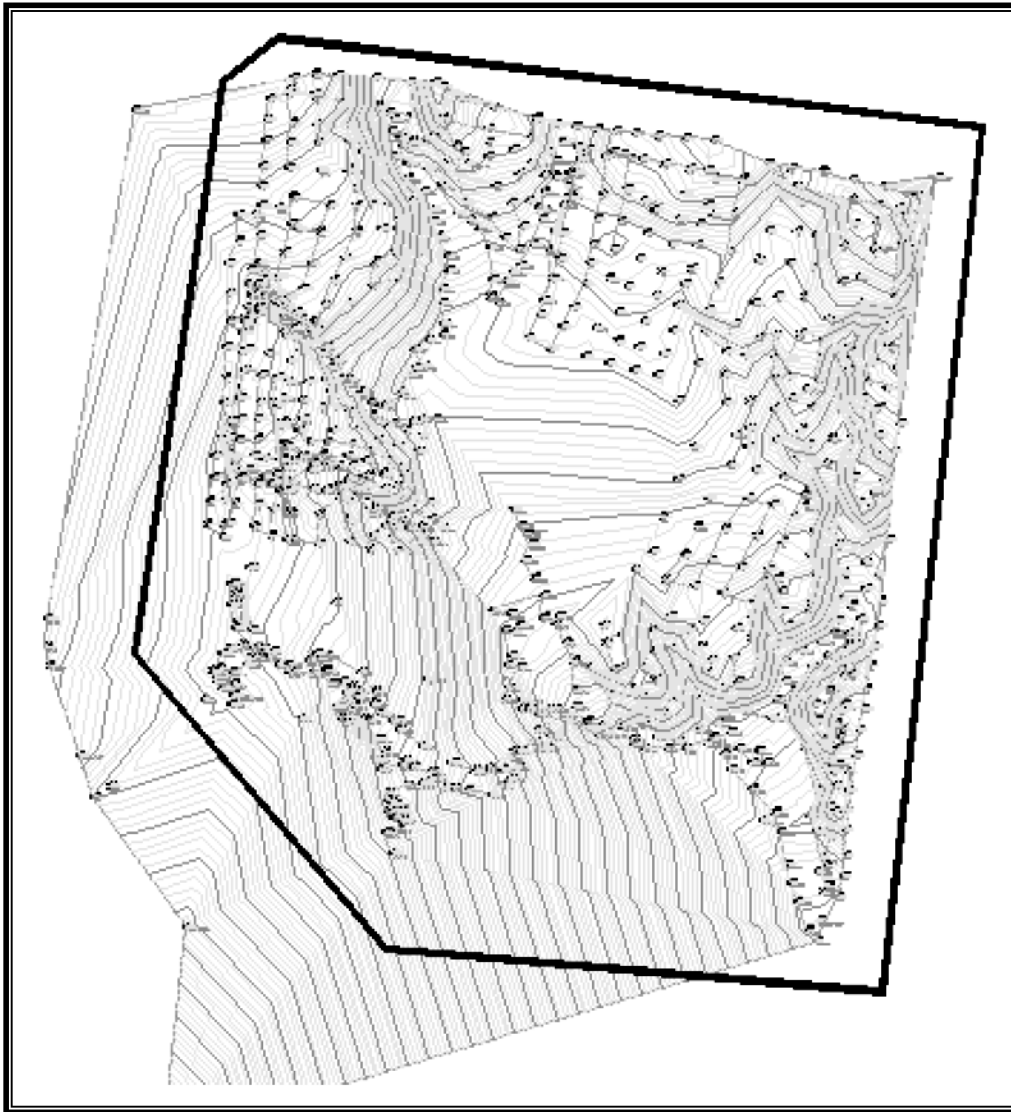


AutoCAD Civil 3D 2008 SURVEY



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Section 1: Survey Least Squares

In this section you will learn how to:

- Import multiple Field Books to a network.
- Create a Least Squares survey.
- Create a Least Squares input file.
- Evaluate Least Squares input.
- Perform a Least Squares adjustment.
- Update the Least Squares survey and figures.

