White Paper

The STAR*NET Advantage

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MicroSurvey® STAR*NET

Adjust your expectations.

Introduction

MicroSurvey STAR*NET performs rigorous least-squares adjustments on field measurements to provide maximum precision in your projects, regardless of sensor or manufacturer. STAR*NET not only integrates data from multiple hardware sensor types, such as total stations, levels, and GNSS receivers, but remains brand-neutral as well. This means that it also supports data from most manufacturers, including Leica, Trimble, Topcon, Carlson, Spectra, Sokkia, and many more. The purpose of this paper is to identify simplified workflows in STAR*NET which allow seamless integration into current processes and hardware arrangements, in order to support the modern surveyor as they aim to provide the highest quality data to their clients in the most efficient method.

Supported Formats

MicroSurvey strives to maintain brand-neutrality in its products, and STAR*NET supports many data formats, which may be reviewed in the chart below. This is one of the primary benefits of STAR*NET; full compatibility between brands and measurement types.

File Extension	Source
.asc	Leica SKI-ASCII, Trimble Data Exchange Format
.cgr	C&G
.dat	Trimble DiNi, MicroSurvey STAR*NET
.dc	Trimble TSC
.dl	TopDL
.exp	Waypoint
.geo	Geodimeter
.gsi	Leica DNA
.iob	NovAtel
.job	Geodimeter
.jxl	Trimble Access
.lev	TopDL
.ngs	Blue Book GFile
.obs	Geodimeter
.raw	C&G, Trimble DiNi, Leica DNA, MicroSurvey FieldGenius, SDR, SMI, TDS, Trimble TSC
.rw5	Carlson SurvCE, MicroSurvey FieldGenius, SMI, TDS
.sdr	SDR
.sgl	Sokkia
.ssf	Trimble GPSurvey
.ssk	Trimble GPSurvey
.ts?	Topcon
.tvf	Topcon
.txt	GeoGenius, NGS Opus Report, others
.xcf	Leica Captivate DBX
0*.*	Ashtech

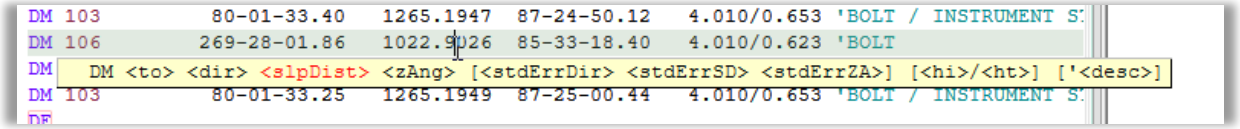
The STAR*NET Legacy

STAR*NET has a long history, and has been trusted to deliver high quality adjustments since 1986. It has become the industry standard in many regions and is recognized globally among land surveyors today. As such, STAR*NET formats are well documented, highly recognized, and are supported by several other third party applications. In certain jurisdictions, STAR*NET reports are required by the land agency for all control surveys performed.

Practical Data Editor

STAR*NET uses a proprietary text-based data format and encoding system to standardize input for network adjustments. This format is well-documented, and easily created by manual user entry, STAR*NET's included data converters, or third party applications.

STAR*NET's integrated data file editor includes several helpful functions to guide a user through manual entry or editing of data files, including color-coded syntax tips, detailed syntax hover tips, inline error tips, multiline editing, automatic line commenting, and dark mode.



