



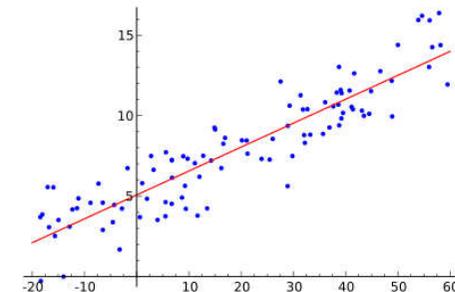
# EZSurv™ Least-Squares Adjustment

October 10<sup>th</sup> 2012

2012 - Training documents

## What is a Least-Squares Adjustment

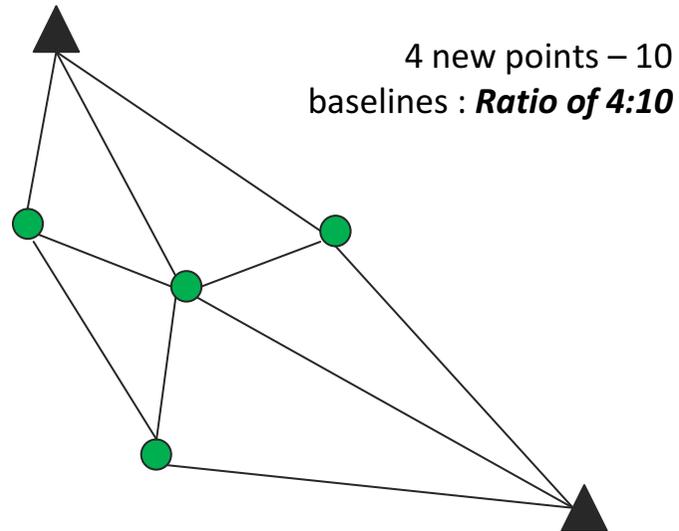
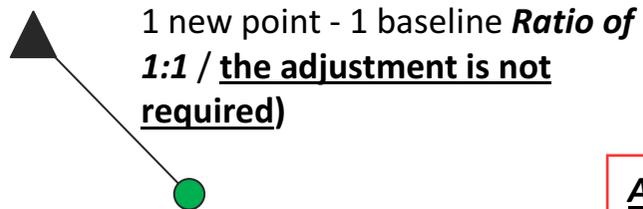
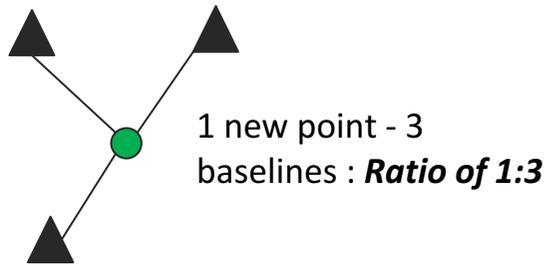
- When you have multiple (redundant) measurements to compute an unknown value, a least-squares adjustment might be appropriate to get the best estimate of the unknown value (using all these measurements).
- For example, when you measure few time a linear distance, a simple average will provide you the best estimate for this distance (it turns out that this simple average is a least-squares)
- In GNSS, when you establish a network of points, you may observed a multiple of vectors connecting all these points, which makes the calculation of the best position for each of these point a complicated task.
- A least-square calculation is the solution of this problem



Fitting a straight line on a series of points could be done with a LS



## Typical Networks

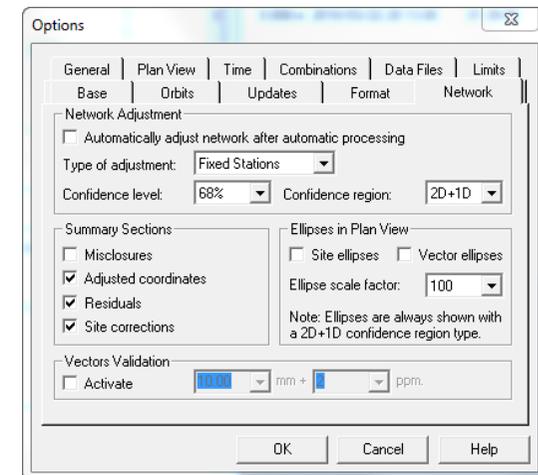


**A simple rule** : the network should be adjusted if number of baselines is greater than number of unknown points (ratio < 1)

## Least-Squares Adjustment Parameters

Basic parameters of the network adjustment are set under **Tools > Option > Network Tab**.

- You can adjust your network through a **Fixed Stations** mode or **Weighted Station** mode (*type of adjustment* drop down box).
- You can select the confidence level of the error ellipses
- Select a confidence level representation
- You can select a series of adjustment results to be output in the report
- You can display the position and vector error ellipses in the Plan View



Network adjustment could be launched automatically after the automatic processing (check the proper box), or manually through the **Tools > Process Manual > Adjust Network**.



