How To
Combined TPS and GPS adjustment

Version 4.6

SWECO

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1. Introduction

This document describes how measurement data from both TPS and GPS data collectors can be imported into MOVE3 and how the data can be adjusted as a combined network.

TPS measurements from Leica GSI/DBX (Leica 1200), Topcon, Sokkia SDR33 and Trimble DC/JobXML format can be added to a MOVE3 project. GPS baselines can be imported from Leica ASC (from LGO) and DBX format (RTK measurements), Trimble DC and JobXML, Topcon tvf and Sokkia SGL.

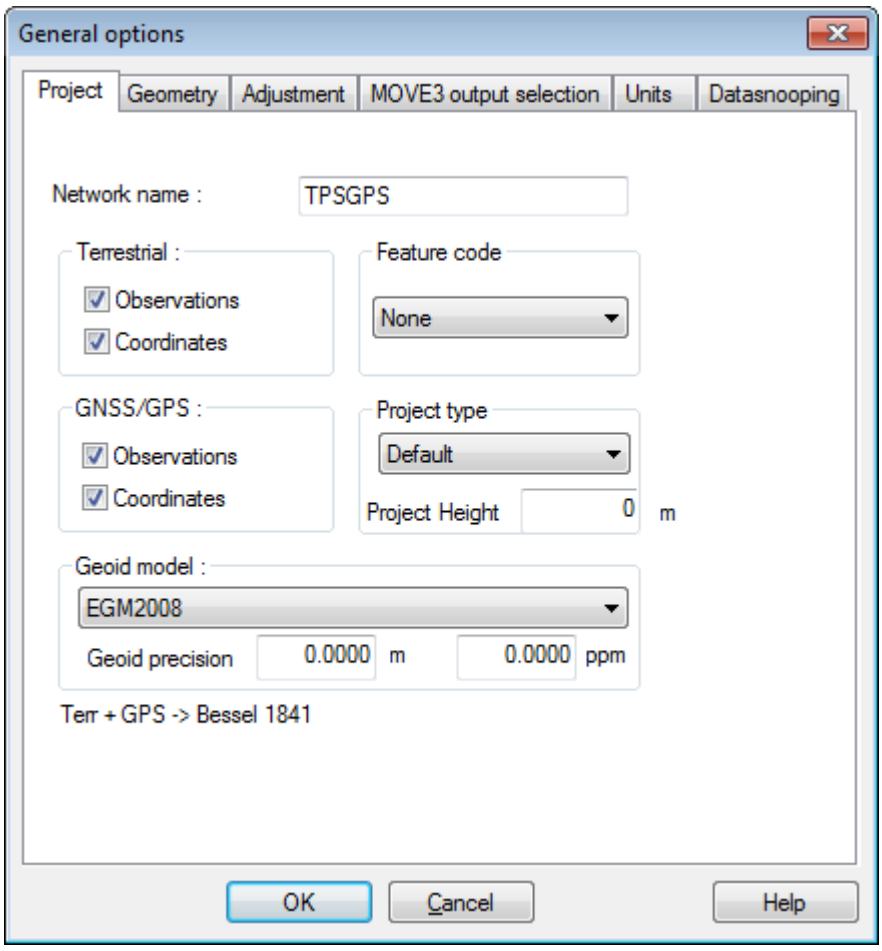
Please note that this is a sample. The actual settings may differ depending on your local requirements.

2. New MOVE3 Project

Create a new MOVE3 project by specifying the project name. A template project (option file) can be selected to use previously defined project settings.

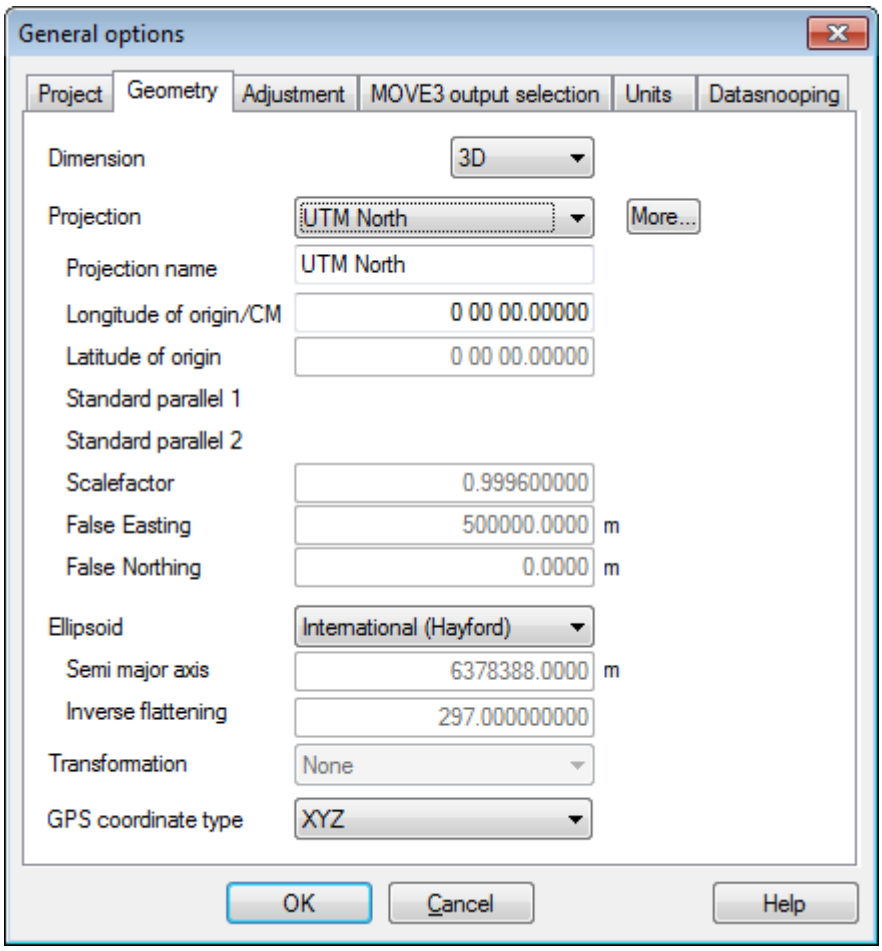
3. Options

Starting a new project without using a template will set all options to the MOVE3 defaults. In this case you must set at least some of the options to meet the combined adjustment requirements. Set the *Project* options to both terrestrial and GPS. Select the proper Geoid model if available. Without geoid model, corrections from orthometric to ellipsoidal heights will not be applied. This may not be a problem if your working area is small (< 5 km) . The EGM 2008 provides worldwide geoid data, but since it is a global model it does not have the highest accuracy (the EGM2008 geoid model must be downloaded and installed separately).



