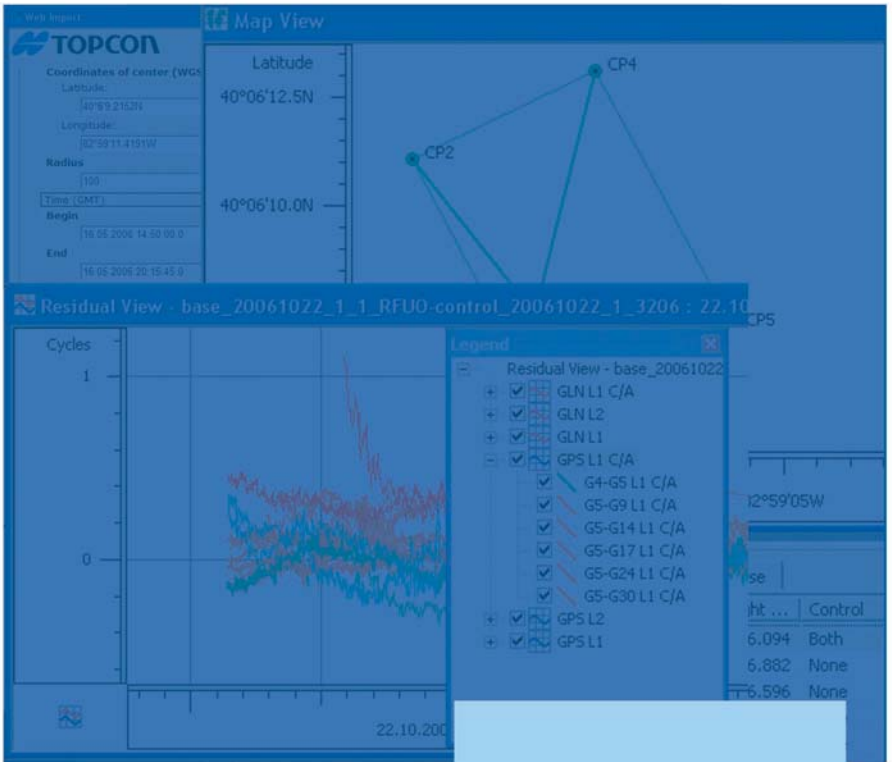


Topcon Tools

Managing Static GPS Occupations



Application Guide



Topcon Tools Managing Static GPS Occupations Application Guide

Part Number 7010-0929

Rev A

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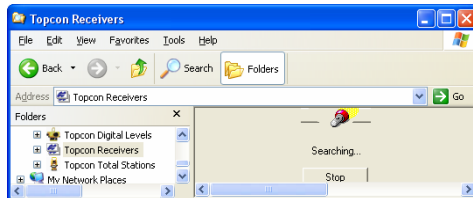
Managing Static GPS Occupations

Downloading Raw Data from GPS Receivers to the Computer




1. Installation of Topcon Tools on the computer creates four additional system folders in the computer:

Other	
 Topcon Digital Levels	System Folder
 Topcon Memory Cards	System Folder
 Topcon Receivers	System Folder
 Topcon Total Stations	System Folder

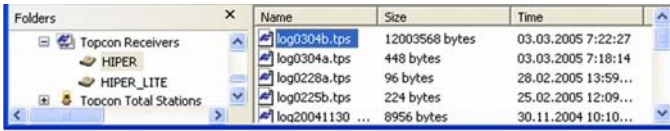
2. Before connecting the receiver's USB port to the computer's USB port, the TPS USB driver must be installed on the computer. The driver is available for download on the TPS website (<http://www.topcongps.com/software/updates.html>).
3. Connect the receiver (s) and computer using the RS232 or USB cable, and turn on the receiver(s).
4. Open *Windows Explorer* and click the *Topcon Receiver* folder. The right panel of the window displays the automatical start of searching of Topcon receivers connected to any of the computer ports (COM and USB).



5. When finished, all the receivers connected to the computer ports will be listed:

Folders	Name	ID
 Topcon Receivers	Search for connected rece...	
 HIPER	HIPER	80DNK3H5R6RK
 HIPER_LITE	HIPER_LITE	8R60ZZZQJO

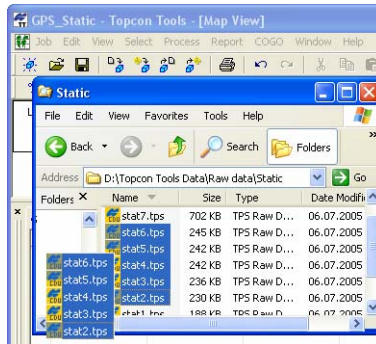
- To view collected raw data file, click a desired receiver.



- To import the file(s) from the receiver to a folder, select the desired file(s) and copy them to the folder using the drag-and-drop method.