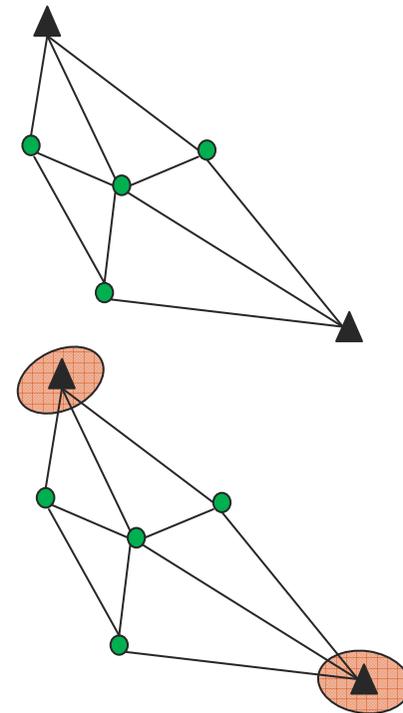
## Least-Squares Adjustment

### Fixed Station mode:

Coordinates of reference site are held fix in the adjustment. They are assumed to be errorless. If these coordinates are not accurate, final positions will be biased (as well as their statistics)

### Weighted Station mode:

Coordinates of reference sites are not held fix in the adjustment. A level of uncertainty is attached to each of them to reflect their non-perfect accuracy. This is done through standard deviation that can be input in the Site Editor





## Sites Positions – Before Adjustment

Before adjustment, you have access to a list of all your positions in **Analysis > Survey Sites > Post-Processed Coordinates**.

Post-Processed Coordinates

Project: C:\Users\denis\Documents\Presentation\2012\Pentax\Data\Network2\EZSurv (2)\20120609.spr  
 Geoid Model: EGM2008 [EGM2008 Und\_min2.5x2]  
 Mapping System: UTM\_ETRS89\_Auto  
 Projection Template: Universal Transverse Mercator, Automatic (UTM-A)  
 Datum: European Terrestrial Reference System - 1989

Sites from Baselines

Site	Solution	Position				Standard deviation			Baseline count
		X (m)	Y (m)	EllHgt (m)	MSL (m)	X (m)	Y (m)	Hgt (m)	
FARB	*	655338.146	5683311.373	112.661	66.170	*	*	*	10
HARD	*	673587.930	5647139.616	65.899	20.099	*	*	*	10
HUNG	*	603364.782	5695832.550	183.210	135.341	*	*	*	10
PBIL	*	538457.784	5596787.707	107.485	58.336	*	*	*	10
POOL	*	576812.794	5625465.028	68.766	20.975	*	*	*	10
SANO	*	626330.640	5612464.822	91.142	44.664	*	*	*	10
SOTN	*	607470.098	5644011.351	73.736	26.850	*	*	*	10
STRO	*	548237.180	5732309.854	72.977	23.173	*	*	*	10
TAUT	*	494479.139	5652429.727	80.489	29.222	*	*	*	10
WAAS	*	557166.520	5672921.105	177.545	128.571	*	*	*	10

\* Not adjusted

*Solution type as well as standard deviations are not displayed if a site is connected to more than one baseline*



## Sites Positions – After Adjustment

After adjustment, the solution type is no longer displayed but the standard deviations are displayed (now there is a unique solution for every site)

Post-Processed Coordinates  
POST-PROCESSED COORDINATES  
EZSurv 2.91

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Project | C:\Users\denis\Documents\Presentation\2012\Pentax\Data\Network2\EZSurv (2)\20120609.spr  
 Geoid Model | EGM2008 [EGM2008 Und\_min2.5x2]  
 Mapping System | UTM\_ETRS89\_Auto  
 Projection Template | Universal Transverse Mercator, Automatic (UTM-A)  
 Datum | European Terrestrial Reference System - 1989

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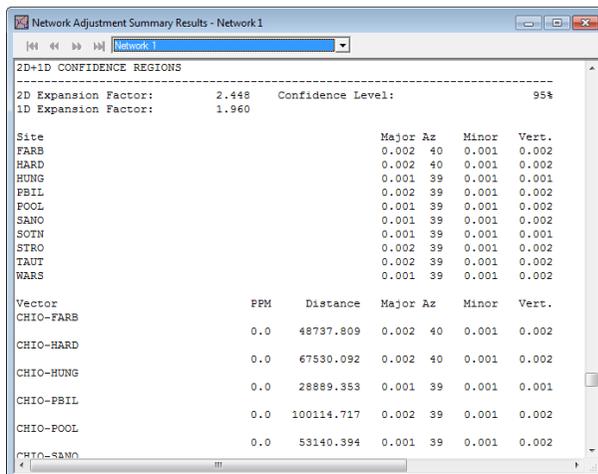
Adjusted Results (from Least Squares)

