Leica Infinity

Advanced Network Adjustment

Version 2.0 - **EN**

- when it has to be **right**

Table of Contents

Introduction

This is a step-by-step tutorial in which the topics that were discussed in the “Advanced Adjustment Concepts” are used to help identify potential problems in a combined network adjustment and provide solutions.

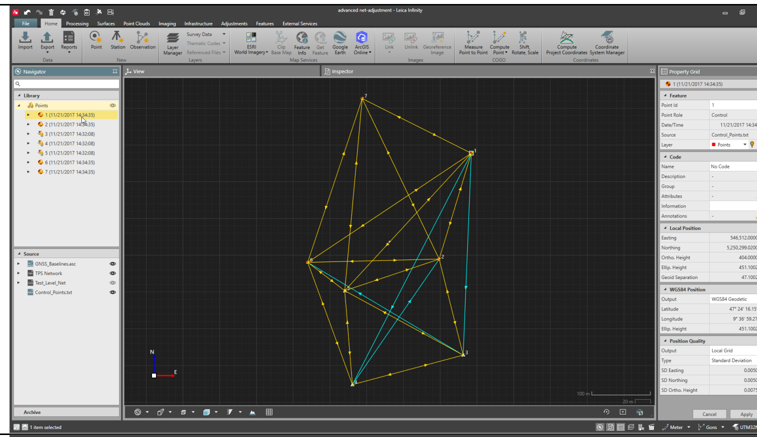
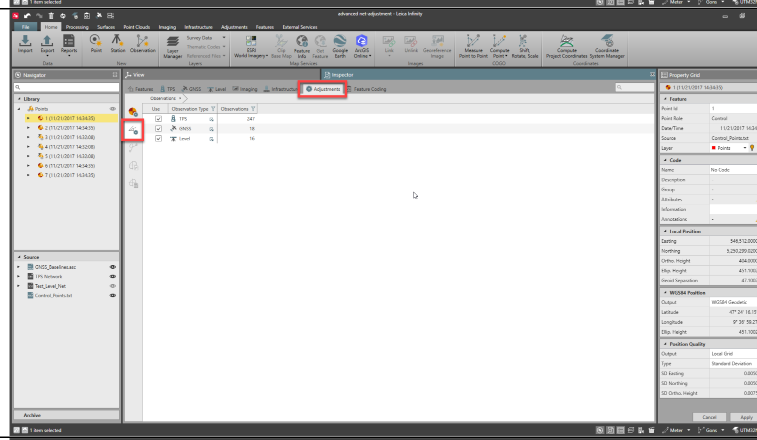
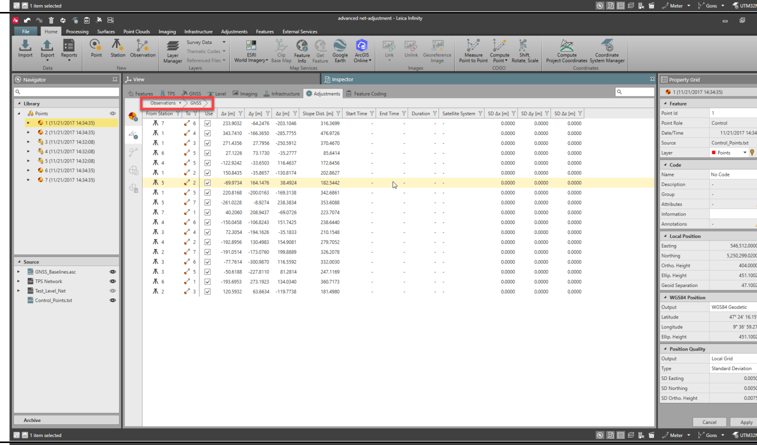
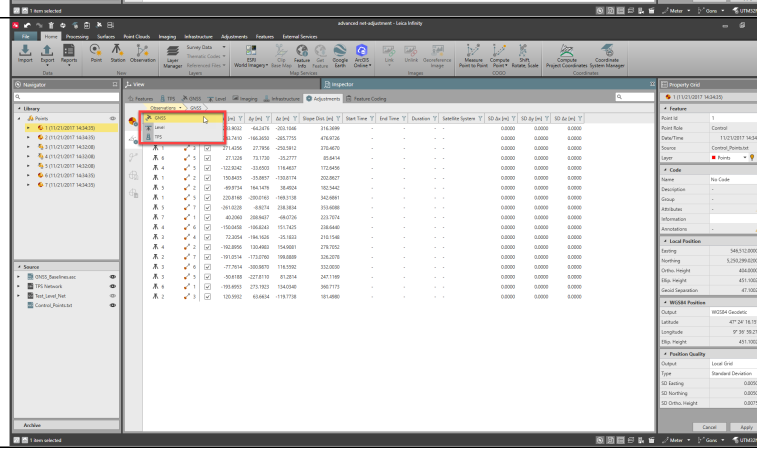
A network of GNSS, TPS and Level observations has been set up over seven points. Four of those are control points. The goal is to arrive at a constrained adjustment solution that is both accurate and reliable.

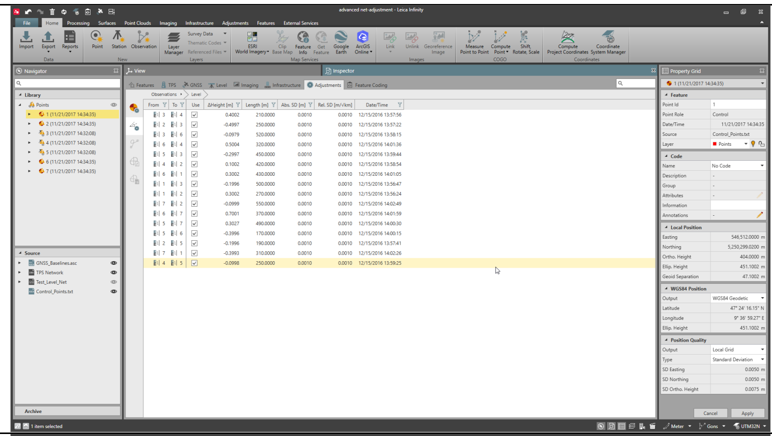
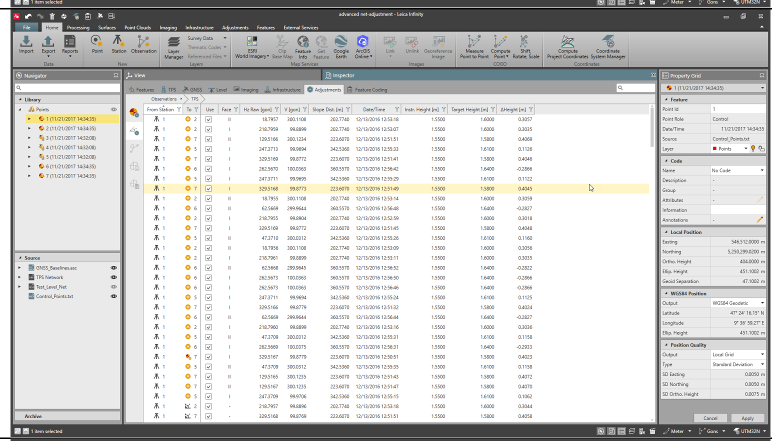
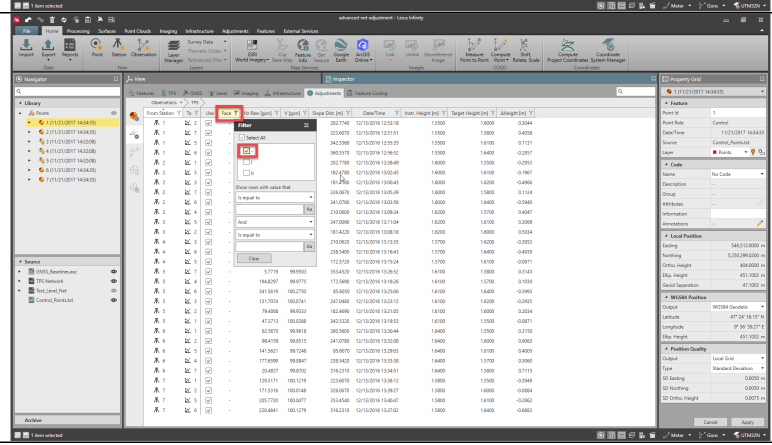
The functionality discussed in this guide requires the Network Adjustments license.

