TUTORIAL

Version 4.6

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Contents

1.1. Tutorial

1.1.1. Introduction

In this tutorial the following conventions are used:

Italics	*Italics* represent text as it appears on screen. This format is also used for anything you must type literally.
Underline	The hot key of the MOVE3 menu options is shown underlined, similar to the appearance on the screen.

After installing MOVE3 a demo project is available in the Public Documents folder (Windows 10: C:\Users\Public\Documents\Sweco\MOVE3\Sample Data). The demo files contain data of a small network, shaped as a braced quadrilateral, called 'Kamerik'. The network contains both terrestrial and GNSS/GPS observations: directions, distances, zenith angles, height differences and GNSS/GPS baselines. This network should not be regarded as representative for the average survey project; it serves merely as a means to illustrate the main MOVE3 features.

The following subjects will be demonstrated hereafter:

- starting MOVE3;
- handling a project;
- controlling geometry and dimension;
- editing;
- adjustment in phases and testing;
- saving a project and leaving MOVE3.

1.1.2. Starting and Using MOVE3 for Windows

To start MOVE3 for Windows click the *MOVE3* item under *Programs*.

You are now in the MOVE3 Windows graphical user interface (GUI). This interface can be used to create new projects, edit data, start computations and view the results. The horizontal menu bar lists the names of the available drop down menus.

1.1.3. Projects

You are about to open the demo project Kamerik. In MOVE3 a project is defined, as a group of files comprising all data needed to process a network. The project Kamerik consists of:

kamerik.prj	project file with options and parameters
kamerik.tco	terrestrial coordinate file
kamerik.gco	GPS coordinate file
kamerik.obs	observations file

The PRJ file is the key file in the project because it contains the parameters, which control how the network is processed. For this reason projects are opened and saved by selecting the corresponding PRJ file.

From the *Project* menu select *Open...*. A file selection box opens showing by default all PRJ files in the current directory. Select *KAMERIK.PRJ* from the subdirectory *Sample Data*. As a result the input files of this project are read as indicated by the message box. The Kamerik network appears on your screen.

Now go to *Options* ➔ *General* and select *Project...* from the drop-down menu. The dialog box reveals more information on the Kamerik project (Figure 1.1-1). The network comprises a combination of terrestrial and GNSS/GPS observations and coordinates. At the base of the box it reads:

$$Terr + GPS \rightarrow RD$$

This means that the terrestrial and GNSS/GPS observations in the network will produce adjusted coordinates in the RD (Dutch stereographic) map projection. By definition, in MOVE3 the adjusted coordinates will be given in the map projection pertaining to the input known coordinates.