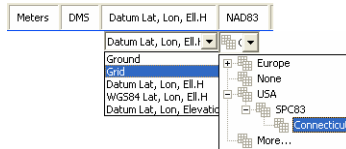
Importing Raw Data to a Topcon Tools Job

- Run Topcon Tools. Open an existing job or create a new job.
- Open the folder which contains the raw data files and copy these files to the current Topcon Tools job using the drag-and-drop method



- After opening the GPS raw data files, the *Points* tab displays navigation coordinates of the points where GPS raw data were collected in WGS-84 coordinate system. To change the datum or set a projection for grid or ground coordinates, double-click on

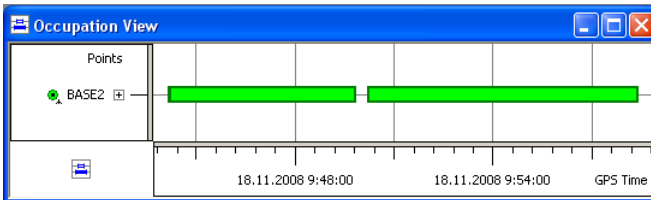
the appropriate box of the *Status Bar* and select a desired coordinate system and projection from the lists:



Importing Files with Identical Point Names - Merging Two Occupations

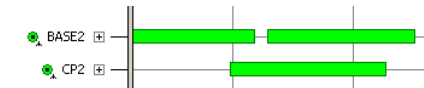
When importing the file that contains occupations with names already existing in the current Topcon Tools job, the software will compare the plane and vertical coordinates for such occupations (points).

- If the difference between the navigation solutions is less than 30 m, the software will automatically import this occupation to the current job without changing the name. In this case two corresponding occupations will be present for the point with this name:



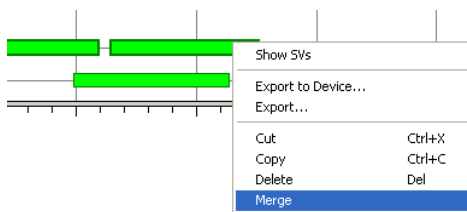
Note, that similar situation can occur when a user changes the power battery for the base station.

To avoid creating several GPS observations for one rover occupation from two base occupations

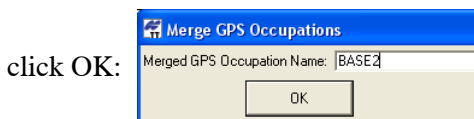


we recommend merging these base occupations:

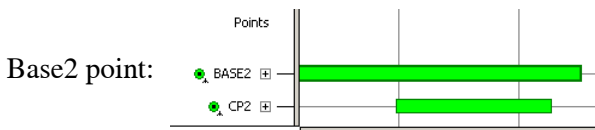
- highlight all occupations for the same point and left-click any highlighted occupation.
- select the *Merge* option (this option will be enabled, if the *Advanced* module of Topcon Tools is activated) from the pop-up menu



- and if all rules for merging two and more occupations are satisfied, the *Merge GPS Occupations* dialog box will appear. Type in a name for being created occupation and

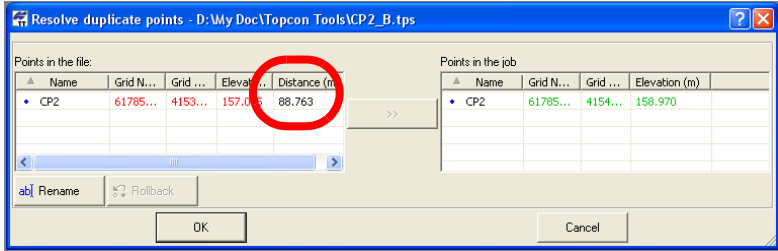


- The *Occupation View* displays ONE occupation for



- If the difference between the navigation solutions is more than 30 m the software displays the *Resolve duplicate points* dialog box. This dialog box allows the user to consider which

points to use in the job and how to rename the points with identical names:



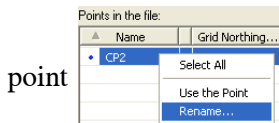
There are three ways to deal with this situation:

1. Click *OK* without changing any name and the software will automatically imports this occupation to the current job. In this case two corresponding occupations will be present for the point (this way is identical to the previous scenario). To set the coordinates of the imported point in the current job instead of existing ones, before clicking *OK*, select the desired point(s) in the left pane and click the double arrows button. The coordinates of the imported point override the old coordinates:

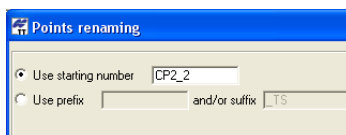
Points in the job			
Name	Grid Northing (m)	Grid Easting (m)	Elevation (m)
CP2	6178538.965	4153...	157.075
	61785...	415427.955	158.970

Click *OK* to continue with the import of this file to the job.

2. Right-click on the imported point and select *Rename* from the pop-up menu to give a new name to



– Type in a desired name and click *OK*:



- Click **OK** in the *Resolve duplicate points* dialog box to start the import.
- In this case two separate points will be present in the job:

Icon	Name	Grid Northing (m)
	CP2	6178538.965
	CP2_2	6178592.060

- To terminate the import of the file to the current Topcon Tools's job, click the *Cancel* button.

Importing Files from the Internet

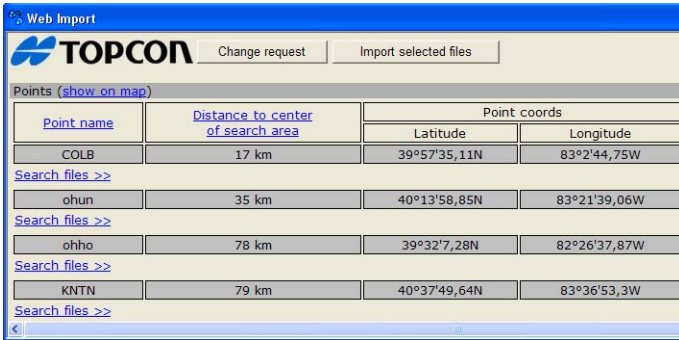
Importing RINEX files from the Internet allows the user to find, select and download the RINEX files from the remote host(s) to your current job.

