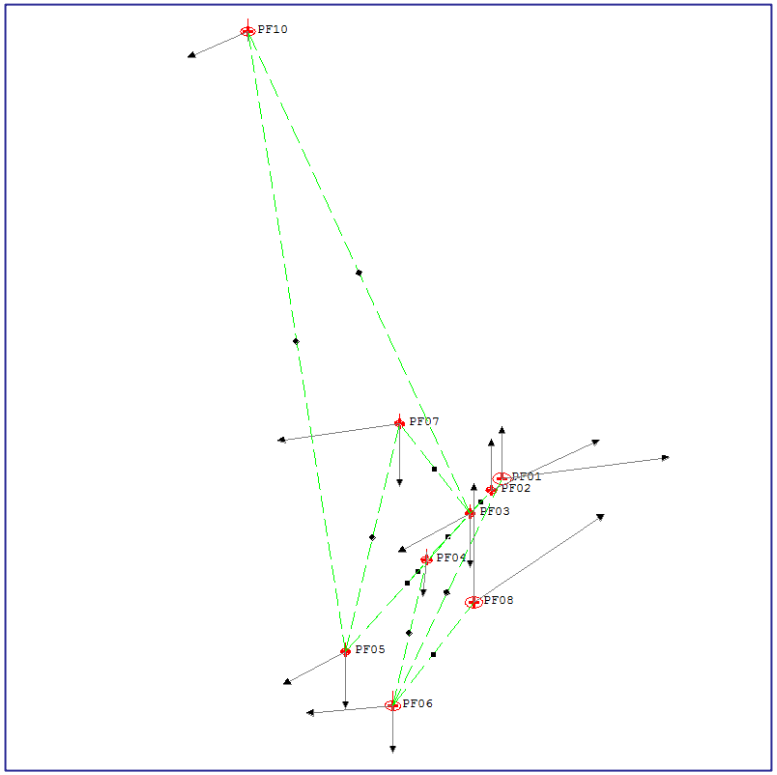
Monitoring

Lab 5

Deformation Analysis

1. Task of the deformation analysis

A deformation analysis is applied to prove the stability or movement of points. For this reasons a geodetic network will be measured several times and the results will be analysed subsequently.

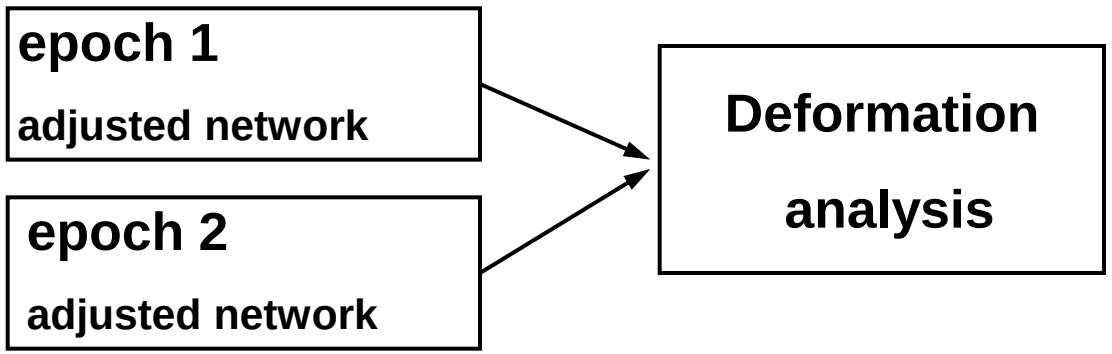


1.1 Preparation for deformation analysis

Requirement for a deformation analysis in PANDA is a 1-,2-, or 3-dimensional geodetic network, which is measured twice (two epochs)→ two-epoch comparison

Each epoch must be adjusted separately

The two adjusted versions are the basics for the deformation analysis.



1.2 Input data

Approximate coordinates (Koord_WGS84.txt)

Raw data of GPS-base lines (epoch_2003.ski, epoch_2012.ski)

- epoch 1 (2003)
- epoch 2 (2012)

Koord_ETRS89.txt

PF01	4161483.5014	665654.7471	4772037.18
PF02	4161465.6854	665636.1842	4772052.61
PF03	4161431.1130	665597.6134	4772082.90
PF04	4161360.9589	665522.4225	4772144.76
PF05	4161227.5309	665372.0038	4772276.05
PF06	4161305.6636	665284.2432	4772235.49
PF07	4161316.5533	665745.4769	4772152.73
PF08	4161437.6956	665452.1002	4772096.27
PF10	4161068.2994	666386.0873	4772299.28