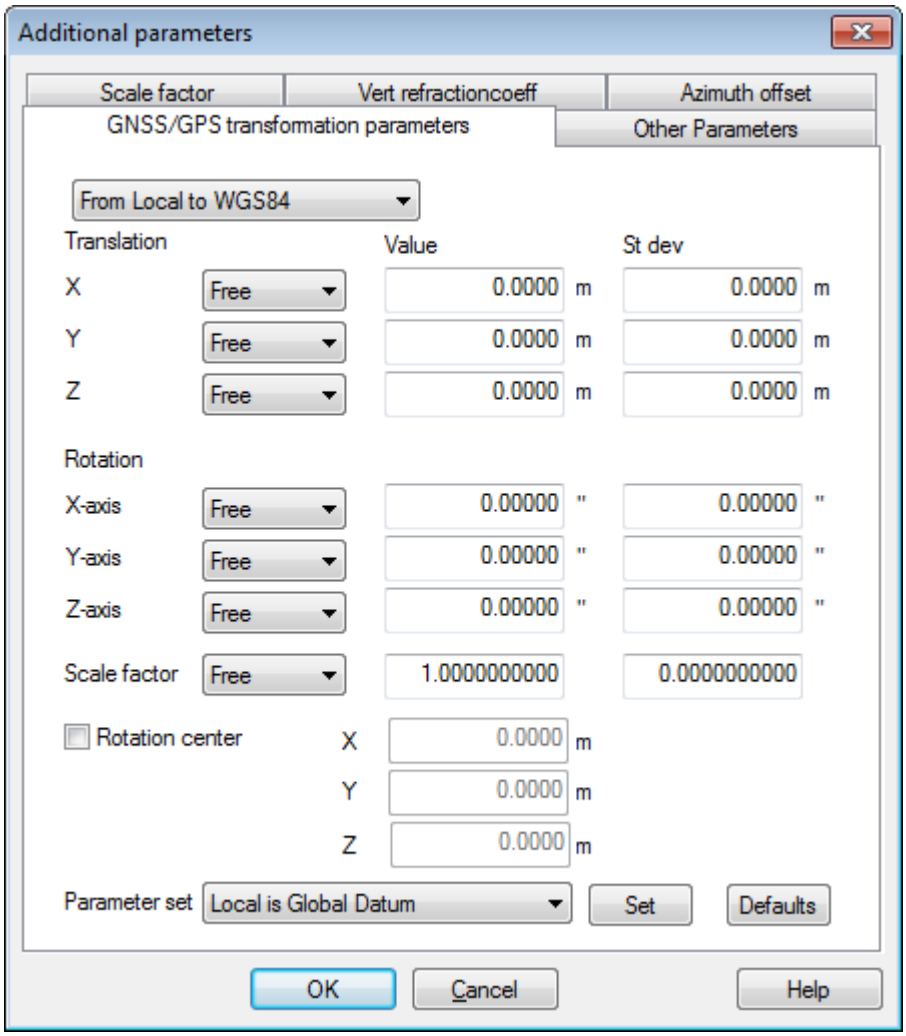
Project tab sheet.

In the *Geometry* tab the Dimension must be set to 3D or 2D, depending on the results you want to achieve. Please note that points measured with GPS will always be processed in 3D even if the Dimension switch is set to 2D. Select the proper projection and set the required projection parameters and ellipsoid.



Geometry tab sheet.

If GNSS/GPS parameters between WGS84 and the local system are available, they can be entered in the GPS transformation parameter tab.

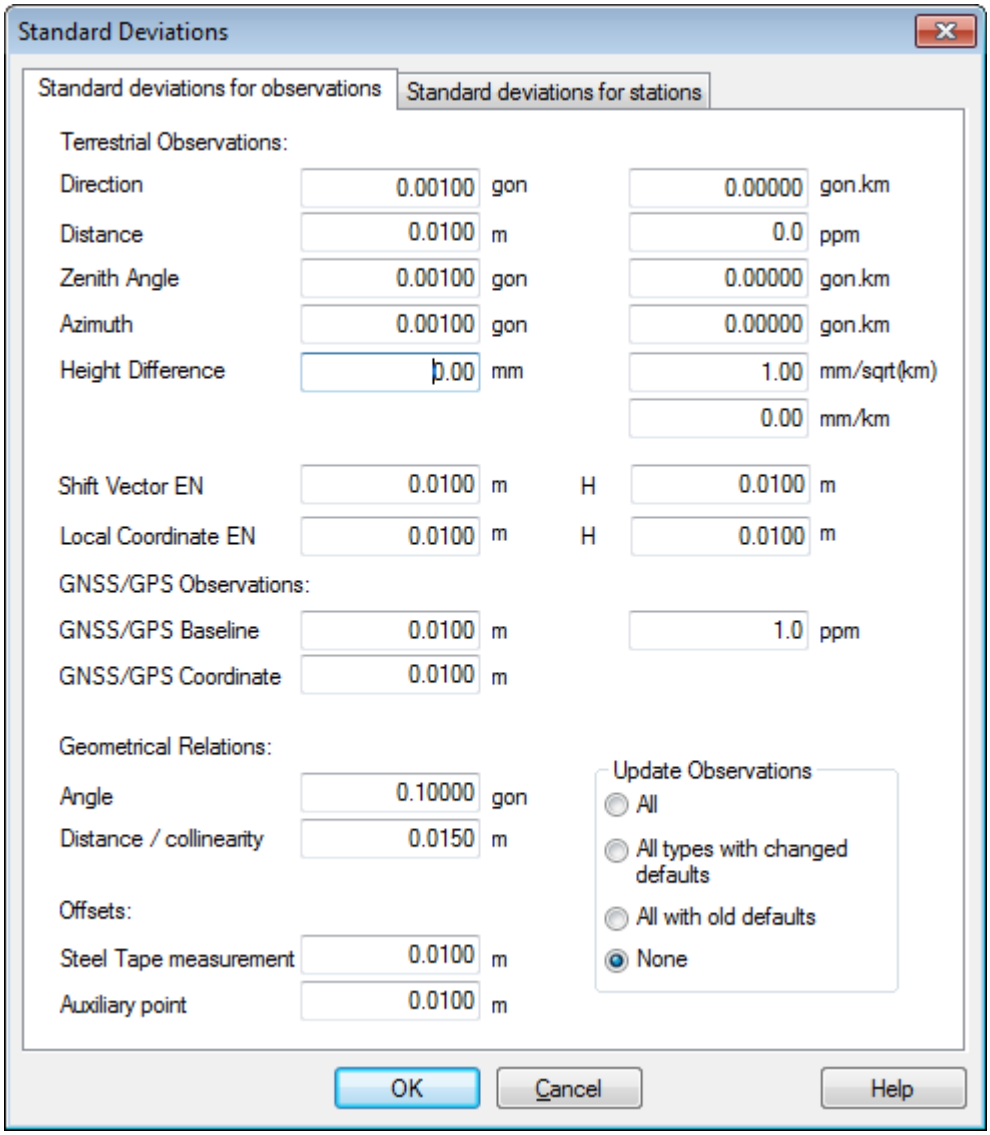


GNSS/GPS transformation parameters tab sheet.

Set parameters to fixed and enter the appropriate values. Please check whether the parameters are available From Local to WGS84 or From WGS to Local.