Least Squares

A field crew's survey observations contains errors, such as errors in the instrument, a non-steady hand holding the prism, or poorly maintained optics. The observations made by these instruments must have some adjustment made to their data to reduce error so that the survey is accurately interpreted.

A Least squares adjustment is a statistical method, giving the "statistically most likely" location of multiple defined points (points with multiple observations and multiple locations).

A Least Squares adjustment minimizes the weighted sum squares of residuals within the possible point coordinates (i.e., the least amount of error for the location of all points). In a survey, you can get from one point to another (angle, distance, or both) in more than one way. The actual measurements of a survey give slightly different point locations, depending on the path of the survey making the observations. The goal of a Least Squares adjustment is to compute a single (most likely) location for each point from all of the different measurements to the point.

A surveyor can apply Least Squares to an overall survey or an individual traverse. A Least Squares adjustment can be done on any collection of field observations containing redundant observation values.

- A Least Squares adjustment can be in 2D or 3D.
- The survey must contain points with multiple observations (observed from several locations throughout the survey).

The crucial error estimation values come from the Equipment Database's assigned instrument. The values in this file create the estimate of errors for each observation. You should always have an up-to-date library of instruments. If you do not have an equipment library, you should have at least one definition that is general enough for all instruments used.

After properly setting up the survey and importing the data, the next step is creating a Least Squares input file. This file contains all observation data and breaks down the AD field book observations to angle and distance measurements. If the data contains elevations, the vertical measurements are included in the data.



Practice - Creating a Least Square Survey

Task 1 - Set Up the Drawing

1. If you are not in AutoCAD Civil 3D, double-click on the icon to start the program.
2. Close the current drawing and do not save it.
3. Select the *Prospector* tab to make it current and set it to **Master View** mode.
4. Expand the Template branch, right-click on AutoCAD Civil 3D (Imperial) NCS Extended, and select **Create New Drawing**.
5. Select **File>Save As...** and save the drawing as **NJ-Least Squares**.
6. Select the *Settings* tab to make it current.
7. In the *Settings* tab, right-click on the name of the drawing (NJ-Least Squares) at the top and select **Edit Drawing Settings...**
8. Select the *Units and Zone* tab and select **USA, New Jersey** in the Categories drop-down list.
9. Select **NAD 83 New Jersey State Planes, US Foot** in the Available Coordinate Systems drop-down list.
10. Select the *Object Layers* tab to make it current.
11. Scroll to the survey entries. Change the *Survey Network and Figure modifier* to **Suffix** and enter -* as the value.
12. Click **OK** to exit Edit Drawing Settings.
13. Save the drawing.

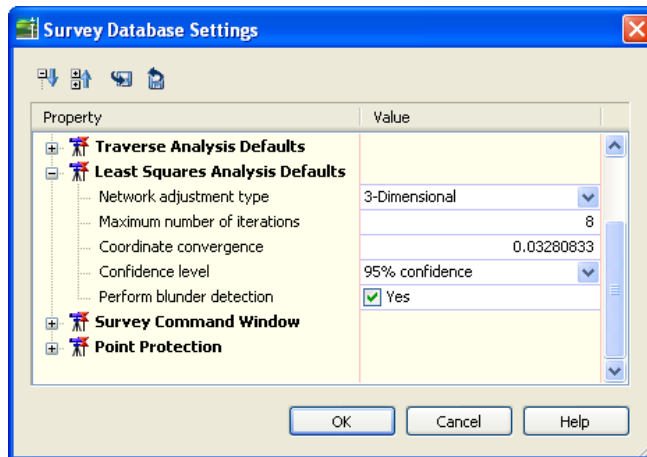
Task 2 - Set Survey User Settings

1. If necessary, select **Survey>Open Survey Toolspace**.
2. Select the *Survey* tab to make it current.
3. Click on the **Survey User Settings** button and, in the Survey User Settings dialog box, expand the *Import Defaults* section.