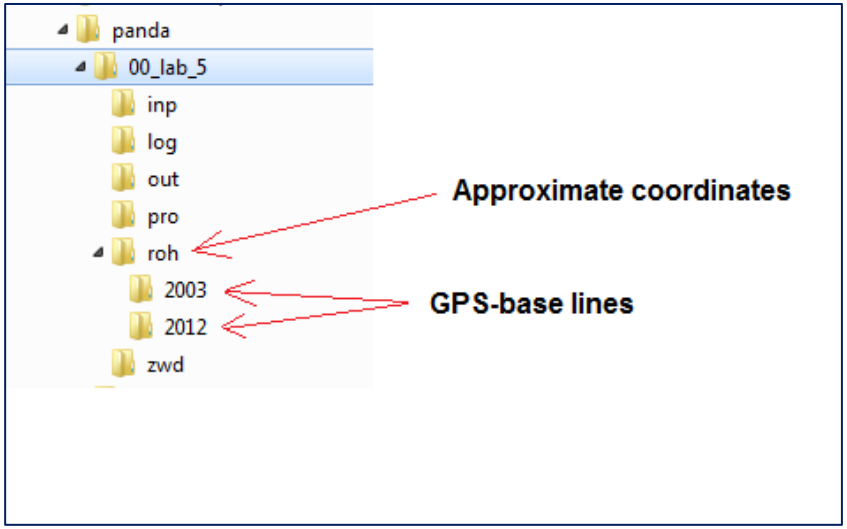
epoch_2003.ski

```
@%Unit:                  m
@%Coordinate type:       Cartesian
@%Reference ellipsoid: WGS 1984
@#PF01                4161482.2025    665654.6481   4772038.0917           MEAS    0.0004  12
@&   0.47690   0.00000033  -0.00000001   0.00000018   0.00000008   0.00000003   0.00000041
@E   0.00021019    0.00013584    0.34021485    0.00035225
@+PF06              4161304.3553   665284.1560  4772236.4072
@-PF01                 177.9072      370.5121     -198.2854
@=    0.4769   0.00000033  -0.00000001   0.00000018   0.00000008   0.00000003   0.00000041
@:      -0.1880        0.0000
@;       0.1920        0.0000
@*09.08.2012 09:28:14
@E      0.0000       0.0000       0.0000       0.0000
@#PF01                4161481.2140    665654.9660   4772037.2246           NAV     1.5438  12
@&  97.64915   0.00007838   0.00000675   0.00004966   0.00002868   0.00001172   0.00014289
@E   0.73643616    0.51114046    0.11865960    1.25686854
@#PF02                4161463.9196    665635.6211   4772052.9504           MEAN    0.0006  12
@&   0.00039   0.98001813   0.13192661   0.59231991   0.17633278   0.09474292   1.15872395
@E   0.00026807    0.00015326    0.00000000    0.00050493
@*09.08.2012 09:32:44
@E      0.0000       0.0000       0.0000       0.0000
@+PF05              4161225.7781   665371.4377  4772276.3887
@-PF02                 238.2012      264.2036     -223.4086
@=    0.3256   0.00000022   0.00000001   0.00000012   0.00000006   0.00000001   0.00000024
@:      -0.1840        0.0000
@;       0.1900        0.0000
@*09.08.2012 09:32:44
@E      0.0000       0.0000       0.0000       0.0000
@+PF03              4161429.3581   665597.0454  4772083.2423
@-PF02                  34.6219       38.5954      -30.2607
@=    0.3404   0.00000023   0.00000004   0.00000012   0.00000006   0.00000003   0.00000030
@:      -0.1840        0.0000
@;       0.1850        0.0000
@*09.08.2012 12:30:34
@E      0.0000       0.0000       0.0000       0.0000
@#PF02                4161463.9200    665635.6209   4772052.9517           MEAS    0.0003  12
@&   0.34044   0.00000023   0.00000004   0.00000012   0.00000006   0.00000003   0.00000030
@E   0.00013099    0.00008121    0.00929461    0.00021388
@#PF02                4161463.9196    665635.6211   4772052.9498           MEAS    0.0002  12
@&   0.28520   0.00000022   0.00000001   0.00000012   0.00000006   0.00000001   0.00000024
@E   0.00009524    0.00006863    0.11064181    0.00016910
@#PF02                4161463.9193    665635.6213   4772052.9501           MEAS    0.0002  12
@&   0.32560   0.00000022   0.00000001   0.00000012   0.00000006   0.00000001   0.00000024
@E   0.00010870    0.00007835    0.11101137    0.00019301
@#PF02                4161463.7133    665635.5288   4772052.7988           NAV     1.5931  12
@&  90.79797   0.00010537   0.00003696   0.00006514   0.00005291   0.00003091   0.00014956
@E   0.72632312    0.57752763   -0.31357788    1.29494657
@#PF03                4161429.3581    665597.0454   4772083.2423           REF     1.5049  12
@&  85.21376   0.00011843   0.00004657   0.00006350   0.00005973   0.00002803   0.00013374
```

1.3 Create new project

Create a new project in PANDA

Copy the input data in project folder (...\roh)



- Creation of GPS-point list as standard point list
- Import of the approximate coordinates in GPS-point list