4. Default standard deviations

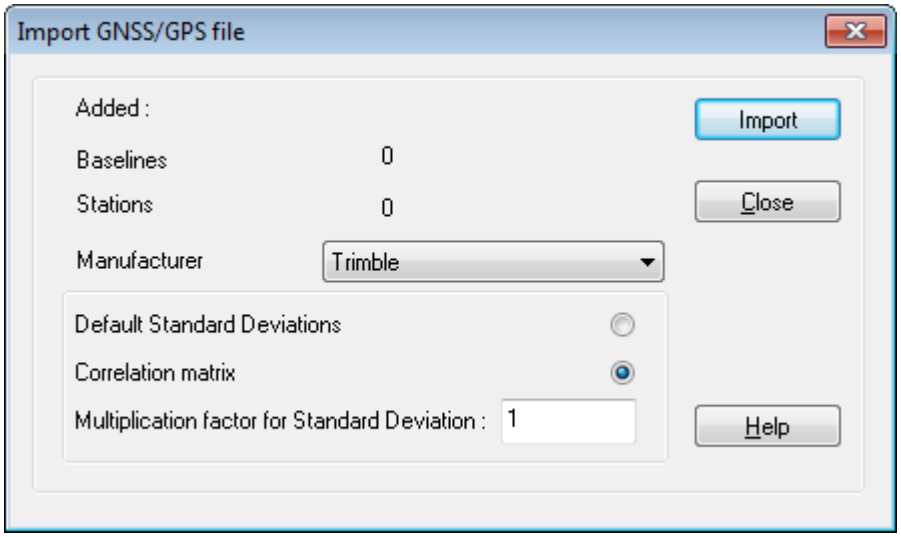
Before importing the data it is important to properly set the defaults for the standard deviations of the TPS observations direction, distance and zenith angle. The standard deviations have an absolute part and a relative. The default values are added to each imported observation. For GPS observations the covariance matrix will also be imported.



Standard Deviations.

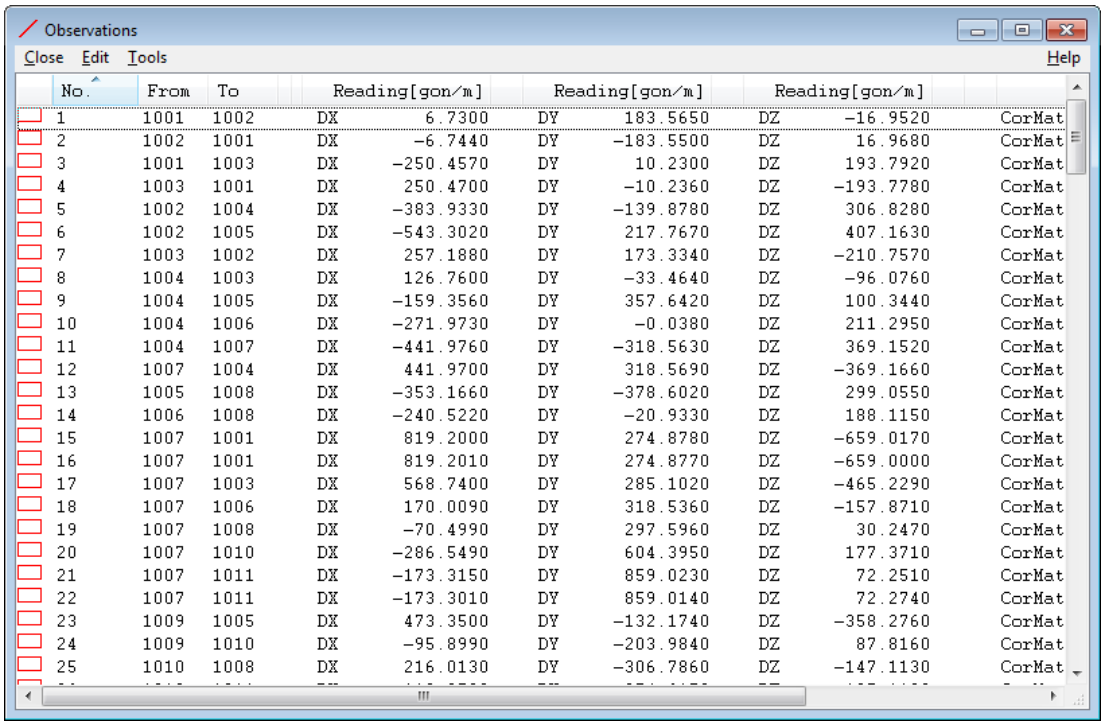
5. Import GNSS/GPS baselines

Select the menu option Import/export | GNSS/GPS baselines and specify the manufacturer. Then click Import and select the GNSS/GSP data file(s).



Import GNSS/GPS file dialog.

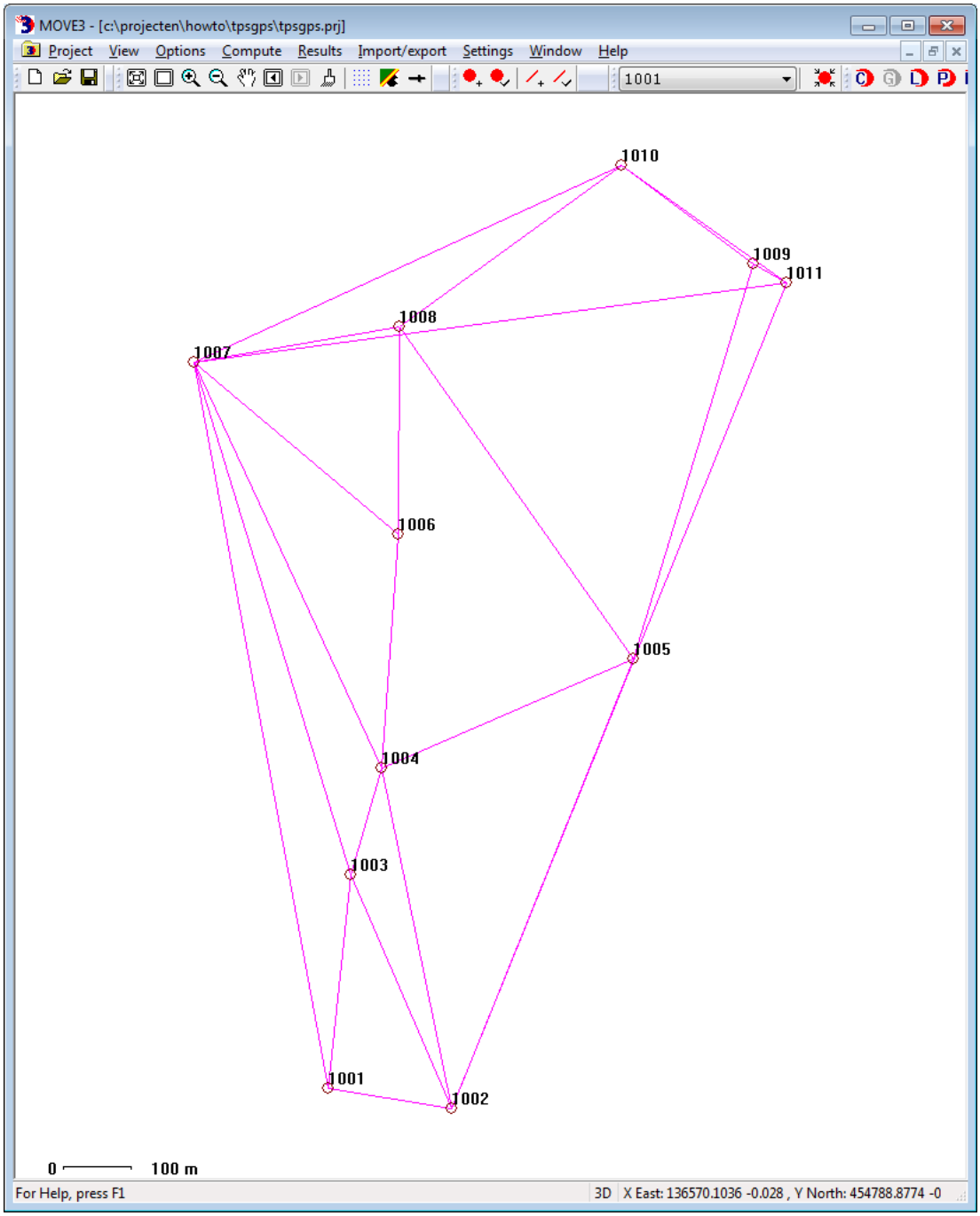
The imported data will be shown in the observation list that can be opened under View | Observations.



