Adjusting the Network

TRIMBLE BUSINESS CENTER TUTORIAL

Corporate office:

Trimble Navigation Limited
Engineering and Construction Division
5475 Kellenburger Road
Dayton, Ohio 45424-1099
USA

Phone: +1-937-233-8921
Toll free (in USA): +1-800-538-7800
Fax: +1-937-233-9441

www.trimble.com

Copyright and trademarks:

© 2005-2011, Trimble Navigation Limited. All rights reserved.

The Globe & Triangle logo and Trimble are trademarks of Trimble Navigation Limited. All other trademarks are the property of their respective owners.

About this tutorial

In this tutorial, you will adjust the network for a project that contains GNSS, total station, and level data.

Notes:

- To perform a network adjustment on combined GNSS, total station, and level data as described in this tutorial, you must be running **Trimble Business Center** software with the ***Survey Advanced*** product license. To verify the product license for your installation, select **Help > About Trimble Business Center** and click the **License** button. Licensed features are displayed in the **Features** list.
- If you need additional help at any time you are using the software, press **F1** to display the online help.

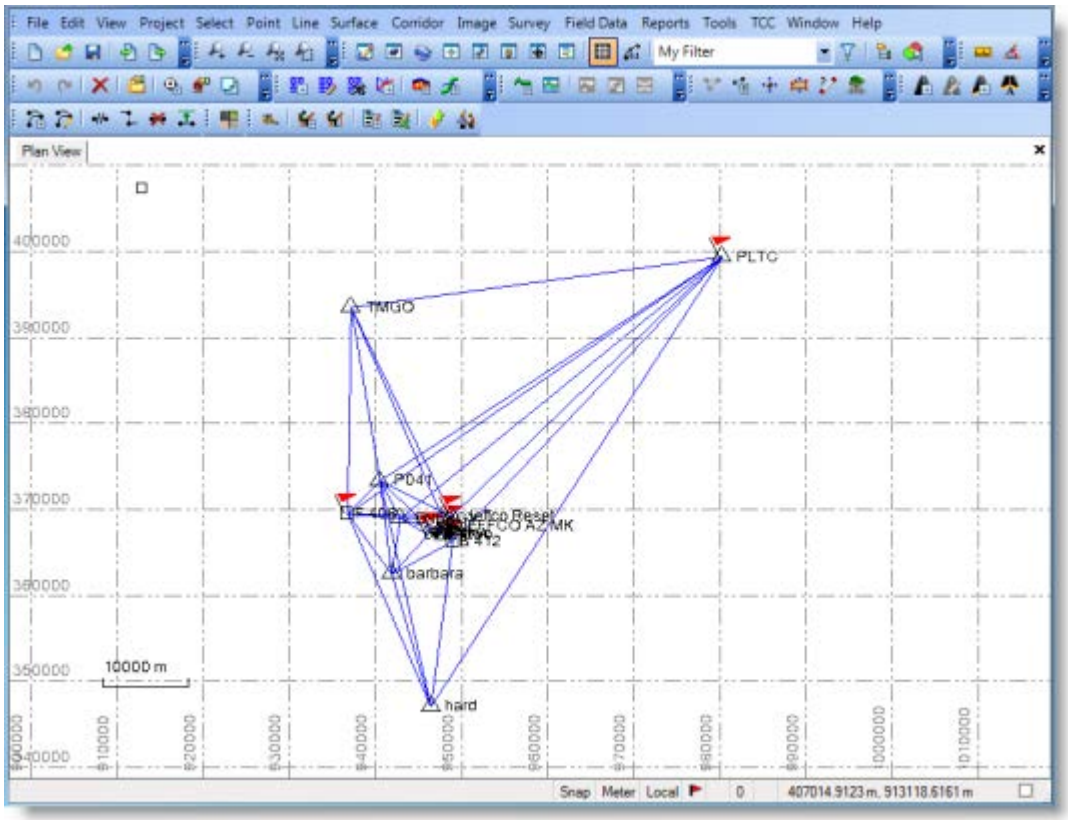
Step 1. Open the project

For this tutorial, you will use the project file *Adjusting the Network.vce*. GNSS, total station, and level data has already been imported into the project, and GNSS baselines have been processed.