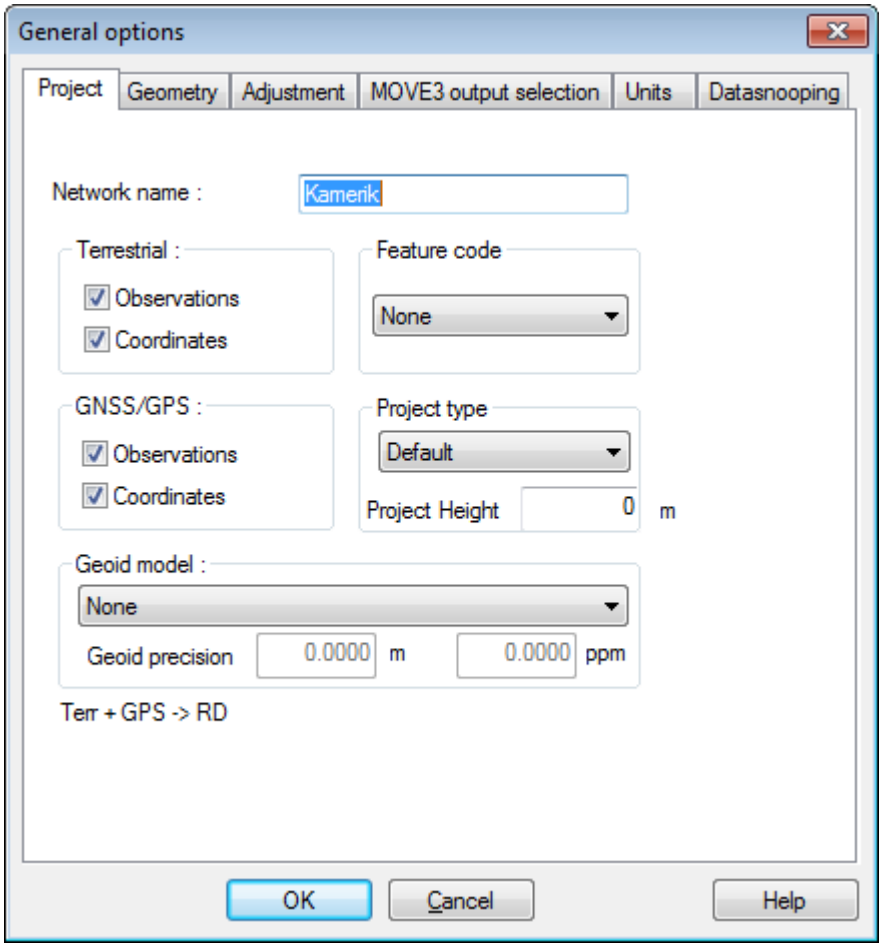


Figure 1.1-1: The Kamerik project in the Options dialog box.

The *Project* tab sheet enables you to exclude or include observation and/or coordinate types prior to the adjustment. Click the upper left check box, the switch for terrestrial observations. This indicates that terrestrial observations are now excluded. At the base of the box it now reads:

$$GPS \rightarrow RD$$

Switch the terrestrial observations back on.

1.1.4. Controlling Geometry

To learn more about the current map projection, select *Geometry*, the tab sheet on the right of *Project* option. The *Geometry* tab sheet provides first of all information on the dimension of the solution (Figure 1.1-2). As a matter of fact you have now arrived at one of the main features of MOVE3: the Dimension Switch. The choice of the dimension of the solution depends on the observations: when stations are connected with observations controlling the horizontal situation as well as the height, a 3D solution is possible. In other instances only a 2D or 1D solution is feasible. Note that as much as possible of the information contained in the observations is utilized, e.g. GNSS/GPS baselines (typically controlling 3D geometry) can also contribute to a 2D solution.