Site	Position				Standard deviation			Source
	X (m)	Y (m)	EllHgt (m)	MSL (m)	X (m)	Y (m)	Hgt (m)	
FARB	655338.144	5683311.373	112.660	66.169	0.000	0.000	0.001	Network
HARD	673587.929	5647139.616	65.899	20.099	0.001	0.001	0.001	Network
HUNG	603364.780	5695832.551	183.210	135.341	0.000	0.000	0.001	Network
PBLL	538457.782	5596787.708	107.485	58.336	0.001	0.001	0.001	Network
POOL	576812.794	5625465.028	68.766	20.975	0.000	0.000	0.001	Network
SANO	626330.639	5612464.821	91.141	44.663	0.000	0.000	0.001	Network
SOTN	607470.098	5644011.350	73.735	26.849	0.000	0.000	0.001	Network
STRO	548237.178	5732309.855	72.974	23.170	0.001	0.001	0.001	Network
TAUT	494479.136	5652429.727	80.487	29.220	0.001	0.001	0.001	Network
WARS	557166.518	5672921.106	177.544	128.570	0.000	0.000	0.001	Network

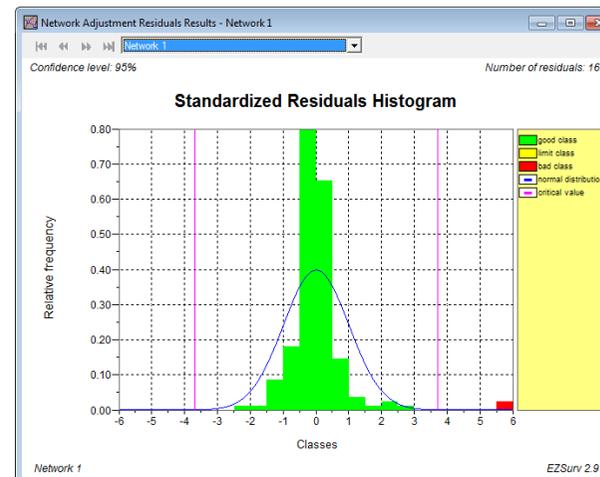
This means that results are from a network adjustment

## Baseline – Least-Squares Adjustment

The least-Squares adjustment results can be visualized in graphic mode (residuals histogram) as well as in a text form



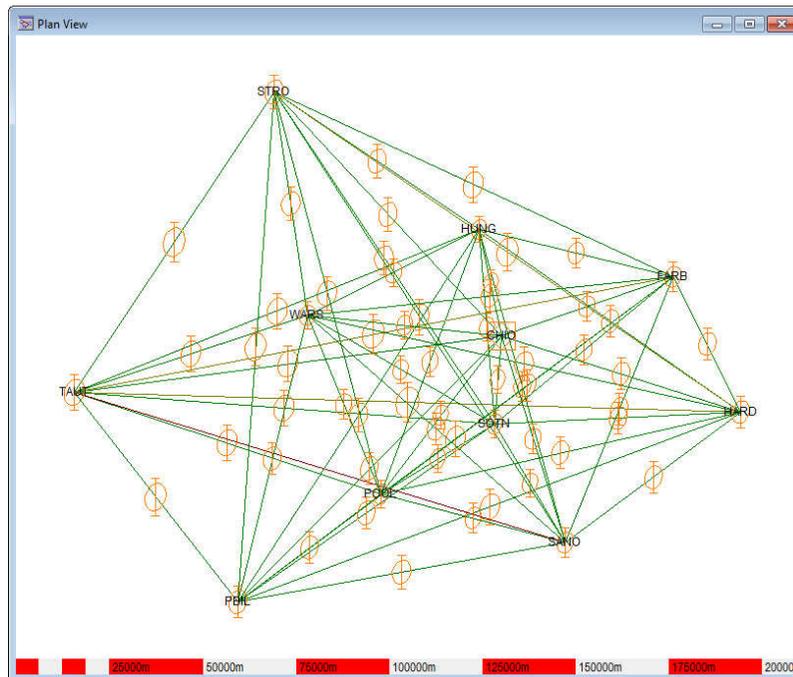
Analysis > Network Adjustment > Network Adjustment Summary



Analysis > Network Adjustment > Network Adjustment Residuals

All text reports can be saved and all graphics can be printed (right click, Save As... or print)

## Baseline – Least-Squares Adjustment



Error ellipses can be displayed in the Plan View (point and vector ellipses).