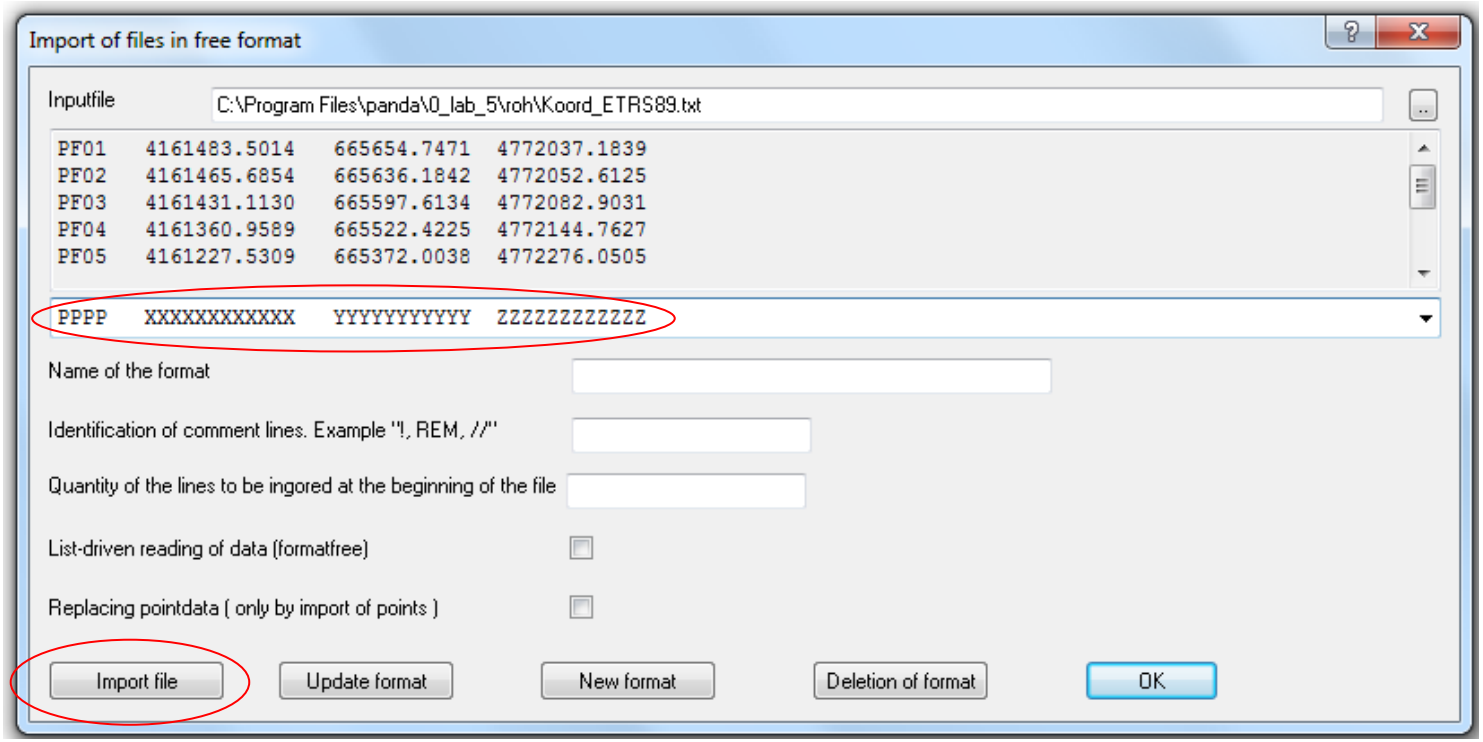
-> the results will be shown in horizont system