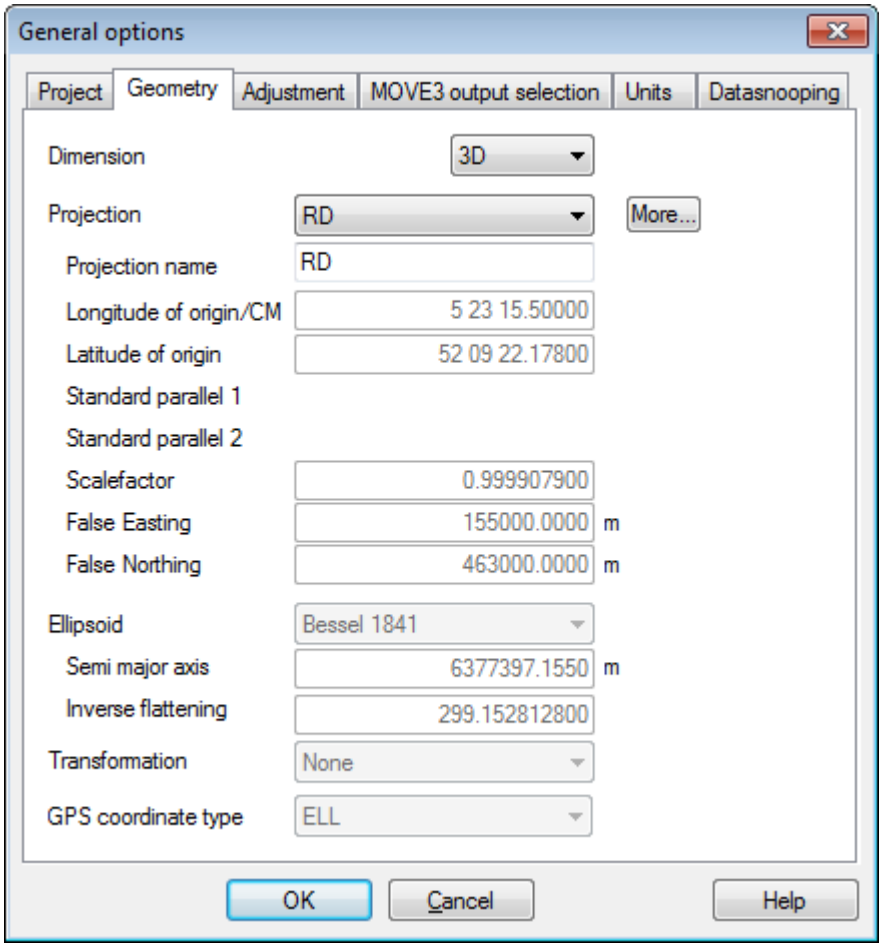


Figure 1.1-2: The Geometry tab sheet.

Now move to the *Projection* drop-down list box, and have a look at the map projections supported by MOVE3. Some projections are completely predefined, for others you must enter certain parameters, e.g. the central meridian in case of a UTM projection. In MOVE3 the ellipsoid is of vital importance. The ellipsoid is the reference surface in the adjustment. It is necessary to specify an ellipsoid for every adjustment, even when you are not using a map projection. Make sure the dimension is *3D* and the map projection is *RD* and close the *Options* box by clicking the OK button.

1.1.5. Compute

Move to *Compute*, the next item on the menu bar and select *MOVE3*. This will activate the MOVE3 adjustment module. An output selection box appears, displaying the default output file name. Clicking *OK* will activate the MOVE3 adjustment module. Because Kamerik is a small network the adjustment runs very quickly and in a few moments the adjustment is completed (Figure 1.1-3).

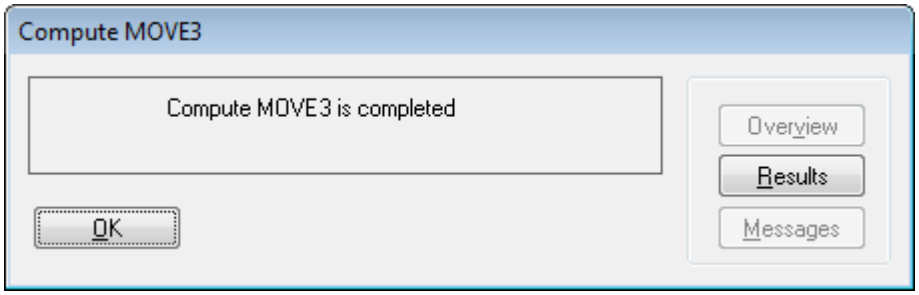


Figure 1.1-3: MOVE3 computation.

You have just completed a free network adjustment!

In a free network adjustment only observations are tested. Later on a constrained network adjustment will be executed, where known stations will also be tested.

To analyse the free network adjustment results, select the *Results* button of the *Compute MOVE3* dialog box. The results have been written to an XML output file, the OUT1.XML file. A file viewer, enabling you to scroll through the file now presents this file on screen. Scroll through the file until you find *F-test*. As you can see, the F-test or overall model test is rejected. Probably there is an outlier present in the network. To identify this outlier the W-test is used. The W-test examines each observation individually. The Test Summary shows the list of rejected observations. The observation with the largest W-test is listed first. In this case there is just one rejected observation: the distance (S0) between OC&L and Afslag (Figure 1.1-4).