The data from the following folders will be used in this tutorial:

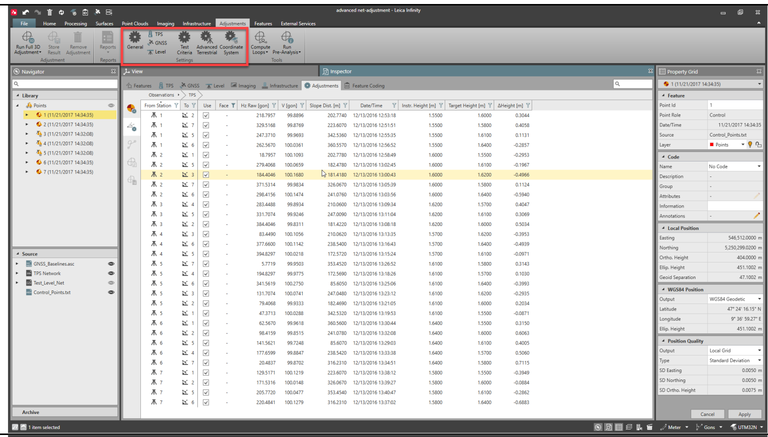
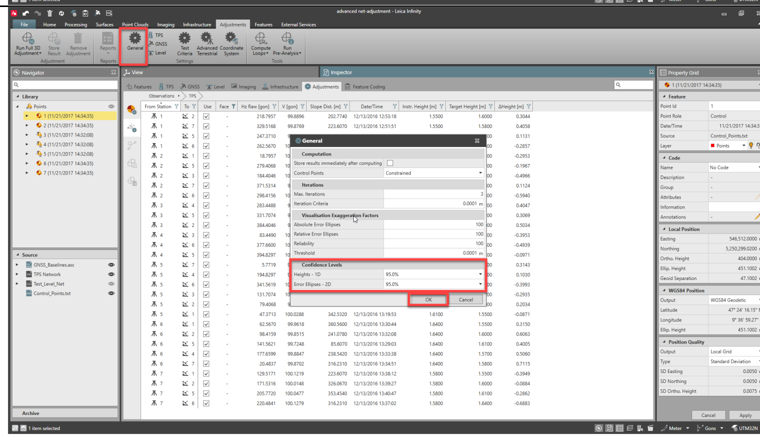
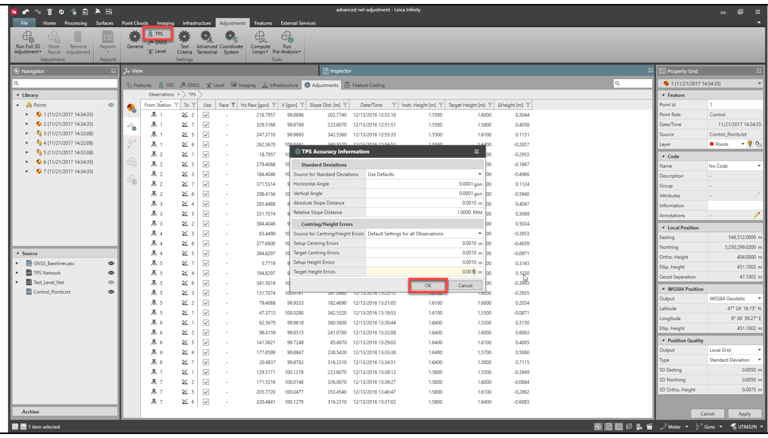
- Data\ contains the Infinity project.

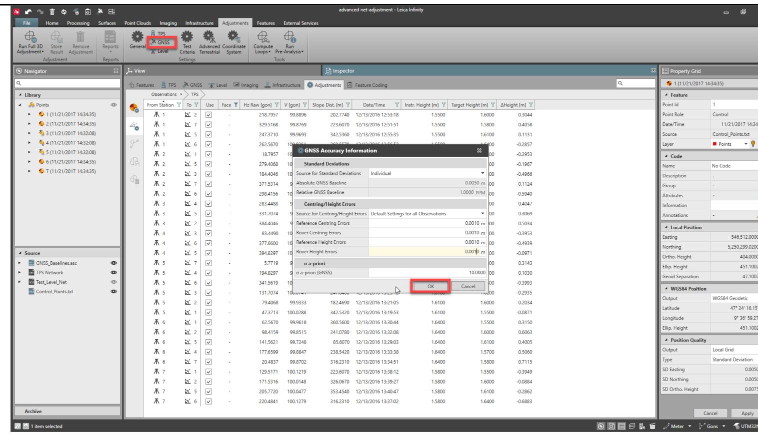
1. Getting familiar with the dataset

1.1	Start **Infinity** and register the project from the data folder. ☞ A network of GNSS, TPS and Level observations is displayed in the view.	
1.2	To view the number and the type of the network observations, move to the **Adjustments** tab of the **Inspector** and select the **Observations** side tab.	
1.3	To view the GNSS baselines, drill in the **GNSS** category. ☞ You can exclude a GNSS observation, by unchecking it in the **Use** column.	
1.4	To view the Level observations, drill in the **Level** category.	

	☞ You can exclude a Level observation, by unchecking it in the **Use** column.	
1.5	To view the TPS observations, drill in the **TPS** category. ☞ You can exclude a TPS observation, by unchecking it in the **Use** column.	
1.6	This dataset contains reduced TPS observations that have been derived from Sets of Angles. To view the reduced observations only, select the filter button next to **Face** column, and activate the "-" option. • The list is filtered to show only the reduced observations.	

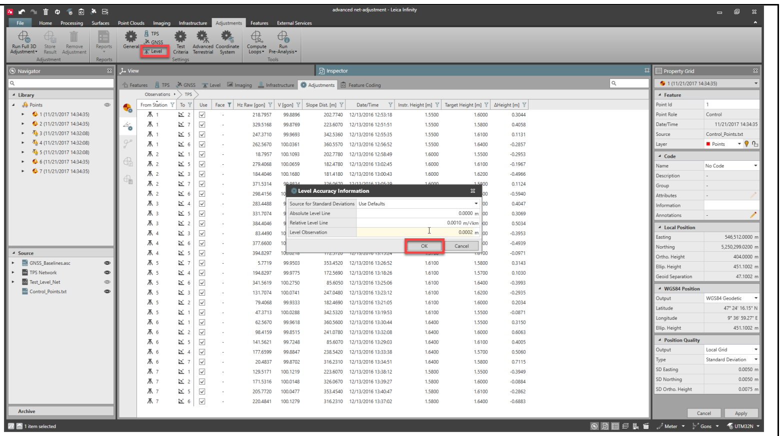
2. Define the adjustment settings

2.1	To define the adjustment settings, move to the **Adjustments** ribbon bar.	
2.2	Select **General** from the ribbon bar, set the **Confidence Levels** for **Heights – 1D** and **Error Ellipses – 2D** to 95.0% and select **OK** to accept the changes. ☞ **General**: it includes the general adjustment settings. Here, you can change the confidence levels and fine tune the visibility of the error ellipses and the reliability boxes. ☞ **Controls: Constrained** means the control points will be kept fixed during adjustment and their standard deviations will be set to zero. ☞ **Controls**: **Weighted** means the control points will receive corrections during adjustment and their standard deviations will be the ones entered by the user.	
2.3	Select **TPS** from the ribbon bar and make the following changes: • **Source for Standard Deviations**: Use Defaults • **Horizontal Angle:** 0.0001 gon • **Vertical Angle**: 0.0001 gon • **Absolute Slope Distance**: 0.001m • **Relative Slope Distance**: 1 PPM • Set all **Centring/Height Errors** to 0.001m by default	

	• Select **OK** to accept the changes. ☞ **TPS Accuracy Information**: it includes the accuracy information for the TPS observations, based on the total station model that was used. Whatever is set here will affect the weight matrix of the TPS observations.	
2.4	Select **GNSS** from the ribbon bar and make the following changes: • Set all **Centring/Height Errors** to 0.001m by default • Select **OK** to accept the changes. ☞ **GNSS Accuracy Information**: it includes the accuracy information for the GNSS observations. Whatever is set here will affect the weight matrix of the GNSS observations. ☞ **Individual** means that the Qxx matrix of the baseline processing will be used in the weight matrix. ☞ **Use Defaults** to override the Qxx matrix and calculate the weights, based only on the length of each baseline. ☞ The **σ a-priori (GNSS)** is used to further scale the weight matrix of the GNSS observations, so that their contribution to the total weight matrix of the adjustment is more realistic.	