1. On the **Trimble Business Center** menu bar, select **File > Open Project**. Or, click the **Open Project** icon on the toolbar.
2. In the **Open File** dialog, browse to ***C:\Trimble Tutorials\TBC\Projects\Adjusting the Network.vce*** and click **Open**.

   If you installed the tutorial to a location other than the default location shown here, browse to that location.

The project opens in the **Trimble Business Center** window.



Note: This figure shows the **Plan View** tab with a white background. Your background may be black. If you want to change it to white, select **Tools > Options** and select **Background color: White** in the **Options** dialog.

The project file is read-only. You can perform the tutorial steps without saving the project file. However, if you are interrupted while performing the tutorial, you can save it by selecting **File > Save Project As** and saving it to ***..\My Documents\Trimble Business Center***, which is the typical location for storing project files on your computer. Then, you can re-open the project to continue the tutorial at a later time.

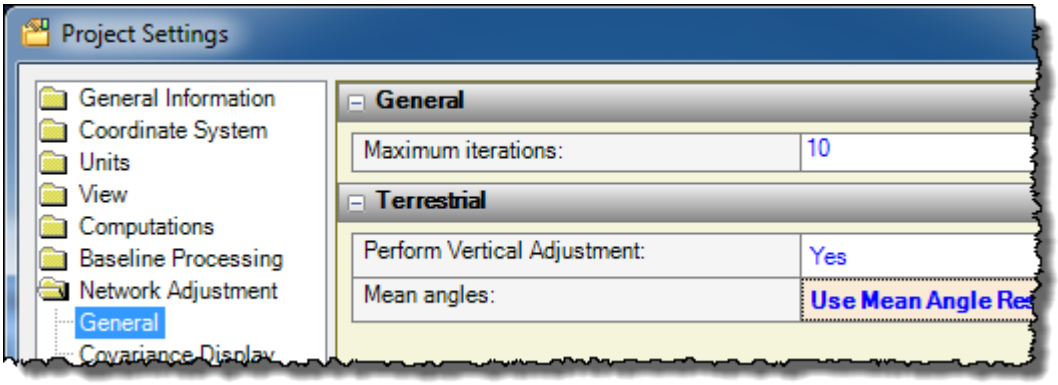
Before you adjust the network in your project, you must make a few changes to your project settings.

Step 2. Modify project settings

In this step, you will select the sources to use for default standard errors. Then, you will specify default standard errors for total station, leveling, and GNSS data.

1. Select **Project > Project Settings**. Or, click the **Project Settings** icon on the toolbar.

2. In the navigation (left) pane in the **Project Settings** dialog, select **Network Adjustment > General.** Then select *Use Mean Angle Results* in the **Mean angles** drop-down list.



3. In the navigation pane, select **Default Standard Errors.** Then select options as follows:

   - **Total Station:**
     - Source for standard errors: *Imported Files*
     - Source for centering errors: *Project Settings*
   - **Leveling:**
     - Source for standard errors: *Project Settings*
   - **GNSS:**
     - Source for standard errors: *Baseline Processor*
   - **Azimuth:**
     - Source for standard errors: *Project Settings*

4. In the navigation pane, select **Default Standard Errors > Total Station.** Then select options as follows:

   - **Default Standard Errors:**
     - Horizontal angle: *0°00'05"*
     - Vertical angle: *0°00'05"*
   - **Default Centering Errors:**
     - Instrument centering error: *0.002 m*
     - Target centering error: *0.002 m*
   - **Default Height Errors:**
     - Error in height of instrument: *0.002 m*
     - Error in height of target: *0.002 m*

5. In the navigation pane, select **Default Standard Errors > Leveling.** Then select options as follows:

   - **Default Standard Errors:**
     - Default standard error on 1 km of double leveling: *0.0 mm*
     - Default standard error for each station setup: *3.0 mm*

6. In the navigation pane, select **Default Standard Errors > GNSS.** Then select options as follows:

   - **Default SetupErrors:**
     - Error in height of antenna: *.002*
     - Centering error: *.005*

7. Click **OK** to close the **Project Settings** dialog.

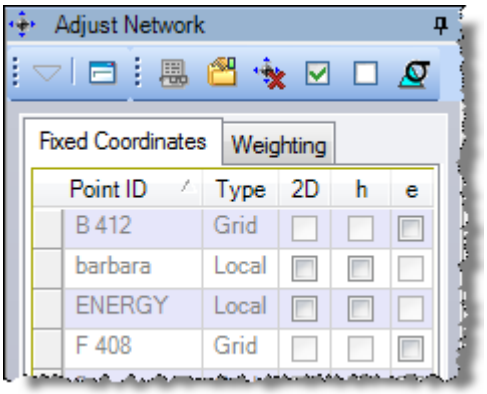
You are now ready to perform a network adjustment. You will do this using a two-step process. First, you will perform a minimally constrained network adjustment. Then, you will perform a constrained network adjustment.

