
Where:
Constant = Given EDM Constant
PPM = Given ppm constant divided by 1 million
N = number of distance measurements averaged

Distance Std Err = +/- Constant/ √N

Eg.: EDM with PPM = 5, constant = .005 meters averaging 2 measurements:
Constant = .005m / √2 = .00353m
Eg: EDM with PPM = 1, constant = .002 meters averaging 15 measurements:
Constant = .002m /√15 = .000516 meters
</td>
<td>
NOTES:

If PPM and constant are only available in metric, switch your project units to Meters to enter these values, and then switch back to feet.
PPM is the same regardless of number of observations.

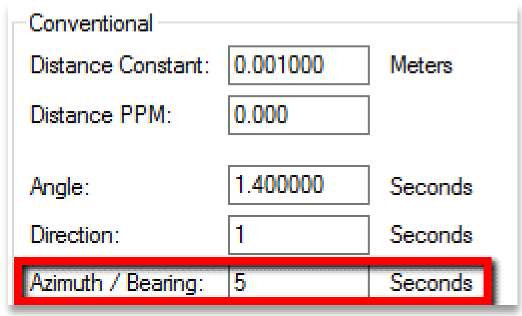




</td>
</tr>
</table>

Azimuth/Bearing

Directional accuracy to be applied to given bearings, gyroscopic or astronomical observation.

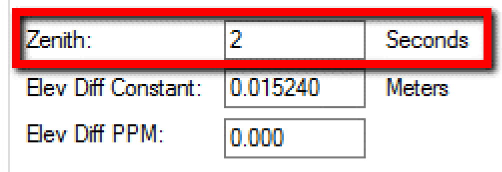


Zenith

Directional accuracy of zenith angles. Typically 2 X the Direction setting.

Or if direction is averaged from N observations::
Std Error = (2*DIN 18723) / √N

Eg: 2 observations with a 1 second instrument:
2*1”/ √ 2 = 1.414”
Eg: 6 observations with a 2 second instrument:
2*2”/ √ 6 = 1.633”



Elev Diff Constant and Elev Diff PPM

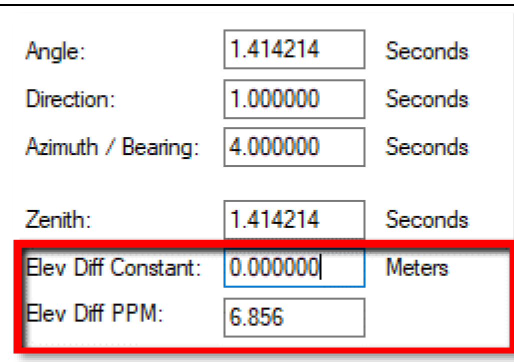
ONLY takes effect if you are manually entering 3D data in the form of horizontal distances and vertical differences. *Not used very often.*

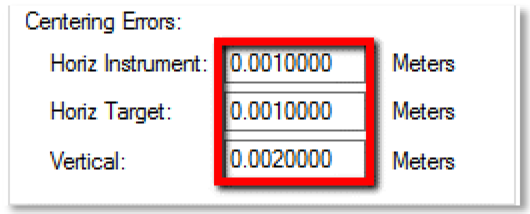
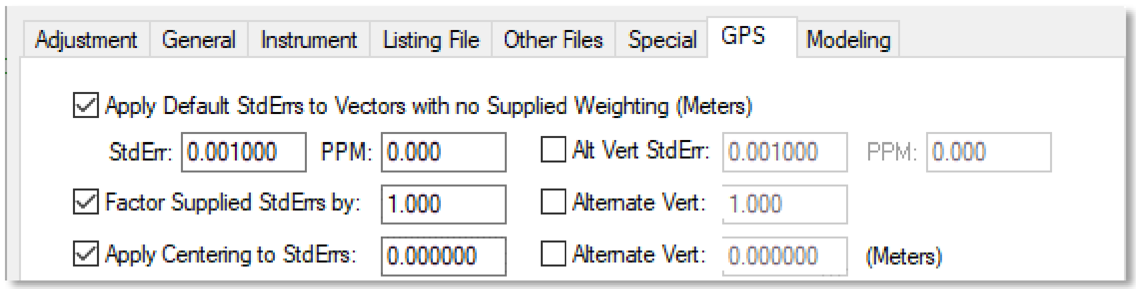
Elev Diff Constant: *use your judgement!*
Elev Diff PPM: if Delta V was computed from zenith observations you can derive a PPM after computing the zenith value above.

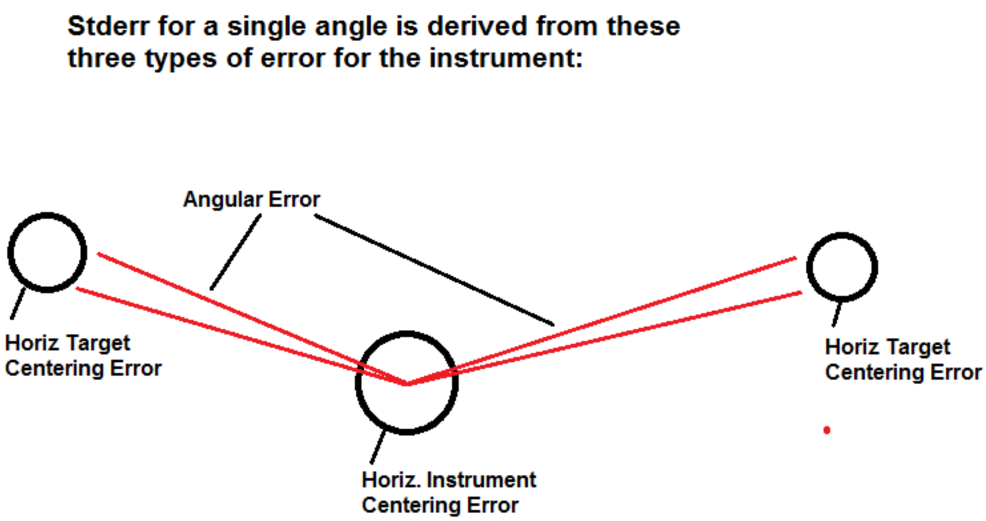
PPM=tan(zenith)*1000,000

Eg: 2 observations with a 1 second instrument:
Tan(1.414”)*1,000,000 = 6.856 PPM
Eg: 6 observations with a 2 second instrument:
Tan(1.633”)*1,000,000 = 7.95 PPM

The PPM values give similar results to zenith values for computed Z values when slopes are shallow, but are less effective for steep observations.



<table>
<tr>
<td>Centering Errors
Horiz. Instrument: How well is the instrument centered over the target?
Horiz. Target: How well is a target prism centered over the target?
Vertical: How well is the Height of Target or Instrument measured?</td>
<td>
</td>
</tr>
<tr>
<td colspan="2">Related GPS Options:

</td>
</tr>
</table>

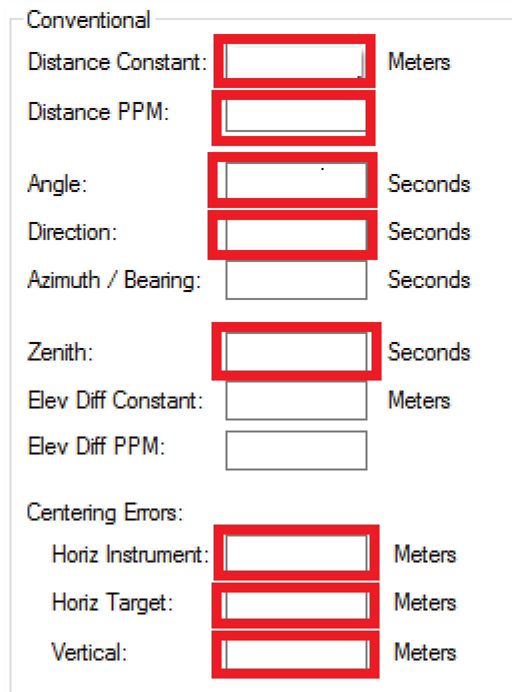


Activity: Calculate Instrument settings for the following scenario:

Instrument specs:

- DIN 18723 = 1" or .3 MilliGons
- Distance PPM = 2
- Distance Constant = 1 mm
- All angles and distances will be measured 6 times and averaged.
- Instrument and Target will be "forced centred" during observations.
- HI and HT measured with a pocket tape +/- 3 mm

Calculate the settings for each of the highlighted dialogs:



Online Utility: support.microsurvey.com/convert/instrumentsettings.html

Assessment: Test: 3 STAR*NET Instrument Standard Errors

Pre-Analysis

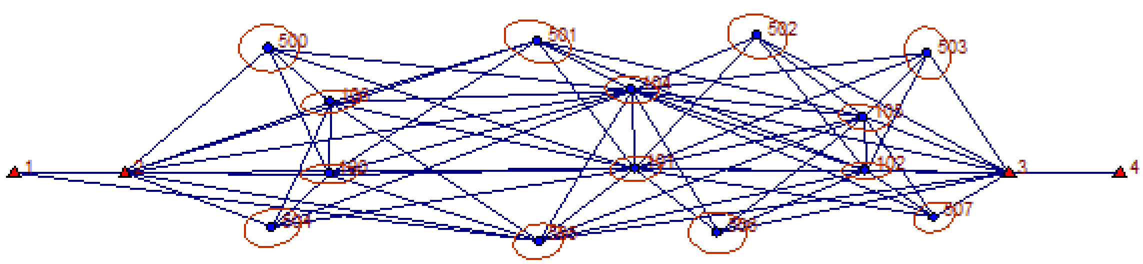
Objective: Understand how pre-analysis *predicts* the strength of a network using entered standard errors (Instrument settings.) A deformation study will be used to show the feature.
Resource: Full Data Posting 2011.pdf in "4 Preanalysis" folder
Resource: "Preanalysis demo" Project in "4 Preanalysis" folder
Resource: "Preanalysis" Project in "4 Preanalysis" folder
Resource: "Tunnel Monitoring" Project in "4 Preanalysis" folder

Deformation Study Introduction:

- View "Tunnel Monitoring" to see an example of a deformation monitoring project.
- Look at "Coordinate changes from Entered Provisionals" listing
- Look at "Dump" feature
- View "FULL DATA POSTING 2011.pdf" for an example of output

Preanalysis using "Preanalysis Demo" Project: Use examples to demonstrate how Pre-Analysis can predict Error Ellipses in this familiar project. Results can be seen in: "Station Coordinate Deviations" and "Station Standard Error Ellipses" sections of the listing.

Preanalysis: Look at Preanalysis demo project. Run pre-analysis in order to predict the magnitude of error ellipses. Uncheck the "Simulation" data file and check the "Preanalysis" data file to prepare students for the pre-analysis exercise:



Look in Listing. The Error Ellipses need to be smaller than the tolerances for point movement.

Activity: Students follow steps outlined in "Preanalysis" to estimate how many observations need to be added to this network in order to provide results that will be reliable 68% of the time. Have students keep track of modifications they made and report to the class.

Assessment: Poll: 4 STAR*NET Preanalysis

Using Convertors to Import Conventional Data

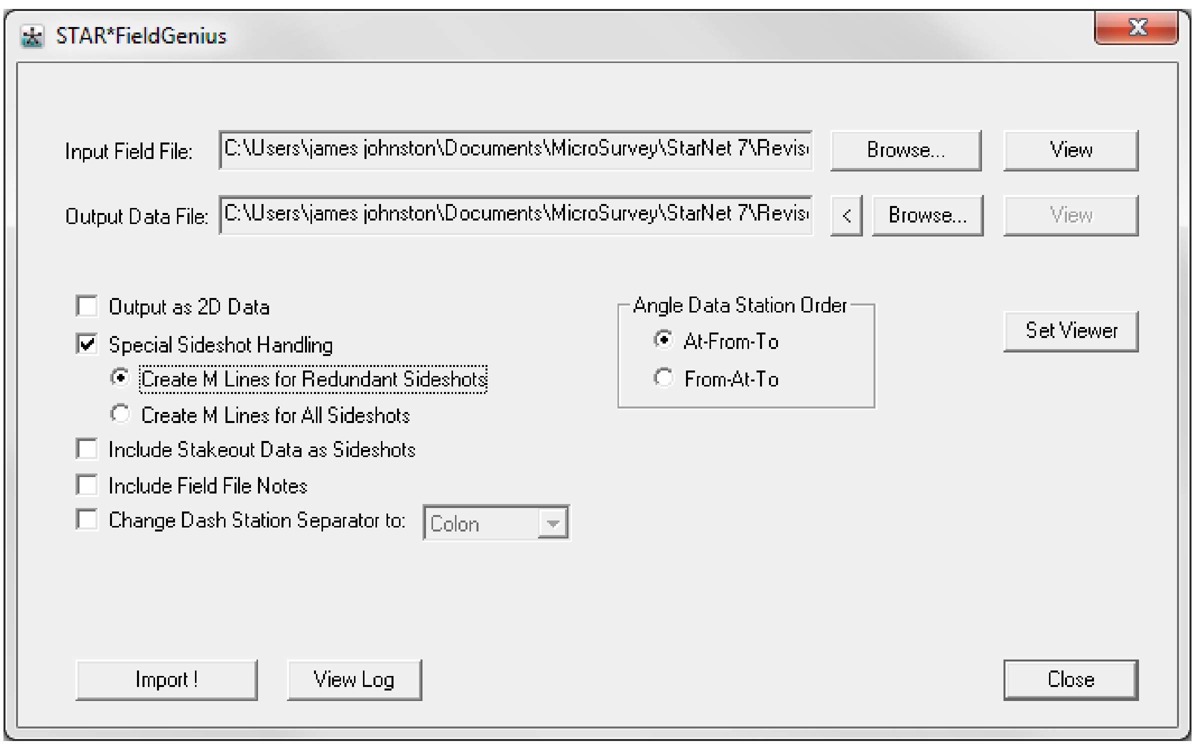
Objective: Students will set appropriate conditions for a project and gain experience using a convertor to import conventional traverse data and perform an adjustment. Students will also understand the difference introduced by SS vs M records.
Resources: FIELDTESTTPS.raw in "5 Using Convertors to Import Conventional Data" folder
Resources: FIELDTESTTPS_to use if you don't have a converter.dat in "5 Using Convertors to Import Conventional Data" folder
Resources: STAR*NET Import Troubleshooter: http://helpdesk.microsurvey.com/index.php?/Troubleshooter/Step/View/5
Alternative Dataset Resources: DBX samples: "DBX Resections," "DBX TPS Traverse Example" or "Benson Sculpture Park Demo Files"

Lesson: Discuss the variety of import and conversion options available from MicroSurvey or other manufacturers

Demonstrate using the FieldGenius converter to create a dat file and view the Input and Output files. Show how results can vary by overwriting the dat file while selecting a variety of options including "Output as 2D," "Special Sideshot handling" and "Change Station separator."