- Click *Job-Import from the Internet*
- The *Web Import* dialog box displays the coordinates of the job's geometric center and the common time interval for GPS raw data of the job:

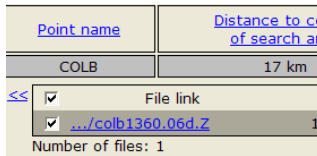
The user can edit every field in this box.

- To start searching for a desired station(s), click the *Search Points* button.

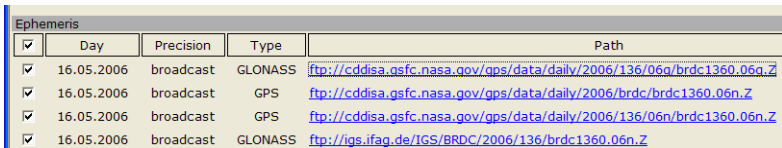
- After the software finds the corresponding station(s), the following window appears. This window contains a list of all stations, which are located within the determined radius:



- To search for a file collected at a point, click [Search files >>](#) below the point name:



- Select the desired file.
- To download the selected file(s) to the current Topcon Tools job, click [Import selected files](#). Only selected file(s) in the opened list for the corresponding point will be downloaded to the job.
- To download the corresponding ephemeris file, click a desired ephemeris file from the *Ephemeris* pane:



Importing Coordinate Files to a Topcon Tools Job

The user can import a file containing control points used for processing, adjustment and localization to the current Topcon Tools job.

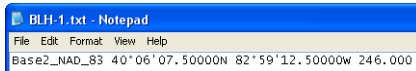
Topcon Tools allows importing text coordinate files that do not contain information about the coordinate system. These files contain ONLY the values of the coordinates.

To import the point coordinates in the corresponding coordinate system, the user has to:

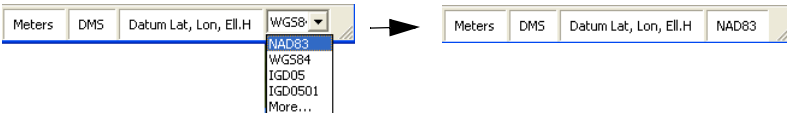
- know this coordinate system or projection;
- set this coordinate system / projection as current (in the *Status Bar*) before importing.

For example, let us create a coordinate file in NAD 83 using the text editor Microsoft Notepad and import this file to the Topcon Tools job:

1. Create and save a file containing coordinates of two points in any desired coordinate system (e.g. NAD 83).



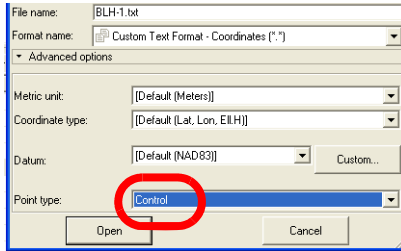
2. Select NAD 83 coordinate system in the *Status Bar*:



3. This file (BLH-1.txt) has an arbitrary file format (by default Topcon Tools does not support BLH file format with space delimiter), to import this file the user has to create and save a user-defined format. To do it, take the following steps:

- click **Job-Import**

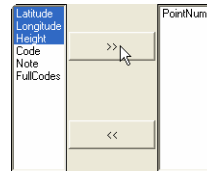
- In the dialog box, select ‘*Custom Text Format*’ in the *Format name* field, type ‘BLH-1.txt’ in the *File name* field and click **Open**.



- In the *Custom format properties* dialog box, enter the file’s parameters:



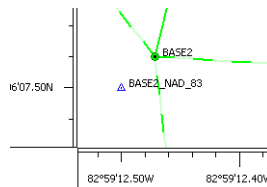
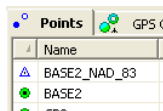
- select the coordinates, then use the right arrow button to move it from the left field to the right field



- enter the format name and the format’s extension

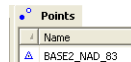
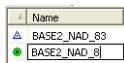


- Click *OK*. Topcon Tools will save this format in the list of the coordinate file formats and import this file into the job.
- *Points* tab and *Map View* display all points of the job:

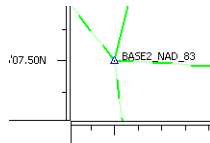


- To assign the coordinates of the imported point to the point, where GPS raw data were collected, replace the name of GPS point with the name of the corresponding control point:

Points Tab



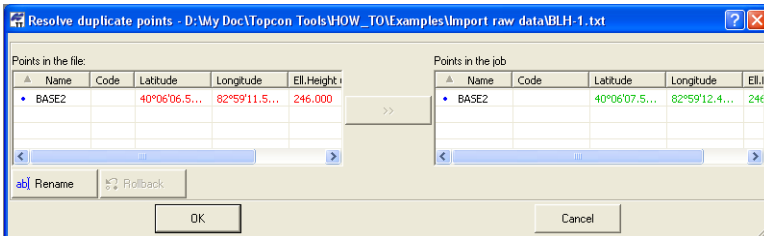
Points Tab



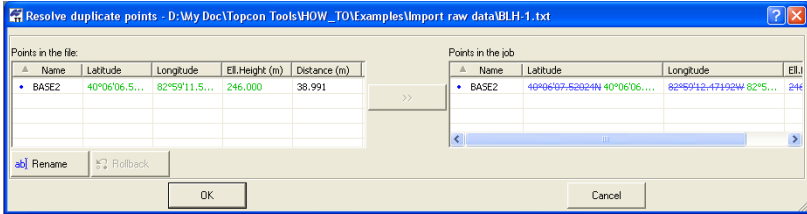
Map View

Note, that the user can use the same point names for the control points and GPS points. In this case, after importing the coordinate file to the current job, Topcon Tools automatically assigns the coordinates from the file to corresponding GPS points, if the coordinate difference is less than 30 meters for a given GPS point.