Step 3. Perform a minimally constrained network adjustment

To evaluate the internal consistency of the survey network, you must first perform a minimally constrained network adjustment, which uses the minimum number of constraints required to define the coordinate system.

1. Select **Survey > Adjust Network**.

   The **Adjust Network** pane displays.



   There are 13 control points listed on the **Fixed Coordinates** tab. Ten are the vertical control points from the DiNi level data and the data sheet:

   - *B412*
   - *barbara*
   - *ENERGY*
   - *F 408*
   - *flange*
   - *hard*
   - *Jeffco AZ MK*
   - *Jeffco Reset*
   - *Jeffco Reset*
   - *sixtwo*

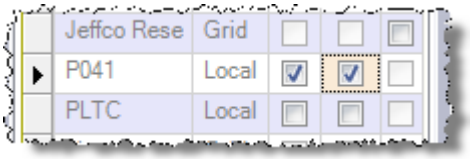
   Three are horizontal control points from the CORS (Continuously Operating Reference Stations) data sheet:

   - *P041*
   - *PLTC*

- *TMGO*

For this project, you will perform a minimally constrained adjustment by holding the station *P041* fixed in **2D** and **h**.

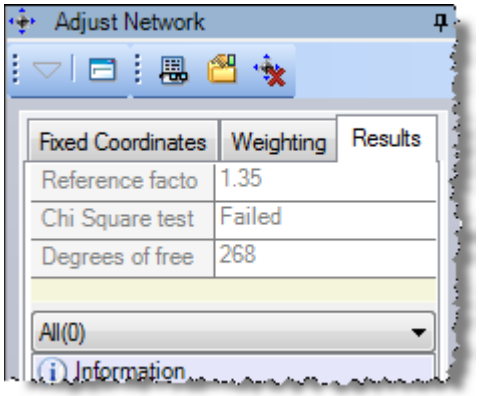
2. On the **Fixed Coordinates** tab, select the **2D** and **h** checkboxes for *P041*.



3. Click the **Adjust** button.

A message displays asking if you want to resolve project computation errors. Click the **Yes** button to continue the network adjustment without resolving the errors.

A summary of the results of the adjustment displays on the **Results** tab in the **Adjust Network** pane.



The **Reference factor** is *1.35*, the **Degrees of freedom** is 268, and the **Chi Square** test has *Failed*. This indicates that some vectors may have been flagged as outliers in the adjustment and/or it is necessary to apply a weighting strategy to the processed vectors.

4. In the **Adjust Network** pane, click the **Report** icon .

The *Network Adjustment Report* displays in your browser window. To navigate to the various sections of the report, click the links in the navigation pane on the left side of the report, or use your mouse to scroll through the report.

5. Review the report, paying particular attention to the "Observations" sections.

Observations with a standardized residual that fails the Tau criteria are displayed in red. These observations are outliers. In this case, the post-processed vectors *TMGO --> PLTC (PV135)* and *filter --> 5 (PV22)* are flagged as outlier (red text) in the "Adjusted GPS Observations" section.

Adjusted GPS Observations

Observation ID		Observation	A-posteriori Err
TMGO --> PLTC (PV135)	Az.	82°24'51"	0.034 s
	ΔHt.	-170.169 m	0.005
	Ellip Dist.	43541.309 m	0.007
filter --> 5 (PV22)	Az.	51°23'55"	4.419 s
	ΔHt.	11.207 m	0.004
	Ellip Dist.	442.723 m	0.005

Note: The software automatically assigns a number in parenthesis to each set of observations. The numbers in your report may vary from the numbers shown above.