In the **View** menu check «Show site ellipses» and «Show vector ellipses»



## Inverse Report

You can generate an Inverse using **Analysis > Inverse Computation**, then select two points using the drop down box.

All parameters between two geodetic points are displayed (when a TM mapping system is selected, some mapping related parameters are also displayed)

Inverse Computation

From: CHIO To: TAUT

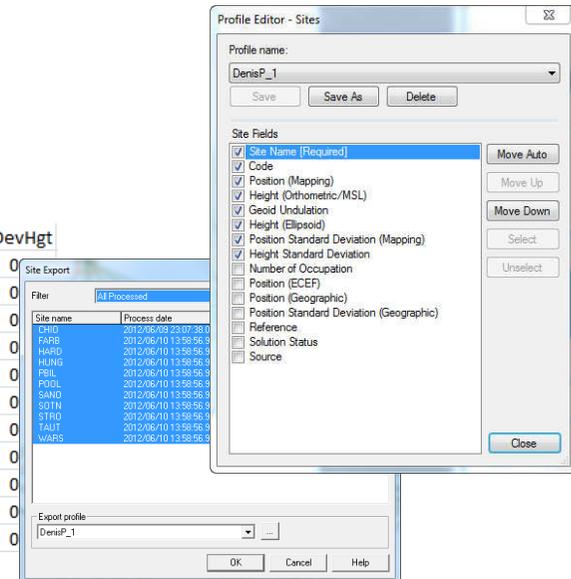
Site parameters			
Site Name	CHIO	TAUT	
Mapping - X	609228.491 m	494479.136 m	
Mapping - Y	5667552.995 m	5652429.727 m	
Undulation	47.208 m	51.267 m	
Mean Sea Level	81.106 m	29.220 m	
Latitude	N 51°08'56.37136"	N 51°01'24.23083"	
Longitude	W 1°26'17.94007"	W 3°04'43.38644"	
Ellipsoid Height	128.314 m	80.487 m	
ECEF - X	4007952.647 m	4014255.590 m	
ECEF - Y	-100633.880 m	-215908.604 m	
ECEF - Z	4944059.246 m	4935245.128 m	
Mapping Scale Factor	0.999746495	0.999600374	
Convergence	-0°01'16.42506"	0°00'03.84482"	
Vector parameters			
Mapping Azimuth	262°29'31.32629"		
Forward Geodetic Azimuth	263°42'27.38525"		
Backward Geodetic Azimuth	82°25'52.27914"		
t-T Correction	0°00'02.71970"		
ECEF - DX	6302.944 m		
ECEF - DY	-115274.723 m		
ECEF - DZ	-8814.118 m		
Delta Height (MSL)	-51.886 m		
Delta Height (Ell.)	-47.827 m		
Line Scale Factor	0.999646488		
Elevation Scale Factor	0.999983664		
Combined Scale Factor	0.999630158		
Mapping distance	115741.642 m		
Geodetic distance	115782.572 m		

# Exporting Adjusted Site Positions

Once adjusted, positions can be exported in the following formats

- Simple text files (Mapping or geographic)
- DXF formats
- Global Sites DB

SiteName	Code	X	Y	MSL	Und	EllHgt	StdDevX	StdDevY	StdDevHgt
CHIO	19194M001	609228,491	5667552,995	81,106	47,208	128,314	0,000	0,000	0
FARB		655338,144	5683311,373	66,169	46,491	112,660	0,001	0,001	0
HARD		673587,929	5647139,616	20,099	45,800	65,899	0,001	0,001	0
HUNG		603364,780	5695832,551	135,341	47,869	183,210	0,001	0,001	0
PBIL		538457,782	5596787,708	58,336	49,149	107,485	0,001	0,001	0
POOL		576812,794	5625465,028	20,975	47,791	68,766	0,001	0,001	0
SANO		626330,639	5612464,821	44,663	46,478	91,141	0,001	0,001	0
SOTN	13274M001	607470,098	5644011,350	26,849	46,886	73,735	0,001	0,001	0
STRO		548237,178	5732309,855	23,170	49,804	72,974	0,001	0,001	0
TAUT		494479,136	5652429,727	29,220	51,267	80,487	0,001	0,001	0
WARS		557166,518	5672921,106	128,570	48,974	177,544	0,001	0,001	0





## Least-Squares Adjustment in short

The least-squares module allows :

- «*Fixed Station*» and «*Weighted*» Station adjustment mode
- Produce a full report with complete adjustment results (including each vector residuals for blunder detection)
- Display «*standardized residuals*» graphic
- Display error ellipses in the PlanView (site and vectors ellipses)
- A complete «*Inverse report*» for field check