If this difference is more than 30 meters for a given GPS point, the software displays the *Resolve duplicate points* dialog box. This dialog box allows the user to analyse the control point(s) and select which coordinates to use in the job:



To use the coordinates of the imported point, select the point in the left panel and click the double arrows button. The coordinates of the imported point override the old coordinates.



Importing Control Points in the Ground Coordinate System

To perform localization in a Topcon Tools job, two sets of coordinates in the different systems are needed for the same points:

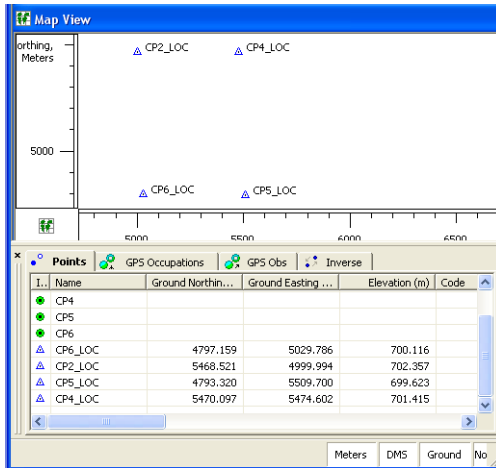
- in the WGS-84 coordinate system (any datum or any grid coordinates can be converted to WGS-84 using pre-defined parameters)
- in a Local coordinate system.

Before importing a local coordinate file, the user has to set the

Ground coordinate system in the *Status Bar*: Meters DMS Ground None .

After importing the corresponding Control points in the Local coordinate system, the Points tab and Map View will display only

these point in Ground coordinate system. This step is the first step to perform Localization in the current job.



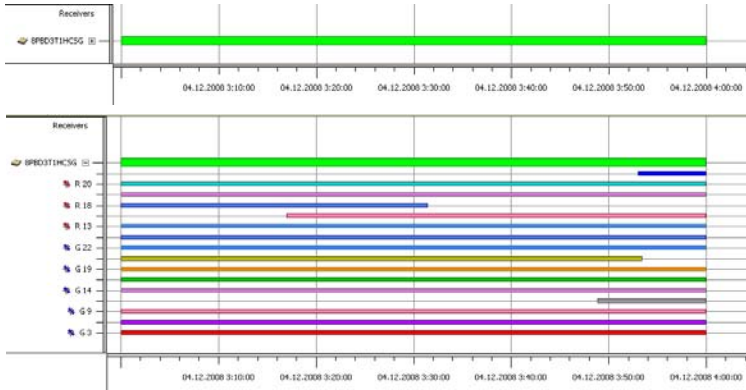
Viewing Downloaded and Created Objects

Map View and *Tab View* display all downloaded points and unprocessed baselines and trajectories in the current job.

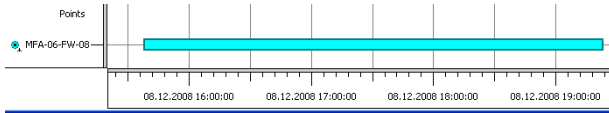
How to See Satellites Whose Signals Were Collected in TPS file

To view individual satellites for imported occupation(s), click **View-Occupations View**, then click the node for a point or receiver. When

the node is expanded, the satellite availability bars will be displayed for this occupation:



Note: The *Occupation View* displays individual satellites plot only for post-processing occupations and does not display individual satellites plot for RTK occupations:



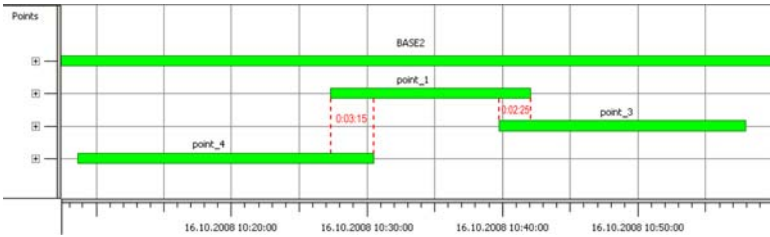
For Static Occupations

Baselines will automatically be created for any pair of static occupations (which were imported into the job), if common time of these occupations is more than the minimum observation time. This time can be set by the user in the *Minimum Duration* field of the *General* tab in the *GPS+ PostProcess* group of the *Process Properties* dialog box:

Minimum duration	
Fixed Time	<input type="text" value="60"/>
Min observation time(sec)	<input type="text" value="60"/>

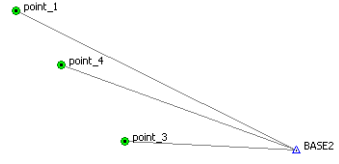
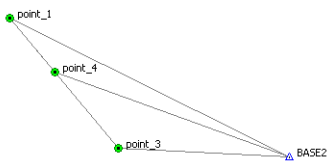
By default this time is 60 sec. This feature is useful to remove short-distance baseline from processing. Such baselines can be accidentally

formed when raw data from two or more independent rover receivers were imported .



A Min observation time(sec)

B Min observation time(sec)



In scenario A, Topcon Tools creates GPS observations for two occupations with duration more than 60 sec. And all possible GPS observations for these four occupations will be created.