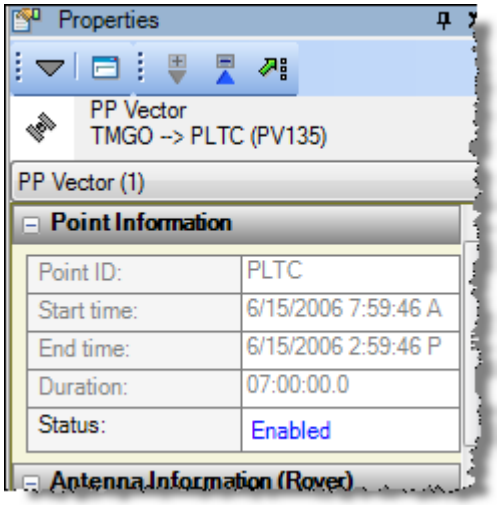
Since you have a high-level redundancy in the network, you can disable *TMGO --> PLTC (PV135)* and *filter --> 5 (PV22),* then readjust the network.

6. In the *Network Adjustment Report,* click the *TMGO --> PLTC (PV135)* link in the "Adjusted GPS Observations" section.

   This selects the vector in the project.

7. In the **Trimble Business Center** window, right-click on the **Plan View** and select **Properties** in the context menu.

   The **Properties** pane displays showing *TMGO --> PLTC (PV135)*.



Note: If you click anywhere else in the window before right-clicking on the **Plan View**, the vector will no longer be selected.

8. In the **Status** drop-down list, select **Disabled.**

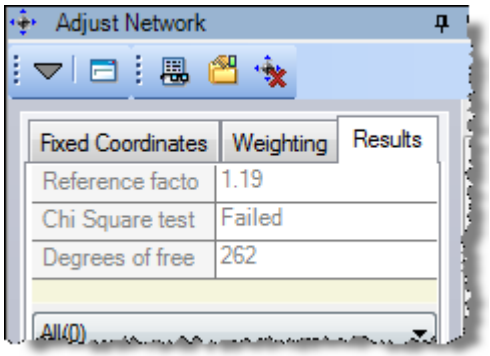
The **Clear Adjustment** message dialog displays asking whether you want to keep or clear the results of the previously performed network adjustment.

9. In the **Clear Adjustment** dialog, click the **Clear Adjustment** button.
10. Repeat steps 6 through 8 for vector *filter --> 5 (PV22)*

    With *TMGO --> PLTC (PV135)* and *filter --> 5 (PV22)* disabled, you can now repeat the network adjustment process.
11. Select **Survey > Adjust Network**. Then click the **Adjust** button to repeat the minimally constrained network adjustment.

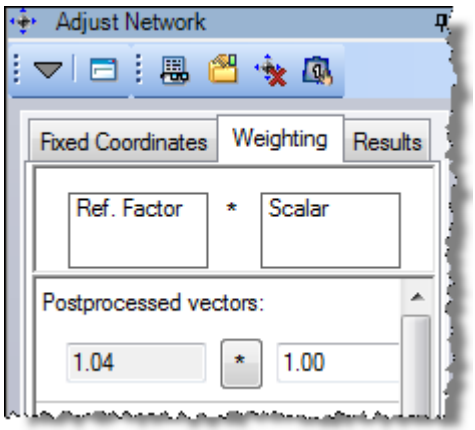
    A message displays asking if you want to resolve project computation errors. Click the **Yes** button to continue the network adjustment without resolving the errors.

    A summary of the results of the adjustment displays on the **Results** tab in the **Adjust Network** pane.



12. Click the **Report** icon to view the *Network Adjustment Report*.

    The **Chi Square** test has still failed, so it is necessary to apply a weighting strategy to the processed vectors. Applying a weighting strategy will improve the initial a priori error estimates for the observations. A priori errors are estimated errors for observations before a network adjustment is performed.
13. In the **Adjust Network** pane, select the **Weighting** tab.



    In the **Postprocessed vectors** section, the network reference factor is listed in the box on the left as *1.04*. The goal is to get the reference factor to *1.0.*
14. In the **Postprocessed vectors**, **Horizontal angles**, **Vertical angles**, **Slope distances**, and **Leveling** sections, click to apply a scalar to the estimated errors.