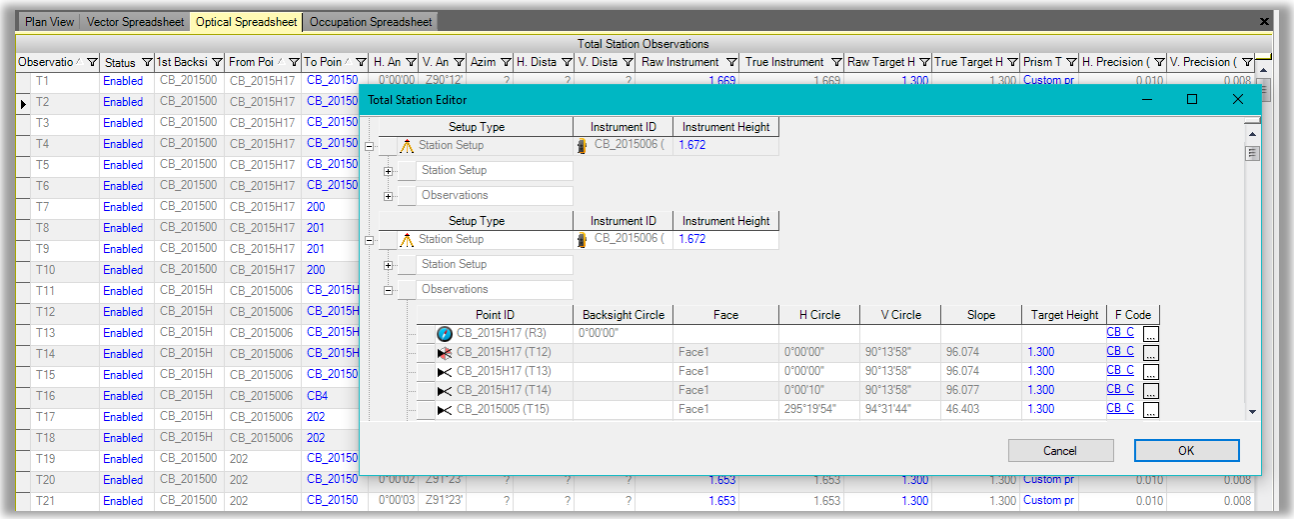
Syntax hover tips show expected values for each column

The data file editor may appear daunting at first glance, but once familiarized, a user can be much more effective when editing a text file than when editing measurement tables as are typically found in other software packages.

A text file feels very familiar to users, and navigation between files is simple within the tabbed interface. Multiline editing allows users to make a change to multiple lines of text simultaneously, and a familiarity with the entire project and its measurements reduces the "black box" feeling which users might experience from other programs.

Escape the Black Box with STAR*NET

The “black box” is the feeling of importing data and simply “clicking a button” with little-to-no data review, after which the program returns adjusted values. This can be unnerving for an adjustment professional, who often likes to ensure the data looks correct prior to adjustment, rather than trusting the computer to have translated all input data correctly.



Data editing in table-based program. Note the differing editor tabs and dialogs per data type.

```
# Ties to GPS points
M 0051-0013-0015  240-35-47.03  1601.22  90-27-52  5.40/5.40
M 0052-0051-0015  320-50-46.25  2499.61  90-05-49  5.36/5.41
# M 0052-0051-0015  140-50-46.25  2499.61  270-05-49  5.36/5.41
M 0052-0051-0016  142-02-01.50  2639.68  90-07-37  5.36/5.40
M 0053-0052-0016   61-14-43.77  2859.65  90-20-19  5.35/5.42
M 0053-0052-0016   61-14-43.77  2861  90-20-19  5.35/5.42

G0 'V1 Day125(1) 14:14 00120013.SSF
G1 0012-0013 -507.727507 -5749.936110 -8484.248757
G2  6.28935385644552E-008  2.06625279624819E-007  7.58668347058871E-008
G3  7.06118738719731E-008 -1.86927109221877E-008 -6.31652646092924E-008

G0 'V2 Day125(1) 14:14 00120016.SSF
G1 0012-0016 5291.643580 -4337.804352 -3048.755348
G2  3.98576651985032E-008  1.44261570067136E-007  5.07546169262266E-008
G3  4.37312438134303E-008 -1.22258519615360E-008 -4.48392388320672E-008
```

*Data editing in STAR*NET. All data types are contained in the same file and easily editable.*

Most other adjustment packages offer disjointed and inefficient data review, further adding to the “black box” feeling. Surveyors make a habit of providing the best data possible through realistic error modelling, and STAR*NET allows customized input of common error types for blunder detection and error mitigation.