<table>
<tr>
<td>2.5</td>
<td>Select Level from the ribbon bar and make the following changes:

Source for Standard Deviations: Use Defaults
Absolute Level Line: 0.000m
Select OK to accept the changes.

☞ Level Accuracy Information: it includes the accuracy information for the levelling lines, based on the level model that was used. Whatever is set here will affect the weight matrix of the level observations.</td>
<td></td>
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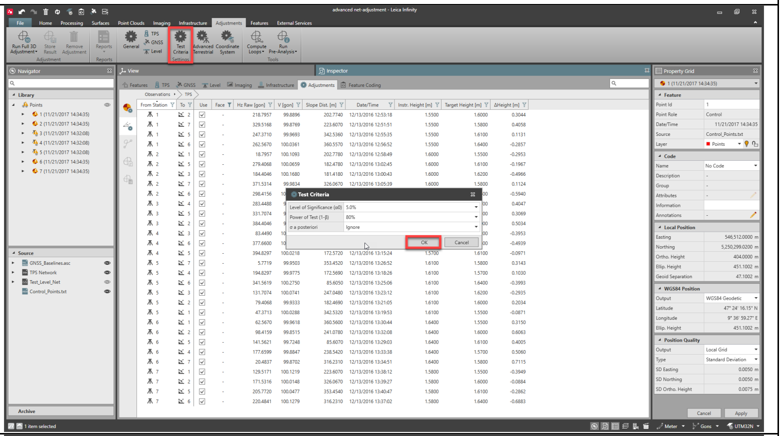
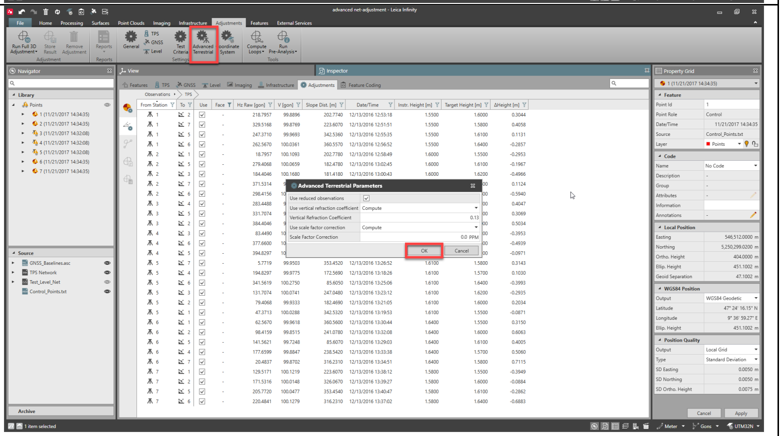
<tr>
<td>2.6</td>
<td>Select Test Criteria from the ribbon bar and make the following changes:

σ a posteriori: Ignore
Select OK to accept the changes.

☞ Test Criteria: it includes the significance levels for the B-Method of statistical testing.
☞ The σ a posteriori will not be used to rescale the variance-covariance matrices.</td>
<td></td>
</tr>
<tr>
<td>2.7</td>
<td>Select Advanced Terrestrial from the ribbon bar and make the following changes:

Use reduced observations: checked
Use vertical refraction coefficient: Compute
Use scale factor correction: Compute
Select OK to accept the changes.