No.	From	To	Reading[gon/m]		Reading[gon/m]		Reading[gon/m]	
1	1001	1002	DX	6.7300	DY	183.5650	DZ	-16.9520	CorMat
2	1002	1001	DX	-6.7440	DY	-183.5500	DZ	16.9680	CorMat
3	1001	1003	DX	-250.4570	DY	10.2300	DZ	193.7920	CorMat
4	1003	1001	DX	250.4700	DY	-10.2360	DZ	-193.7780	CorMat
5	1002	1004	DX	-383.9330	DY	-139.8780	DZ	306.8280	CorMat
6	1002	1005	DX	-543.3020	DY	217.7670	DZ	407.1630	CorMat
7	1003	1002	DX	257.1880	DY	173.3340	DZ	-210.7570	CorMat
8	1004	1003	DX	126.7600	DY	-33.4640	DZ	-96.0760	CorMat
9	1004	1005	DX	-159.3560	DY	357.6420	DZ	100.3440	CorMat
10	1004	1006	DX	-271.9730	DY	-0.0380	DZ	211.2950	CorMat
11	1004	1007	DX	-441.9760	DY	-318.5630	DZ	369.1520	CorMat
12	1007	1004	DX	441.9700	DY	318.5690	DZ	-369.1660	CorMat
13	1005	1008	DX	-353.1660	DY	-378.6020	DZ	299.0550	CorMat
14	1006	1008	DX	-240.5220	DY	-20.9330	DZ	188.1150	CorMat
15	1007	1001	DX	819.2000	DY	274.8780	DZ	-659.0170	CorMat
16	1007	1001	DX	819.2010	DY	274.8770	DZ	-659.0000	CorMat
17	1007	1003	DX	568.7400	DY	285.1020	DZ	-465.2290	CorMat
18	1007	1006	DX	170.0090	DY	318.5360	DZ	-157.8710	CorMat
19	1007	1008	DX	-70.4990	DY	297.5960	DZ	30.2470	CorMat
20	1007	1010	DX	-286.5490	DY	604.3950	DZ	177.3710	CorMat
21	1007	1011	DX	-173.3150	DY	859.0230	DZ	72.2510	CorMat
22	1007	1011	DX	-173.3010	DY	859.0140	DZ	72.2740	CorMat
23	1009	1005	DX	473.3500	DY	-132.1740	DZ	-358.2760	CorMat
24	1009	1010	DX	-95.8990	DY	-203.9840	DZ	87.8160	CorMat
25	1010	1008	DX	216.0130	DY	-306.7860	DZ	-147.1130	CorMat

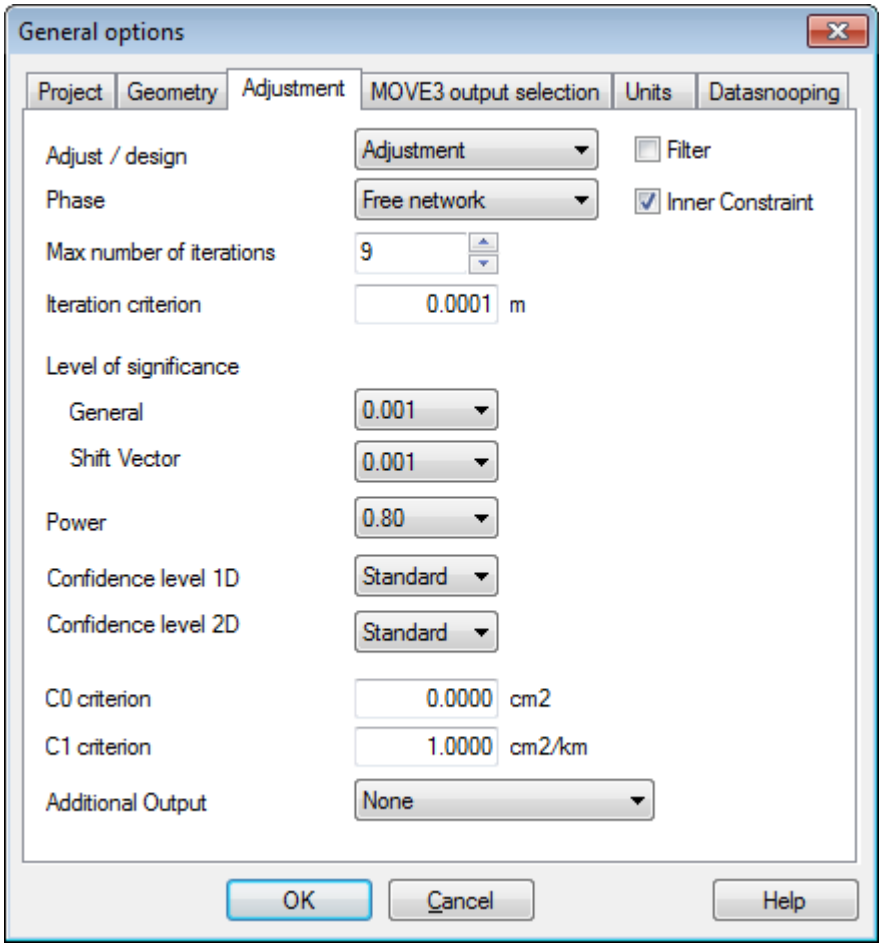
Observation dialog

The import also adds approximate GPS coordinates for all points and will give a proper display of the network.