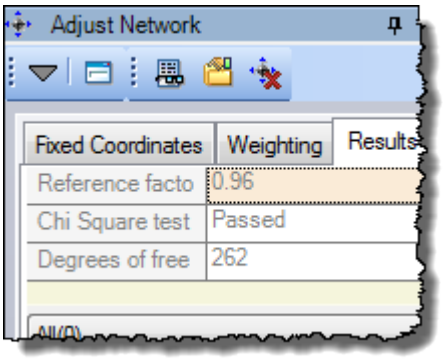
The software computes a new scalar using the network reference factor from the last adjustment. This scalar is applied to the initial error estimates for all postprocessed vectors in the adjustment.

You are now ready to re-compute the minimally constrained adjustment.

15. Click the **Adjust** button

    A message displays asking if you want to resolve project computation errors. Click the **Yes** button to continue the network adjustment without resolving the errors.

    The **Results** tab displays in the **Adjust Network** pane.



    The network **Reference factor** is now *.96* and the **Chi Square** test has *Passed*. The initial a priori error estimates agree with the adjusted errors for the network vectors.

You are now ready to perform a constrained network adjustment.

Step 4. Perform a constrained network adjustment

In this step, you will perform a constrained adjustment in which the remaining control points are held (fixed) to the coordinates from the imported data sheets. The object is to compute adjusted coordinates for the measured points in the survey network, relative to the existing control stations.

The stations in this survey are of mixed survey quality, including:

- CORS (Continuously Operating Reference Stations) quality
- Varying qualities from national network reference stations
- Adjusted DINI observation quality

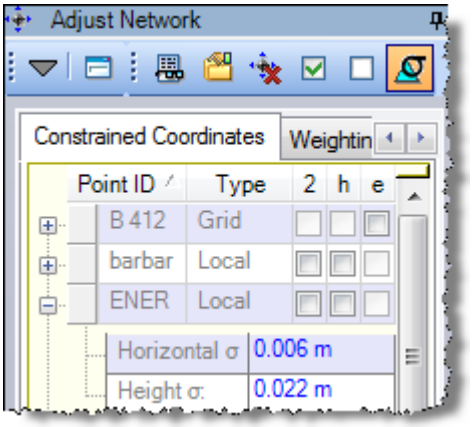
You can assign standard error values to each control point based on its quality, using previously adjusted values from past surveys or error estimates from CORS or national network reference station adjustments. When you assign a standard error to a control point, you enable the network adjustment to adjust the coordinate value of the control point based on the quality of the observations and the other control points.

If you choose not to assign standard error values, a “fixed” value of 0.000001m (micrometer) is assigned to each point regardless of point quality.

For this tutorial, you will enter “fixed” values for the CORS stations, accuracy estimates from the National Geodetic Survey (NGS) datasheets, along with some assumed values for the lower order control points.

1. In the **Adjust Network** pane, select the **Fixed Coordinates** tab. Then click the **Use assigned weighting** icon at the top of the pane.

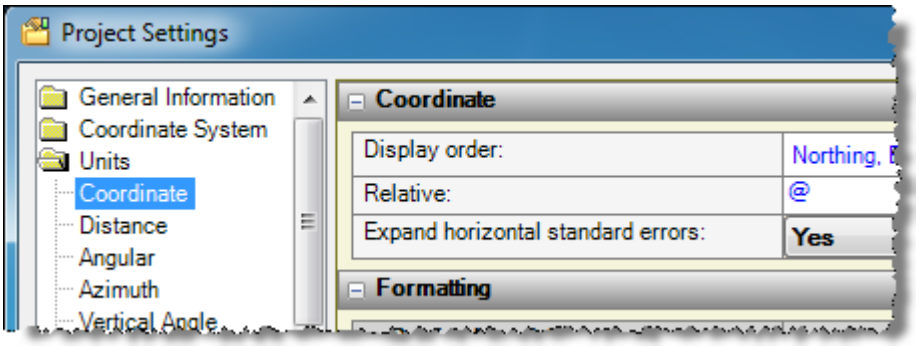
   The **Fixed Coordinates** tab is replaced by the **Constrained Coordinates** tab.



   You can now expand each control point to enter standard error estimates. For this tutorial, you will enter the North and East values of the estimates. (If available, you can enter the horizontal values.) However, before doing so, you will need to make some changes to your project settings.