☞ Advanced Terrestrial Parameters: it includes additional parameters that control the parametrisation of the mathematical model of the network adjustment.
☞ For relatively small distances, it is suggested to compute the vertical refraction coefficient.
☞ When combining GNSS and TPS</td>
<td></td>
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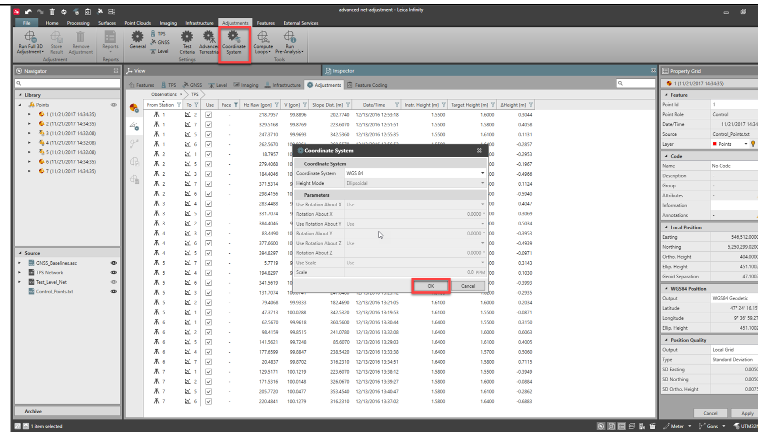
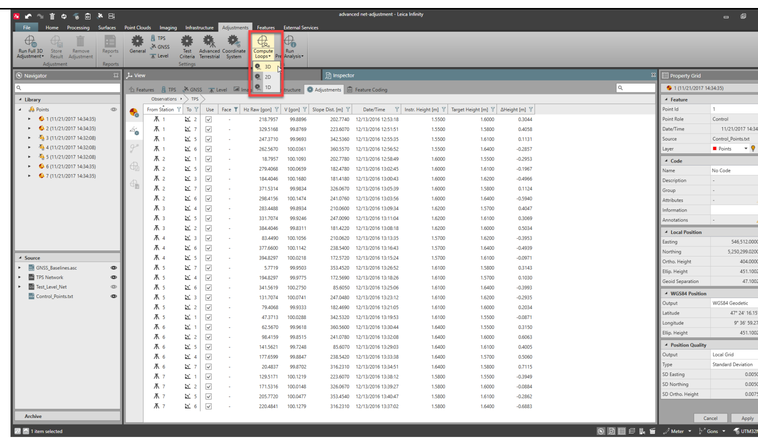
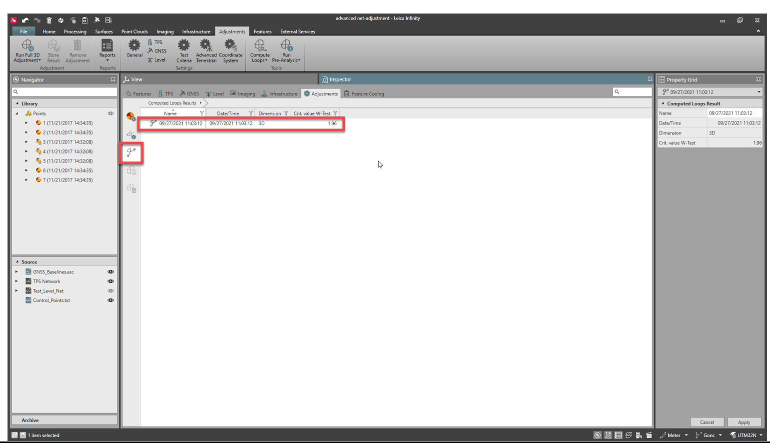
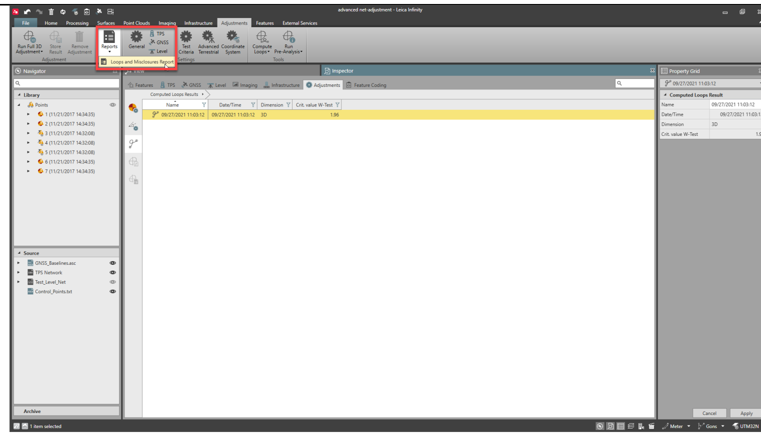
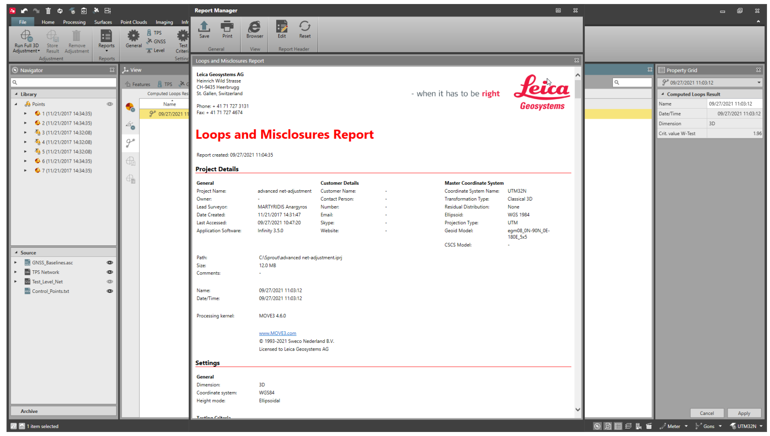
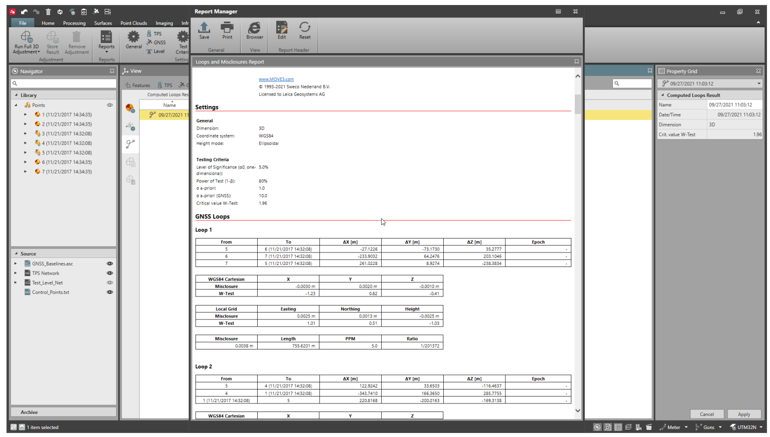
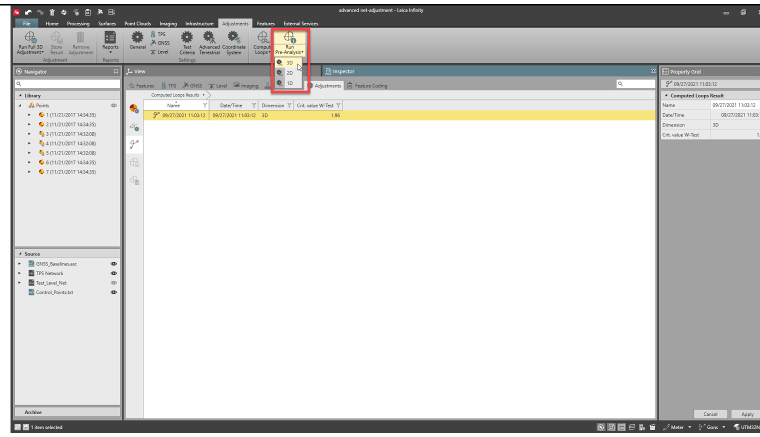
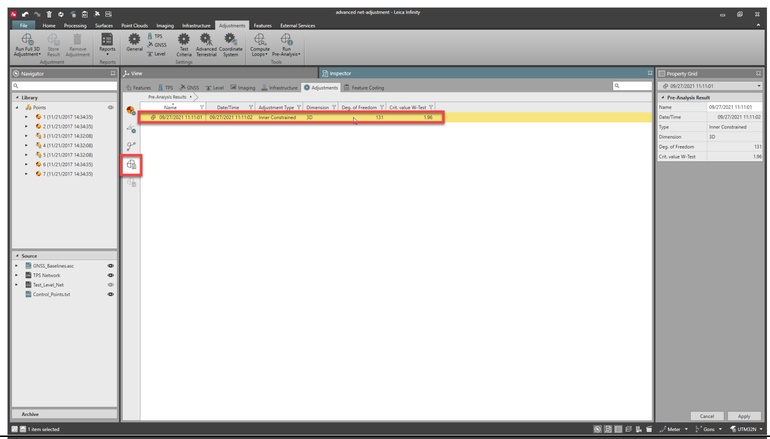
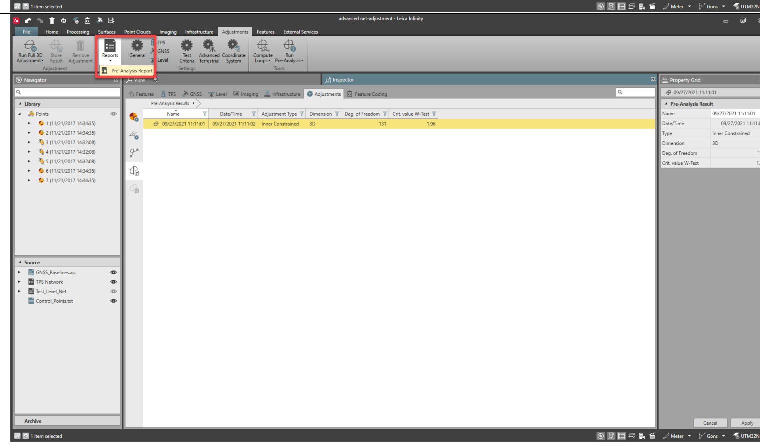
	observations, it is suggested to compute the scale factor correction.	
2.8	Select **Coordinate System** from the ribbon bar and make the following changes: • **Coordinate System**: WGS84 • Select **OK** to accept the changes. • **Coordinate System**: you can select the coordinate system type that fits best to your data. When GNSS and TPS observations are combined, it is suggested to use **WGS84**. If control points are used, then it is suggested to use **Local Geodetic**, provided that at least 3 control points are kept fixed during adjustment.	

3. Check loop misclosures before the adjustment

3.1	To check loop misclosures before running a network adjustment, select **Compute Loops→3D** from the **Adjustments** ribbon bar. • The results for the loop computation can now be viewed in the **Computed Loops Results** side tab of the **Inspector**. ☞ Checking loop misclosures might indicate the poor quality of the observations in general, although it cannot identify specific outliers.	 