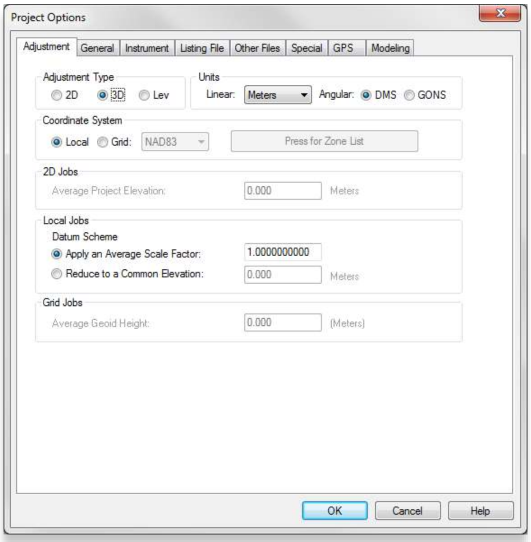
Demonstrate the steps required to import and adjust this example raw file.

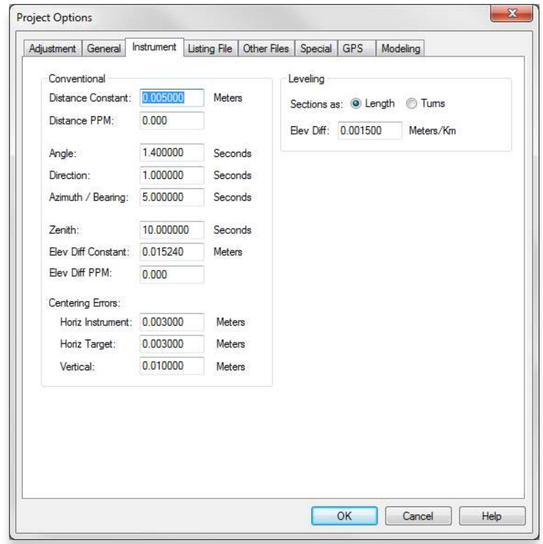
1. Use the StarFieldGenius converter to convert the raw file into a dat file.



2. Create a STAR*NET Project

3. These are the settings required for this project:

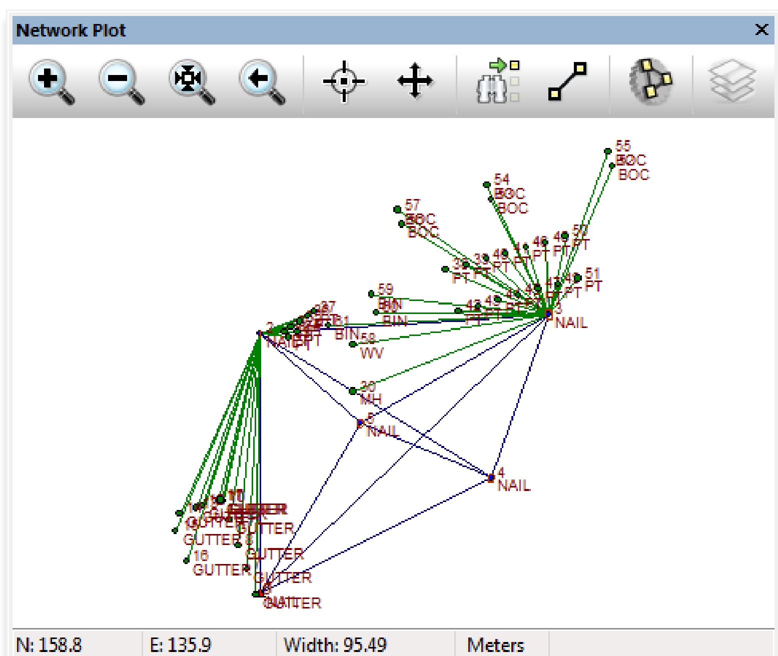




4. Import the .dat file
5. Set One fixed point
6. Set One fixed direction

Activity Choice 1: Students convert FIELDTESTTPS.raw into a .dat file and import the data into a new project. Adjust the data and process the network so that it passes the Chi-Square test.

Activity Choice 2: Students import "FIELDTESTTPS_to use if you don't have a converter.dat" into a new project. Adjust the data and process the network so that it passes the Chi-Square test.



Assessment: Poll: 5 STAR*NET Converters

-results won't match unless instrument settings defined in the comments are set

Troubleshooting 1: Sort Residuals by Size

Objective: To understand how the Standardized Residuals are used to calculate the Error Factor and how the "Adjusted observations and residuals" section of a listing shows how individual measurements fit in the overall network.
Resource: FIELDTESTTPS project from previous exercise
Resource: "FGTPS with Outlier" Project in "6 Troubleshooting 1 Sort Residuals"
Resource: Chi Square test<-Total Error Factor<-Measurement Class Error Factors<-StdErr section of "Adjusted observations and residuals"

Introduction: Use "FIELDTESTTPS" project to show how introducing an outlier can affect the Chi-Square test and then find the outlier using "Sort Adjusted Observations and Residuals by: Std Residual" feature in the listing. Find the outlier using the "Adjusted Observation and Residuals" section of the listing. *The outlier should be about 10 or more minutes to have an impact in this network because of short distances.*

Activity:

Open "FGTPS with Outlier" and identify the outlying observation.

Comment out the observation and test again until the Chi-Square test passes.

Alternatively, unweight the angle but leave the other observations untouched by: ***&&**

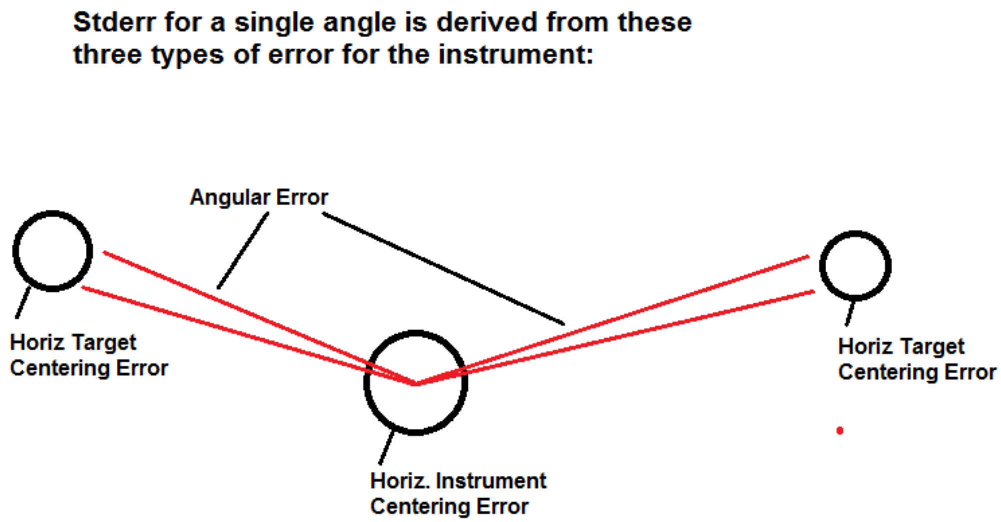
Early finishers challenge: How much of an error is there? What strategy did you use to solve that problem?

Assessment: Poll: 6 STAR*NET Troubleshooting 1

STAR*NET Certification Session 3

Combining Conventional Data from Different Sources Using the Instrument Library

Objective: Introduce students to .instrument option for combining data from total stations with different angular accuracies.
Resource: Chapter 4, Instrument Library in Help Menu
Resource: "Computing Error Factors" in this manual
Resource: 7 Instrument Library



Introduction: The Instrument library allows the combination of data from a wide variety of sources. In a large network you may need to combine data from different instruments, measured by different crews of varying experience or under different environmental conditions. You may need to use the instrument library to ensure that measurements from different sources are weighted appropriately within the same network.

Lesson: Open Instrument Library project. Demonstrate the two different data sets that are combined in the project. Show how the chi square test passes when you apply the project instrument settings to the original older traverse, but fails on the lower bounds when you add the newer traverse. Create a pair of instruments in the Instrument Library and use .INST to demonstrate how to make the traverses work together.

Activity: Students complete exercise in Multiple Instruments project.

Early finishers challenge: Compare stderrs for 1991 and 2013 data:
What's the pattern?
Why is line 2:8 different (doesn't fit the pattern)
Why is it so similar to 1:98?

Assessment: Poll: 7 STAR*NET Instrument Library
-Ensure class can find Adjusted Observations section in Listing

Computing Error factors

The following discussion relating to the calculation of the individual and total error factors is general in nature and illustrates how certain values are created for 2D and 3D networks. The same information, however, also applies to simple 1D level networks.

The total number of observations in the network define the number of condition equations to be solved by the adjustment. Basically, each observation such as distance, angle, or partially fixed coordinate contributes one condition equation. Note that any coordinate component entered with a standard error value (i.e. not fixed or not free) is considered an observation just like an angle or distance. The "count" of coordinates in the statistics listing is the number of individual components (northings, eastings or elevations) that have standard errors given, not the number of stations. For example, the count of 3 shown in the sample listing might indicate that a northing, easting and elevation have each been entered with a standard error. Measurements such an angles and distances that are entered as "free" (using the "*" code) are not included in the observation count. A "free" observation does not contribute in any way to the adjustment, and therefore will not affect the statistics.

The number of unknowns is counted by adding up the "adjustable" coordinate components. Each 2D station will add two unknowns (or less depending on whether any components are fixed), and in a like manner, each 3D station will add three unknowns. Any northing, easting or elevation component that is entered as fixed (using the "!" code) is not counted as an unknown. In addition, every direction set present in the data will add another unknown. (Each set of directions includes a single unknown orientation that will be solved during the adjustment.) The network is considered "uniquely determined" if the observations equals the unknowns, and "over-determined" if the observations exceeds the unknowns, making the number of redundant observations or degrees of freedom greater than zero. The network cannot be solved if the degrees of freedom are less than zero.

For example, a simple 2D quadrilateral with two fixed stations has four unknowns (two free stations times two coordinates per station). If five distances and eight horizontal angles are measured, the number of redundant observations is equal to nine (13 - 4). In general, the more redundant observations the better. However, the added observations should be spread evenly throughout the network. If you had measured only the four exterior distances of a quad, you would not add as much strength by measuring those distance twice, compared to measuring the cross-quad distances, even though you might add the same number of degrees of freedom to the solution.

Next, the Statistical Summary contains a line for each data type existing in the network. Each line lists a count of the number of observations of that type, the sum of the squares of their standardized residuals, and an error factor. A residual is the amount the adjustment changed your input observation. In other words, the residual is simply the difference between the value you observed in the field, and the value that fits best into the final adjusted network. The standardized residual is the actual residual divided by its standard error value. This value is listed in the "StdRes" column for every observation in the "Adjusted Observations and Residuals" section of your output listing file. See page 1 for more details and a sample listing.

To compute each total in the "Sum Squares of StdRes" column, each Standardized Residual is squared and summed. (This total is also often called the sum of the squares of the weighted residuals.) For example, all StdRes entries are squared and summed for these Zenith Observations:

Sum Squares of StdRes = $\sum (StdRes_i - StdRes_n)^2$

Adjusted Zenith Observations (DMS)

From	To	Zenith	Residual	Distance	StdErr	StdRes	File:Line
309	331	90-17-56.79	-0-00-10.21	-0.0160	2.00	5.1*	2:33
309	331	90-17-56.79	-0-00-09.08	-0.0142	2.00	4.5*	2:27
3080	331	90-19-35.81	-0-00-08.93	-0.0185	2.00	4.5*	2:46
309	331	90-17-56.79	-0-00-08.50	-0.0133	2.00	4.2*	2:39
309	331	90-17-56.79	-0-00-08.23	-0.0129	2.00	4.1*	2:37
309	331	90-17-56.79	-0-00-08.06	-0.0126	2.00	4.0*	2:30
309	331	90-17-56.79	-0-00-07.86	-0.0123	2.00	3.9*	2:26
309	331	90-17-56.79	-0-00-07.59	-0.0119	2.00	3.8*	2:35
3080	331	90-19-35.81	-0-00-05.36	-0.0111	2.00	2.7	2:50
3080	331	90-19-35.81	-0-00-05.20	-0.0108	2.00	2.6	2:47
3080	3078	90-11-43.12	0-00-04.49	0.0028	2.00	2.2	2:51
3080	241932	89-29-14.82	0-00-02.98	0.0023	2.00	1.5	2:48
309	3078	89-48-20.54	-0-00-02.69	-0.0010	2.00	1.3	2:31
309	241932	89-02-51.67	-0-00-02.45	-0.0016	2.00	1.2	2:40
309	3080	90-04-05.64	0-00-02.09	0.0011	2.00	1.0	2:38
309	3079	89-34-08.58	-0-00-01.53	-0.0010	2.00	0.8	2:32
3080	3079	89-58-01.75	0-00-00.82	0.0003	2.00	0.4	2:49
309	312	89-37-26.67	0-00-00.00	0.0000	2.00	0.0	2:36

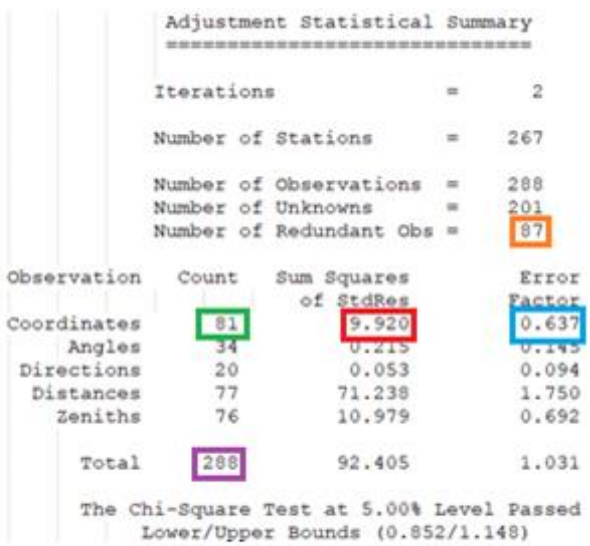
And entered as below in the Statistical Summary:

```
Adjustment Statistical Summary
==============================

Iterations              =     2

Number of Stations      =     7

Number of Observations  =    54
Number of Unknowns      =    17
Number of Redundant Obs =    37

Observation   Count   Sum Squares       Error
                        of StdRes      Factor
 Directions      18         0.001       0.008
  Distances      18         0.669       0.233
    Zeniths      18       174.086       3.757

      Total      54       174.756       2.173

Warning: The Chi-Square Test at 5.00% Level Exceeded Upper Bound
                Lower/Upper Bounds (0.773/1.227)
```

A large total for this summation is not that meaningful in itself, because the size of the total is a function of the number of observations of that data type. The totals displayed in the Error Factor column, however, are adjusted by the number of observations, and are a good indication of how well each data type fits into the adjustment.