2. Select **Project > Project Settings** and do the following:

   a. Select **Units > Coordinate** and select **Yes** in the **Expand horizontal standard errors** drop-down list.



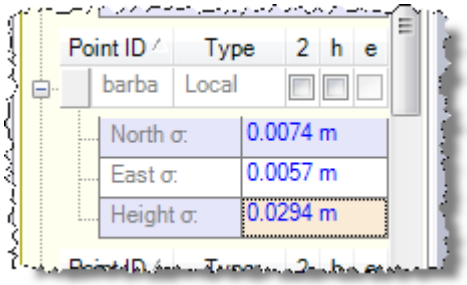
   b. Select **Units > Distance** and select **0.1234** in the **Decimal precision** drop-down list.

   c. Click **OK** to close the **Project Settings** dialog.

3. On the **Constrained Coordinates** tab in the **Adjust Network** pane, do the following:

   a. Click the plus symbol to expand *B412.* Then enter *0.0100 m* in the **Elevation** field.

b. Click the plus symbol to expand *barbara* and enter:
0.0074 m in the **North** field
0.0057 m in the **East** field
0.0294 m in the **Height** field



Typically , you would enter error estimates for the rest of the points as well. However, for this tutorial the additional values have already been entered.

Error estimates entered for a point are used in the adjustment only if you select one or more of the "fix" checkboxes for the point, making it a constraint point.

Although, in practice, you would generally take a more incremental approach to the constrained adjustment and add only one control point at a time, for this tutorial you will complete the constrained adjustment in two steps. First, you will constrain the NAD83 local geodetic coordinates for the three horizontal control points. Then, you will add the elevation constraints for the Trimble DiNi control elevation.

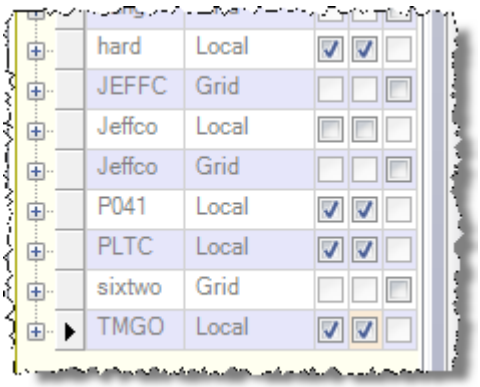
Note the following:

- Local (**2D** and **h**) values refer to NAD83 local geodetic (latitude, longitude, and ellipsoid height) coordinates imported from the data sheets.
- Grid (**e**) values refer to NAVD88 elevations imported from the data sheet or the adjusted digital level files.

For this tutorial, you will constrain points using the local geodetic coordinates. You will add elevation constraints later.

4. Collapse the expanded point nodes and select the constraints for the adjustment by selecting the **2d** and **h** checkboxes for the following points:

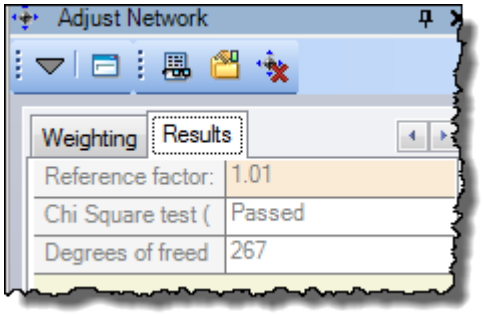
- *hard*
- *P041* (should already be checked)
- *PLTC*
- *TMGO*



5. Click the **Adjust** button.

   A message displays asking if you want to resolve project computation errors. Click the **Yes** button to continue the network adjustment without resolving the errors.

   The **Results** tab displays.



   Typically, you would now review the *Network Adjustment Report*. Based on that review, you might decide to select some other horizontal control points. For this tutorial, you will proceed without selecting other horizontal control points.

   Next, you will constrain only the 2D coordinates for the three horizontal control points. You will also add the benchmark elevations as vertical constraints. In this way, the network is constrained horizontally to the NAD83 local geodetic coordinates and vertically to the NAVD88 benchmark elevations as measured by the DiNi level.

6. On the **Constrained Coordinates** tab, deselect the **h** checkbox for each of the four local points:

   - *hard*
   - *P041*
   - *PLTC*
   - *TMGO*

   This removes the ellipsoid height constraints that you added earlier.