1.4 Import of approximate coordinates

Import configuration for free format

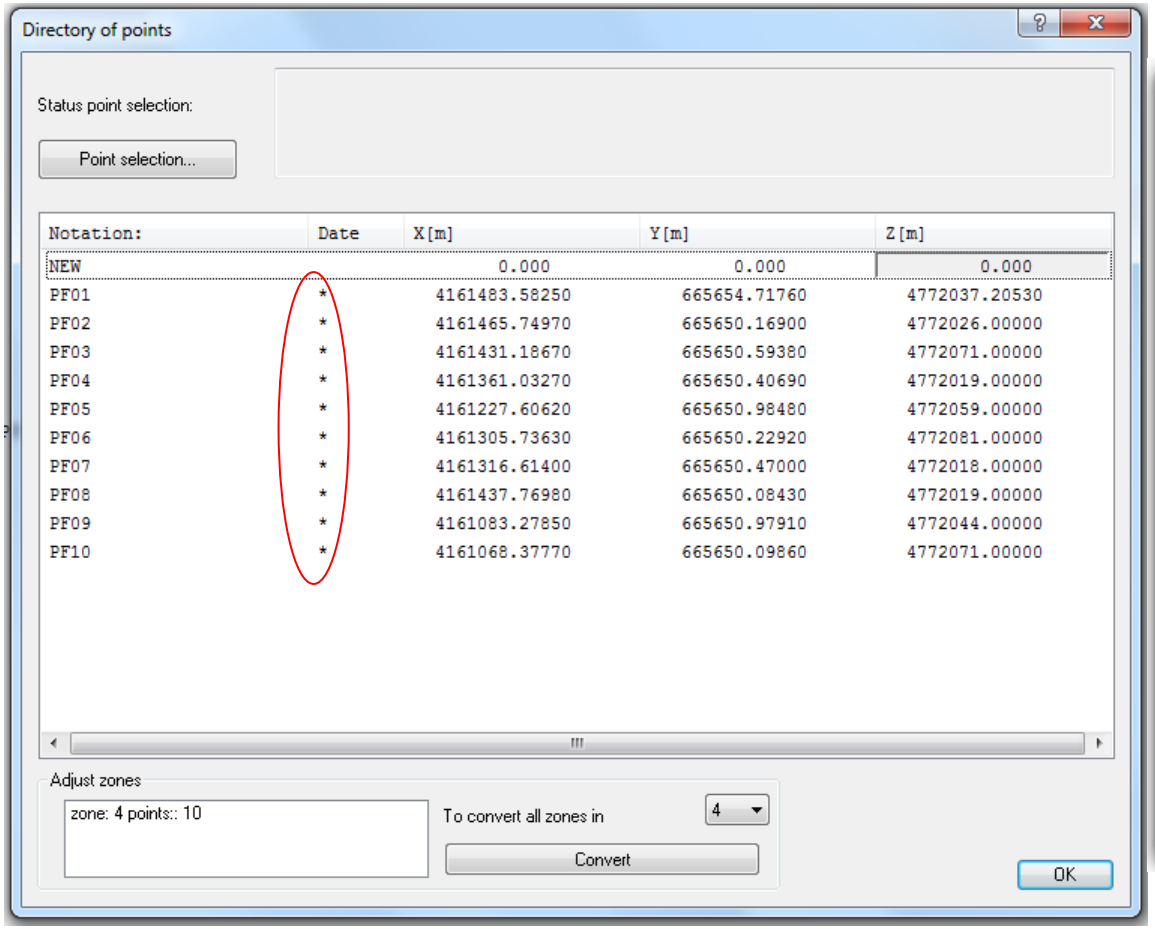
1.

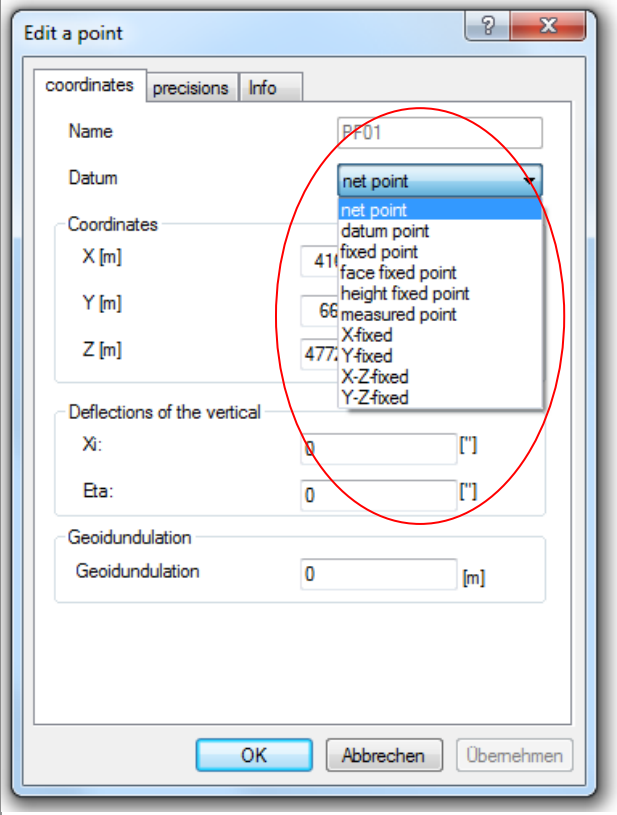
2.



1.5 Datum establishing

Before calculation, all network points in the list must be defined as datum points. (free network adjustment/minimum constraint adjustment)





1.6 The Net Datum

Constrained adjustment

- Number of defining components is greater than the minimum data requirement
- Net geometry will be fitted

Unconstrained adjustment

- Number of defining components exactly equals the minimum datum requirement
- Net geometry is not altered

Weak datum

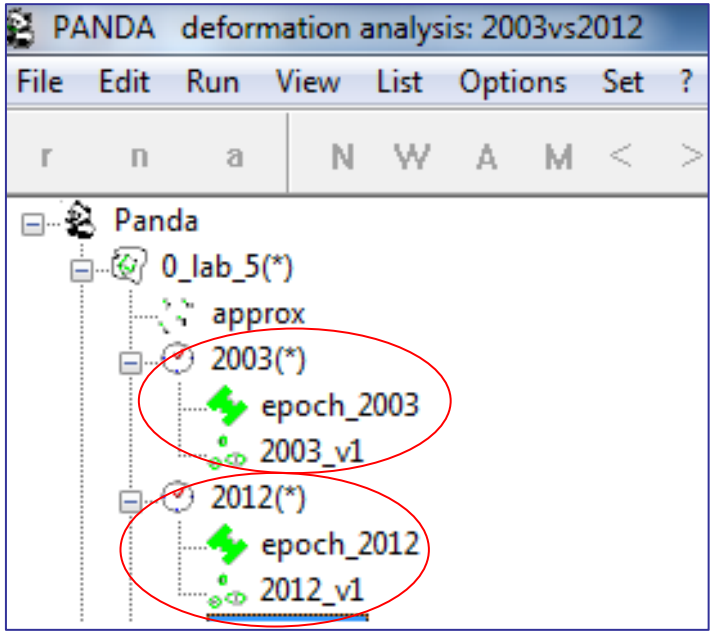
- Measured coordinates define the datum of the net
- Net geometry and datum determination influence each other