The Error Factor given for each observation type is an indicator of the overall "goodness of fit" of that observation type within the network. It is calculated as the square root of the Sum of Squares divided by the Count times the square root of the Total Count divided by the Redundancy number.

Error Factor = SQRT(Sum Squares of StdRes/COUNT)*SQRT(Total Count/Number of Redundant Observations)



```
Adjustment Statistical Summary
==============================

Iterations              =      2

Number of Stations      =    267

Number of Observations  =    288
Number of Unknowns      =    201
Number of Redundant Obs =     87

Observation   Count   Sum Squares     Error
                        of StdRes    Factor
Coordinates     81        9.920       0.637
     Angles     34        0.215       0.145
 Directions     20        0.053       0.094
  Distances     77       71.238       1.750
    Zeniths     76       10.979       0.692

      Total    288       92.405       1.031

The Chi-Square Test at 5.00% Level Passed
     Lower/Upper Bounds (0.852/1.148)
```

Error Factor = SQRT(Sum Squares of StdRes/COUNT)*SQRT(Total Count/Number of Redundant Observations)

Among different data types, these Error Factors should be roughly equal, and should all approximately be within a range of 0.5 to 1.5. If for example, the Error Factor for angles is equal to 15.7 and that for distances is equal to 2.3, then there is almost certainly a problem with the angles in the adjustment.

An Error Factor may be large for several reasons. There may be one or more large errors in the input data, there may be a systematic error (i.e. EDM calibration problem), or you may have assigned standard errors that are unrealistically small. Note also that a large angle error can easily inflate the distance Error Factor, due to the interconnection of common stations. The final section in this chapter provides a number of techniques for locating potential sources of problems in the adjustment.

The "Total Error Factor" is an important item in the Statistical Summary. It is calculated as the square root of the Total Sum of the Squares of the Standardized Residuals divided by the Number of Redundancies:

Total Error Factor = SQRT (Total Sum Squares of StdRes / Number of Redundant Observations)

```
Adjustment Statistical Summary
==============================

Iterations                =     2

Number of Stations        =   267

Number of Observations    =   288
Number of Unknowns        =   201
Number of Redundant Obs   =    87

Observation   Count   Sum Squares        Error
                        of StdRes        Factor
Coordinates      81         9.920         0.637
     Angles      34         0.215         0.145
 Directions      20         0.053         0.094
  Distances      77        71.238         1.750
    Zeniths      76        10.979         0.692

      Total     288        92.405         1.031

      The Chi-Square Test at 5.00% Level Passed
           Lower/Upper Bounds (0.852/1.148)
```

Total Error Factor = SQRT (Total Sum Squares of StdRes / Number of Redundant Observations)

GPS Vectors

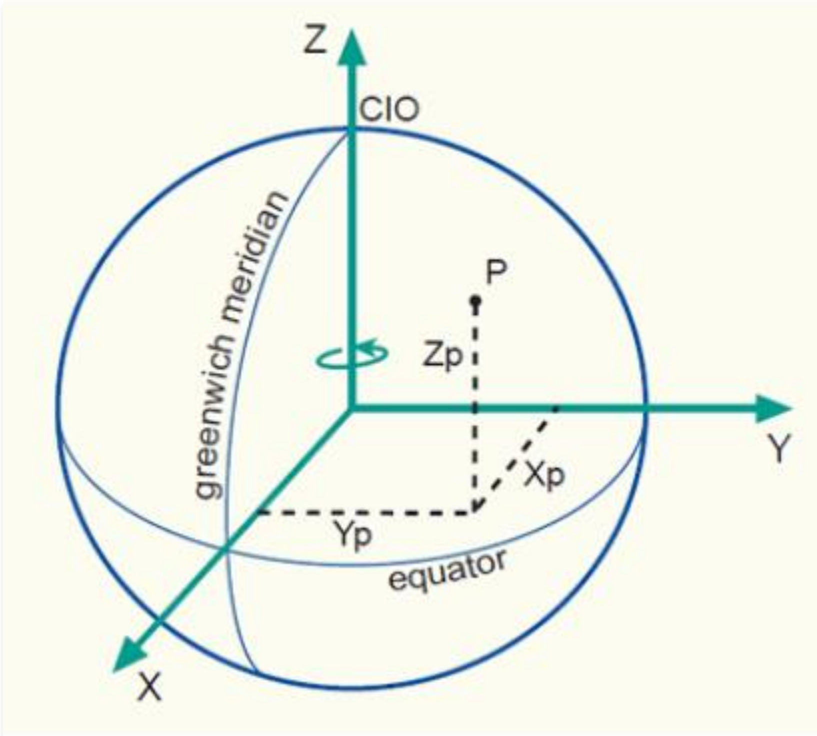
Objective: Students will set appropriate conditions for a project, gain experience importing GPS Vector data and perform an adjustment.
Resource: "Leica Vectors from Heerbrugg" files in "8 GPS Vectors"
Resource: Heerbrugg.snproj

Lesson: This is an example of importing Post-Processed Leica vectors, but the concepts are similar for many supported formats. Discuss new concepts when dealing with GPS:

- Selecting Coordinate Systems
- Explain Cartesian Coordinates
- "Instrument Settings" do not apply, see G2 and G3 lines and GPS section of Project Options.

It is typical to use "Factor Supplied Errors by" feature in GPS tab as reported Variances and Co-variances are often "Over Optimistic" depending on the manufacturer. This "exaggerates" the reported standard errors. The amount to exaggerate needs to be settled through field testing but 3 to 5 is typical with Leica and Trimble.

- Lat/Longs Output
- Ground Output


Z
CIO
greenwich meridian
P
Zp
Y
Xp
Yp
equator
X

Activity: Demonstrate the steps to importing Leica Vectors. Then have Students:

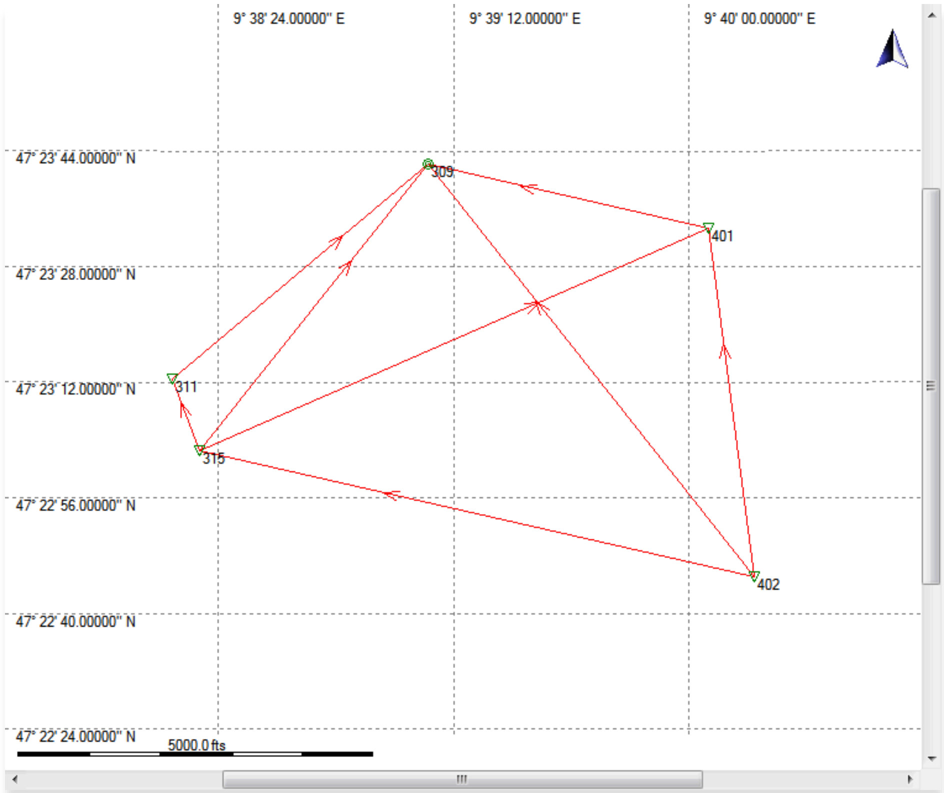
1. Open Heerbrugg.snproj
2. *Important:* Read comments to set project options
3. Set project settings as per instructions!
4. See step 2 ☺
5. Import the Leica Vectors file: Sample_Static_m.asc
6. Adjust network
7. View Lat/Long files and Ground Files

You can use the points below for control, they are also listed in the dat file:

.units meters

.order EN

c 309	549282.26	5248890.18	413.07 !!!
c 315	548314.88	5247659.36	419.72
c 402	550691.54	5247142.54	418.67



Assessment: Test: 8 STARNET GPS Vectors (don't neglect hints below)

-Project units need to be US feet to answer this question!

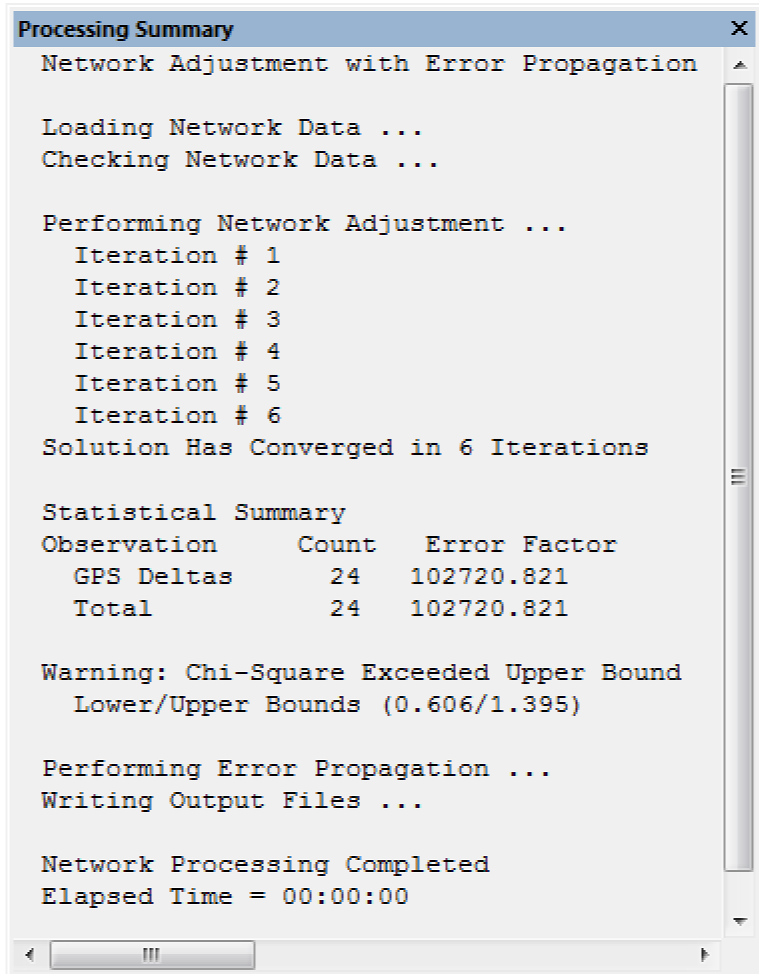
-alternatively, you can output a ground file with no scale assigned

-fixed control points are both metric and EN order, so two inline options are required

Troubleshooting 2: Using .data inline entry

Objective: Introduce students to a strategy for finding a blunder in input data.	
Resource: "9 Troubleshooting 2 data on off strategy" files	

Introduction: Use Leica Vectors from Heerbrugg project to demonstrate adding a blunder and then either commenting out or using data on/data off strategy for identifying the blunder.