Listing and Reporting

The STAR*NET listing (reporting) format is recognized as one of the most complete and legible adjustment reports in the industry. The text-based format makes it easy to review, and copying and pasting sections into external applications works flawlessly. Hyperlinks to the data file allow seamless movement between residual values and their associated measurements.

```
   Adjusted GPS Vector Observations Sorted by Standardized Residuals (Meters)

Datum Transformations
  Scale Factor 0.999998390813  :        1.609187 PPM (Solved)
  Rotation Around North Axis   :        0.862439 Sec (Solved)
  Rotation Around East Axis    :       -0.567918 Sec (Solved)
  Rotation Around Vert Axis    :        0.067712 Sec (Solved)

From              Component          Adj Value      Residual   StdErr StdRes File:Line
To

(V4 Day125(1) 14:12 00130016.SSF)
0013                Delta-N           6495.7466        0.0140   0.0034   4.1*    1:47
0016                Delta-E           4793.3485       -0.0066   0.0032   2.1
                    Delta-U            -23.9521       -0.0027   0.0047   0.6
                    Length            8072.8859

(V2 Day125(1) 14:14 00120016.SSF)
0012                Delta-N          -3611.0790        0.0093   0.0033   2.8     1:37
0016                Delta-E           6562.8591       -0.0077   0.0031   2.5
                    Delta-U            -42.0599       -0.0018   0.0043   0.4
                    Length            7490.8464
```

*GNSS measurement error values in STAR*NET. Standardized residuals outside tolerances shown with an asterisk. Double-clicking the File:Line code highlights the associated measurement.*

Adjusted GNSS Observations

Observation ID		Observation	A-posteriori Error	Residual	Standardized Residual
EGL2+A-504+A (V238)	Az.	200°03'55"	0.000 sec	0.000 sec	4.612
	ΔHt.	-0.769 m	0.000 m	0.000 m	-3.192
	Ellip Dist.	740.002 m	0.000 m	0.000 m	-1.321
EGL2+A-504+A (V411)	Az.	200°03'55"	0.000 sec	0.000 sec	4.612
	ΔHt.	-0.769 m	0.000 m	0.000 m	-3.192
	Ellip Dist.	740.002 m	0.000 m	0.000 m	-1.321
EGL2+A-504+A (V640)	Az.	200°03'55"	0.000 sec	0.000 sec	4.612
	ΔHt.	-0.769 m	0.000 m	0.000 m	-3.192
	Ellip Dist.	740.002 m	0.000 m	0.000 m	-1.321
EGL2+A-311+A (V218)	Az.	14°57'29"	0.000 sec	0.000 sec	-1.476
	ΔHt.	0.072 m	0.000 m	0.000 m	-2.420
	Ellip Dist.	360.238 m	0.000 m	0.000 m	4.191
EGL2+A-311+A (V391)	Az.	14°57'29"	0.000 sec	0.000 sec	-1.476
	ΔHt.	0.072 m	0.000 m	0.000 m	-2.420
	Ellip Dist.	360.238 m	0.000 m	0.000 m	4.191

GNSS measurement error values in other HTML-formatted report. Standardized residuals outside tolerances highlighted in red. Clicking the observation ID highlights the associated measurement.