Free net adjustment

- Based on approximate coordinates of several stations (datum points)
- Helmert transformation (7- Parameters) to the approximate coordinates
- Use of all stations: total constraint; use part of the stations: partial constraint
- Net geometry and datum determination are independent from each other
- Net geometry remains intact

1.7 Creation of epochs and import of raw data

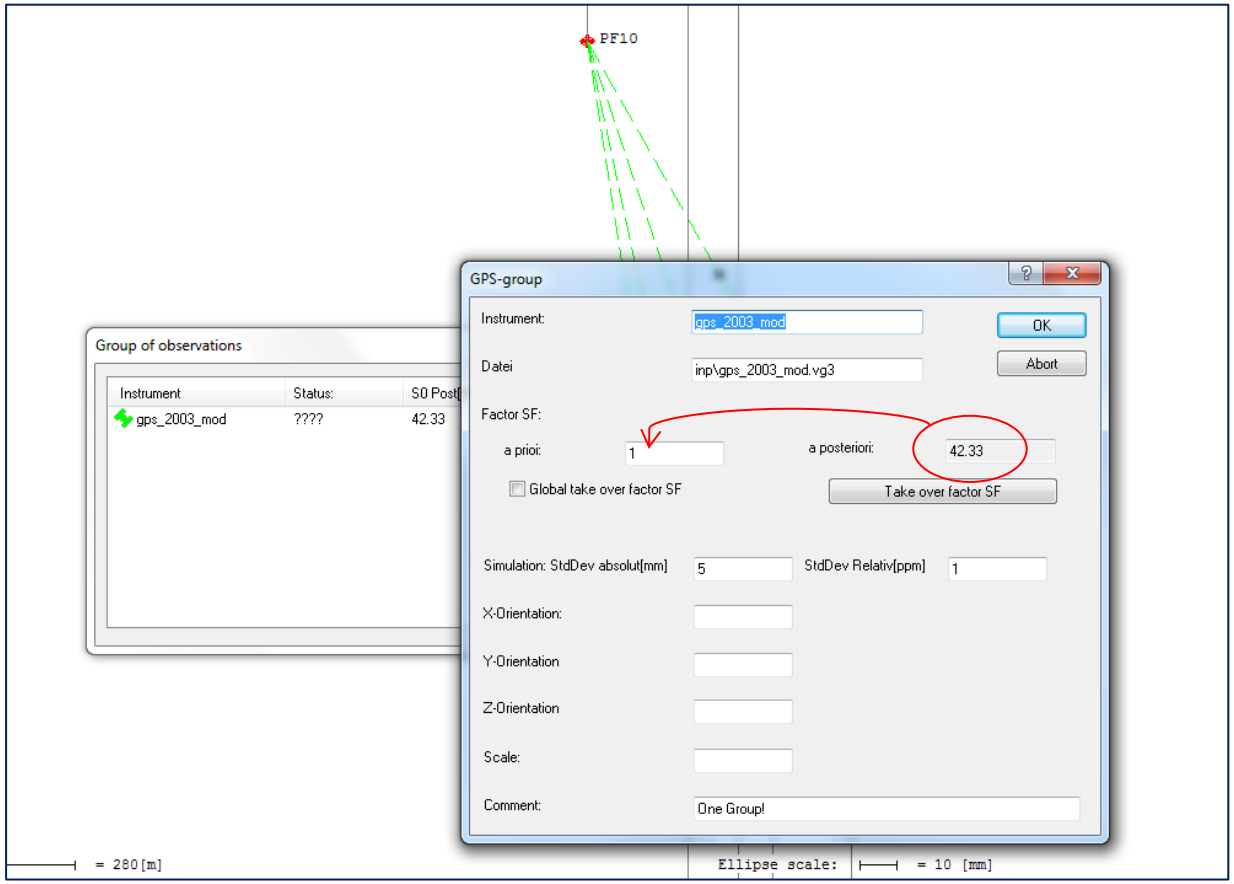
- Creation of epochs 2003 and 2012
- Import the raw data (GPS-base lines) in each epoch (*epoch_2003.ski, epoch_2012.ski*)
- Reduction of all fieldsheets
- Creation of new version in each epoch
  (minimal constraint adjustment)