For scenario B, Topcon Tools creates GPS observations for two occupations with duration more than 600 sec. Duration for the pairs ‘point-1’ -’point_3’ and ‘point-1’ -’point_4’ is less than 600 sec and GPS observations for these occupations will not be created.

Using settings in this window (the *General* tab in the *GPS+ PostProcess* group of the *Process Properties* dialog box) allows not creating GPS Observations for the lines whose lengths exceed the value set in the field:

Max length of vector(km)

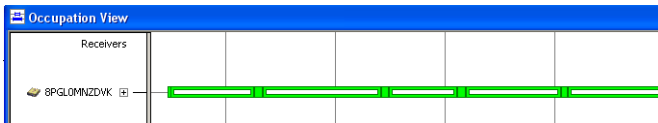
If the distance of a job vector exceeds the specified limit, Topcon Tools will not create GPS observation for it.

All created GPS observations can be processed:

Points	GPS Occupations	GPS Obs			
I...	Point From	Point To	Start Time	Duration	Method
	BASE2	point_3	16.10.2008 10:39:45	0:18:15	PP
	BASE2	point_1	16.10.2008 10:27:20	0:14:50	PP
	BASE2	point_4	16.10.2008 10:08:40	0:21:55	PP

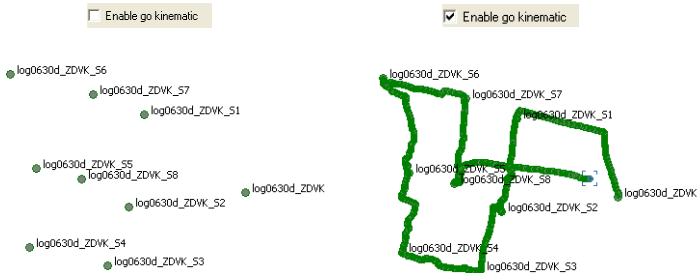
For Stop and Go Occupations

After importing a file that contains Static and Kinematic occupations into a project,

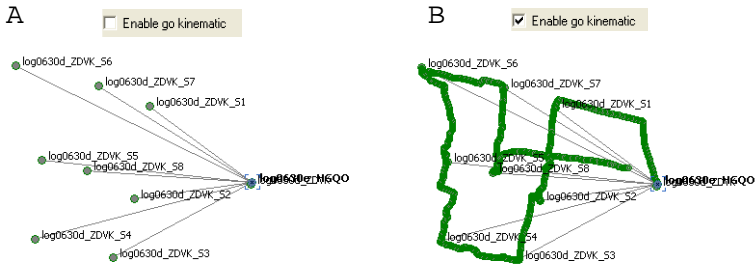


Map View allows one to display either only points measured in the *Stop* mode, or these points and the trajectory of movement of the rover antenna measured in the *Go* mode.

Click Enable go kinematic (in the *General* tab of the *GPS+ PostProcess* group in the *Process Properties* dialog box) to display the trajectory of antenna movement (by default this option is unchecked). The MAP View displays either points or points and trajectory:



After importing the corresponding reference station, MAP View will display either points and GPS Observations or points, GPS Observations and trajectory:

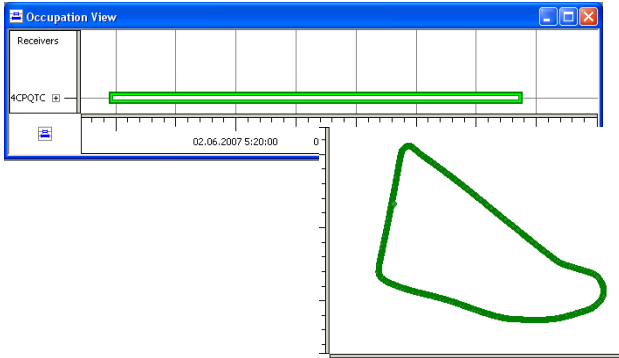


For case A, all created GPS observations can be processed. For case B, all created GPS observations and all trajectories (from point to point) can be processed:

<input type="radio"/> Points <input checked="" type="radio"/> GPS Occupations <input checked="" type="radio"/> GPS Obs						
▲	Point From	Point To	Start Time	Duration	Method	
📍	log0630e_HGQO	log0630d_ZDVK...	30.06.2007 14:07:47	0:00:22	PP Stop	
📍	log0630e_HGQO	log0630d_ZDVK...	30.06.2007 14:13:17	0:00:21	PP Stop	
📍	log0630e_HGQO	log0630d_ZDVK...	30.06.2007 14:16:53	0:00:25	PP Stop	
📍	log0630e_HGQO	log0630d_ZDVK...	30.06.2007 14:20:11	0:00:22	PP Stop	
📍	log0630e_HGQO	log0630d_ZDVK...	30.06.2007 13:37:28	0:00:01	PP Go	
📍	log0630e_HGQO	log0630d_ZDVK...	30.06.2007 13:37:29	0:00:01	PP Go	
📍	log0630e_HGQO	log0630d_ZDVK...	30.06.2007 13:37:30	0:00:01	PP Go	
📍	log0630e_HGQO	log0630d_ZDVK...	30.06.2007 13:37:31	0:00:01	PP Go	

For Kinematic Occupations

The Map View displays a trajectory for any kinematic occupation after importing this occupation into the job:



After importing the corresponding reference station, the GPS Observations tab will display the created GPS observations for each epoch:

I.	Point From	Point To	Start Time	Duration	Method
1	BASE1	log0602a_Sync...	02.06.2007 5:09:29	0:00:01	PP Kin
2	BASE1	log0602a_Sync...	02.06.2007 5:09:30	0:00:01	PP Kin
3	BASE1	log0602a_Sync...	02.06.2007 5:11:05	0:00:01	PP Kin
4	BASE1	log0602a_Sync...	02.06.2007 5:11:06	0:00:01	PP Kin
5	BASE1	log0602a_Sync...	02.06.2007 5:11:07	0:00:01	PP Kin
6	BASE1	log0602a_Sync...	02.06.2007 5:11:08	0:00:01	PP Kin
7	BASE1	log0602a_Sync...	02.06.2007 5:11:09	0:00:01	PP Kin

The trajectory can be processed.