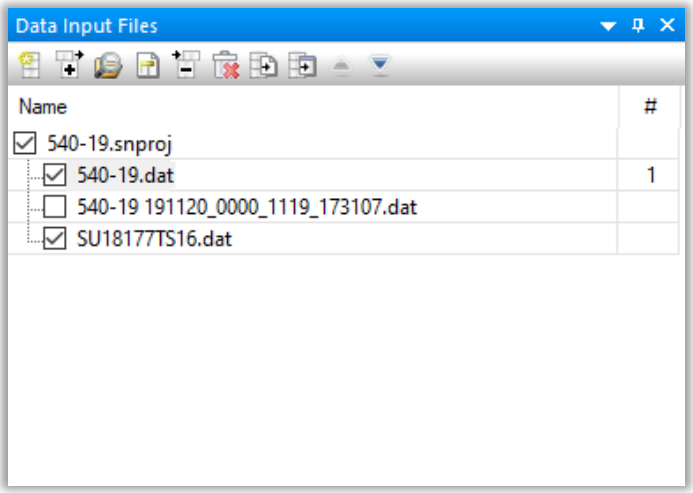
Personal preference plays a part, but many users find the reports from STAR*NET to be more concise and legible, providing the most useful information at a glance.

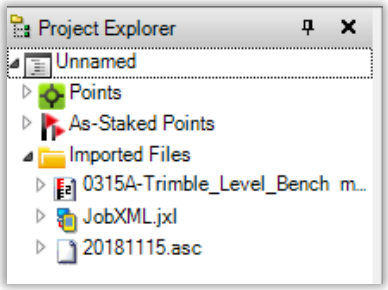
Data Control

Order of operations is important; this is taught by mathematics teachers around the globe.

This is one noteworthy difference between STAR*NET and other adjustment programs. It's easy to see which files are in use, and the order in which they are used.

A couple clicks allows users to toggle between two similar files with varying approaches to a problem, test data sources individually when searching for errors, toggle daily files on and off to quickly check data, or manage data types within individual files.





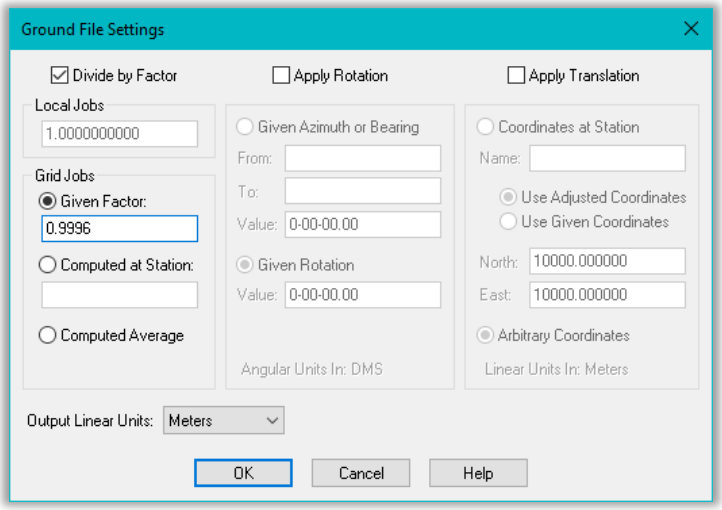
In this example from a competitive product, you can see that while all contents of the project are shown, there is no means by which to turn data on and off within the project. It is not easily recognizable from this point the order in which data will be processed.

Data Customization

In STAR*NET, it is easy to create a "ground points" file of transformed adjustment results.

STAR*NET allows you to set rotations, translations, and transformations to create a secondary set of adjusted coordinates, which may include ground coordinates, localized site-specific coordinates, or coordinates in an adjacent zone to your current coordinate system.

Where other adjustment programs typically force you to create coordinates in one coordinate system and manually compute localizations by some other method, STAR*NET allows you to create both simultaneously.



Weighting

Weighting is simple and scalable. STAR*NET's weighting logic uses defined weights, such as fixed, standard, and unweighted, with full customization available through the use of standard error values.

This set of weighting values is carried through all measurements and coordinate values, and may be added, removed, or manipulated within seconds. Weights are added by adding specific symbols into the data file following data entries, and holding a measurement fixed is as fast as typing "!!!".

```
P 0012  33-04-44.24402 112-54-36.04569 224.299 ! ! ! 'North Rock
P 0017  32-58-09.73117 112-47-13.55717 209.384 ! ! ! 'AZDOT 80-1339
E 0013  205.450  !  'BM-9331
```

Preanalysis

STAR*NET has the unique ability to analyse a *proposed* network adjustment based on its size, geometry, and input instrument standard error values, allowing a plan to be formulated before field work is ever performed.