7. Select the **e** checkbox for the grid points:

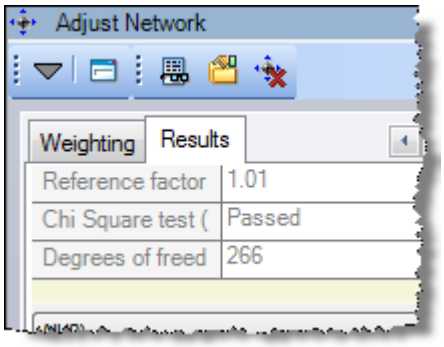
   - *B 412*
   - *F 408*
   - *sixtwo*

   This adds the benchmark elevation for the adjustment.

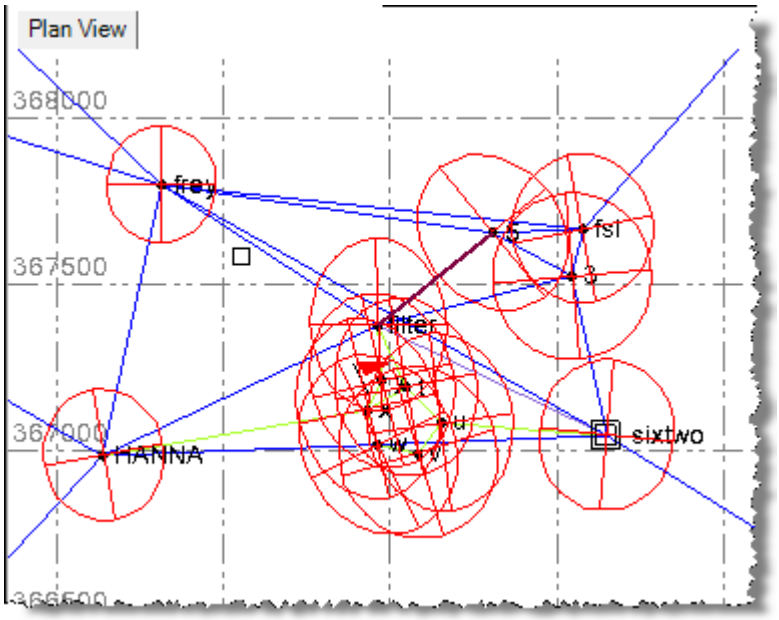
8. Click the **Adjust** button.

   A message displays asking if you want to resolve project computation errors. Click the **Yes** button to continue the network adjustment without resolving the errors.

The **Results** tab displays.



9. In the **Trimble Business Center** window toolbar, click the **Zoom In** icon as necessary to enlarge the view as shown here. Or, click on the **Plan View** and use your mouse wheel to zoom in. Press the mouse wheel and move the mouse to center the points.

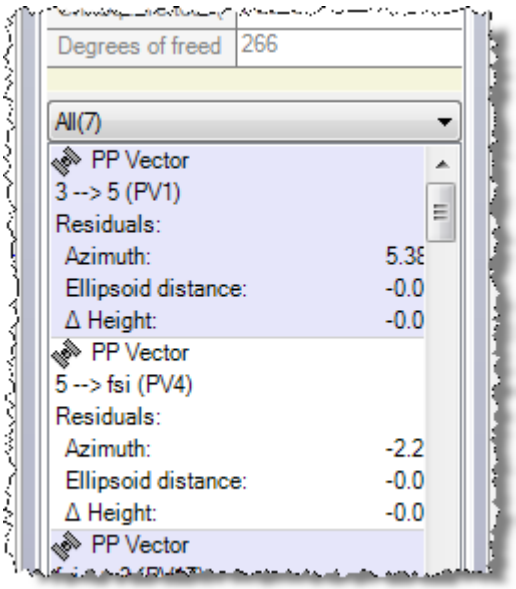


The error ellipses are displayed in red.

10. In the **Adjust Network** pane, click the **Report** icon and view the "Adjusted Grid Coordinates" section.

    This section of the report illustrates which coordinates were held fixed in the adjustment. All coordinates except for control points have estimated errors.

The **Results** tab in the **Adjust Network** pane displays errors and residuals for one or more selected points, observations, or postprocessed vectors. In the **Plan View**, select the items you want to view by drawing a box around them. Your selections display in the **Results** tab.