3.2	To create a report for the loop misclosures, highlight the result in the **Inspector** and select **Reports→Loops and Misclosures Report** from the **Adjustments** ribbon bar, or use the context menu.	
	• The **Loops and Misclosures Report** is displayed. ☞ In this report, information about all independent GNSS, TPS and Level loops can be found.	
	☞ Four kinds of loops are supported: **GNSS**, **Direction and Distance**, **Zenith Angle and Distance** and **Height Difference** loops. ☞ For each loop, the misclosures and their statistical tests are displayed. ☞ If the statistical test of a misclosures exceeds the tolerance that is calculated by the defined **Level of Significance (α0)**, it is marked in bold red.	

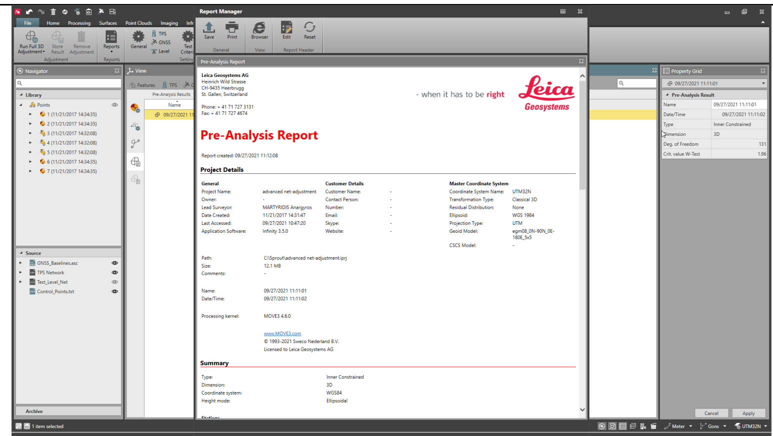
4. Run Pre-Analysis

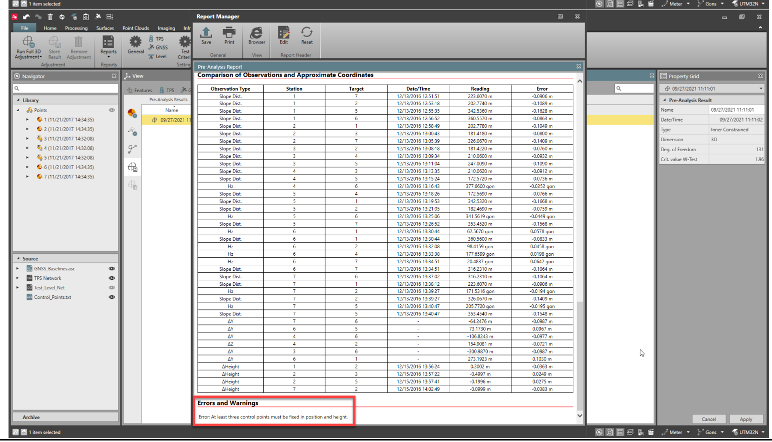
4.1	To run a pre-analysis of the network, select **Run Pre-Analysis→3D** from the **Adjustments** ribbon bar. • The results for the Pre-Analysis computation can now be viewed in the **Pre-Analysis Results** side tab of the **Inspector**. ☞ Pre-Analysis can identify possible weaknesses in a network, detect unknowns that cannot be solved and check input data.	 
4.2	To create a Pre-Analysis report, highlight the result in the **Inspector** and select **Reports→Loops and Misclosures Report** from the **Adjustments** ribbon bar, or use the context menu.	

- The **Pre-Analysis Report** is displayed.

☞ In this report, information about **Configuration Defects**, **Comparison of Identical Observations**, **Comparison of Observations and Approximate Coordinates**, **Possibly Identical Observations**, **Possibly Identical Stations** and various **Errors and Warnings** can be found.

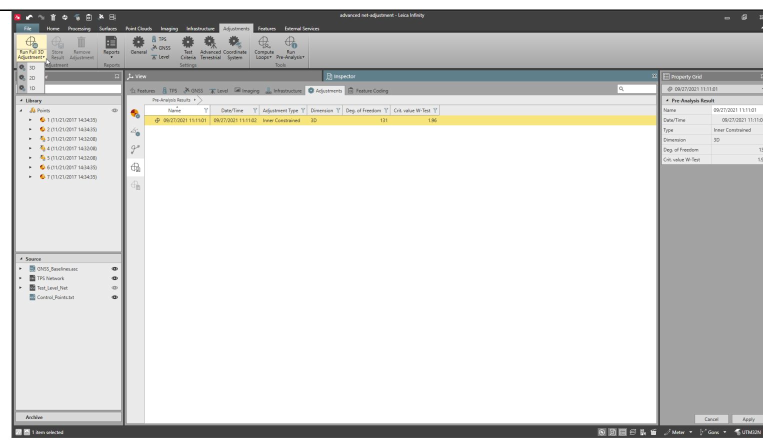
☞ In this example, the error message indicates that if we need to run a constrained adjustment for this dataset, we must keep at least three control points fixed.





5. Run an inner-constrained adjustment

5.1 To run a 3D network adjustment, select **Run Full Adjustment** from the **Adjustments** ribbon bar.



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- The results for the adjustment can now be viewed in the **Adjustment Results** side tab of the **Inspector**.
- The **F-Test** value is bigger than the **Crit. Value F-Test.** This is an indication of problems that can be related to either the wrong weight of observations or to the existence of outliers among the observations or to an unsuitable mathematical model used or to any combination of those causes.

☞ The inner-constrained adjustment is used to check the quality of the observations and detect possible outliers in the network, before constraining it to the datum of the control points.

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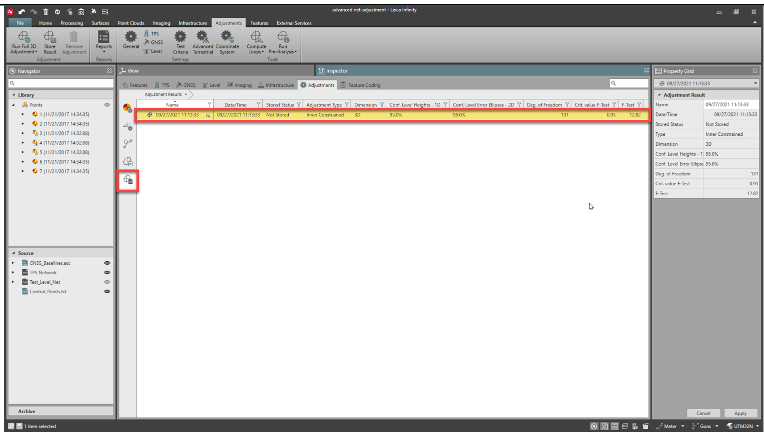
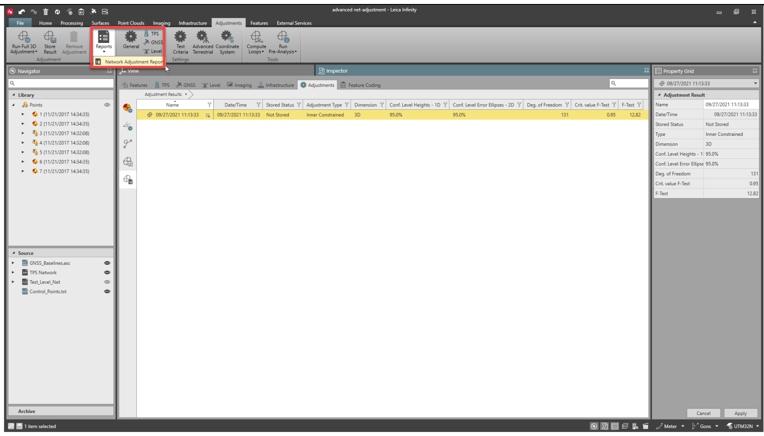
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>

To identify the reasons for the failure of the F-Test, highlight the result in the **Inspector** and select **Reports→Network Adjustment Report** from the **Adjustments** ribbon bar, or use the context menu.