This function allows you to determine an estimated timeline and accuracy for a proposed network before it is completed, which can be useful in preparing proposals and estimates for clients, scheduling crews, and more. It will allow you to determine the amount of time required on a project to achieve the precision required.

Historical Measurements

Using STAR*NET, it is possible to enter historical traverse data (as written) from multiple sources and varying assumed bearings into a single adjustment. These measurements may then have weights applied to them, depending on the confidence in the original survey and how it compares to modern-day measurements, allowing for a full and complete adjustment and calculation of true boundaries.

Contrasted with other comparable programs, where they often require manual additions to angles and bearings during entry to a "keyed-in instrument" data type, STAR*NET reduces the opportunity for errors within the adjustment and allows entry in the same format as all other data.

Vertical Error Mitigation

STAR*NET supports two types of vertical error mitigation: geoid modelling and vertical deflection modelling.

Geoid modelling is relatively common in the surveying industry and, when applied, allows calculation of orthometric elevations from input ellipsoidal heights. A combined scale factor will be produced for each point in the project, which represents the scale factor required to convert coordinates from grid coordinates (on the datum) to ground coordinates (on the geoid), which are more true-to-reality and may be used to combine total station, level, and GNSS data.

Vertical deflection modelling uses a model of the direction of gravitational pull to model any deflection from the vertical based on gravitational anomalies in the earth. This is most useful in areas with large gravitational anomalies affecting the level plane.

Statistical Analysis at a Glance

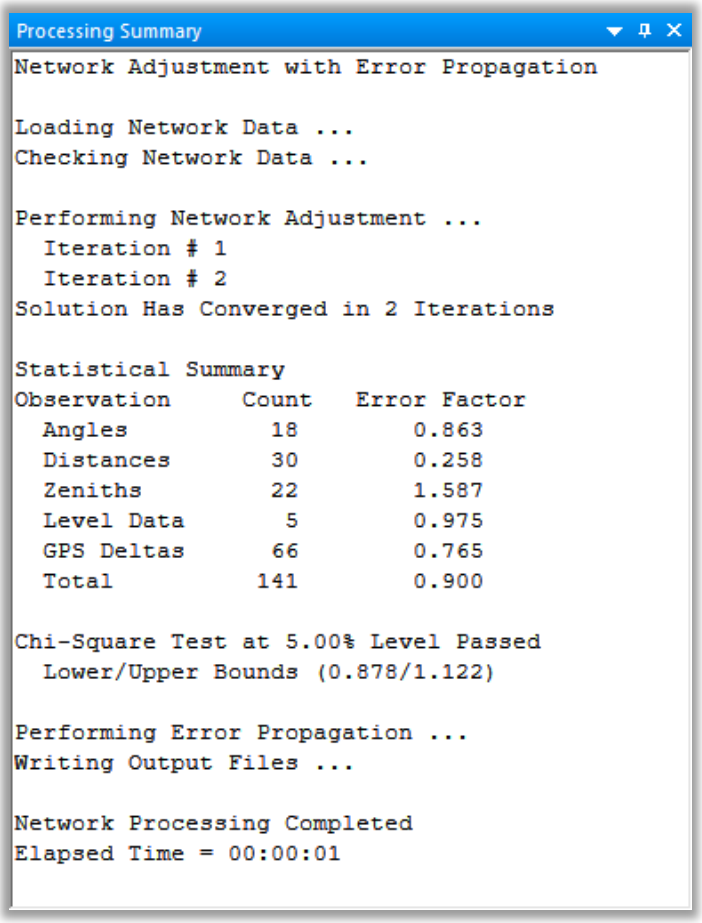
The chi-squared test is often called the “goodness-of-fit” test. It is used to determine the probability that any measurement in the network falls within the defined standard error values by analysing the relationship between expected results of a network adjustment (given geometry and standard error values) and the actual results of the network adjustment.