1.8 Least Square Adjustment

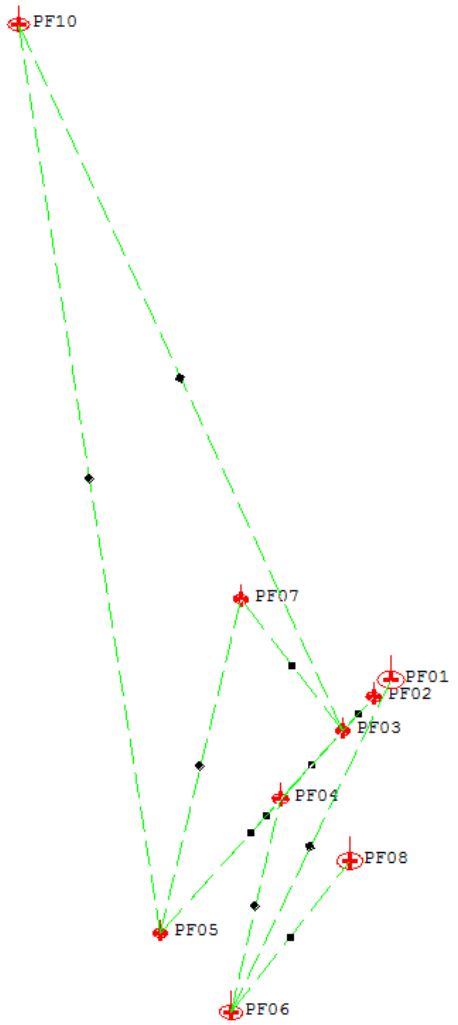
Adjust each version

Subsequently the accuracy level has to be adjust repeatedly until no improvements are achieved.



1.9 Adjustment

Figure of the Network after adjustment (epoch 2003)



The objectives of the adjustment are:

- Improvement of the accuracy of the values
- Detection of gross errors in the observation
- Adaption of pre-given level of required accuracy

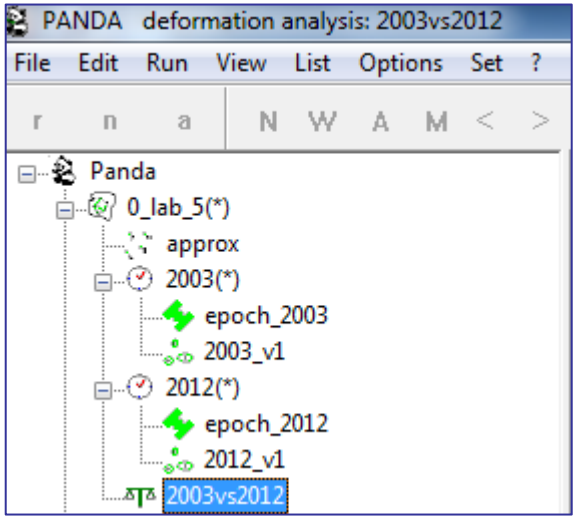
2. Deformation analysis

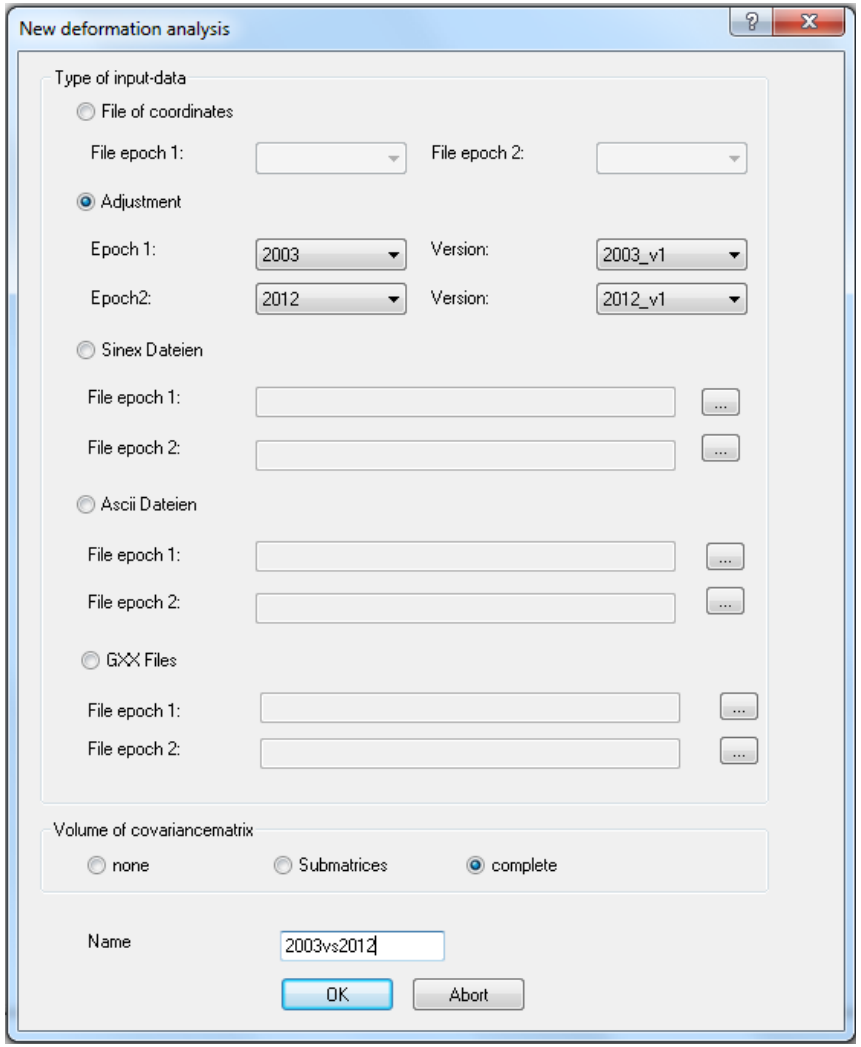
Create a new deformation analysis (e.g. *2003vs2012*)