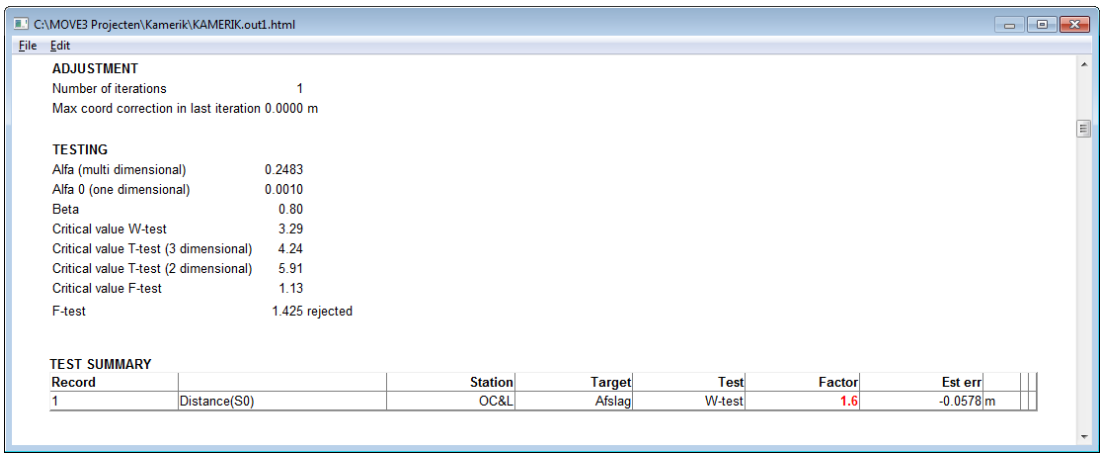
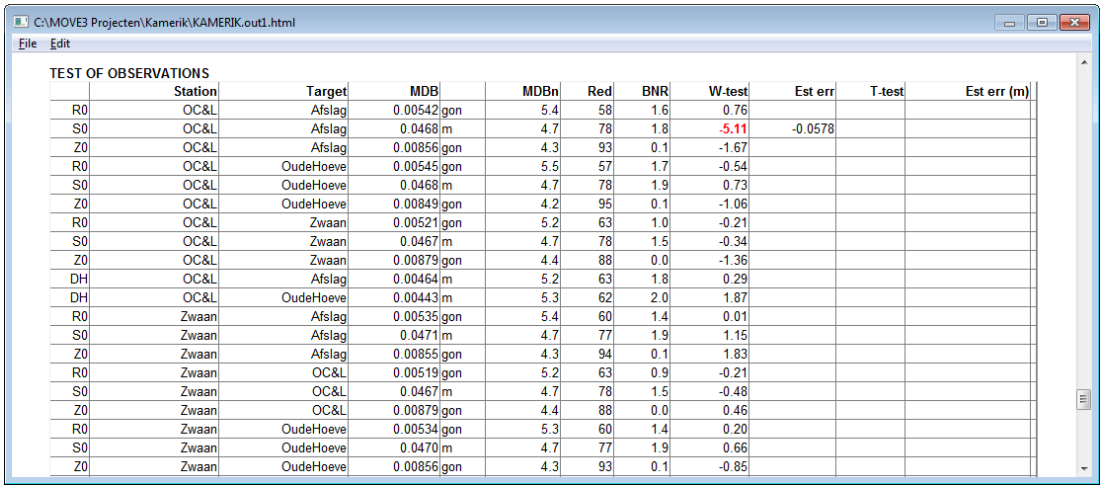


Figure 1.1-4: Rejection W-test distance OC&L - Afslag.