By default, the probability of the analysis is determined within two standard deviations of the mean (2σ, or 95%), but may be increased to three (3σ, or 99% confidence). More redundancy (degrees of freedom in the statistical analysis) within a network allows better distribution of error and better determination of outliers.

A chi-squared test result of 1.000 indicates that the statistical analysis of the errors within the actual measurements precisely matches the statistical analysis of the expected errors, which are determined from the standard error values. A lower value indicates that the measurements are more precise than expected, and a higher value indicates that the measurements are less precise than expected.

The program determines a lower and upper bound for this test as an overall analysis of the network. Failing on the lower bounds indicates that the instrument settings should be reviewed, as the measurements are better than expected. Failing on the upper bounds indicates that either the instrument settings are too constrained, or more likely, there are random errors in the adjustment that should be removed.

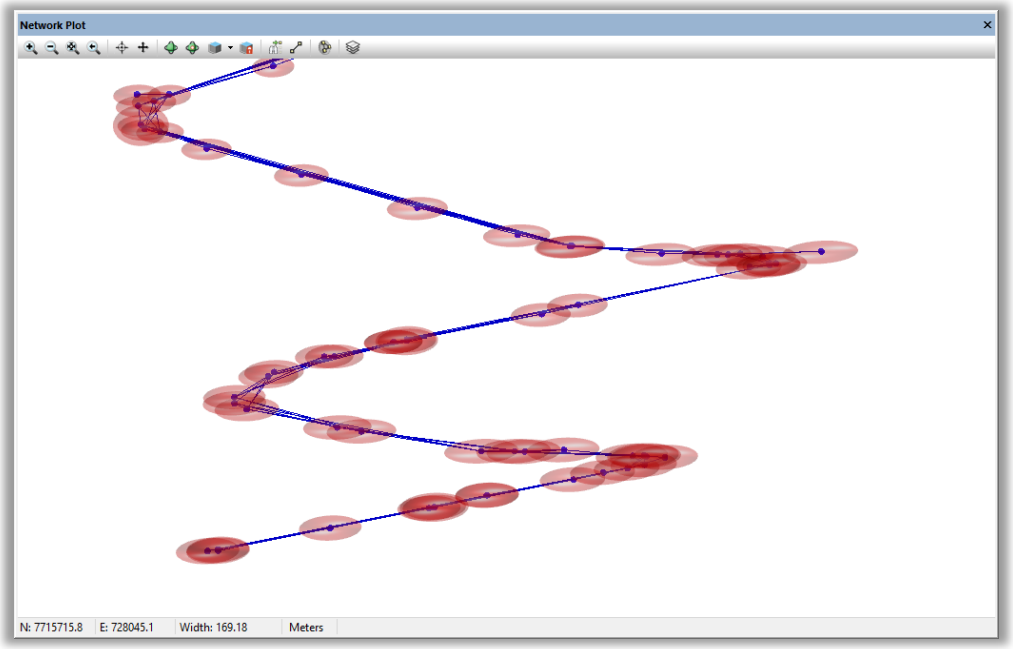
STAR*NET provides an analysis of error factor for each observation type, which can be indicative of systematic errors, quality of input data, improper instrument settings, or random errors in specific data types. In the example image provided, the zenith angles are determined to be of a lower quality than their standard errors would imply. The network still passes as a result of the quality of the remainder of the network, but the user may choose to examine the zenith angles, instrument settings, instrument and rod heights, or even the tape measure used, as this indicates a slight misrepresentation of the expected vertical error.



```
Processing Summary

Network Adjustment with Error Propagation

Loading Network Data ...
Checking Network Data ...

Performing Network Adjustment ...
  Iteration # 1
  Iteration # 2
Solution Has Converged in 2 Iterations

Statistical Summary
Observation      Count   Error Factor
  Angles           18        0.863
  Distances        30        0.258
  Zeniths          22        1.587
  Level Data        5        0.975
  GPS Deltas       66        0.765
  Total           141        0.900

Chi-Square Test at 5.00% Level Passed
  Lower/Upper Bounds (0.878/1.122)

Performing Error Propagation ...
Writing Output Files ...

Network Processing Completed
Elapsed Time = 00:00:01
```