4. Toggle on the following options in the Import Defaults section: **Erase Survey Points from Drawing**, **Reset Network**, and **Delete Network Figures**.
5. Click **OK** to close the dialog box.

Task 3 - Create and Set Up the Survey Database

1. In the Survey Toolspace, right-click on the Survey Databases heading and select **New Local Survey Database...**
2. In the New Local Survey Database, enter **Monroe Topo** as the name, and click **OK** to create the database.
3. Right-click on Monroe Topo and select **Edit Survey Database Settings...**
4. Expand the *Units* section in the Survey Database Settings dialog box. Click on the ellipsis for the Coordinate Zone.
5. Select **USA, New Jersey** in the Categories drop-down list.
6. Select **NAD 83 New Jersey State Planes, US Foot** in the Available Coordinate Systems drop-down list.
7. Click **OK** to return to the Survey Database Settings dialog box. The *Units* section should now be set to **US Foot**.
8. Expand the *Least Squares Analysis Defaults* section. Make sure your settings match the values shown below.



9. Click **OK** to exit the dialog box.

Task 4 - Define the Network

1. Under Monroe Topo, right-click on Networks and select **New...**
2. In the Network dialog box, enter **5168** as the network name and click **OK** to create the network.

Task 5 - Import the 5168 Topo Field Books

1. Copy the **5168-1.fbk**, **5168-2.fbk**, and **5186-3a.fbk** training files to the 5168 folder in the *C:\Civil 3D Projects\Monroe Topo* directory.
2. In the Survey toolspace under Monroe Topo, right-click on 5168 in the Networks list and select **Import field book...**
3. Double-click on the 5168 folder in the Field Book Filename dialog box.
4. Select the **5168-1.fbk** file in the 5168 folder and click **Open**.
5. Make sure the following options are toggled on in the Import Field Book dialog box: **Show interactive graphics**, **Erase Survey Points from Drawing**, **Reset Network**, and **Delete Network Figures**.
6. Click **OK** to import the file.
7. In the Duplicate Point dialog box click **Ignore** to continue importing the file. The file contains a second set of coordinates for some points.
8. In the Survey Toolspace under Monroe Topo, right-click on 5168 in the Networks list and select **Import field book...**
9. Double-click on the 5168 folder in the Field Book Filename dialog box.
10. Select the **5168-2.fbk** file in the 5168 folder and click **Open**.
11. Make sure the following options are toggled off in the Import Field Book dialog box: **Erase Survey Points from Drawing**, **Reset Network**, and **Delete Network Figures**.
12. Click **OK** to import the file.
13. In the Duplicate Point dialog box click **Ignore** to continue importing the file. The file contains a second set of coordinates for some points.
14. In the Survey Toolspace under Monroe Topo, right-click on 5168 in the Networks list and select **Import field book...**

15. Double-click on the 5168 folder in the Field Book Filename dialog box.
16. Select the **5168-3a.fbk** file in the 5168 folder and click **Open**.
17. Make sure the following options are toggled off in the Import Field Book dialog box: **Erase Survey Points from Drawing**, **Reset Network**, and **Delete Network Figures**.
18. Click **OK** to import the file.
19. In the Duplicate Point dialog box click **Ignore** to continue importing the file. The file contains a second set of coordinates for some points.

Task 6 - Review the Survey Data

1. Expand the *Control Points* section of the 5168 Network and review the values of some of the control points.
2. In the Survey Toolspace under Monroe Topo, right-click on the Survey Points heading and select **Edit...**
3. After reviewing the survey points, exit the vista.
4. In the Survey Toolspace under Monroe Topo, right-click on 5168 in the networks list and select **Insert into drawing...**
5. Right-click on the network in the drawing and select **Object Viewer**. Review the survey for any obvious vertical errors.
6. After reviewing the survey, exit the Object Viewer.
7. In the Survey Toolspace under Monroe Topo, right-click on 5168 in the Networks list and select **Remove from drawing...**
8. Save the drawing.