The preconditions are:

2 adjusted versions of 2 epochs with identical datum defect.

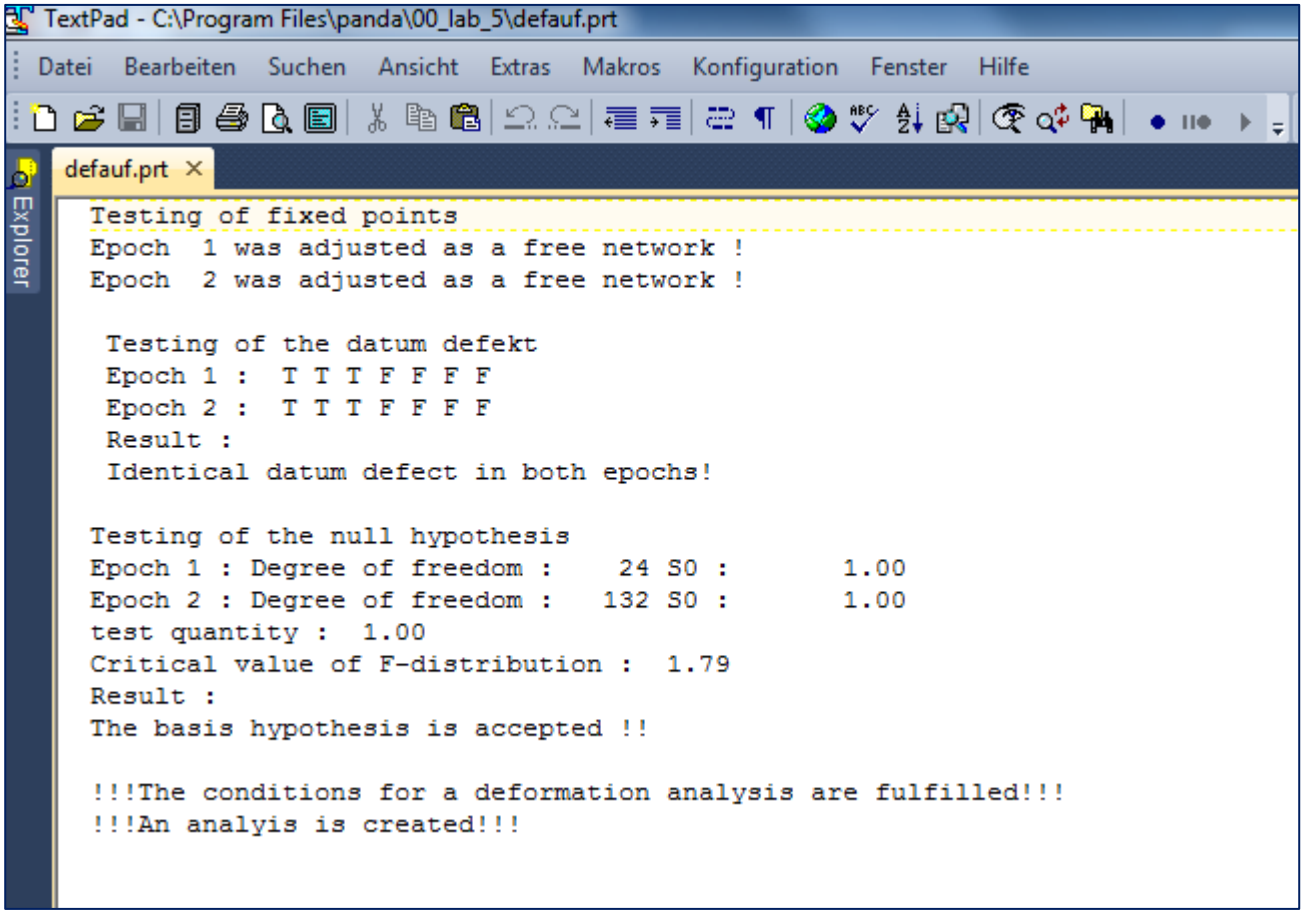
The configuration could be set as follows :





2.1 Pre-analysis of the deformation analysis

Interpretation of the pre-analysis (*panda/project folder/defauf.prt*)