C:\MOVE3 Projecten\Kamerik\KAMERIK.out1.html

File Edit

TEST OF OBSERVATIONS

	Station	Target	MDB		MDBn	Red	BNR	W-test	Est err	T-test	Est err (m)
R0	OC&L	Afslag	0.00542	gon	5.4	58	1.6	0.76			
S0	OC&L	Afslag	0.0468	m	4.7	78	1.8	-5.11	-0.0578		
Z0	OC&L	Afslag	0.00856	gon	4.3	93	0.1	-1.67			
R0	OC&L	OudeHoeve	0.00545	gon	5.5	57	1.7	-0.54			
S0	OC&L	OudeHoeve	0.0468	m	4.7	78	1.9	0.73			
Z0	OC&L	OudeHoeve	0.00849	gon	4.2	95	0.1	-1.06			
R0	OC&L	Zwaan	0.00521	gon	5.2	63	1.0	-0.21			
S0	OC&L	Zwaan	0.0467	m	4.7	78	1.5	-0.34			
Z0	OC&L	Zwaan	0.00879	gon	4.4	88	0.0	-1.36			
DH	OC&L	Afslag	0.00464	m	5.2	63	1.8	0.29			
DH	OC&L	OudeHoeve	0.00443	m	5.3	62	2.0	1.87			
R0	Zwaan	Afslag	0.00535	gon	5.4	60	1.4	0.01			
S0	Zwaan	Afslag	0.0471	m	4.7	77	1.9	1.15			
Z0	Zwaan	Afslag	0.00855	gon	4.3	94	0.1	1.83			
R0	Zwaan	OC&L	0.00519	gon	5.2	63	0.9	-0.21			
S0	Zwaan	OC&L	0.0467	m	4.7	78	1.5	-0.48			
Z0	Zwaan	OC&L	0.00879	gon	4.4	88	0.0	0.46			
R0	Zwaan	OudeHoeve	0.00534	gon	5.3	60	1.4	0.20			
S0	Zwaan	OudeHoeve	0.0470	m	4.7	77	1.9	0.66			
Z0	Zwaan	OudeHoeve	0.00856	gon	4.3	93	0.1	-0.85			

Figure 1.1-5: Test of Observations.

At the end of the output file the testing of the observations is shown. MOVE3 has estimated an error of -0.058 m present in the distance at issue. Note the MDB (Minimal Detectable Bias) values in the fourth column (Figure 1.1-5), representing the internal reliability. The MDB of the distance OC&L - Afslag indicates that a error larger than 0.047 m will be detected by the W-test with a probability of 80%. The external reliability is represented by the BNR (Bias to Noise Ratio). The depicted value of 1.8 implies that the influence of the MDB on any coordinate never exceeds 1.8 times the standard deviation of the coordinate. The T-test for GNSS/GPS baselines is the 3-dimensional equivalent of the W-test.

Close the file viewer and select the *OK* button of the *Compute MOVE3* box.

1.1.6. Adjustment in Phases

As you may recall from the results of the adjustment, a rejection with an associated estimated error of nearly 0.06 m is present in the network. The easiest solution is to remove the observation at issue, the distance OC&L - Afslag, by selecting the observation from the list of rejected items in the menu *Results* ➔ *Rejected items* by double clicking. Select the *Deselection* check box of the distance observation (Figure 1.1-6). The distance is now temporarily deselected. Select the *OK* button to leave the editor.