For Ephemeris Data

When only observation RINEX files were downloaded into the job, the corresponding GPS observation(s) will be created, but processing will fail for this GPS observation:

Solution Type
Failed, No Ephemeris

The cause of this problem is the absence of ephemeris information for the occupations. The *Orbit* column of the *GPS Observations* tab displays the current ephemeris status:

Orbit
Absent

There are no GPS/GLONASS ephemeris for this GPS observation. This vector cannot be processed.

Orbit
Broadcast

There are broadcast GPS/GLONASS ephemeris for this GPS observation. This vector can be processed.

Orbit
Precise

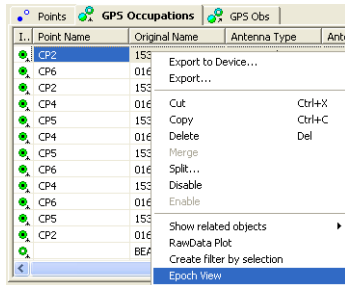
There are precise GPS/GLONASS ephemeris for this GPS observation. This vector can be processed.

Coordinates the Points Tab Displays

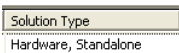
An imported tps file can contain coordinates of different types. It depends on which service was used during data collection:

- If a receiver is collecting data in the standalone mode, the coordinates for each epoch can be navigational or standalone
- If a receiver is collecting data in the RTK mode, the coordinates for each epoch can be fixed or float, e.g. obtained with phase solution
- If a receiver is collecting data in the code differential mode using correction data from a beacon or WAAS/EGNOS satellites, the coordinates for each epoch can be obtained with code differential solution.

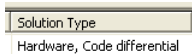
To see the type of coordinates, after importing a tps file into a Topcon Tools job, open the *GPS Occupations* tab, right click the desired occupation and select the *Epoch View* option (this option will be enabled, if the *Advanced* module of Topcon Tools is activated):



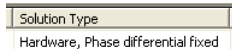
The left panel of the *Epoch View* window contains *Solution Type* column:



for coordinate, collected in standalone mode



for coordinate, collected in code differential mode



for coordinate, collected in RTK mode

When the user imports a file, which contains a static occupation, the *Points* tab displays the averaged coordinates of all epochs collected

for this point. And the *GPS occupations* tab displays the horizontal/vertical position error for the given occupation:

The screenshot shows two views of the 'GPS Occupations' tab. The top view shows a single row for point 'BASE2' with columns for Icon, Name, Latitude, Longitude, and Ell. Height (m). The bottom view shows a detailed table with columns: I., Point Name, Original Name, Antenna Type, Antenna H..., Ant H..., Start Time, Stop Time, H RMS (m), and V RMS (m).

Icon	Name	Latitude	Longitude	Ell. Height (m)
	BASE2	40°06'07.52051N	82°59'12.47055W	280.176

I..	Point Name	Original Name	Antenna Type	Antenna H...	Ant H...	Start Time	Stop Time	H RMS (m)	V RMS (m)	
	BASE2	01580516a...	HPer XT		1.787	Slant	16.05.2006 14:...	16.05.2006 20:...	4.521	4.058

When the user imports a file, which contains a kinematic occupation, the *Points* tab displays the coordinates for each epoch collected for this trajectory. Averaging coordinates for the kinematic occupation is not performed, and the coordinate error will be determined by the type of solution (see *Epoch View*):

The screenshot shows the 'Points' tab with a list of kinematic occupations. The table has columns: I., Name, Latitude, Longitude, and Ell. Height ...

I..	Name	Latitude	Longitude	Ell. Height ...
	BEACON_ZZDA 1505.260501000	40°06'07.30778N	82°59'12.74564W	248.157
	BEACON_ZZDA 1505.260502000	40°06'07.31036N	82°59'12.74716W	247.900
	BEACON_ZZDA 1505.260503000	40°06'07.30865N	82°59'12.74009W	247.585
	BEACON_ZZDA 1505.260504000	40°06'07.30865N	82°59'12.73801W	247.608
	BEACON_ZZDA 1505.260505000	40°06'07.30687N	82°59'12.73641W	247.847
	BEACON_ZZDA 1505.260506000	40°06'07.30455N	82°59'12.73404W	248.103

Editing Occupations Before Post-processing

This section describes some useful steps, the user can take before post-processing and adjustment

Editing Point Name

When the user uses MINTER for creating Stop-and-Go file, the names of static points are very long. To change names for all *Stop* points, do the following:

- Open the *Points* tab,
- Sort the occupations by icons:

The screenshot shows the 'Points' tab with a list of occupations sorted by icons. The table has columns: Icon and Name.