Activity:

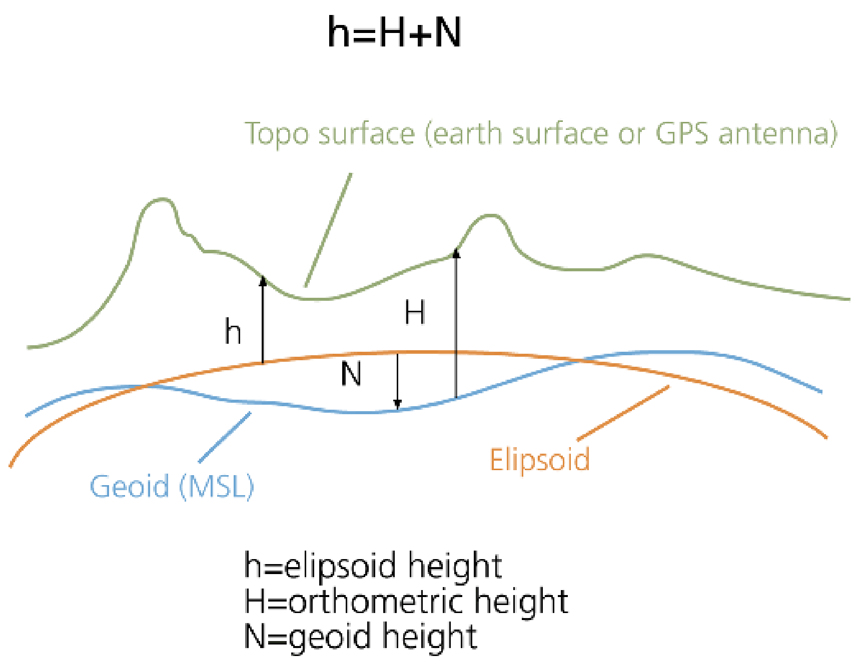
1. Open "Troubleshooting2.snproj"
2. Follow instructions
3. Run adjustment and note poor results
4. Find the blunder and comment it out

Assessment: Poll: 9 STAR*NET Troubleshooting 2:

Modeling Exercise:

Objective: Introduce students to assigning a geoid and correcting elevations for geoid separation.	
Resource:	10 Modeling Exercise\g2012bu5.bin 10 Modeling Exercise\Geoid Exercise.snproj 10 Modeling Exercise\16BAC01-160629S-SPED.ASC and 16BAC01-180402-CAPE.ASC

A geoid file allows conversion of elevations from the theoretical "Ellipsoid" model of the Earth's surface to the observation based "Orthometric" model which accounts for gravity fluctuations:



Introduction: Demonstrate how to assign a geoid to a project and how to test using a new project with a PH record to store one point. (Use an example 33-00-00 118-05-00 0 in CA zone V with Geoid 2012bu.bin)

- P record stores a lat/long and height
- PH record stores a lat/long and Ellipsoid Height
- If you test with a PH record and set your project to use the .bin file for modeling your Coordinates listing will display the Geoid height which differs from the ellipsoid height
- Assign a specific Geoid in the Modeling tab of the project settings

<u>Download Geoids from:</u>

helpdesk.microsurvey.com -> Downloads -> Geoid Downloads

<u>Copy geoid files to:</u>

C:\ProgramData*\MicroSurvey\StarNet\V*\Mapping\

*Note: the "ProgramData" or "Application Data" folder is hidden by default.

Activity:

1. Open “Geoid Exercise.snproj”
2. Follow Directions
3. Test by viewing in Google Earth
4. Check that Orthometric elevation BKMS = 154.553229 us feet

Assessment: Poll: 10 STAR*NET Geoid modeling. *Make sure you know how to change your output units*

Custom Coordinate Systems in STAR*NET and other customization files

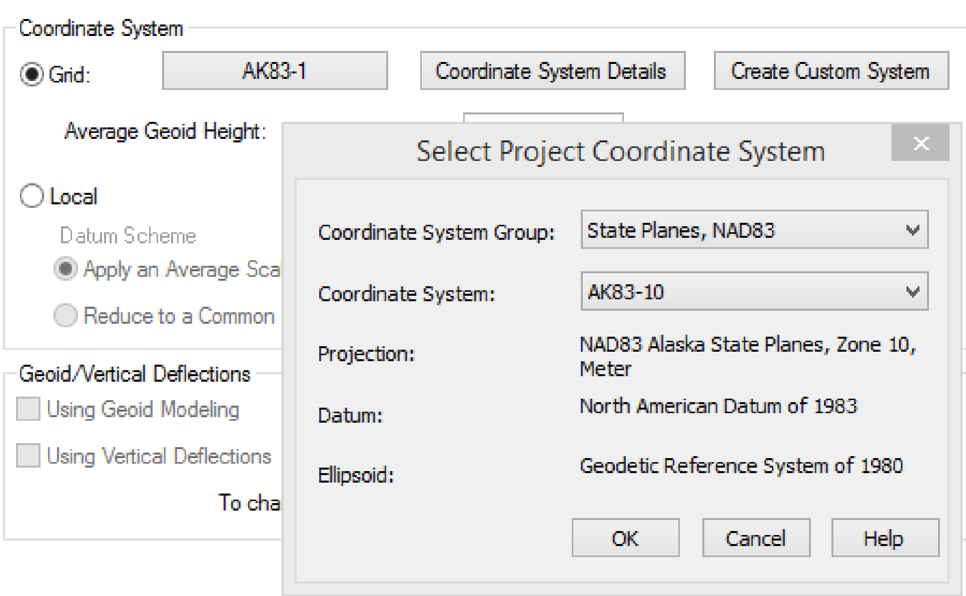
Objective: Introduce STAR*NET customization files. Introduce both Predefined and User Defined Coordinate Systems and a method for testing coordinate systems.
Resource: 11 Custom Coordinate Systems Files\Idaho95.snproj **Resource:** 12 Custom Output Format Files (optional topic)

Introduction to customization files:

1. Ensure all attendees have access to:
C:\ProgramData\MicroSurvey\StarNet\V*
2. Discuss purposes of:

Mapping\Coordsys, Datums and Ellipsoid	Binary files that store all coordinate system definitions. Found in Mapping folder.
*.gdc files	Gridshift definitions
Company.def	Company Settings (defaults)
template.dat	Default dat file
StarNet.fmt	Custom pts output definitions

Lesson: STAR*NET includes a range of pre-defined coordinate systems which users can select from Project Options when creating their project:



But if the coordinate system you require does not appear in the predefined list you can define one by accessing "Create Custom System"

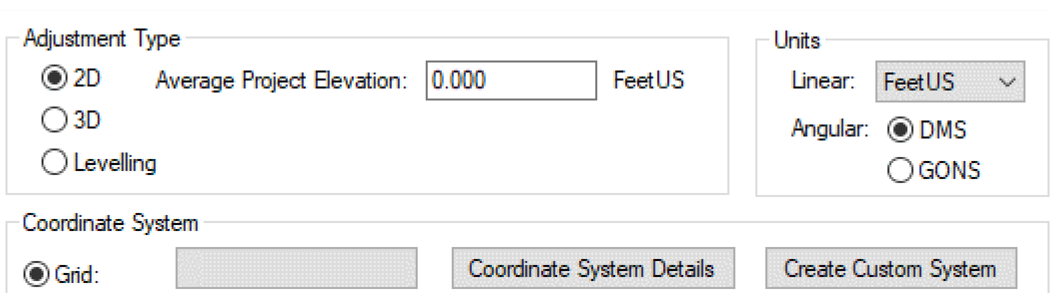
Activity: Add Idaho:95 to STAR*NET using the information below and test it in a new project. The purpose of this system is to minimize scale factor when surveying a stretch of highway between the Canadian border and Couer D'Alene in Idaho:

(Note: this is a fictional simulation of how the system would appear in EPSG)

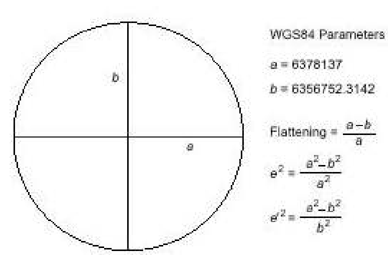
```
PROJCS["NAD83(NSRS2007) / Idaho 95",
    GEOGCS["NAD83(NSRS2007)",
        DATUM["NAD83_National_Spatial_Reference_System_2007",
            SPHEROID["GRS 1980",6378137,298.257222101,
                AUTHORITY["EPSG","7019a"]],
            TOWGS84[0,0,0,0,0,0,0],
            AUTHORITY["EPSG","6759"]],
        PRIMEM["Greenwich",0,
            AUTHORITY["EPSG","8901"]],
        UNIT["degree",0.01745329251994328,
            AUTHORITY["EPSG","9122"]],
        AUTHORITY["EPSG","4759"]],
    UNIT["metre",1,
        AUTHORITY["EPSG","9001"]],
    PROJECTION["Transverse_Mercator"],
    PARAMETER["latitude_of_origin",47.0000000],
    PARAMETER["central_meridian",-116.5833333],
    PARAMETER["scale_factor",0.99999],
    PARAMETER["false_easting",500000],
    PARAMETER["false_northing",0],
    AUTHORITY["EPSG","3526"],
    AXIS["X",EAST],
    AXIS["Y",NORTH]]
```

Steps:

1. Open "Idaho95" Project in "11 Custom Coordinate Systems Files"



2. Assign the Coordinate System type as "Grid"
3. Options | Project | Adjustment "Create Custom System"
4. Create the system as per values shown above from EPSG website. Follow the tips below:
   - User defined systems must have a ":" in their name.
   - The Datum (or Transformation) is "None"
   - a and inverse flattening (f) for GRS80 ellipsoid are given, you must compute b: **b=(fa-a)/f**
   - The Projection is Transverse Mercator
   - Longitudes are negative west of Greenwich
   - Curvilinear values from the EPSG source are decimal



degrees and must be entered as DMS

- latitude of origin = -116.5833333 = -116-35-00.000

5. Select the Idaho:95 system from "User Defined Systems" group
6. Test your system using the entries below:

```
P 100 49-00-01.94    116-10-52.10 !!  'border
P 101 48-17-25.32    116-32-56.19 !!  'Sand Point
P 102 47-41-55.62    116-47-30.25 !!  'Coeur d'Alene
```

(NOTE: it is normal to see a warning that there are no observations, this is just a test)

7. Test by opening in Google Earth
8. Examine your listing: Adjusted Station Information | Convergence Angles and Grid Factors at Stations

Assessment: Poll: 11 STAR*NET Custom Coordinate Systems

Other types of GPS Data

Objective: Students will gain experience importing GPS Vector data.
Resource: FIELDTESTGNSS.raw in “13 Other types of GPS Data” folder
Resource: Opus Points Report from NY Central Zone in “13 Other types of GPS Data” folder
Resource: DBX GPS Vectors Example in “13 Other types of GPS Data” folder
Resource: DBX TPS Traverse Example in “13 Other types of GPS Data” folder

(Assign or demonstrate these optionally, depending on the students' requirements)

Demonstrate: Importing an Opus Station Report: **Opus Points Report from NY Central Zone**

Demonstrate: Importing RTK Vectors: FIELDTESTGNSS **(GPS observations using FieldGenius UTM zone 11)**

Demonstrate: other GPS formats and converters as necessary

STAR*NET Certification Session 4

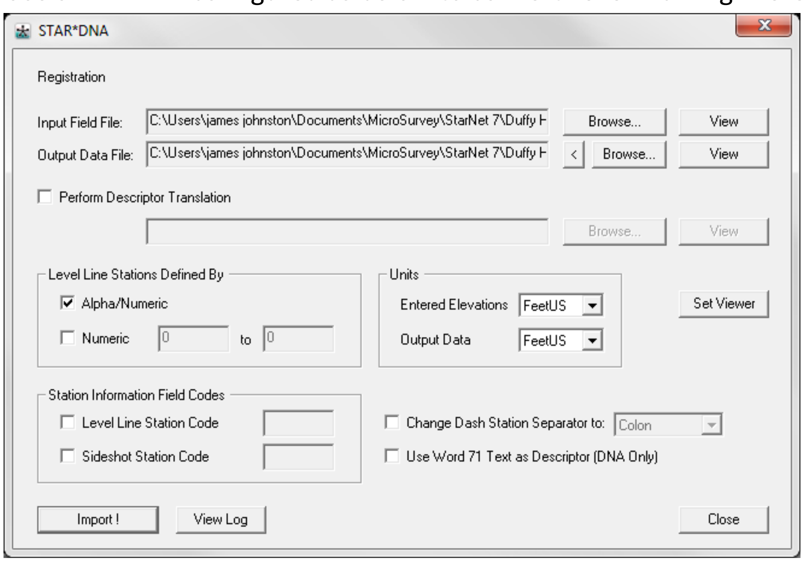
Leveling Data Conversion Exercise

Objective: Students will gain experience using a convertor for leveling data.
Resource: "TrimbleDemo.raw"
Resource: "Trimble Project.snproj"
Resources: Level Training File.GSI in "14 Leveling Data"
Resources: Level Training File_use_if_no_converter.dat in "14 Leveling Data"
Resources: Level Training XY Points.dat in "14 Leveling Data"

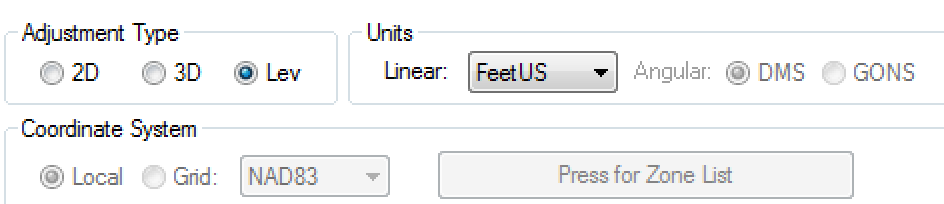
Lesson: Discuss supported data formats and the requirement for a point identification scheme that identifies points that are meant to be considered stations. Use Trimbledemo.raw to demonstrate a conversion that uses alphanumeric IDs to identify stations. Open Trimble Project.snproj, add the new dat file, uncomment the benchmark and process.

Activity:

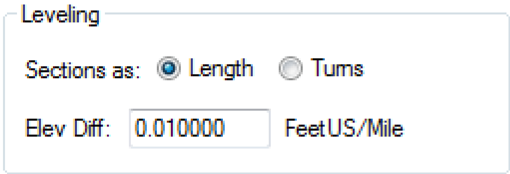
1. Use STAR*DNA configured as below to convert Level Training File.GSI



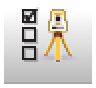
2. ALTERNATIVELY: skip step 1 and use "Level Training File_use_if_no_converter.dat" if no converter is available.
3. Start a leveling project. Set project type to "Lev."
4. Configure the Adjustment tab as shown:



5. Configure the Instrument tab as shown:



6. add Level Training XY Points.dat
7. Uncomment the E record for B98
8. Perform a Loop Check to check closure



9. Adjust Network and verify chi-square test passes

Assessment: Poll: 14 STAR*NET Leveling Data Conversion

-ensure class can find unadjusted observations section in listing

Troubleshooting 3: Using Level Loop Check

Objective: Introduce students to a strategy for finding a blunder or outlier in input data by using the "Loop Check" feature.
Resource: 109985Emod.DAT
Resource: 109985Emod with error.DAT
Resource: Level Loop Check 2
Resource: Level Loop Check in "15 Troubleshooting 3 Level Loop Check"

Lesson: Open Level Loop Check project. With "109985Emod.DAT" checked demonstrate adjusting the network and then running a Level Loop Check. Now uncomment the error, verify that chi-square fails, and demonstrate finding the misclosure using Level Loop Check.

Activity: Students will try to find a loop that needs to be re-run.

1. Open "Level Loop Check 2" project
2. Run adjustment and note Chi-Square test has failed
3. Identify the loop with an error using the Level Loop Check tool.
4. Use Loop closure report and "break the chain" around the quarter sections until the results improve

Early Finishers: How much was the error?