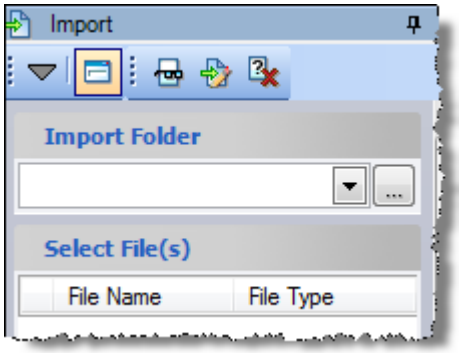
You are done adjusting the network. Next, you will import additional data into your adjusted project.

Step 5. Import additional data into the adjusted project

If the additional job data you are importing includes the same point IDs as your adjusted project, you can select to have the new coordinates based on the adjusted coordinate values. In this case, you will import a new data file that includes a traverse from point *5* to point *frey*, points that already exist in your adjusted project.

1. Select **File > Import.** Or, click the **Import** icon on the toolbar.

   The **Import** pane opens in the right side of the **Trimble Business Center** window.



2. In the **Import** pane, click the **Browse** button .

3. In the **Browse for Folder** dialog, browse to ***C:\Trimble Tutorials\TBC\Data\Adjusting the Network*** and click **OK**.

4. In the **Select File(s)** list, select *53frey.jxl* and click the **Import** button.

   Since the software detects a difference between the coordinate system specified in the project and the coordinate system specified in the imported file, the **Project Coordinate System** message dialog displays.

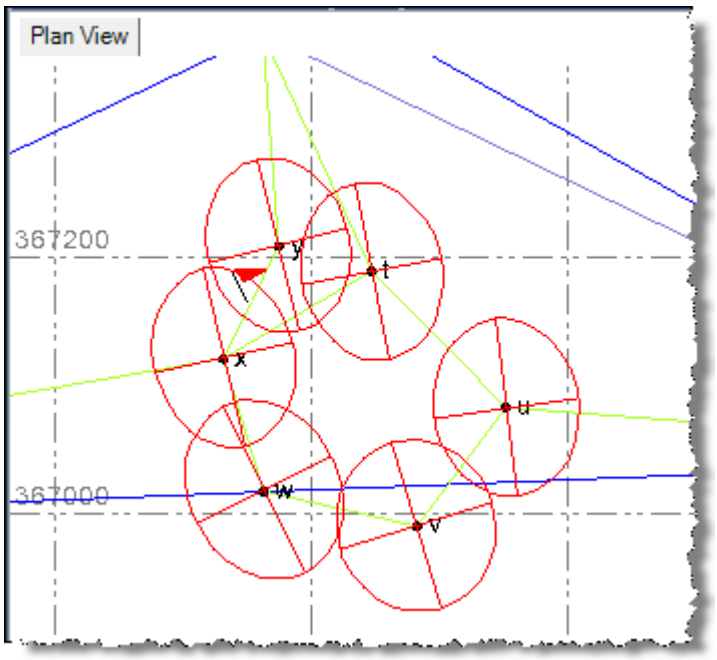
5. Select the **Keep the existing project definition** option in the **Project Coordinate System** message dialog. Then click **OK.**

   The **Clear Adjustment** message dialog displays asking whether or not to keep the network adjustment you just completed. For this tutorial, you will keep the adjustment after importing the new data.

6. In the **Clear Adjustment** dialog, click the **Keep Adjustment** button.

   The new data is imported based on the coordinate values of points *5* and *frey* that were calculated in the network adjustment.

   In the **Trimble Business Center** window toolbar, you can click the **Zoom In** icon (or use the mouse wheel) as necessary to enlarge the view as show here to see the newly imported traverse.



7. Select **View > Project Explorer**. Then, in the **Project Explorer** pane, right-click **Points > *frey*** and select **Point Derivation Report.**

   The *Point Derivation Report* displays in a browser window.

   The report shows the value where point *frey* was established. In this case, it is the network adjusted value. You can also see the coordinate value from the *53frey.jxl* file import.

   You are done adjusting the network.

8. In the **Trimble Business Center** window, select **File > Close Project**.

   The **Save Changes** dialog displays. If you saved the project to a new location or with a new name, you can click **Yes**. Otherwise, click **No**.