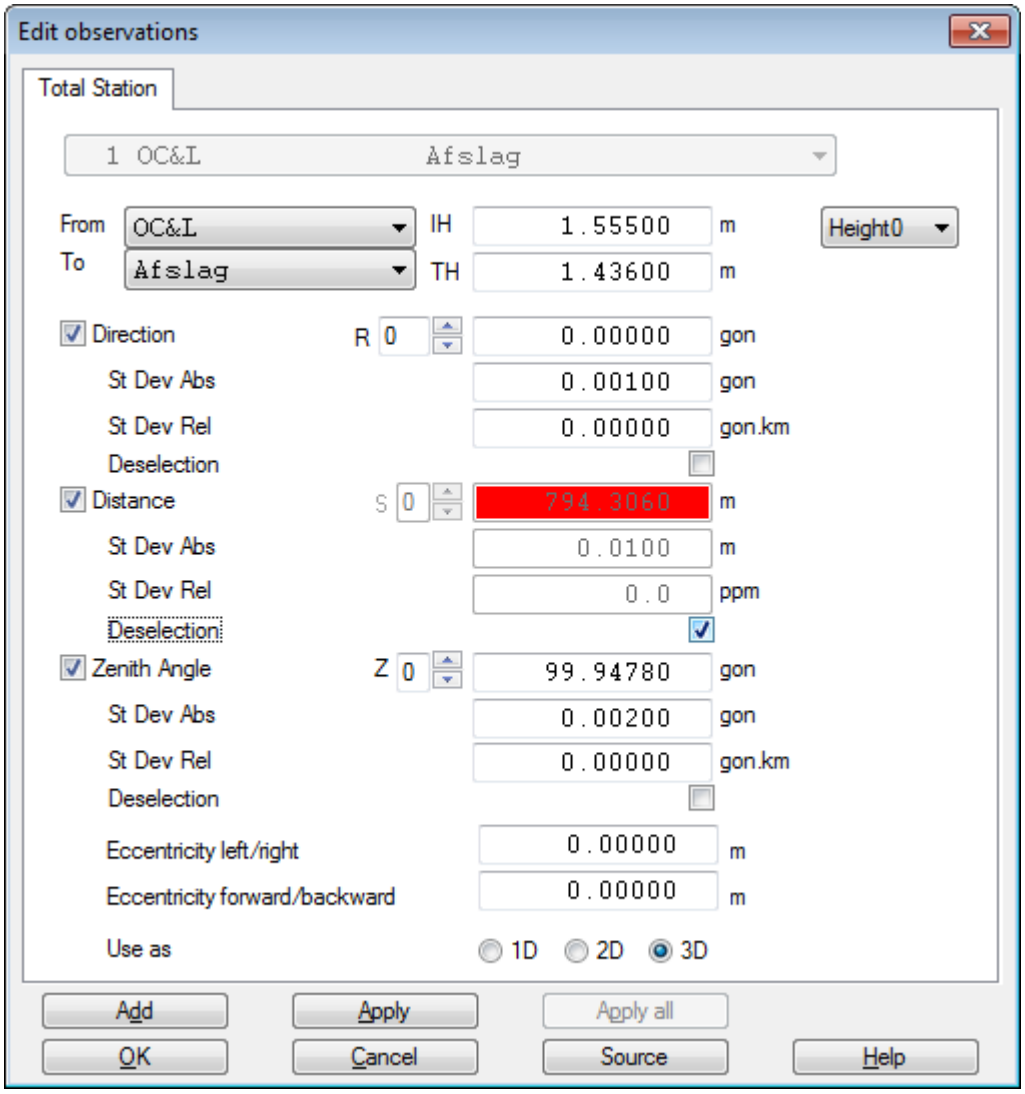
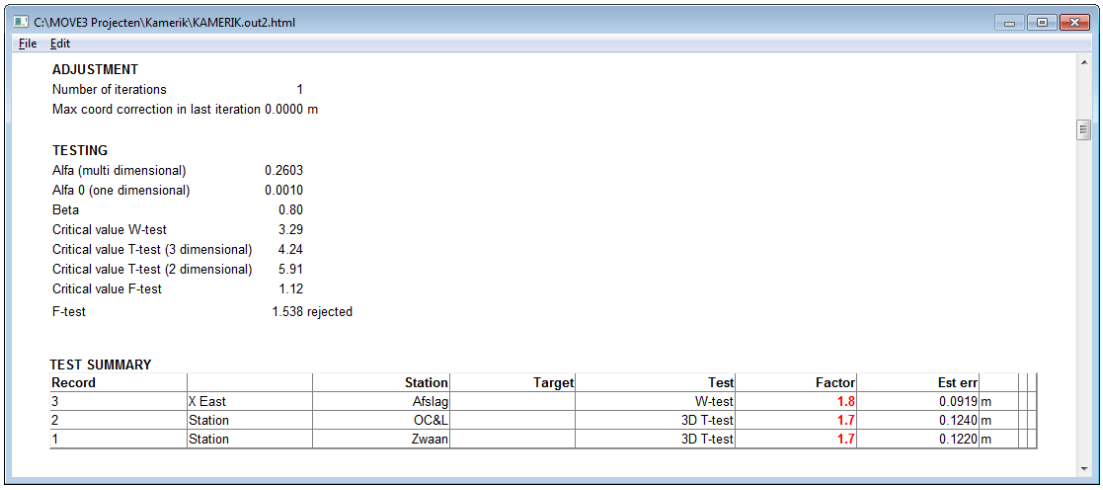