</td>
<td></td>
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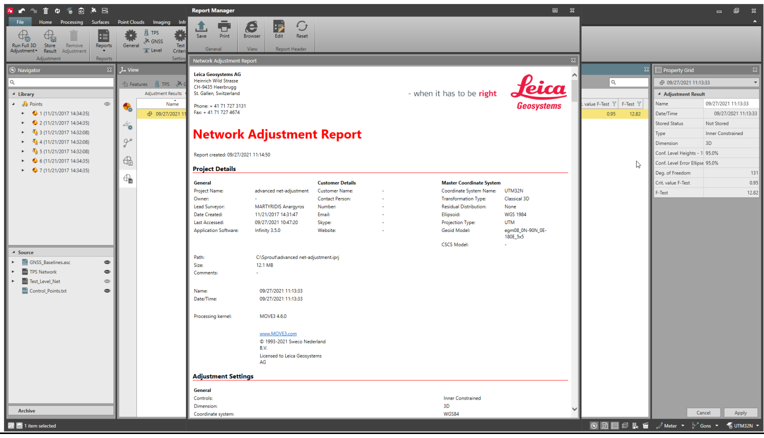
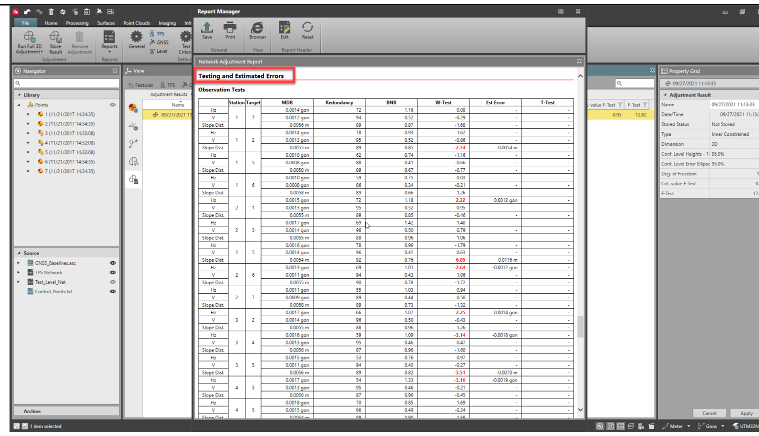
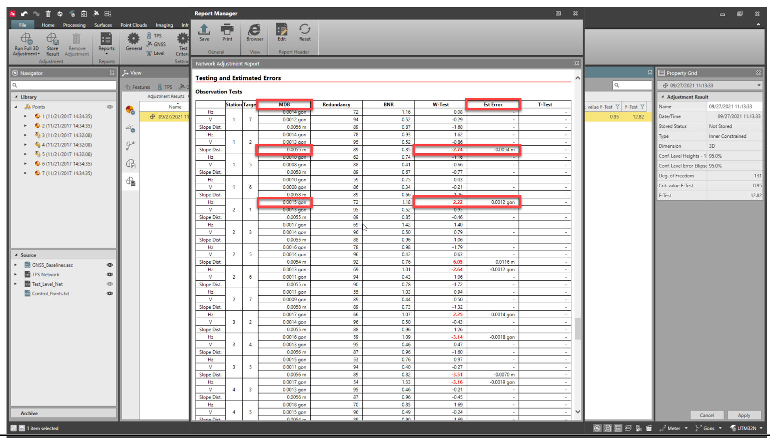
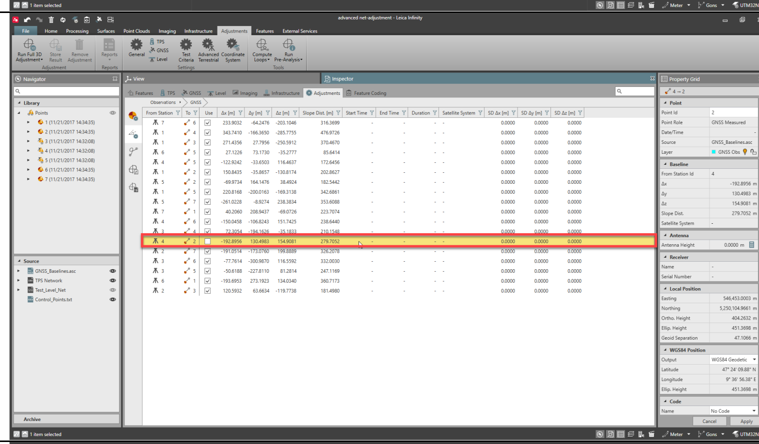
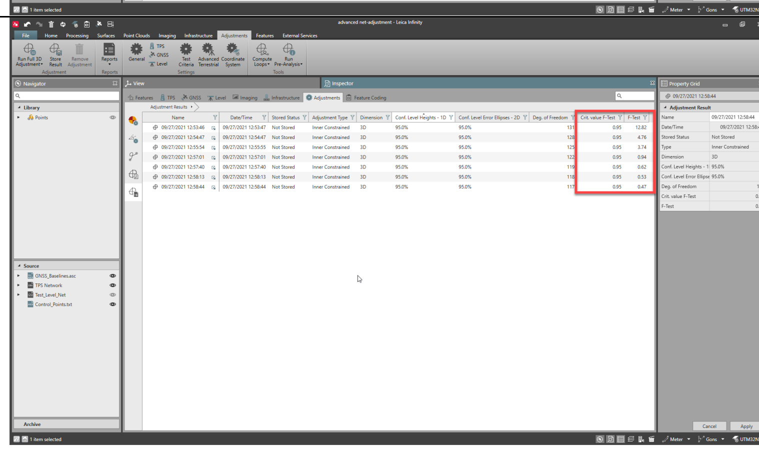
<td>

- The **Network Adjustment Report** is displayed.

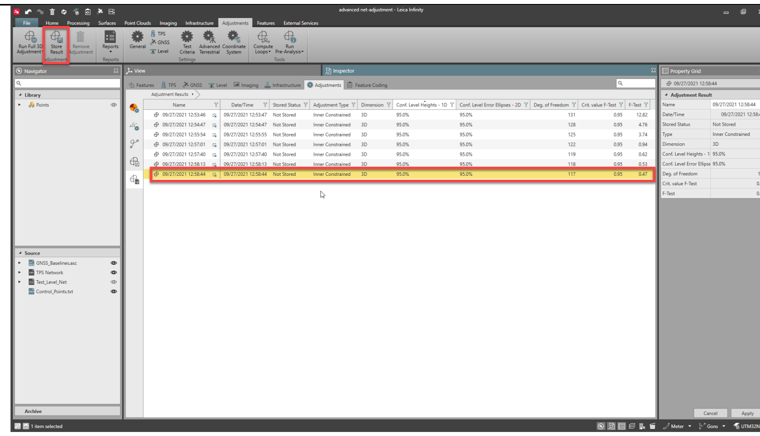
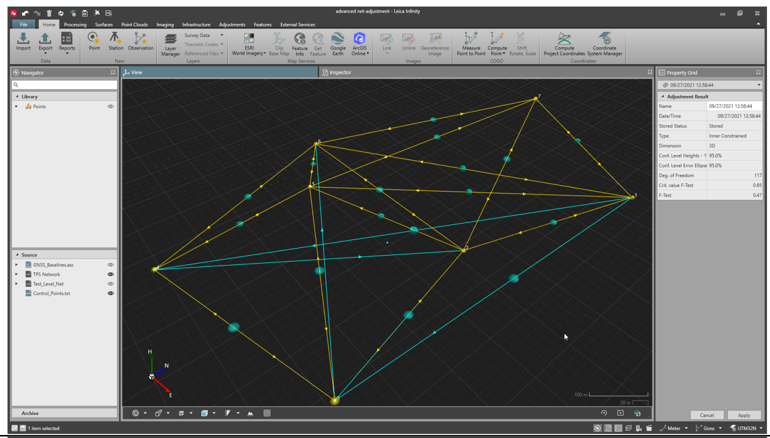
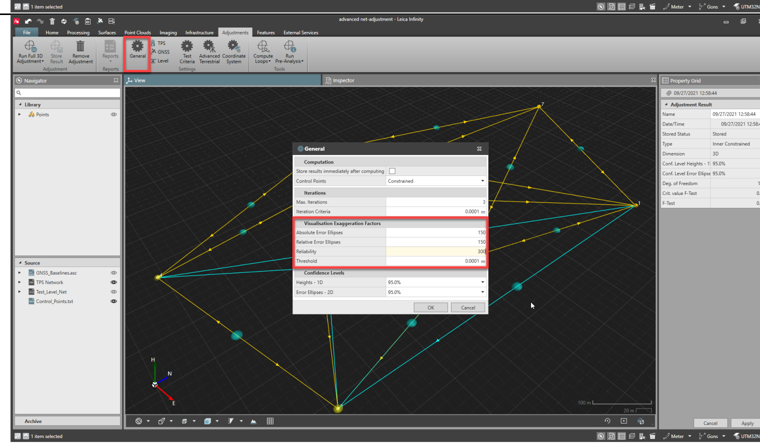
☞ In this report, information about everything related to the adjustment run can be found.