Assessment: Poll: 15 STAR*NET

Combining Data

Objective: Students will see and practice two strategies for combining different types of data: • The "One Step" method • The "Two Step" method
Resource: 16 Combining Data\FIELDTESTGPS EXAMPLE PROJECT.snproj
Resource: 16 Combining Data\FIELDTESTTPS.dat
Resource: 16 Combining Data\Grant Beach at Stewart Weir Two Step levels then GPS\ED3534882.snproj
Resource: Additional Resources in: 16 Combining Data\Combining data demos

Introduction: Open "16 Combining Data\FIELDTESTGPS EXAMPLE PROJECT.snproj." Show how the two FieldGenius projects can be run as either a conventional project or as a combined network project.

This is an example of a "One Step" approach. The RTK vectors are weak relative to the conventional traverse but they balance out so that you end result is a grid project which is strengthened by conventional observations.

"One Step" Technique:

- demonstrate gps vectors working alone
- add "FIELDTESTTPS.dat"
- demonstrate vectors and TPS working together

"Two Step" Technique:

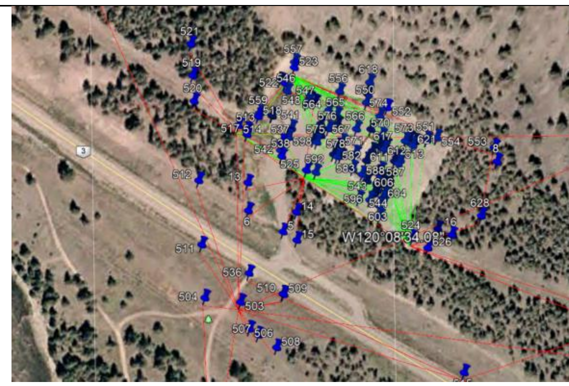
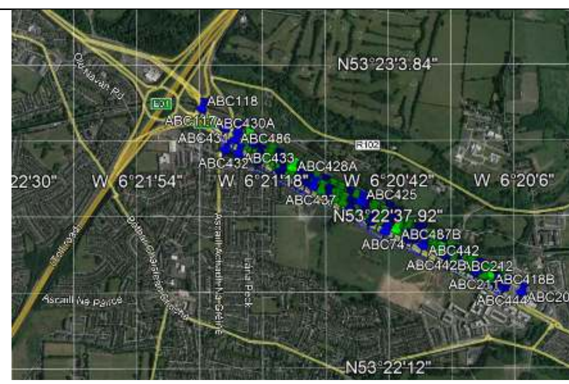
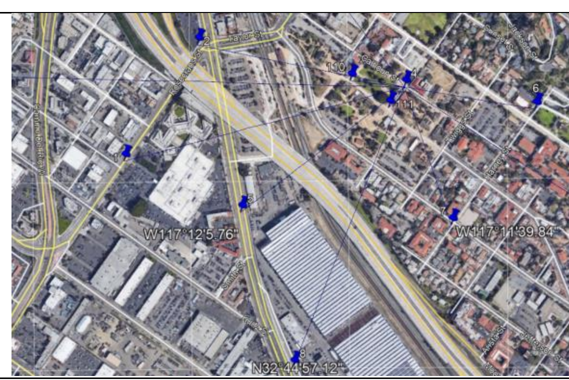
- uncheck the TPS data
- set output format to "STAR NE"
- Run adjustment
- Copy C records for one and two into TPS file
- Uncheck GPS, and check TPS file
- Modify TPS file so that all points are derived from points 1 and 2

Activity: Students will open project in "Grant Beach at Stewart Weir Two Step levels then GPS" and follow the steps to combine leveling and GPS data using the "Two step" method.

Early Finishers: How would you re arrange this to make it "one step?"

Assessment: Poll: 16 STAR*NET Combining Data

Activity: Demonstrate combining Data using the variety of samples in "16 Combining Data\Combining data demos"

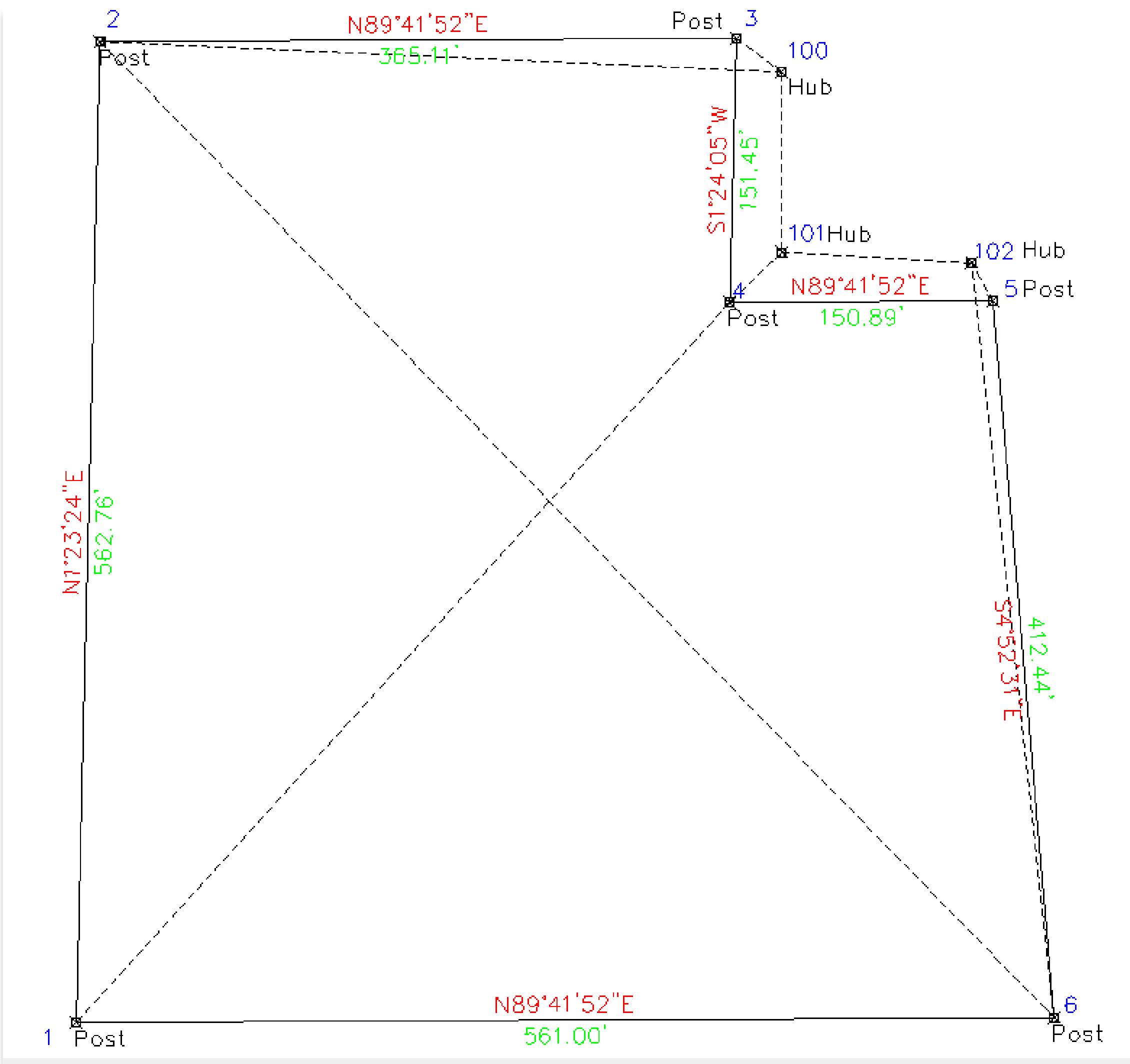
One step method: Combine GNSS and conventional and run together	
Two step method: Combine GNSS and total station by first computing points with GPS, constraining to these coordinates and then adding conventional data.	
"Daisy Chain" method: Maintain leveling and conventional data in two separate projects. But use output from leveling project as initial input in the conventional data project.	
GNSS Vector Transformations: This method allows us to allow leveling to determine elevations for some GPS points and allow STAR*NET to compute a "best fit" between the GNSS vectors and leveled elevations	

Positional Tolerance:

Objective: Students will learn how to include a positional tolerance test and view the results in the listing.
Resource: 18 Positional Tolerance\ Positional Tolerance.snproj
Resource: Help File Entry: Chapter 5: Preparing Input Data | Inline Options | .Relative/.Ptolerance

Introduction:

- Discuss purpose of positional tolerance testing for ALTA surveys in USA
- Discuss general utility of positional tolerance testing or listing
- .REL inline option controls display of Relative error ellipses between stations
- .PTOL inline option controls display of positional tolerance testing in listing



Activity: Students will open Positional Tolerance.snproj and configure it to test for positional tolerance between stations 1 through 6.

Assessment:

Appendix A

Summary of Input Types

Coordinate, Position & Elevation Data Types

*Below is a summary of all possible manual input types, please use this for reference in addition to "Preparing Input Data" in the STAR*NET Help files.*

C	Coordinates for a Station
CH	Coordinates for a Station specifying Ellipsoid Heights
2D Format	C Station North East [Std Errors] ['Description]
3D Format	C Station North East Elevation [Std Errors] ['Description] CH Station North East Elevation [Std Errors] ['Description]
P	Geodetic Positions for a Station
PH	Geodetic Positions for a Station specifying Ellipsoid Heights
2D Format	P Station Latitude Longitude [Std Errors] ['Description]
3D Format	P Station Latitude Longitude Elev [Std Errors] ['Description] PH Station Latitude Longitude Elev [Std Errors] ['Description]
E	Elevation for a Station
EH	Elevation for a Station specifying Ellipsoid Heights
Format	E Station Elevation [Std Error] ['Description] EH Station Elevation [Std Error] ['Description]

Single Observation Data Types

A	Horizontal Angle
Format	A At-From-To Angle [Std Error] ['Description]
D	Distance
2D Format	D From-To Horizontal Distance [Std Error] ['Description]
3D Format 1	D From-To Slope Distance [Std Error] [HI/HT] ['Description]

3D Format 2	D From-To Horizontal Distance [Std Error] ['Description]
V	Vertical Observation
3D Format 1	V From-To Zenith [Standard Error] [HI/HT] ['Description]
3D Format 2	V From-To Elevation Difference [Standard Error] [HI/HT] ['Description]
B	Bearing or Azimuth
Format	B From-To Bearing or Azimuth [Standard Error] ['Description]

Multiple Observation Data Types

M	All Measurements to Another Station
2D Format	M At-From-To Angle Distance [Std Errs] ['Description]
3D Format 1	M At-From-To Angle Slope Dist Zenith [Std Errs] [HI/HT] ['Description]
3D Format 2	M At-From-To Angle Horiz Dist Elev Diff [Std Errs] [HI/HT] ['Description]
BM	Bearing and Measurements to Another Station
2D Format	BM From-To Bearing (or Azimuth) Distance [Std Errs] ['Description]
3D Format 1	BM From-To Bearing (or Az) Slope Dist Zenith [Std Errs] [HI/HT] ['Description]
3D Format 2	BM From-To Bearing (or Az) Horiz Dist Elev Diff [Std Errs] [HI/HT] ['Description]
DV	Distance and Vertical Measurement to Another Station
3D Format 1	DV From-To Slope Distance Zenith [Std Errs] [HI/HT] ['Description]
3D Format 2	DV From-To Horiz Distance Elev Diff [Std Errs] [HI/HT] ['Description]

Sideshot Data Type

SS	Sideshot
2D Format	SS At-From-To Angle Distance ['Description]
3D Format 1	SS At-From-To Angle Slope Distance Zenith [HI/HT] ['Description]
3D Format 2	SS At-From-To Angle Horiz Distance Elev Diff [HI/HT] ['Description]

Direction Set Data Types

DB	Direction Begin
DN	Direction Reading
DM	Direction with All Measurements
DE	Direction End
Example	DB 111 # At 111 begin reading directions DN 7 00-59-31 # Direction to 7 DN 6 08-44-11 # Direction to 6 DM 5 22-27-18 753.55 # Direction & Distance to 5 DM 4 33-10-11 726.78 # etc... DN 3 38-31-19 DE # End the direction set

Traverse Data Types

TB	Traverse Begin
T	Traverse Measurements
TE	Traverse End
Example	TB N45-30-40W # Backsight to fixed bearing T 1 123-40-28 537.52 T 2 217-11-37 719.56

	T 3 113-52-15 397.66 T 4 260-19-24 996.23 TE 5 # End traverse at 5 # TB 1 # Backsight to 1 T 2 120-11-12 473.25 T 6 -101-32-30 625.76 T 7 198-13-09 533.66 T 8 172-07-27 753.22 T 9 -84-32-20 661.01 TE 5 -73-02-46 4 # End, turn angle to 4

Leveling Data Type

L	Differential Level Observation Information
Format 1	L From-To ElevDiff Distance [Std Errs] ['Description]
Format 2	L From-To ElevDiff Turns [Std Errs] ['Description]
Example	L 33-79 2.546 1798 L 79-80 -4.443 931 'Bench 81-1987 L 79-81 0.231 855 L 80-132 1.322 2509 0.14 #Example of explicit Std Error L 92-93 -5.024 752 .LWEIGHT 0.05 #Change Default Weighting L 12-15 0.244 1245 L 15-16 3.145 955

GPS Vector Data

Imported vector information (including any base and rover antenna heights) supplied on G1, G2 and G3 data lines will always be in Meters whether or not the project is setup to run in Meters. When the project is setup to run in other linear units, for example FeetUS, vector information is automatically converted to project units for calculations and output in the listing file.

G0	Vector Identification
G1	Station Names and ECEF DX, DY, and DZ vector components
G2 & G3	Weighting
Covariance Weighting	G2 CvXX CvYY CvZZ #vector covariances G3 CvXY CvXZ CvYZ #vector covariances
Standard Error and Correlation Weighting	G2 SDX SDY SDZ #vector standard errors G3 CrXY CrXZ CrYZ #vector correlations
Example	.GPS WEIGHT COVARIANCE G0 'V532 Day134(3) 01:15 12346643.SSF G1 0036-0040 4861.328134 -348.097034 2463.249801 G2 4.35804625082312E-008 2.00368296412947E-007 1.23348139662277E-007 G3 1.29776877121456E-008 -4.73073036591065E-009 -7.87018453390485E-008

Standard Errors

A "standard error" is a value used to weight an observation. When you enter standard error values on a data line, they always directly follow the group of observations, one standard error value for each observation. A standard error may be entered as a numeric value or as a special symbol. The following table explains the various entries.