Creating a Least Squares Input file

When a survey contains redundant point observations and possibly no traverse, you can create a Least Squares Input file that contains the information necessary for an adjustment. The input file breaks down the field book's AD values to angle and distance entries. Each entry has a standard deviation (estimate of quality) based on the values for the current instrument definition of the Equipment Database.

Below is an example from a Least Squares data file showing the Angle and Distance values and their estimated error.

```

!
! From At To Angle Distance
! Point Point Point Angle Distance Std Error Std Error
SD 1153 100 392.761 0.020
VA 1153 100 90.43379 3.9
A 1151 1153 100 247.30410 9.5
SD 1153 100 392.761 0.020
VA 1153 100 90.43409 3.9
A 1151 1153 100 247.30330 9.5
SD 101 100 440.099 0.022
VA 101 100 90.03042 2.8
SD 101 100 440.089 0.022
VA 101 100 90.03112 2.8
SD 101 102 1208.698 0.060

```

- The angle error is in seconds and the distance error is in feet.
- Points with known coordinates (NE, NESS, or NEZ) are not adjusted.
- All observed points with redundant observation data are adjusted (floating points).
- You can add data to the file and enter estimated error values.
- You can exclude data by placing an exclamation before the line of data.

Points to be adjusted are listed at the top of the Least Squares data file and have a question mark to the left of their numbers. Points that do not have a question mark are not adjusted. You can change the status of a point by adding or removing the question mark to the left of the point's number.

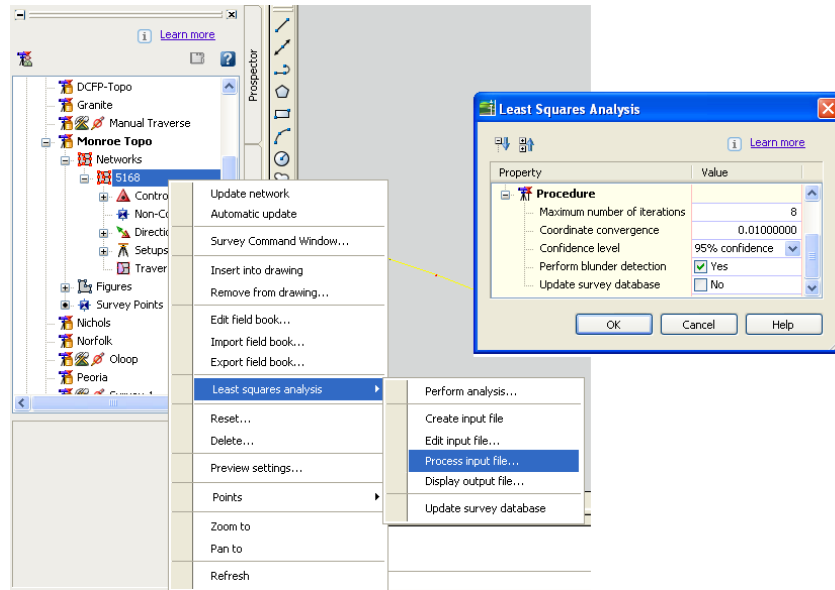
Below is an example showing points that are marked to be adjusted:

```
!3D Input File
!           Least Squares Input File
!           Generated By Survey
!   Point   Northing   Easting   Elevation
?NEZ  100  17634.989383  22353.319301  129.766957
?NEZ  101  17472.296414  22762.231891  129.966290
   NEZ  1153  17761.182578  21981.405937  134.759730
?NEZ  129  17376.379315  23374.803904  135.564365
   NEZ  1151  17622.054456  21859.470581  134.359731
?NEZ  131  17435.520588  23219.865323  133.633393
?NEZ  132  17647.452902  23504.541614  137.079584
```

Preliminary Analysis

You can perform a preliminary analysis that does not affect the current survey. This enables you to review potential changes and fix any errors or remove data from the analysis.

You perform a preliminary analysis by right-clicking on the network and selecting **Least squares analysis>Process Input file**, as shown below, and by toggling off **Update survey database** in the Perform Analysis dialog box.



To adjust a Survey, you can rerun the analysis and toggle on **Update survey database**. You can also select **Update survey database** in the shortcut menu and select the **Network.adj** file.