2.2 Realisation of the deformation analysis in PANDA

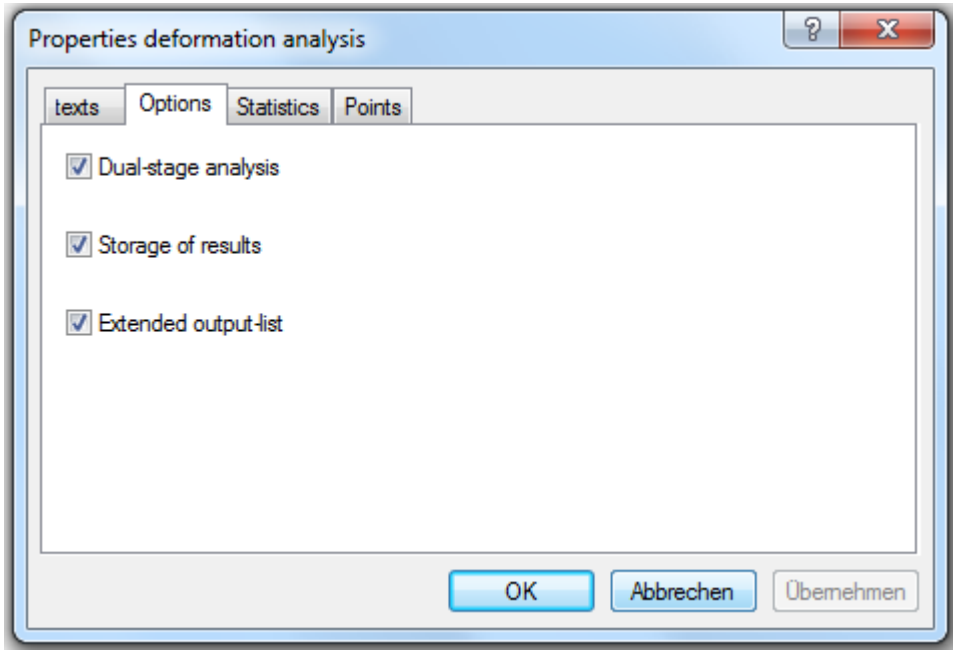
1. The backwards strategy- localisation in reference point region: Points with significant movements will be detected within the reference points list and moved to the object point list. The remaining net is tested again.

2. The forwards strategy - localisation in object point region: One by one, the object point with the least relative discrepancy is considered to be stable and transferred to the reference point list. Now, the extended net of reference points is tested for congruency. This procedure will be repeated until the global congruency test shows a significant discrepancy.

→ PANDA documentation extract, page 208

2.3 Execution of the deformation analysis

- **additional settings:** → properties of the deformation analysis (context-menu of the Def.-Analysis)



2-stage: single point testing (F-testing)

in object region

→ run the deformation analysis

2.4 Results of the deformation analysis

Interpretation of the results: */out/2003vs2012.o3d*

Analysis within reference points (backward)

Global test : Run No: 1
Size of Qxx - matrix : Submatrices
Standard deviation of unit weight : 1.00
Datum points : 5
Degrees of freedom nom. / denom. : 12 / 156
Percentile of F-dist. / critical value : 1.81 < 2.14

Result of the analysis :
H0 is rejected : significant movements in the network !
The analysis within the reference points is being continued !

Result of the localisation : Discrepancies of the reference points

Seq.No.	Point	dx [MM]	dy [MM]	dz [MM]	Dis [MM]	T	Result
1	PF01	-5.58	4.32	-1.30	7.18	0.19	
2	PF04	19.64	1.42	12.70	23.43	0.31	
3	PF05 *	-3.47	-8.58	-8.30	12.43	0.92	Pt moved
4	PF06	-8.17	1.42	-13.80	16.10	0.47	
5	PF10	-2.42	1.42	10.70	11.06	0.24	

3. Adaption of the datum definition

- Creation of a new adjustment version in all epochs
- Points indicated as moved in the deformation analysis, will be defined as net points now.

Notation:	Date	X[m]	Y[m]	Z[m]
NEW		0.000	0.000	0.000
PF01	*	4161483.58250	665654.71760	4772037.20530
PF02	*	4161465.74970	665650.16900	4772026.00000
PF03	*	4161431.18670	665650.59380	4772071.00000
PF04	*	4161361.03270	665650.40690	4772019.00000
PF05	0	4161227.60620	665650.98480	4772059.00000
PF06	*	4161305.73630	665650.22920	4772081.00000
PF07	*	4161316.61400	665650.47000	4772018.00000
PF08	*	4161437.76980	665650.08430	4772019.00000
PF09	*	4161083.27850	665650.97910	4772044.00000
PF10	*	4161068.37770	665650.09860	4772071.00000

- After adjustment of new versions and the adaption of the accuracy levels, a new deformation analysis has to be created
- Choice of the new adjusted versions for the new deformation analysis

4. New deformation analysis

Repeat the deformation analysis with new point configuration.

Compare the results !

Good luck!