Figure 1.1-6: Observations editor.

The adjustment you have carried out is a free network adjustment. In a free network adjustment only the observations are tested. The minimum number of known coordinates is used in a free network adjustment: just enough to fix location, orientation and scale of the network. In a constrained network adjustment the network is connected to all known coordinates and these known coordinates are also tested. To switch from free network adjustment to constrained network adjustment, go back to the *Options* ➔ *General* drop-down menu and select the *Adjustment* option. In the *Adjustment* tab sheet which appears, change the value in the *Phase* drop-down list box from *Free network* to *Pseudo constrained*. Close the *Options* dialog box by clicking the *OK* button.

Now you are ready to run a constrained adjustment in which the known stations are tested as well as the observations. Go to the *Compute* menu and, as you have done earlier, select *MOVE3*. When the adjustment is completed, select the *Results* button of the *Compute MOVE3* box. Again you will see the F-test is rejected. Since you have already eliminated the rejections of observations, this rejection is probably due to an error in the known stations. As the X East coordinate of station Afslag has the largest W-test value, this coordinate is marked as the most suspect known coordinate (Figure 1.1-7).



C:\MOVE3 Projecten\Kamerik\KAMERIK.out2.html

File Edit

ADJUSTMENT

Number of iterations 1

Max coord correction in last iteration 0.0000 m

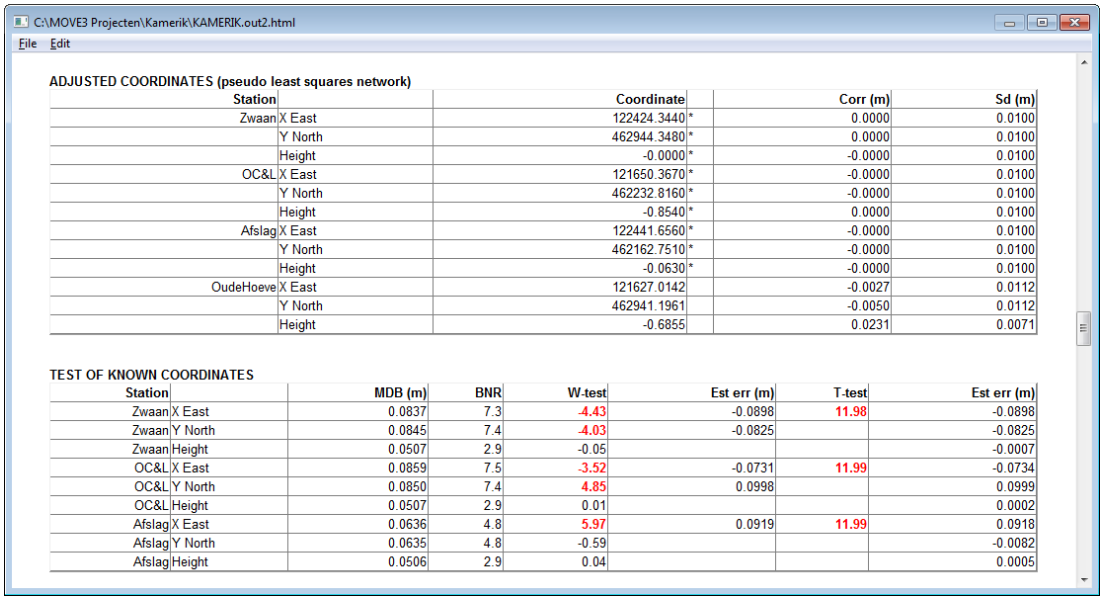
TESTING

Alfa (multi dimensional)	0.2603
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	1.12
F-test	1.538 rejected

TEST SUMMARY

Record		Station	Target	Test	Factor	Est err	
3	X East	Afslag		W-test	1.8	0.0919	m
2	Station	OC&L		3D T-test	1.7	0.1240	m
1	Station	Zwaan		3D T-test	1.7	0.1220	m

Figure 1.1-7: : Rejected W-test and estimated error for station Afslag.



C:\MOVE3 Projecten\Kamerik\KAMERIK.out2.html

File Edit