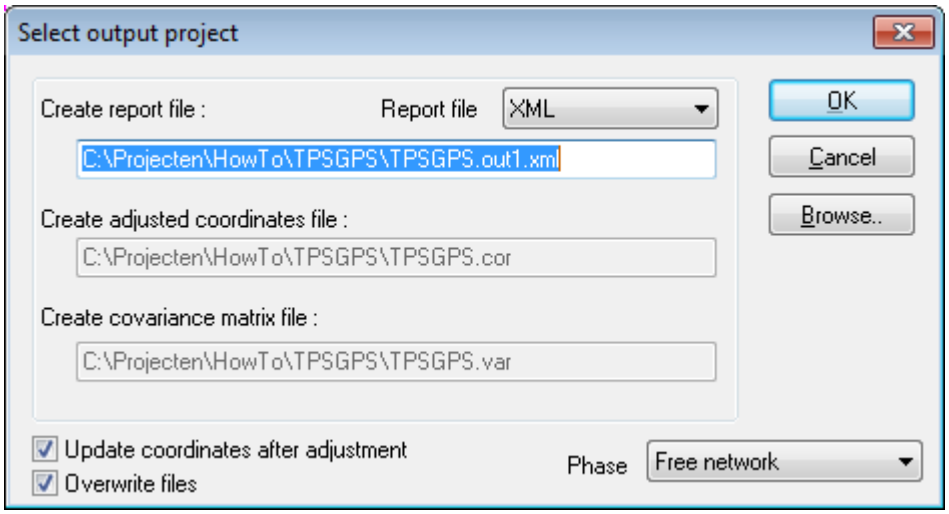
6. Inner constraint network adjustment

This network can be adjusted as a free network if you select to use the inner constraint adjustment in the Adjustment tab



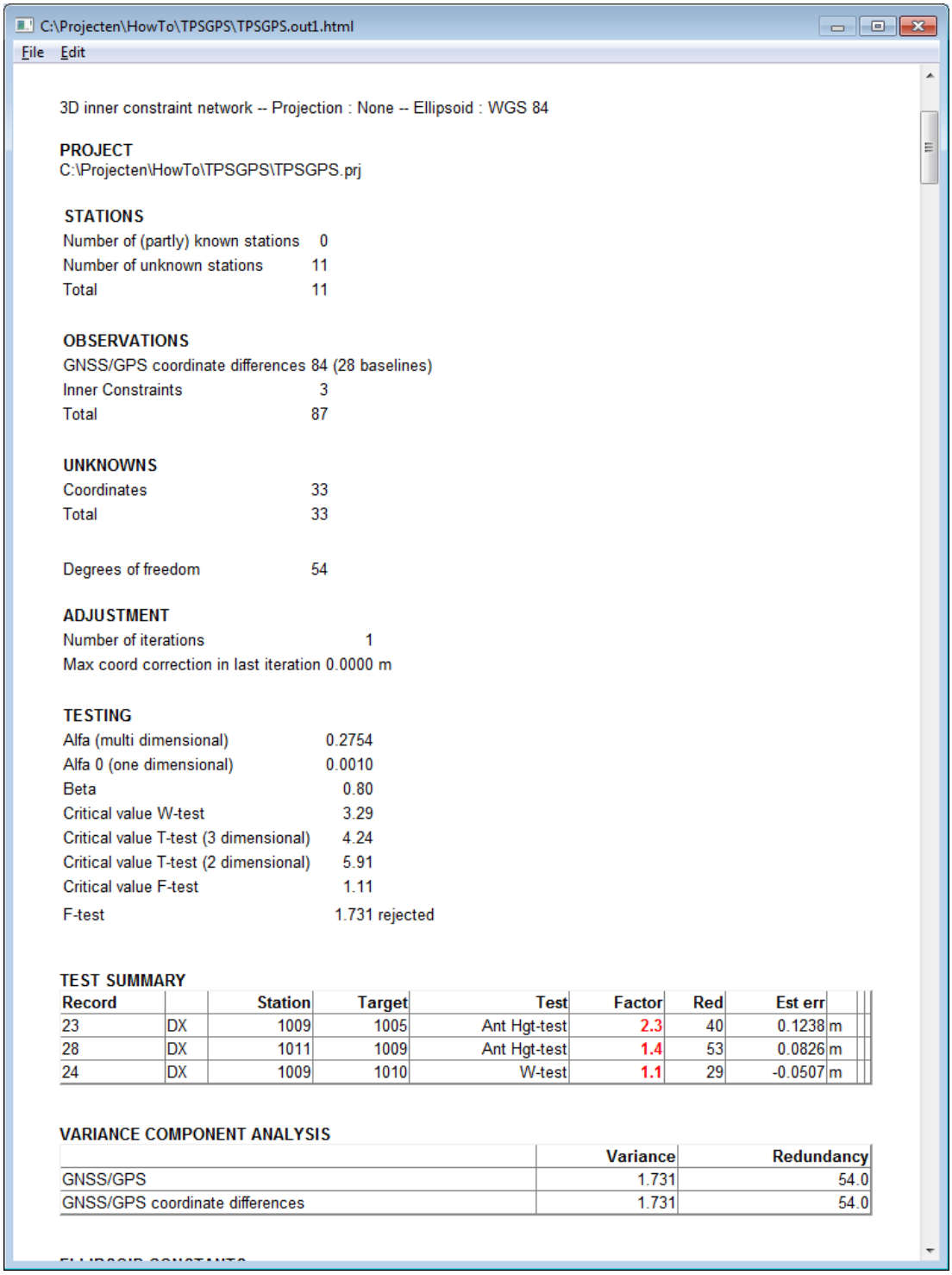
General options Adjustment tab

Then go to Compute| MOVE3 and adjust the free network to find errors in the observations.



Compute Free network

The MOVE3 report will give the testing results of the adjustment, allowing to identify errors when sufficient redundancy is available.



C:\Projecten\HowTo\TPSGPS\TPSGPS.out1.html

File Edit

3D inner constraint network -- Projection : None -- Ellipsoid : WGS 84

PROJECT
C:\Projecten\HowTo\TPSGPS\TPSGPS.prj

STATIONS

Number of (partly) known stations	0
Number of unknown stations	11
Total	11

OBSERVATIONS

GNSS/GPS coordinate differences	84 (28 baselines)
Inner Constraints	3
Total	87

UNKNOWNS

Coordinates	33
Total	33

Degrees of freedom	54

ADJUSTMENT

Number of iterations	1
Max coord correction in last iteration	0.0000 m

TESTING

Alfa (multi dimensional)	0.2754
Alfa 0 (one dimensional)	0.0010
Beta	0.80
Critical value W-test	3.29
Critical value T-test (3 dimensional)	4.24
Critical value T-test (2 dimensional)	5.91
Critical value F-test	1.11
F-test	1.731 rejected