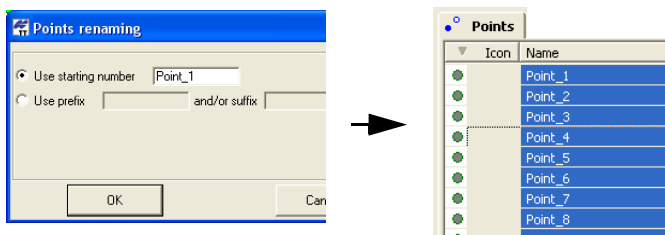
Icon	Name
	log0630d_ZDVK
	log0630d_ZDVK_S1
	log0630d_ZDVK_S2
	log0630d_ZDVK_S3
	log0630d_ZDVK_S4
	log0630d_ZDVK_S5
	log0630d_ZDVK_S6
	log0630d_ZDVK_S7
	log0630d_ZDVK_S8

- Highlight all *Stop* points,
- Right-click on any highlighted point and select *Rename Points*

from the pop-up menu:



- Type in 'Point_1' as the name for the first point and click Ok. The software will add the increment "1" to the name of every point:



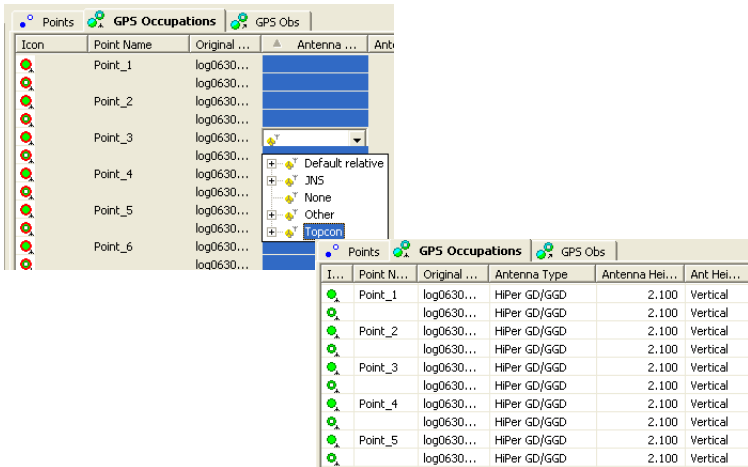
Editing Antenna Parameters

When the user uses MINTER for creating a tps file, as a rule, the information about antenna type, antenna height method and antenna height are absent in the file. After importing such a tps file into a Topcon Tools job, the GPS occupations tab displays the occupation(s) of this file in red (a special test determines that the antenna parameters for GPS occupation(s) are invalid):

GPS Occupations					
Icon	Point Name	Original ...	Antenna Type	Antenna Height...	Ant Height Met...
●	Point_2	log0630...			Vertical
●		log0630...			Vertical
●	Point_3	log0630...			Vertical
●		log0630...			Vertical
●	Point_4	log0630...			Vertical
●		log0630...			Vertical
●	Point_5	log0630...			Vertical
●		log0630...			Vertical

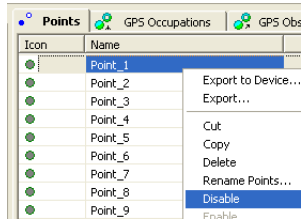
The software allows the user to set the desired antenna type, antenna height method and antenna height for multiple occupations:

- Highlight all desired occupations
- Click a highlighted cell (or press F2) and edit the desired information:
 - Antenna Type – select a desired antenna type from the drop-down list.
 - Antenna Height – type in a new height for the antenna.
 - Antenna Height Method – select the method from the drop-down list.



Disabling Point/GPS Occupation/GPS Observation

The user can disable any object (point/GPS Occupation/GPS Observation) from the current job using the *Disable* option in the pop-up menu for this object:



When a point is disabled, it means that all GPS observations for this point will be disabled from post-processing and adjustment.

When a GPS occupation is disabled, it means that all GPS observations where this GPS occupation is used will be disabled from post-processing and adjustment.

When a GPS Observation is disabled it means that only this GPS observation will not be processed and adjusted.

Changing Occupation Type

If you used MINTER of the receiver for creating a raw data file and did not use the FN button to change the occupation type, the user can obtain a static occupation which contains kinematic data. To switch from static to kinematic, erase the point name for this occupation:

1. Highlight the GPS occupation to edit the point name, and press F2.
2. Press Delete to remove the point name and press Enter.

The static occupation became kinematic that is marked by the corresponding icon (see an example below)

The GPS Occupations tab

I...	Point Name	Original Name	Antenna Type
	log0602_Na_B4E8	log0602_Na_B4E8	

The Points tab

I...	Name	Latitude	Longitude	Ell.Height (m)
	log0602_Na_B4E8	66°14'46.22342N	63°50'19.89235E	585.247

I...	Point Name	Original Name	Antenna Type
		log0602_Na_B4E8	

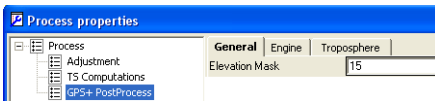
I...	Name	Latitude	Longitude	Ell.Height ...
	log0602_Na_B4E8 1429.536957000	66°13'10.27590N	63°47'11.21383E	88.344
	log0602_Na_B4E8 1429.536958000	66°13'10.11564N	63°47'11.15691E	88.353
	log0602_Na_B4E8 1429.536959000	66°13'09.94910N	63°47'11.09682E	88.384
	log0602_Na_B4E8 1429.536960000	66°13'09.78243N	63°47'11.02292E	88.402
	log0602_Na_B4E8 1429.536961000	66°13'09.61758N	63°47'10.92660E	88.428
	log0602_Na_B4E8 1429.536962000	66°13'09.45813N	63°47'10.79786E	88.442

The *Points* tab displays kinematic points for each epoch, and the name of the kinematic point contains the name of this occupation and the time in the format of the GPS week number and week seconds.