Blank	If no standard error values are given, the instrument settings will be used to weight the observation.
&	This symbol tells STAR*NET to apply the standard error settings from the instrument settings. *This symbol is usually not necessary unless you need to mix project default standard errors with other types of standard error input.*
!	"Fix" an observation - Observation will not be adjusted.

*****	"Float" an observation - Observation will be treated as an initial input value and will carry no weight during the adjustment.
Numeric Value	The numeric standard error value will be applied as the standard deviation for that observation alone.
Examples	C 100 1000.000 1000.000 100.000 'Description # Coordinate input for Point 100 are assumed to be free for adjustment C 101 1000.000 1000.000 100.000 !!! 'Description # Coordinate input for Point 101 will be held "fixed" C 102 1000.000 1000.000 100.000 .01 .01 .01 'Description # Coordinate input for Point 102 will be given the standard deviation of .01 units C 103 1000.000 1000.000 100.000 !!* 'Description # X, Y values for Point 103 will be held "fixed" but the Z value will "float" M 1-2-104 80-00-00 123.456 90-00-00 &&* 1.23/1.45 'Description # Angle and Slope Distance in this M record will be weighted as per project # settings but the Zenith will "float" so it has no weight in the adjustment

Inline Options

#	Specifies beginning of comment, only for current line
.2D	Change data format to 2D
.3D	Change data format to 3D
.3R	Change data format to 3D and reduce slope distance and zeniths to horizontal

	distances (.3REDUCE)
.ADDC ON	Standard errors inflated by centering error settings
.ADDC OFF	Normal behavior, standard errors used as given
.ALIAS NAME	Define Point ID name aliases
.ALIAS NAME ON	Turn name aliasing on
.ALIAS NAME OFF	Turn name aliasing off
.ALIAS NAME CLEAR	Clear previously defined name aliases
.ALIAS PREFIX	Define Point ID aliases using a Prefix Scheme
.ALIAS PREFIX ON	Turn prefix aliasing on
.ALIAS PREFIX OFF	Turn prefix aliasing off
.ALIAS PREFIX CLEAR	Clear previously defined prefix aliases
.ALIAS SUFFIX	Define Point ID aliases using a Suffix Scheme
.ALIAS SUFFIX ON	Turn suffix aliasing on
.ALIAS SUFFIX OFF	Turn suffix aliasing off
.ALIAS SUFFIX CLEAR	Clear previously defined suffix aliases
.ALIAS ADDITIVE	Define Point ID aliases using a Additive Number Scheme
.ALIAS ADDITIVE ON	Turn additive aliasing on
.ALIAS ADDITIVE OFF	Turn additive aliasing off
.ALIAS ADDITIVE CLEAR	Clear previously defined additive aliases
.ALIAS ON	Turn all aliasing on
.ALIAS OFF	Turn all aliasing off

.ALIAS CLEAR	Clear all previously defined aliases
.BASE	Define Base Point ID and reduced antenna height in *.raw vector file
.COPY OFF	Turn off "Copy of Input Data Files" for the Listing File
.COPY ON	Turn on "Copy of Input Data Files" for the Listing File
.CURVE OFF	Turn off correction for earth curvature & refraction, zenith observations assumed to be corrected by user
.CURVE ON	Turn on correction for earth curvature & refraction (Default)
.DATA OFF	Exclude input data that follows this inline option
.DATA ON	Include input data that follows this inline option
.DELTA OFF	Explicitly set to Slope Distances and Zenith Angles Format
.DELTA ON	Explicitly set to Horizontal Distances and Elevation Differences
.EDM ADDITIVE	Set additive method for EDM standard errors - Constant + PPM (Default)
.EDM PROPOGATED	Set propagated method for EDM standard errors - Square root of $Constant^2 + PPM^2$
.ELEV ELLIP	Legacy method to define elevation as ellipsoidal
.ELEV ORTHO	Legacy method to define elevation as orthometric
.ELLIPSE	Show error ellipses only for the list of stations provided

.GPS ADDHIHT #1 #2	Correction to be applied to base and rover heights - #1=base antenna offset, #2=rover antenna offset
.GPS CENTER #1	Same as "Apply Centering to StdErrs" option - #1=horizontal centering
.GPS CENTER #1 VERT #2	Same as "Apply Centering to StdErrs" option - #1=horizontal centering, #2=vertical centering
.GPS DEFAULT #1 #2	Same as "Apply Default StdErrs to Vectors with no Supplied Weighting" option - #1=StdErr, #2=PPM
.GPS DEFAULT #1 #2 VERT #3 #4	Same as "Apply Default StdErrs to Vectors with no Supplied Weighting" option - #1=Hz StdErr, #2=Hz PPM, #3=Vt StdErr, #4=Vt PPM
.GPS DEFAULT FREE	Vectors with missing G2 & G3 lines will be included in the network but have no influence
.GPS DEFAULT IGNORE	Vectors with missing G2 & G3 lines will be excluded from the network
.GPS FACTOR #1	Same as "Factor Supplied Vector StdErrs by" option - #1=Factor
.GPS FACTOR #1 VERT #2	Same as "Factor Supplied Vector StdErrs by" option - #1=Hz Factor, #2=Vt Factor
.GPS FACTOR FREE	Vectors with G2 & G3 lines will be included in network but have no influence
.GPS FACTOR IGNORE	Vectors with G2 & G3 lines will be excluded from the network
.GPS FREE	Free up list of vectors to not influence the adjustment
.GPS IGNORE	Exclude list of vectors from the network
.GPS NETWORK	Vectors following this comand will be

	included in the network adjustment (Default)
.GPS SS	Vectors following this command will be solved after least squares solution is found for the network
.GPS USE #1 #2	Supply custom weighting - #1=StdErr, #2=PPM
.GPS USE #1 #2 VERT #3 #4	Supply custom weighting - #1=Hz StdErr, #2=Hz PPM, #3=Vt StdErr, #4=Vt PPM
.GPS USE FREE	Vectors will be included in the network but have no influence
.GPS USE IGNORE	Vectors will be excluded from the network
.GPS USE OFF	Turn off custom weighting and revert to original
.GPS WEIGHT COVARIANCE	Weighting type set to covariances
.GPS WEIGHT STDERRCORR	Weighting type set to standard errors and correlations
.INCLUDE	No longer necessary, but can be used to insert data from other files
.INST	Set instrument weighting scheme to specified Instrument Library profile
.LONG NEG	Set Negative West Longitude sign convention
.LONG	Set Positive West Longitude sign convention
.LOSTSTATIONS	Specify a list of stations to omit from Network Plot
.LWEIGHT #1	Override "Elev Diff" standard error and sets "Length" section type - #1=StdErr

.LWEIGHT #1 TURNS	Override "Elev Diff" standard error and sets "Turns" section type - #1=StdErr
.LWEIGHT	Return to Project Defaults
.MAP ON	Turn on MAPMODE, horizontal angles in Traverse lines will be read as bearings/azimuths
.MAP OFF	Turn off MAPMODE, Traverse line content back to default
.MAP ON ANG	Turn on MAPMODE, closing angles calculated and included in adjustment
.MEASURED BEA	Bearings will be interpreted as measured (Geodetic)
.MEASURED DIST	Distances will be interpreted as measured (Geodetic)
.MEASURED ANG	Angles will be interpreted as measured (Geodetic)
.MEASURED DIR	Directions will be interpreted as measured (Geodetic)
.MEASURED BEA DIST ANG DIR	Various combinations possible
.GRID BEA	Bearings will be interpreted as grid
.GRID DIST	Distances will be interpreted as grid
.GRID DIST=ELLIP	Distances will be interpreted as ellipsoidal
.GRID ANG	Angles will be interpreted as grid
.GRID DIR	Directions will be interpreted as grid
.GRID BEA DIST ANG DIR	Various combinations possible
.MULTIPLIER	Superseded by .UNITS but can be used to apply a multiplier to input data
.ORDER NE	Set Coordinate Order Northing-Easting

.ORDER EN	Set Coordinate Order Easting-Northing
.ORDER ATFROMTO	Sets order to Station-Backsight-Foresight for input data that include angles
.ORDER FROMATTO	Sets order to Backsight-Station-Foresight for input data that include angles
.PELEV	Redefine project default elevation in "2D" local and grid jobs
.PRISM #1	Prism constant (in mm) to be added to your distance observations - #1=Constant
.PRISM #1 #2	Prism constants (in mm) to calculate correction to apply to your distance observations, Constant 1 minus Constant 2 is used - #1=Constant 1, #2=Constant 2
.PRISM OFF	Turns off previously specified Prism constant correction
.PRISM ON	Turns back on previously specified Prism constant correction
.PRISM CLEAR	Reinitializes any previously defined corrections
.REF #1	Change "Default Coefficient for Refraction" - #1=New Value
.REF 0	Turn off refraction corrections
.REF	Reset refraction coefficient to project default
.REL	Supply list of station pairs that will be included in **relative ellipse listing and plotting**
.REL /OBS	Supply list of station pairs as with .REL, but specify that the list contain all the

	station pairs connected by observations
.REL /CON	Supply list of stations to exhaustively create connections between
.REL /CON =GroupName	Assign named group to list of stations to exhaustively create connections between
.REL /EVERY	Creates an exhaustive list connecting every point
.PTOL	Supply list of station pairs that will be included in **point tolerance checking**
.PTOL /OBS	Supply list of station pairs as with .PTOL, but specify that the list contain all the station pairs connected by observations
.PTOL /CON	Supply list of stations to exhaustively create connections between
.PTOL /CON=GroupName	Assign named group to list of stations to exhaustively create connections between
.PTOL /EVERY	Creates an exhaustive list connecting every point
.SCALE #1	Changes the "Apply an Average Scale Factor" option in 2D/3D "Local" coordinate system projects - #1=Scale Factor
.SCALE	Resets value back to default originally set in Project Options
.SEPARATOR	Provide a character to change the default "dash" used to separate station names in input files
.UNITS METERS	Set linear unit to Meters for following observations
.UNITS FEETINT	Set linear unit to International Feet for

	following observations
.UNITS FEETUS	Set linear unit to US Survey Feet for following observations
.UNITS DMS	Set angular unit to Degrees/Minutes/Seconds for following observations
.UNITS GONS	Set angular unit to Gons for following observations
.UNITS CSECONDS	Set standard error unit to Centesimal Seconds for following observations
.UNITS MGONS	Set standard error unit to Milligons for following observations
.VLEVEL	Legacy method to define Level section input

Appendix B

Exchanging Data between MicroSurvey CAD Programs and STAR*NET

While STAR*NET is relatively new to the MicroSurvey product line, our customers have been using the program for decades so a number of tools have been developed over the years that make these two products complement each other. There are a range of importing/exporting options when exchanging data between the programs.

Below a number of options are described which allow for exchange of data between MicroSurvey CAD programs and STAR*NET. These features exist in all MicroSurvey CAD products, including MicroSurvey CAD, MicroSurvey PointCloud, MicroSurvey inCAD and MicroSurvey embeddedCAD.

STAR*NET to MicroSurvey CAD:

Exporting Points to a MicroSurvey CAD Program:

STAR*NET can be used to export grid or ground scaled points to a MicroSurvey drawing after they have been adjusted. Descriptions will be included, although some extended point information such as photo notes, voice notes, comments and GIS data will be overwritten in the MicroSurvey database. If points and "smart" lines already exist in the MicroSurvey database they will be updated during the import process and all connectivity will be retained.

*Steps in STAR*NET:*

When your project is open go to **Options | Project | Other Files**

Check on "Create Coordinate (PTS) File" and/or "Create Ground Scale Coordinates (GND) File"

For either option, pick on the format pull down and select "Comma Separated."

Run your adjustment

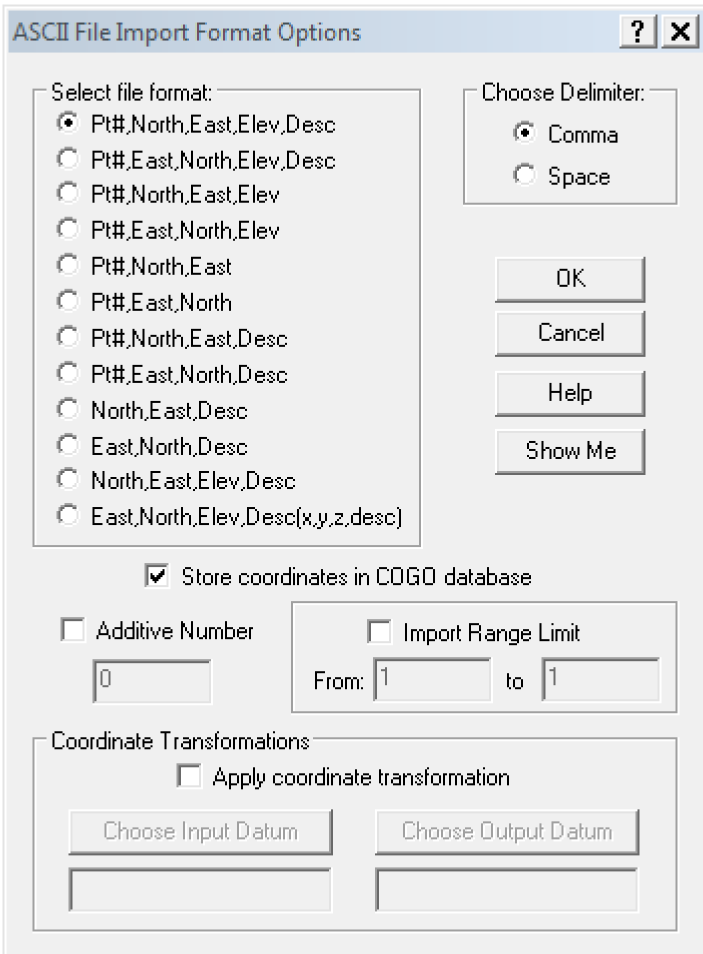
Steps in MicroSurvey CAD Program:

Open your drawing

Go to MsPoints | Import ASCII Points or Lat/Long File

Select "Coordinates Delimited"

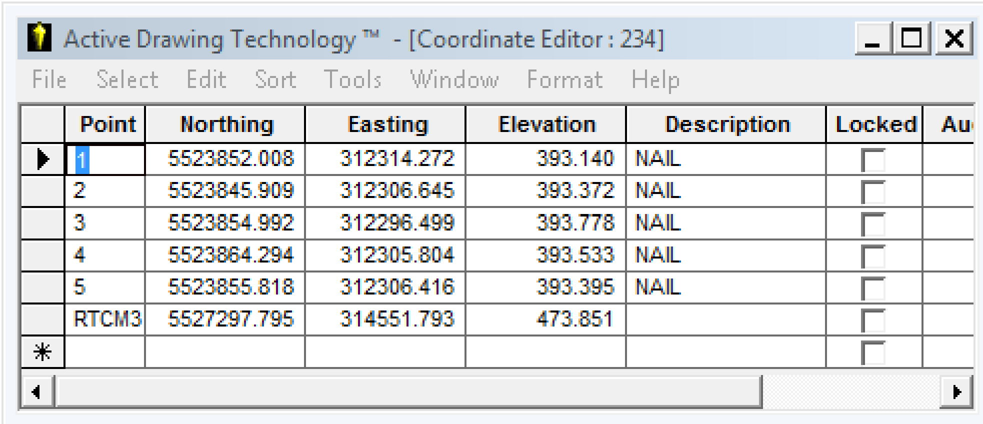
Configure the next dialog as below (Ensure your North, East ordering matches that of the STAR*NET Project)



Pick "OK" twice

Navigate to either the PTS (If you need "Grid" system coordinates in your drawing) or GND (if you need "Ground" coordinates in your drawing) file and then pick "Open."