☞ In most cases, the table of **Testing and Estimated Errors** can provide useful information about the existence of outliers or a weighting problem.

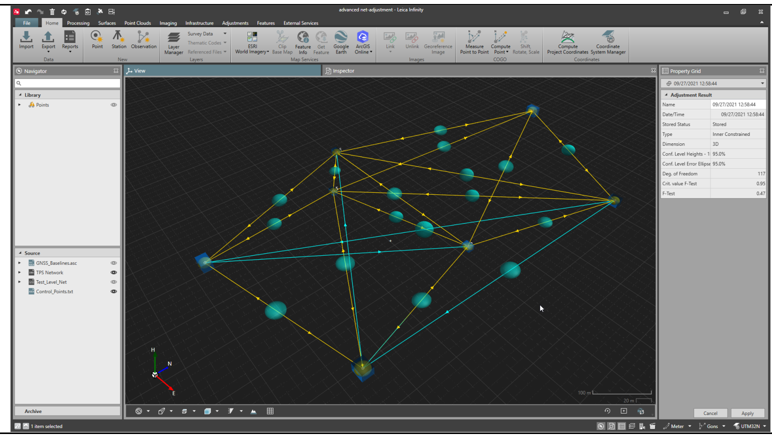
</td>
<td>
</td>
</tr>
</table>

5.3	Scroll down to the table of **Testing and Estimated Errors** and locate the observation with the biggest **T-Test** value. • The baseline 4→2 has the biggest T-Test value and since this value is much bigger than the rest of the failing ones, it can be considered as an outlier and needs to be removed from the adjustment. ☞ Only one observation must be removed from the adjustment at each run. It is the observation with the biggest absolute test value. ☞ Observations with failing tests and **Est Error** values that are smaller than the respective **MDB** values cannot be considered as true outliers.	 
5.4	To remove the possibly outlying baseline observation 4→2, locate it in the **Observations→GNSS** tab of the **Inspector** and uncheck it.	
5.5	Run a new 3D adjustment and repeat the previous steps by removing only one observation each time, until no observations can be considered as actual outliers. • After all possible outliers have been removed, the F-Test passes and all the observations with failing tests have **Est Error** values smaller to the respective **MDB** values. ☞ Reduced TPS observations may have to be removed.	

6. Visualise accuracy and reliability information

6.1	To visualise the absolute and relative error ellipsoids as well as the reliability boxes, follow the next steps: • Activate the layers **Absolute Error Ellipses**, **Relative Error Ellipses** and **Reliability Boxes**. • Make sure that the lighting mode is set to **Shaded with Edges** or **Shaded.** This can be checked by selecting the from the view toolbar: • Highlight the last adjustment result and store it by selecting **Store Result** from the **Adjustments** ribbon bar or by using the context menu. • The absolute and relative error ellipsoids and the reliability boxes are drawn in the view.	 
6.2	To change the scale of the visualised ellipsoids and boxes, select **General** from the **Adjustments** ribbon bar, type in different values at the **Visualisation Exaggeration Factors** and select **OK** to accept the changes.	

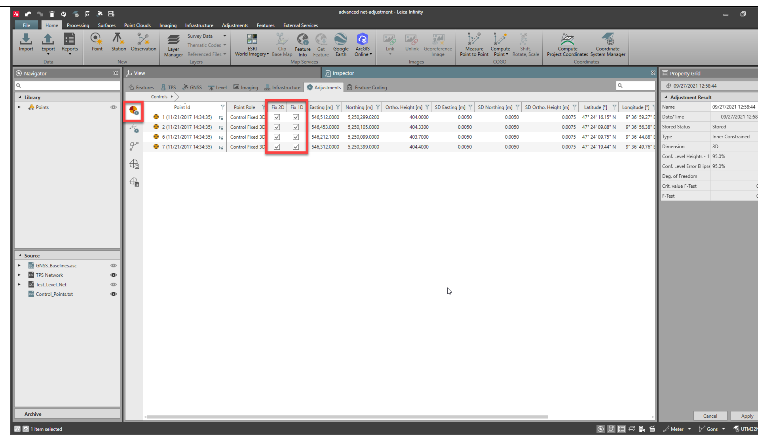
- The absolute and relative error ellipsoids and the reliability boxes are rescaled.



7. Run a constrained adjustment

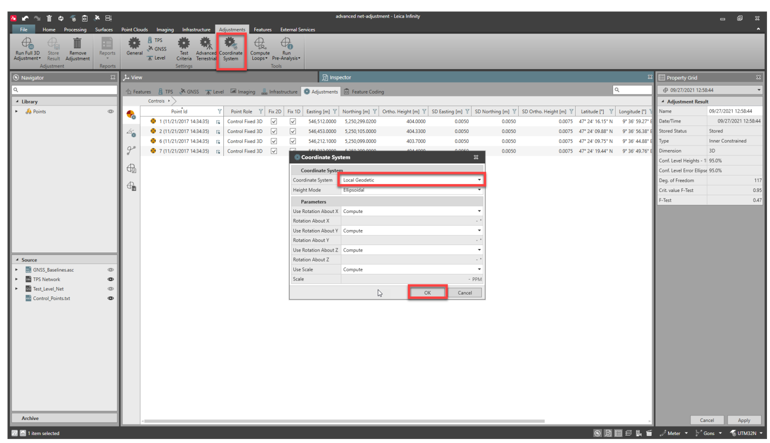
7.1 To run a constrained network adjustment in the datum defined by the control points, these need to be fixed. Follow the next steps:

- Navigate to the **Define Coordinate Constraints** side tab of the **Inspector** and set all the control points to **Fix 2D** and **Fix 1D**.



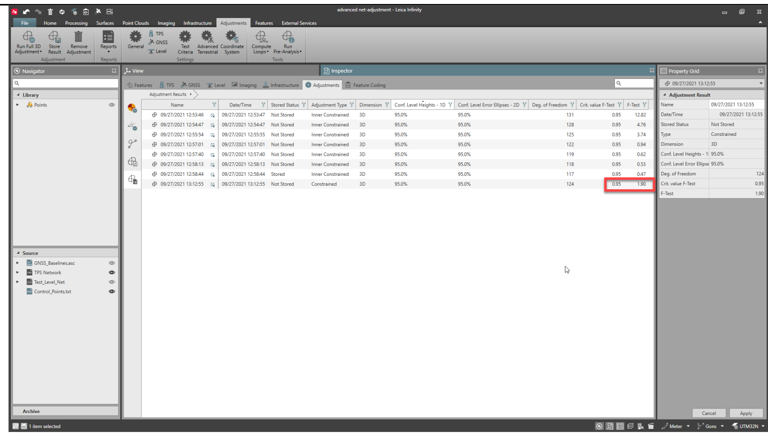
- Set the Coordinate system of the adjustment to **Local Geodetic** and select **OK**.

- **Run Full Adjustment** from the **Adjustments** ribbon bar.