TEST SUMMARY

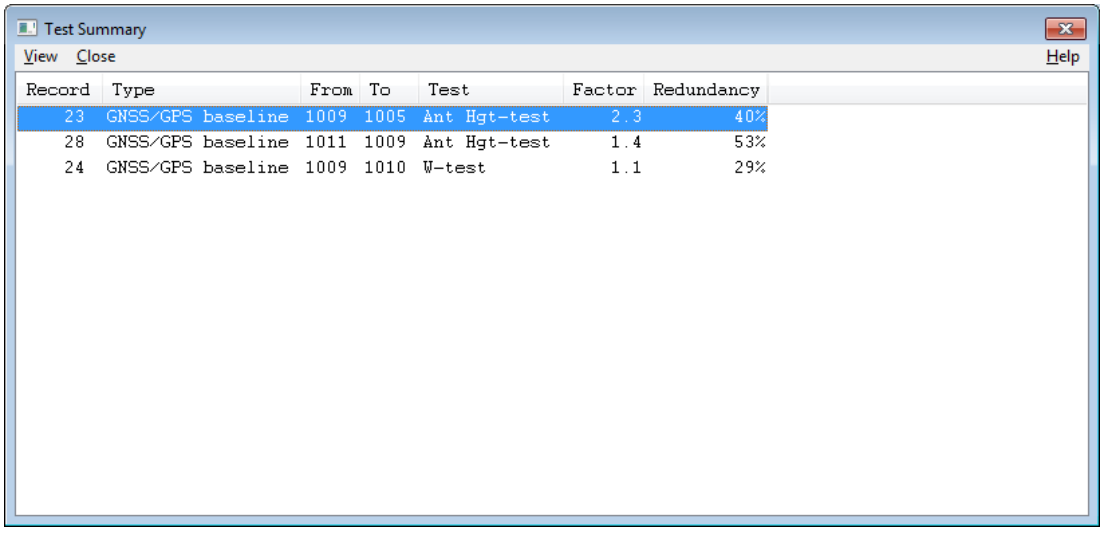
Record		Station	Target	Test	Factor	Red	Est err	
23	DX	1009	1005	Ant Hgt-test	2.3	40	0.1238	m
28	DX	1011	1009	Ant Hgt-test	1.4	53	0.0826	m
24	DX	1009	1010	W-test	1.1	29	-0.0507	m

VARIANCE COMPONENT ANALYSIS

	Variance	Redundancy
GNSS/GPS	1.731	54.0
GNSS/GPS coordinate differences	1.731	54.0

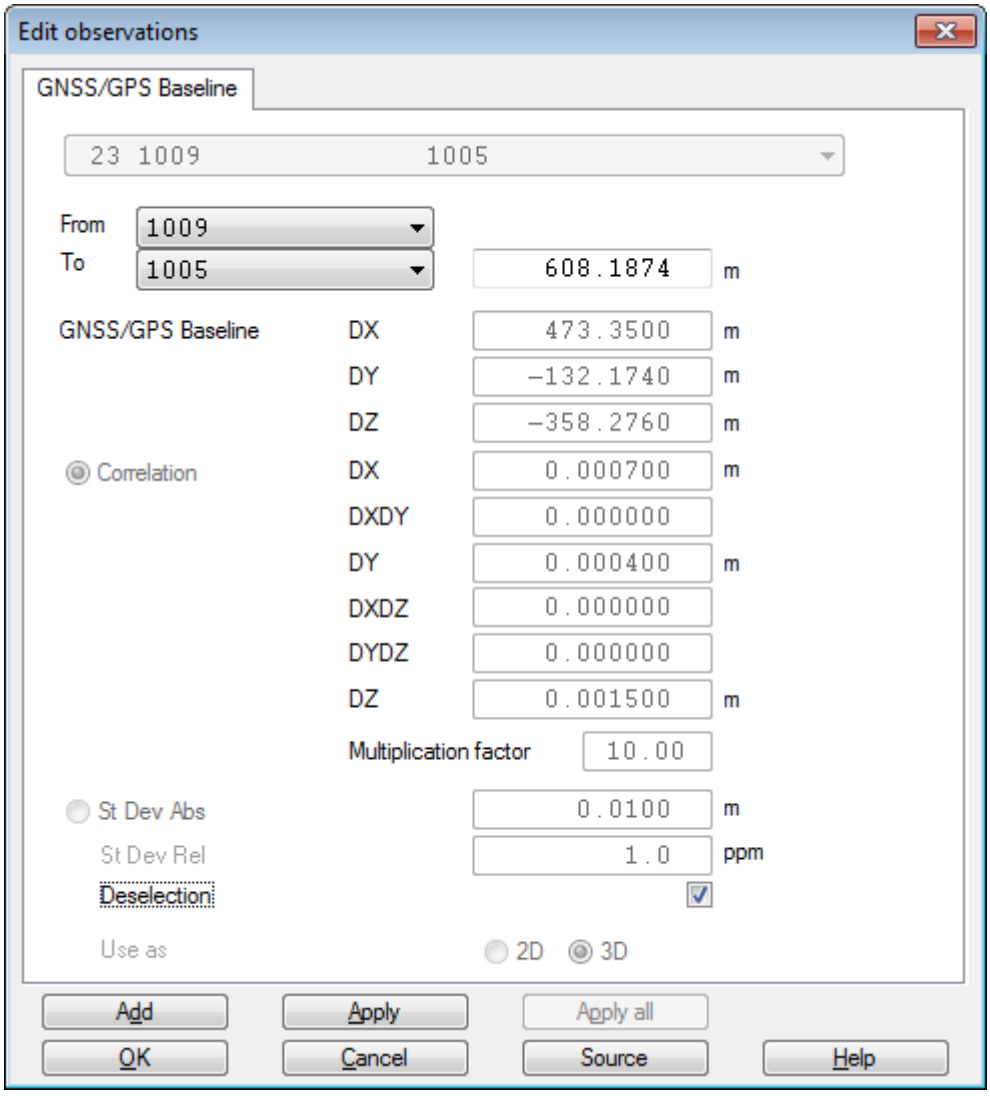
MOVE3 adjustment report

In the report the Test Summary helps identifying errors. The observation with the largest test-factor is the most likely error. To access the observation tab open the rejected items view from the Results menu. This view shows the observations listed in the test summary.



Rejected observations

Click the first item in the list to open the observation tab of the largest rejected observation. In this case we will deselect the rejected baseline. And re-compute the free network to check if other rejections are present.

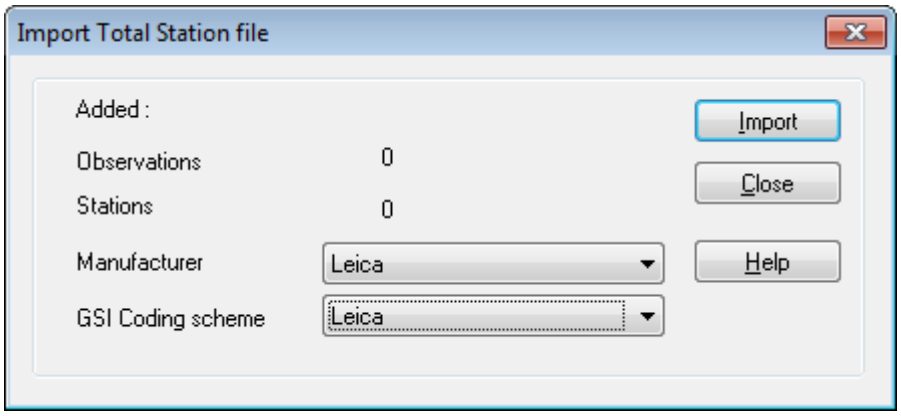


Edit observation tab sheet

Once the free network is accepted additional total station measurements will be added.