ADJUSTED COORDINATES (pseudo least squares network)

Station		Coordinate		Corr (m)	Sd (m)
Zwaan	X East	122424.3440	*	0.0000	0.0100
	Y North	462944.3480	*	0.0000	0.0100
	Height	-0.0000	*	-0.0000	0.0100
OC&L	X East	121650.3670	*	-0.0000	0.0100
	Y North	462232.8160	*	-0.0000	0.0100
	Height	-0.8540	*	0.0000	0.0100
Afslag	X East	122441.6560	*	-0.0000	0.0100
	Y North	462162.7510	*	-0.0000	0.0100
	Height	-0.0630	*	-0.0000	0.0100
OudeHoeve	X East	121627.0142		-0.0027	0.0112
	Y North	462941.1961		-0.0050	0.0112
	Height	-0.6855		0.0231	0.0071

TEST OF KNOWN COORDINATES

Station		MDB (m)	BNR	W-test	Est err (m)	T-test	Est err (m)
Zwaan	X East	0.0837	7.3	-4.43	-0.0898	11.98	-0.0898
Zwaan	Y North	0.0845	7.4	-4.03	-0.0825		-0.0825
Zwaan	Height	0.0507	2.9	-0.05			-0.0007
OC&L	X East	0.0859	7.5	-3.52	-0.0731	11.99	-0.0734
OC&L	Y North	0.0850	7.4	4.85	0.0998		0.0999
OC&L	Height	0.0507	2.9	0.01			0.0002
Afslag	X East	0.0636	4.8	5.97	0.0919	11.99	0.0918
Afslag	Y North	0.0635	4.8	-0.59			-0.0082
Afslag	Height	0.0506	2.9	0.04			0.0005

Figure 1.1-8: Test of Known Coordinates.

Sometimes known coordinates are erroneous because of simple typing errors. The estimated error for the X East coordinate of station Afslag is 0.092 m. Indeed, with the help of this estimate, a typing error is discovered:

X East *122441.656* , should read: X East *122441.566*

To correct the typing error, select the highlighted station Afslag. Change the *X East* coordinate of Afslag and close the *Edit stations* box with the *OK* button. Rerun the adjustment and check the F-test and W-test results. All tests should be accepted now.

⚠ **Never correct readings or known coordinates unless you are convinced that an error is made, and that you are able to recover the correct value!**

1.1.7. Closing MOVE3

Before leaving MOVE3, it is often useful to save the modifications you have made by creating a new project. Go to the *Project* menu and select *Save As*. In the file selection box which opens a new name can be entered. Then select *Exit*, the last option of *Project*, and leave MOVE3.