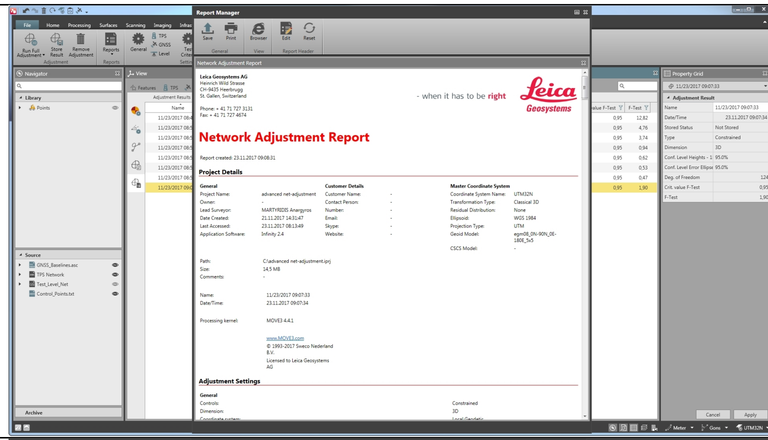
- The F-Test fails. This is a strong indication that there is a problem with the coordinates of the control points.

☞ The fact that the F-Test fails and that the control points are treated as absolutely constrained yields the conclusion that the network does not fit to the datum these control points define. Thus, we need to check for possible inconsistencies.



7.2 To identify the reasons for the failure of the F-Test, highlight the result in the **Inspector** and select **Reports→Network Adjustment Report** from the **Adjustments** ribbon bar, or use the context menu.

- The **Network Adjustment Report** is displayed.

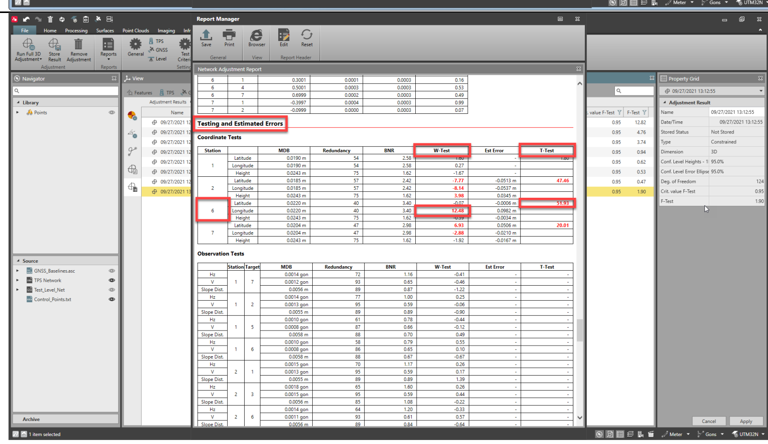


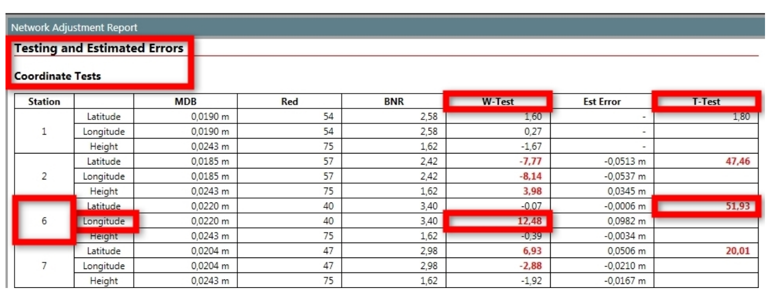
7.3 Scroll down to the **Coordinate Tests sub-**section of the **Testing and Estimated Errors** section and locate the coordinate with the biggest **W-Test** value.

- The longitude of control point 6 has the biggest W-Test value and since this value is much bigger than the rest of the failing ones, it can be considered as an outlier and needs to be removed from the adjustment.

☞ Only one coordinate observation must be removed from the adjustment at each run. It is the observation with the biggest absolute test value.

☞ Coordinate observations with failing tests and **Est Error** values that are smaller than



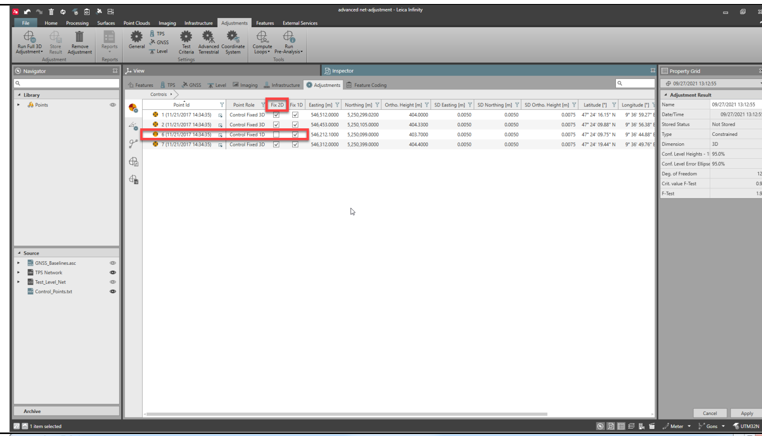
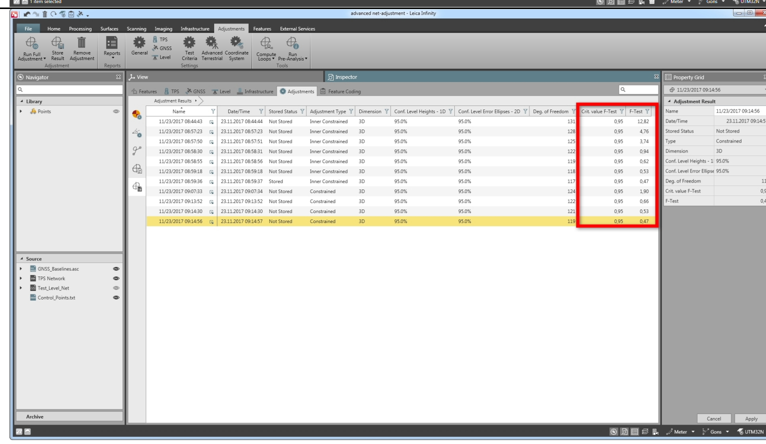


Network Adjustment Report

Testing and Estimated Errors

Coordinate Tests

Station		MDB	Red	BNR	W-Test	Est Error	T-Test
1	Latitude	0,0190 m	54	2,58	1,60	-	1,80
	Longitude	0,0190 m	54	2,58	0,27	-	
	Height	0,0243 m	75	1,62	-1,67	-	
2	Latitude	0,0185 m	57	2,42	-7,77	-0,0513 m	47,46
	Longitude	0,0185 m	57	2,42	-8,14	-0,0537 m	
	Height	0,0243 m	75	1,62	3,98	0,0345 m	
6	Latitude	0,0220 m	40	3,40	-0,07	-0,0006 m	51,93
	Longitude	0,0220 m	40	3,40	12,48	0,0982 m	
	Height	0,0243 m	75	1,62	-0,39	-0,0034 m	
7	Latitude	0,0204 m	47	2,98	6,93	0,0506 m	20,01
	Longitude	0,0204 m	47	2,98	-2,88	-0,0210 m	
	Height	0,0243 m	75	1,62	-1,92	-0,0167 m	

	the respective **MDB** values cannot be considered as true outliers.	
7.4	To remove the possibly outlying longitude coordinate of the control point 6 locate it in the **Define Coordinate Constraints** side tab of the **Inspector** and uncheck **Fix 2D**.	
7.5	Run a new 3D adjustment and repeat the previous steps by removing only one control point coordinate observation each time, until no coordinates can be considered as actual outliers. • After all possible outliers have been removed, the F-Test passes and all the observations with failing tests have **Est Error** values smaller to the respective **MDB** values.	

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- when it has to be **right**