7. Import TPS measurements

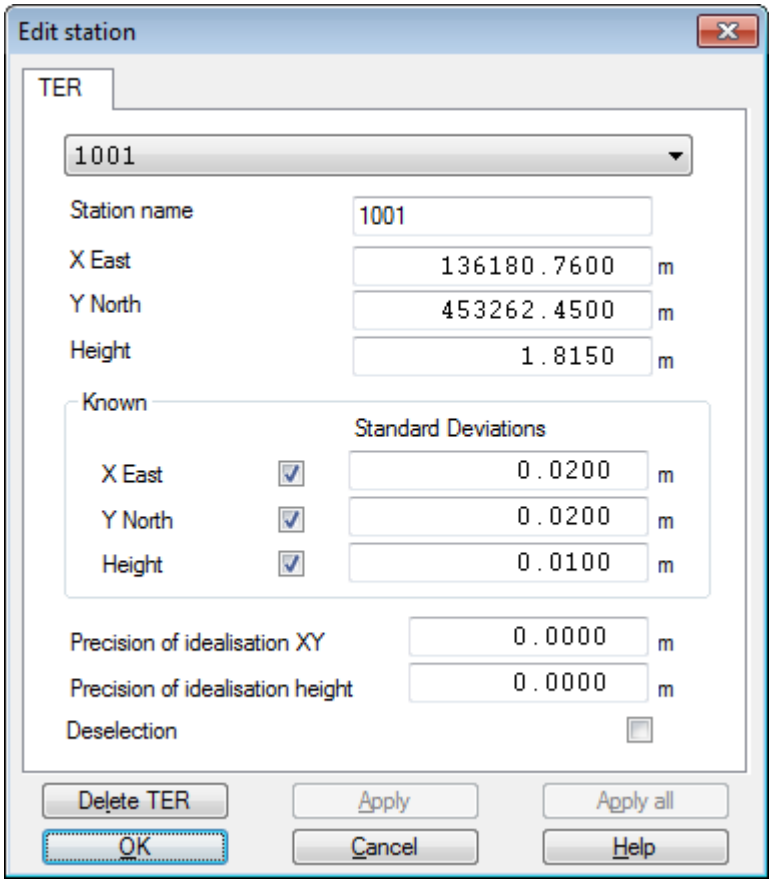
Select the menu option Import/export | Total Station and specify the manufacturer. Then click Import and select the raw data file(s).



Import Total Station dialog.

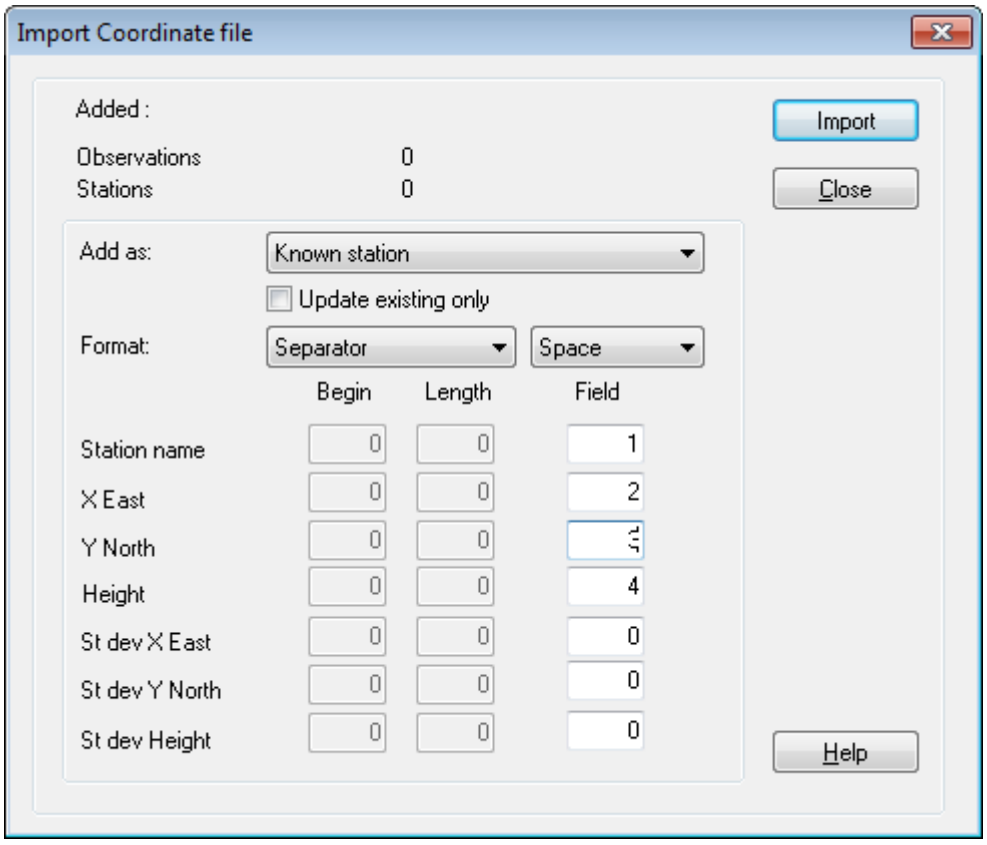
8. Adding known points

A proper adjustment requires that all control points are added as known stations. Go to the View | Station and edit the control stations. Enter the proper station coordinates and check the Known check boxes.



Adding Known Points

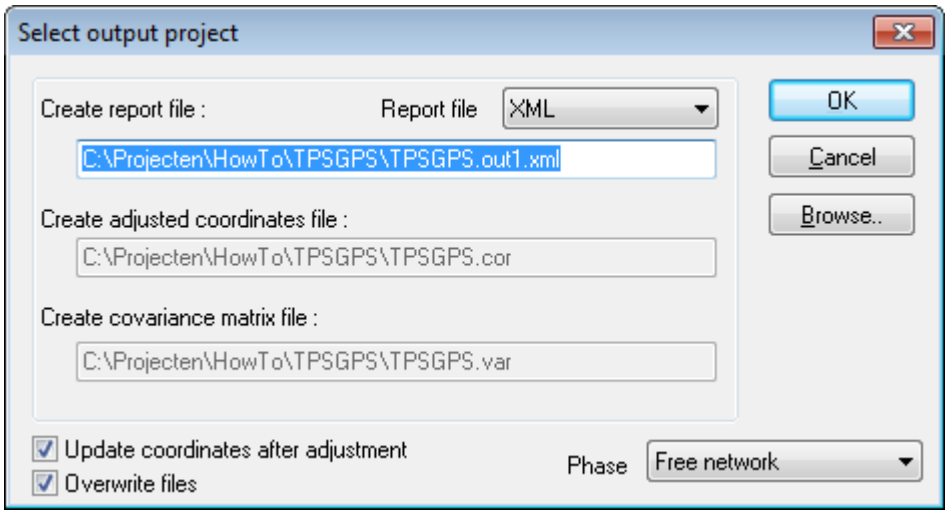
Alternatively known points can also be added via the Import/export menu option Coordinate file.