Your drawing and database will now be populated with the new points:



Point	Northing	Easting	Elevation	Description	Locked	Au
1	5523852.008	312314.272	393.140	NAIL		
2	5523845.909	312306.645	393.372	NAIL		
3	5523854.992	312296.499	393.778	NAIL		
4	5523864.294	312305.804	393.533	NAIL		
5	5523855.818	312306.416	393.395	NAIL		
RTCM3	5527297.795	314551.793	473.851			

Exporting Points *and* Graphics to a MicroSurvey CAD Project:

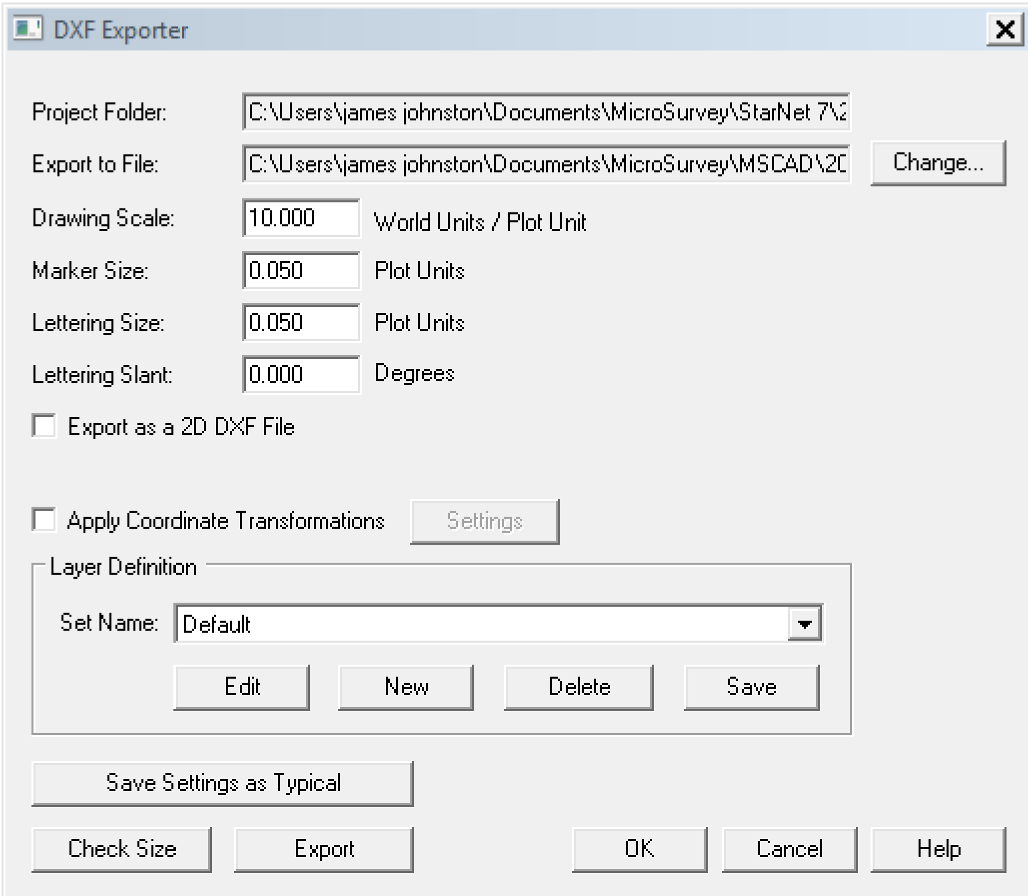
Once an adjustment has been computed in STAR*NET, you can export a dxf file containing all the network lines that were visible in the "Plot" view and open it in any CAD program. Further, you can import the point and line information into the MicroSurvey database and have a "smart" CAD drawing to represent your "smart" STAR*NET network. Some companies have decades worth of fieldwork saved in STAR*NET networks and augment them regularly whenever control points are observed. They are finding that they can add this information to a master MicroSurvey CAD drawing and use "Transfer Points Between MicroSurvey Projects" under the Mspoints menu to export control into new projects. This project can evolve into a great asset for the company, reducing fieldwork costs and improving the resale value of the company.

*Steps in STAR*NET:*

Open your project *and adjust it once*.

Open **Tools | DXF Exporter...**

Configure the dialog as required. I've used Scale and Marker Size settings for a small scale project in this example. You may wish to experiment with different settings for your project:



Note that you can customize the layers that will be created during the export by editing the "Layer Definition" file.

Pick "Export" when ready and a dxf file will be created in the location specified in the "Export to File" field.

Steps in MicroSurvey CAD program:

Importing the Point Blocks:

Open MicroSurvey CAD

Open **File | MicroSurvey Project Manager**

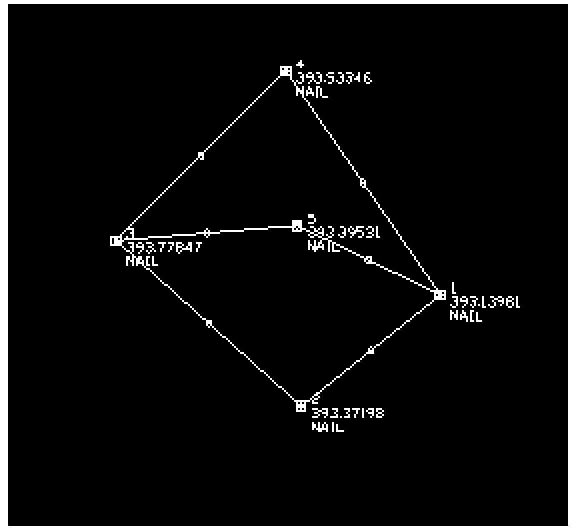
Pick "Browse for Drawing"

Pick on the "Files of Type" pull down and change it to dxf *(Important or you won't see your file)*

Navigate to the location of the DXF file you exported from STAR*NET and double pick on it.

You must zoom to extents before you will see the contents.

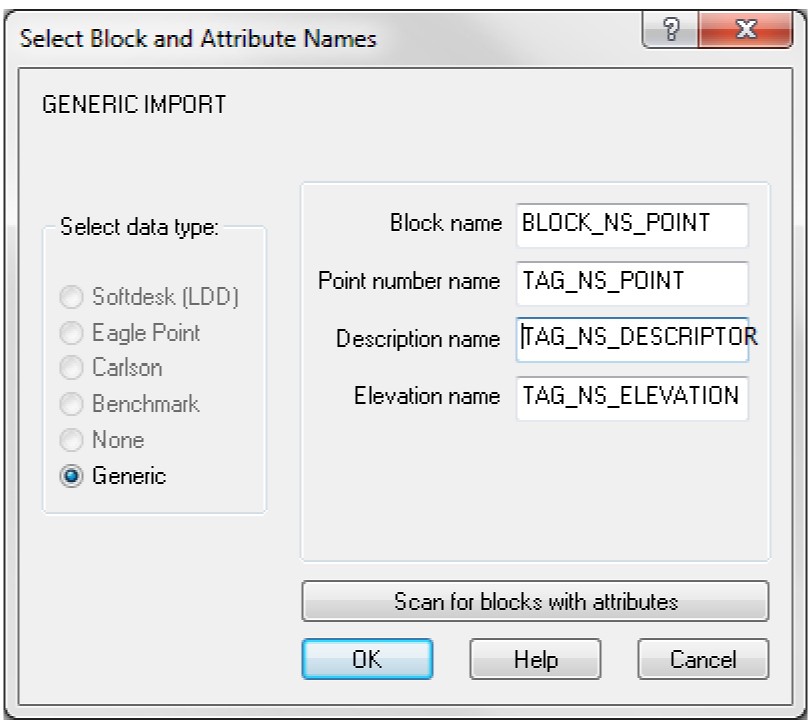
You will see your network:



Now you can import the pointblocks into the MicroSurvey database:

Open **MsPoints | Other Program Ties | Import Point Blocks**

Configure the dialog as below:



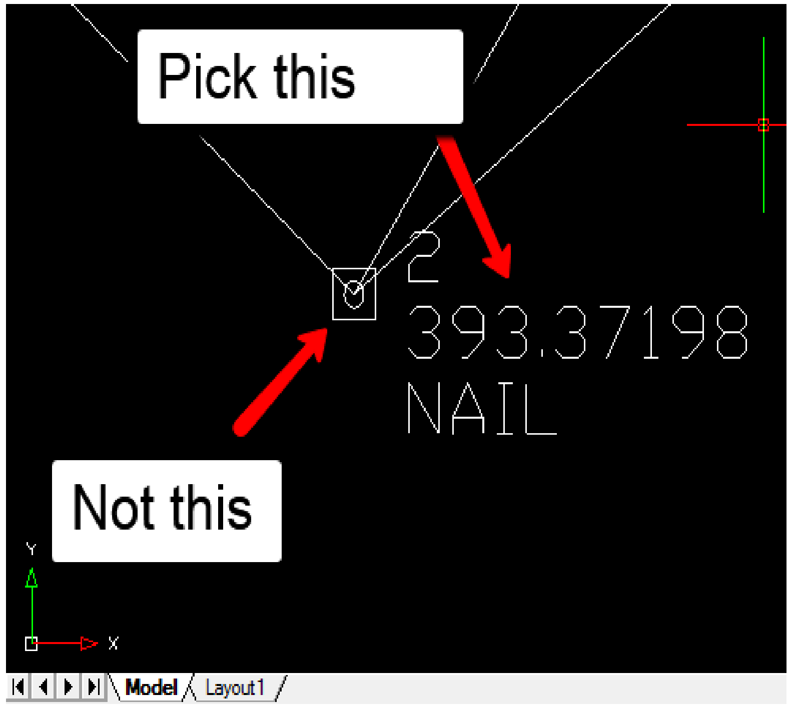
NOTE: The Description Name entry is "TAG_NS_DESCRIPTOR"

Pick "OK"

The next prompt: "Do you want to select Point Blocks to Import" can be answered two ways:

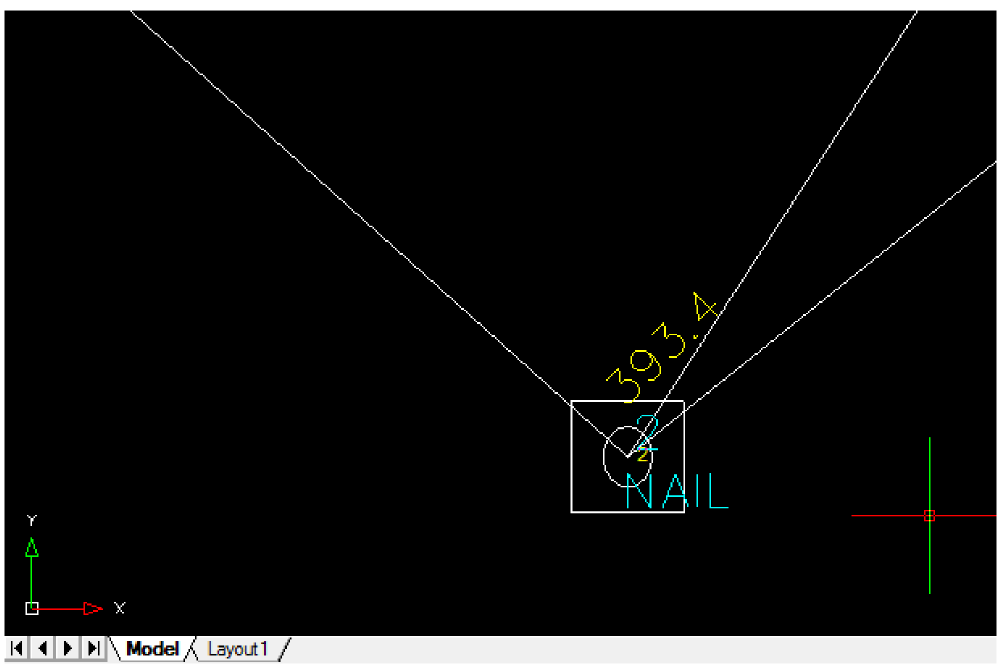
If you select "No" the routine will import all station points into the database

If you select "Yes" the routine will allow you to select the points to be inserted. Be sure to select the text label for the points, NOT the block that represents the point:



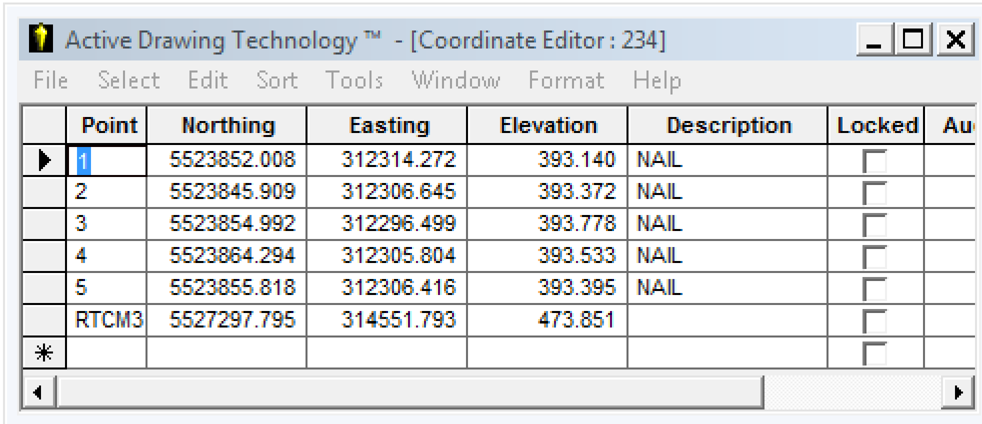
The next prompt: "Delete all the Point Blocks after importing into MicroSurvey?" can be answered "Yes" as this will clean up text labels that are now no longer needed.