Error Ellipsoids

STAR*NET provides automatically-scaled error visualizations within the network plot through use of error ellipsoids. In older versions of STAR*NET, the error was shown using 2-dimensional error ellipses, but in STAR*NET v10, a 3D network plot was added, allowing rotation of the network for better visualization of 3-dimensional networks and associated error ellipsoids. These ellipsoids continue to display a major and minor axis of error, as in 2D ellipses, but also contain the vertical error, which may be reviewed by rotating the plot.



The 3D network plot allows us to review this network in a spiral tunnel and its error ellipsoids

Centering Error

An often-overlooked but important error type is instrument and target centering error. Unless instruments and targets are screwed directly onto a monument, centering error will affect the adjustment. Rather than assuming the instrument will be perfectly centered, STAR*NET allows entry of standard errors for instrument horizontal error, target horizontal error, and vertical measurement error.

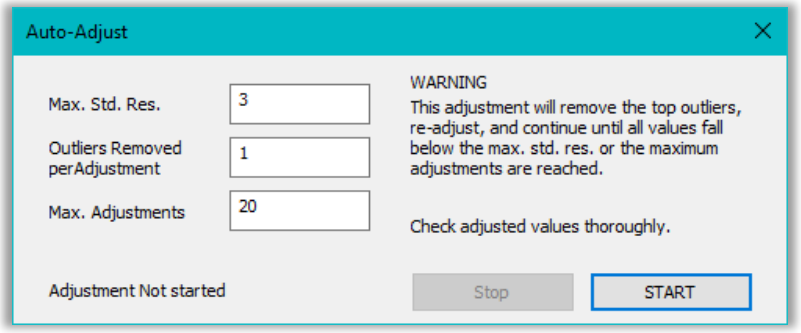
A very small value is automatically applied by default to the horizontal error values to account for misalignment using the optical plummet on a tribrach, and a vertical value may be applied to account for error in measuring instrument or target height with a measuring tape.

Auto-Adjust

One of the goals of a network adjustment is to remove measurements which are statistical outliers. Outliers are those whose residual errors do not fit within the normal distribution of expected error. It would not be practical to directly compare residuals between a linear measurement and an angular measurement, so standardized residual values are computed by STAR*NET. Standardized residuals are calculated for every observation in an adjustment so residuals may be compared between the various observation types.

After completing a standard adjustment, each of the “adjusted observations” sections of the listing file flags standardized residuals with a value of 3 or higher for review by the user. Historically, the user would then locate the largest standardized residual, which *should* indicate the location of an erroneous observation, and remove either the entire measurement or the affected observation from the data file and readjust.

Auto-adjust will perform this workflow autonomously after allowing the user to define a standardized residual threshold, observations to be removed per adjustment, and maximum number of adjustments.



Auto-adjust will not edit the input data files, but will list all removed observations in the listing file. A user may use this information as-is, or may evaluate the removed observations as a summary of measurements for further review. This function can save a lot of time and minimize the effort required to perform a high-quality network adjustment.

Summary

In summary, STAR*NET provides a great balance between usability and technical ability. Adjustments are quickly processed, edits are able to be completed efficiently, and highly technical adjustments are brought within reach of a knowledgeable user. Data neutrality allows the use of data from nearly any source, making STAR*NET attractive to those who prefer equipment from multiple manufacturers who choose to lock users into a vertically integrated hardware/software system.