Import Known Points

9. Adjustment in Phases

You're now ready to adjust the combined network. It is best to do a free network first for the combined network to perform testing on the observations and find outliers. Go to Compute| MOVE3 and set the phase to Free network.

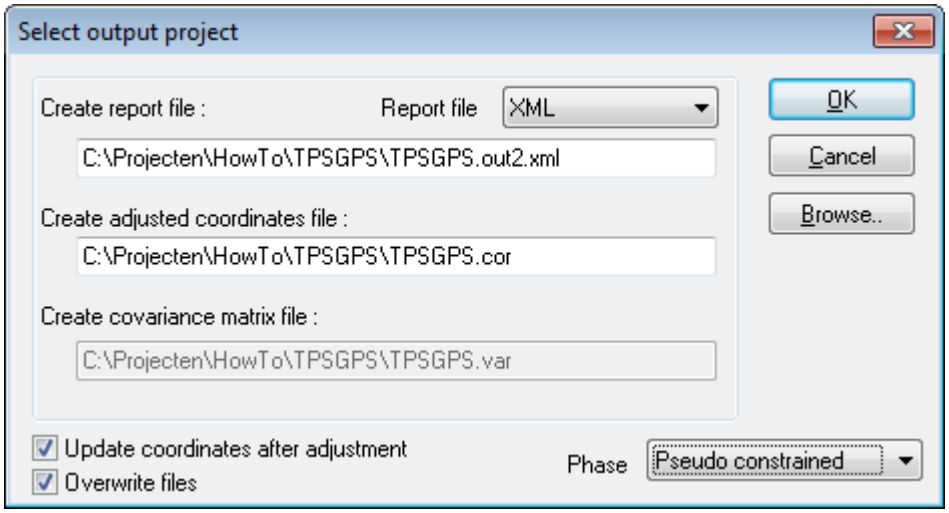


Compute Free network

The MOVE3 report will give the testing results of the adjustment, allowing to identify errors when sufficient redundancy is available.

In case one does not meet the predefined quality of the observations the global F-test will be rejected. This may be caused by either a too optimistic set of standard deviations of the observations or by observation errors. Usually a rejection is caused by errors in the observations. To identify the observation errors one can use the W-test. The observation with the largest W-test is the most suspect observation. One should try to solve the cause of the error, maybe there was a problem during import of the raw observations that can be corrected. The estimated error can be used for this purpose because it gives an estimate of the size of the observational error. If the error cannot be repaired, the observation can be deselected (not used in the adjustment). This will however affect the reliability of the network. In some cases rejected observations may have to be re-measured to maintain proper reliability.

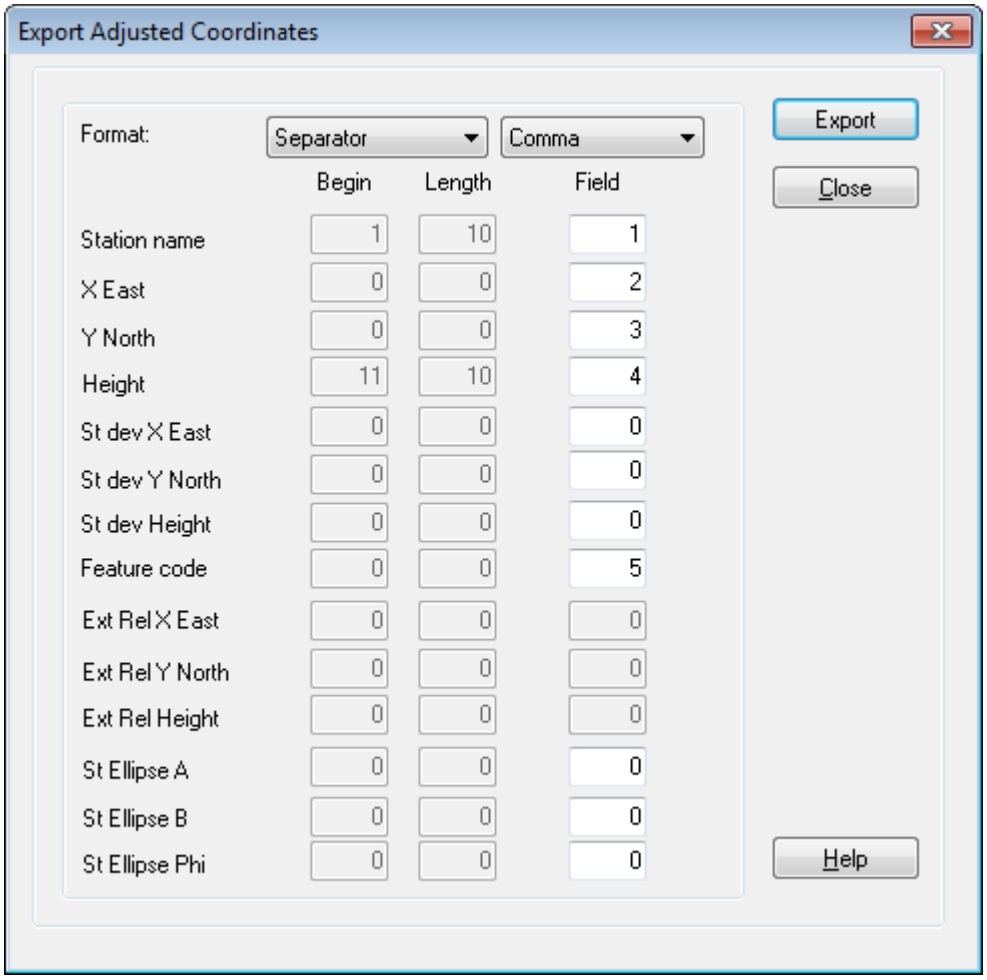
After an acceptable Free network adjustment the combined network can be constrained to all available control points in the Absolute constrained adjustment. This phase will result in testing of the available control heights and the final adjusted coordinate computation.



Compute Absolute constrained network

The quality of the control points (the standard deviation of the known coordinates) is taken into account for testing. If the combined network does not fit to the control points there may be rejected points. If the F-test is rejected, the largest W-test value can be used to identify the errors. If a control point is rejected this may have been caused by a mistake in entering the known points coordinates or by entering a wrong control point. It is best to check this out first. There may be a deformation in the control points as well, causing the error. If the problem cannot be solved the control point can be removed as a control point for the adjustment. The point will then be re-adjusted, getting new adjusted coordinates.

The final results are stored in the MOVE3 report file, but they are also written to the MOVE3 COR file. The adjusted coordinates can also be exported using the Import/export menu option Adjusted Coordinates. Specify the format and the fields you want to export and write the data to an ASCII file.



Export Adjusted Coordinates tab sheet