Now you can take a look at the result. In your drawing you can see labels have been added:



Note: *The labels that are drawn for each imported point are sized according to the drawing scale factor that is displayed when you open the project in MicroSurvey CAD. If you wish to quickly re-size these labels open* **Mspoints | Rescale Complete Drawing** *and enter a different scale factor.*

And your Active Coordinate Editor has been populated:



Point	Northing	Easting	Elevation	Description	Locked	Au
1	5523852.008	312314.272	393.140	NAIL		
2	5523845.909	312306.645	393.372	NAIL		
3	5523854.992	312296.499	393.778	NAIL		
4	5523864.294	312305.804	393.533	NAIL		
5	5523855.818	312306.416	393.395	NAIL		
RTCM3	5527297.795	314551.793	473.851			

Importing the Linework:

For a final step, you will want your network linework to be "smart" linework in the CAD drawing so that linework will update if you import another pts or grd file with updated control points in the future.

Isolate all layers except "ELLIPSES_REL_LINES"

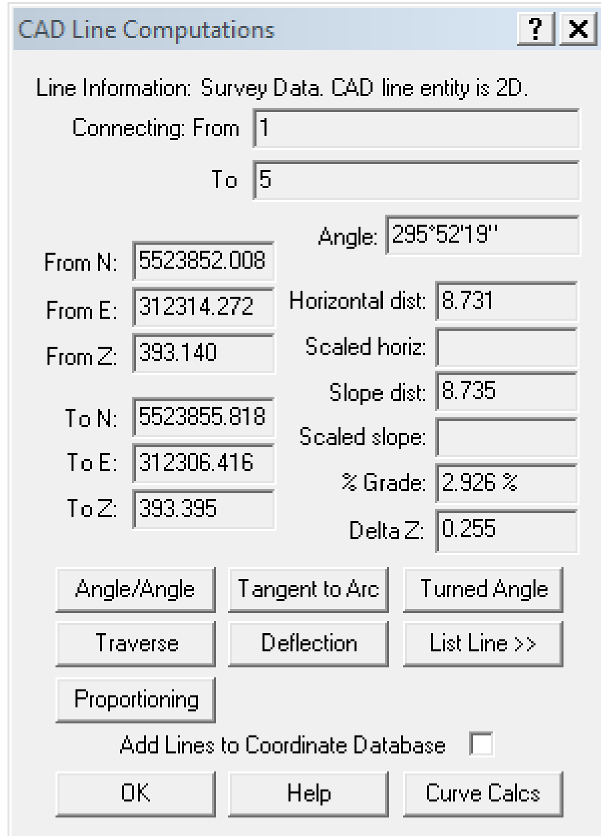
Zoom to extents

Open **Mspoints | Auto Add points to Objects**

Select all lines

Enter

Now when you pick on any line you will see it is associated with the control point (*or in casual terms, it has become a "smart" line.*)



Steps to Export Control Points to a New MicroSurvey Project:

Take note of the points that you wish to send to the new project

Open the new project

Take note if there will be any conflicting point numbers in your new project.

Open **MsPoints | Transfer points between MicroSurvey Jobs**

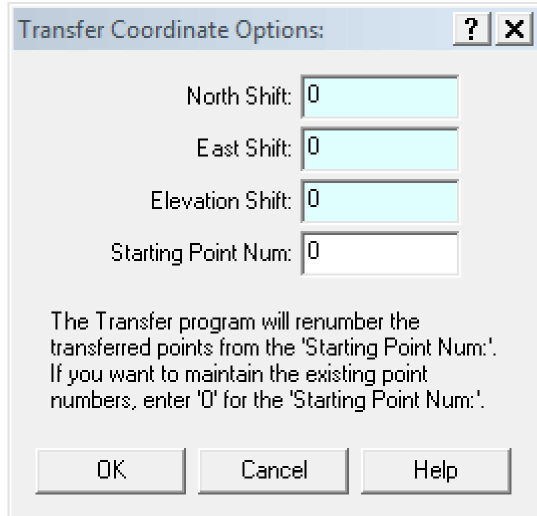
Navigate to the MSZ file of your "Master" project and pick it.

Pick "Open" and you will see the dialog below:

You can renumber your points if there are conflicting point IDs in the destination project.

Or you can retain the existing point IDs by setting the "Starting Point Num:" as zero.

You can apply an XYZ shift if you wish, but take care to ensure these points aren't later re-imported into your "Master" STAR*NET project.



Updating the MicroSurvey Project in the Future:

For future updates to the network just repeat the steps in the "**Exporting Points to a MicroSurvey CAD Program**" section of this article.

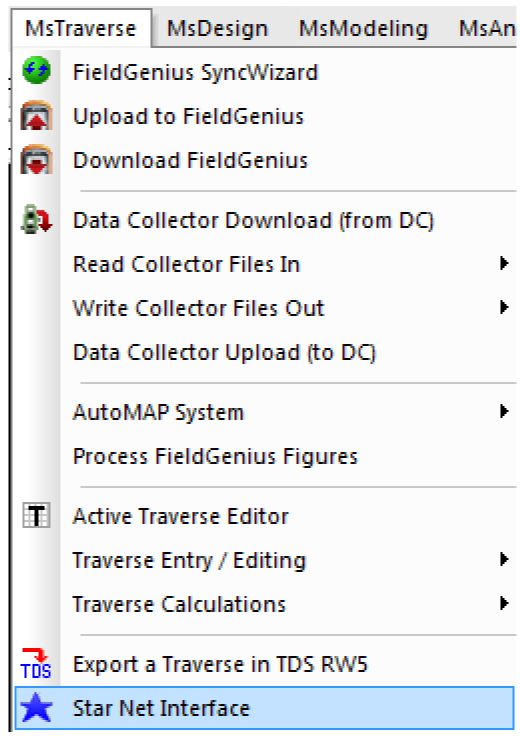
Turn Point Protection on if you want to see an alert when some points shift beyond your project tolerances.

MicroSurvey CAD to STAR*NET:

Traverse Data:

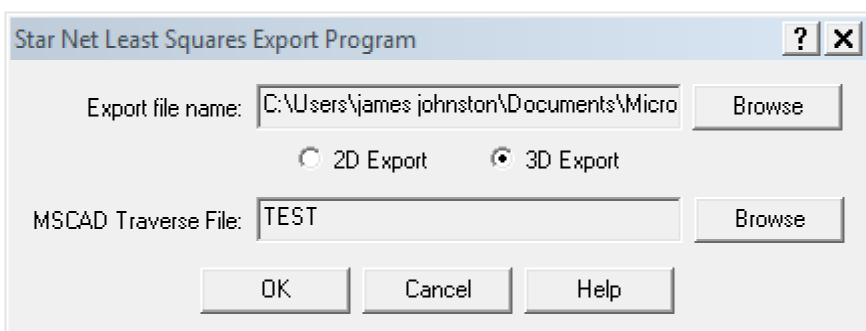
Steps in MicroSurvey CAD program:

Traverses that have been manually entered, created by using the "Existing Point Traverse (new)" routine, read in using theFieldGenius SyncWizard Routine or read in by reading in one of the many supported data collector formats under the **MsTraverse** Menu can be exported directly to STAR*NET using the **STAR*NET Interface**.



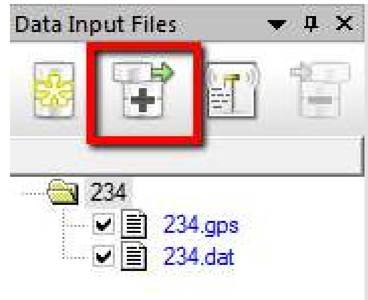
Export file name: This is where you assign a name and location for the STAR*NET dat file to be created

MSCAD Traverse File: This is where you browse inside the MSJ folder of your open project and select the traverse to be exported.



*Steps in STAR*NET:*

This will result in the creation of a STAR*NET format .dat file which can be added to a STAR*NET project.



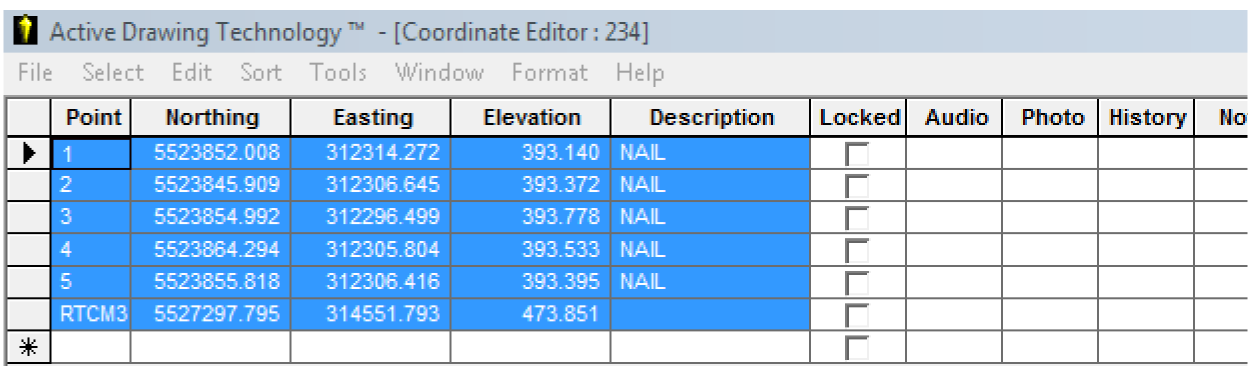
The first two points in the traverse will be included as C records by default, but you may wish to comment these out and manually enter other points from the project as control.

Point Data:

Steps in MicroSurvey CAD program:

The easiest way to copy individual coordinate values from the MicroSurvey program is to open **Active Coordinate Editor** and Copy/Paste using Ctrl C/Ctrl V.

Highlight the columns and rows you need to copy:

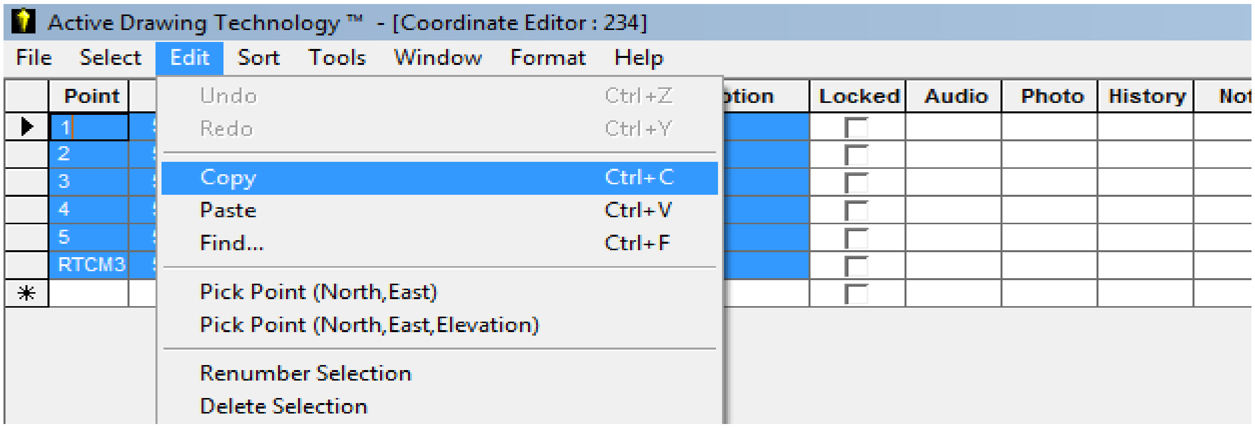


Active Drawing Technology ™ - [Coordinate Editor : 234]

File Select Edit Sort Tools Window Format Help

Point	Northing	Easting	Elevation	Description	Locked	Audio	Photo	History	No
1	5523852.008	312314.272	393.140	NAIL					
2	5523845.909	312306.645	393.372	NAIL					
3	5523854.992	312296.499	393.778	NAIL					
4	5523864.294	312305.804	393.533	NAIL					
5	5523855.818	312306.416	393.395	NAIL					
RTCM3	5527297.795	314551.793	473.851						
*									

File | Copy



*Steps in STAR*NET*

In STAR*NET, open your project, edit the dat file and use ctrl-V to paste the point information:

```
# Job  : 234
# Date : 10-18-2011
# Time : 12:46:49

1    5523852.008 312314.272   393.140 NAIL
2    5523845.909 312306.645   393.372 NAIL
3    5523854.992 312296.499   393.778 NAIL
4    5523864.294 312305.804   393.533 NAIL
5    5523855.818 312306.416   393.395 NAIL
RTCM3    5527297.795 314551.793   473.851


DV 1-2                                      9.7932
DV 1-2                                      9.7632
```

And manually correct the format by adding "C" at the left margin and an apostrophe before the description:

```
# Job  : 234
# Date : 10-18-2011
# Time : 12:46:49

C 1 5523852.008 312314.272   393.140 'NAIL
C 2 5523845.909 312306.645   393.372 'NAIL
C 3 5523854.992 312296.499   393.778 'NAIL
C 4 5523864.294 312305.804   393.533 'NAIL
C 5 5523855.818 312306.416   393.395 'NAIL
C RTCM3 5527297.795 314551.793   473.851
```