- When adjusting a survey that contains figures, update the figures after adjusting the survey.



Practice - Least Squares Input File and Adjustment

Task 1 - Create the Least Squares Input file

This practice continues with the previous drawing.

1. If the Monroe Topo database is not open, click on the Survey toolspace, right-click on Monroe Topo, and select **Open Survey Database**.
2. Expand the Networks branch to view the 5168 network entry.
3. Right-click on 5168 in the Networks list and select **Least squares analysis>Create input file**.

Task 2 - Review the Input file Data

1. Right-click on 5168 in the Networks list and select **Least squares analysis>Edit input file...**
2. Review the points to be adjusted list and the angle (horizontal and vertical) and distance (horizontal and slope) values.
3. Close the file.

Task 3 - Perform a Least Squares Adjustment

1. Right-click on 5168 in the Networks list and select **Least squares analysis>Process input file...**
2. The Network LSO file appears displaying the results of the analysis.
3. The survey fails at the 5% confidence level. This means that too many redundant observations differ by too much. The LSO file marks these observations with an asterisk (*). You should return to the field book to review the data collector error messages and review the circumstances of the observations. You might have to edit the original data after identifying errors or exclude observations from the Least Squares input file. You can exclude data in the file by placing an exclamation point before the data line. When Survey processes the file, the observation data values are ignored.

Blunder Detection Analysis

The *Blunder Detection* section of the adjustment identifies the failed measurements because of their high statistical residuals. These indicate errors within the survey that need attention before you continue.

An example is shown below:

```

*****
Blunder Detection/Analysis
*****

Reliability Tests

Type Pnt1 Pnt2 Pnt3 Adjusted Resid Redun Estimate Marg Ext
-----
SD 101 102 1208.705 0.007 0.956 -0.008 P P
VA 101 102 89-53-51.06 5.562 0.896 -6.204 P F
VA 101 102 89-53-53.06 6.562 0.896 -7.319 P F
ANG 100 101 102 181-00-48.86 1.855 0.525 -3.534 P P
SD 103 102 1461.861 0.001 0.833 -0.002 P P
VA 103 102 90-12-07.07 10.367 0.833 -12.440 F F
SD 103 102 1461.861 -0.009 0.833 0.010 P P
    
```

The adjustment does not affect control points when adjusting a survey, but promotes observed points used as stations to derived control points. All points observed from a station and not promoted to control points remain as observed points (sideshot points).

Number	Name	Easting	Northing	Elevati
143		22862.6338	17861.7611	130.3
144		22932.8907	17990.3515	129.4
145		22967.9823	18090.8268	130.3
146		23441.3154	17891.9324	135.6
147		23319.1069	17938.3173	132.5
148		23178.0699	17978.0992	131.5
149		24142.7750	18454.6496	137.1
150		21883.6324	17558.4060	133.7
151		21925.8302	17783.9229	135.0
152		22000.3688	17807.4299	135.3
153		24294.9464	18399.5470	136.2
154		24137.7689	18457.4981	136.6

Updating the Survey

After tweaking and correcting observations within the data, you must update the survey with the analysis results. This is done from the same shortcut menu used to create and process the survey.

The update routine moves the points to the correct location and adjusts their elevations, if a 3D analysis was done. When updating the survey, the figures become out-of-date. You must then update the figures to the new locations of their point attachments.



Practice - Updating a Survey and Figures

This practice continues with the previous drawing.

1. Under Monroe Topo, right-click on 5168 in the Networks list and select **Insert into drawing...**
2. Right-click on 5168 again in the Networks list and select **Least squares analysis>Update survey database...**
3. Select **Network.adj** in the Least Squares Adjusted File Selection dialog box, and click **Open**.
4. Use the AutoCAD **Zoom** and **Pan** commands to view the error ellipses at the setup locations.
5. The figures are marked as out-of-date. Under Monroe Topo, right-click on Figures and select **Update figures**.
6. Close the Monroe Topo survey database.
7. Save and close the drawing.