Note: The software allows one to change the occupation type only for post-processing occupations and does not allow changing the occupation type for RTK occupations.

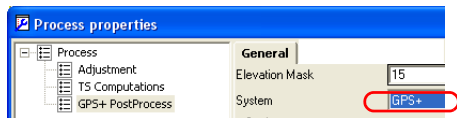
Processing GPS Raw Data

Before processing the user can change the elevation cut-off angle (in degrees) for satellites used in data processing. To do it, click **Process->Process Properties->GPS+ PostProcess**, select *General tab*, type in the desired cut-off angle in the *Elevation Mask* field

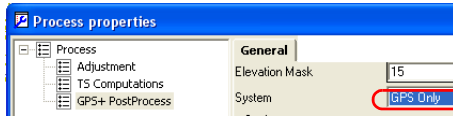


and click **OK**.

To use GPS/GLONASS SV's in post-processing, select the *GPS+* option in the *System* field of this tab:



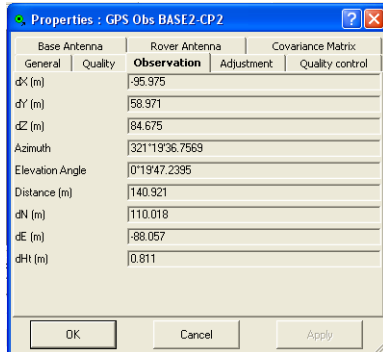
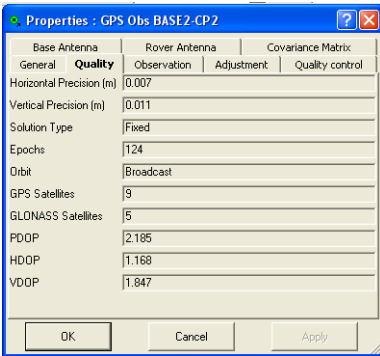
To use only GPS SV's in post-processing, select *GPS Only*:



Click **Process-GPS+PostProcessing** to start processing baselines.

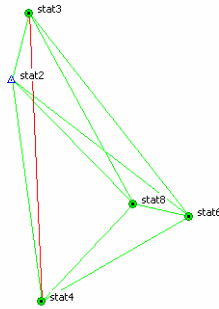
The *Status* bar displays processing in progress GPS+ PostProcessing . Once

the process is finished, the user can view the results of calculation of baselines in the *GPS Obs* tab. To do it, click *GPS obs* tab. To view a result for a single baseline, right click a desired observation in the *GPS Obs* tab, select *Properties* and click the *Observation* tab in the *Properties* window:



After processing, the *Map View* will display green or red static GPS baselines. Red color is used for baselines, whose *Horizontal Precision/Vertical Precision* (these precisions are calculated by the post-processing engine) are worse than the value in the setting for the

current job (**Job - Job Configuration - Quality Control- GPS Obs Precision** tab).



The red baseline has the  icon in the GPS Obs tab.

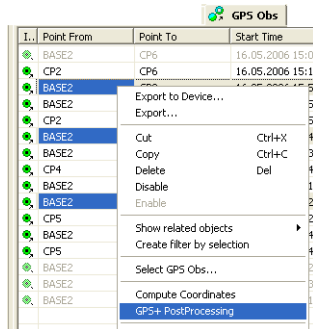
The *GPS Observation Report* will display the name and the corresponding horizontal or vertical precision of this GPS observation in red color:

GPS Observations

Name	dN (m)	dE (m)	dHt (m)	Horizontal Precision (m)	Vertical Precision (m)
stat5- stat7	-55023.890	-58177.946	33.588	0,022	0,037

How to Process Single/Selected GPS Observations

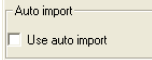
To process one or several highlighted GPS observations, right click on the desired / any highlighted GPS observation and select *GPS+ PostProcessing* from the pop-up menu:



The user can use the given way to process different GPS observations with different settings in the *Process Properties* window.

Auto Import of Data and Auto-processing

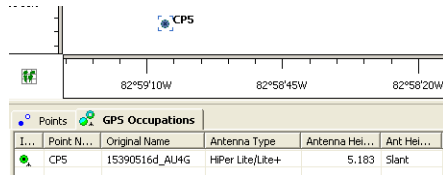
If the user has occupation(s) from only one GPS receiver, he can obtain processed coordinates for these occupations. At first check

mark the box  in the *General* tab in the *GPS+*

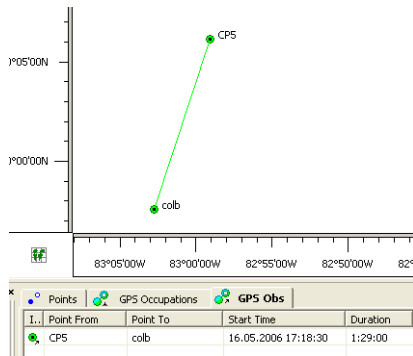
PostProcess group of the *Process Properties* dialog box.

And then click **Process-> GPS+PostProcessing** to start auto-processing for separate occupations. The software will automatically search for a station by the criterion of a minimal distance from an existing point in the job. After finding such a station, the program is searching for the file by the corresponding date and time of the occupation loaded into the job. Then the found file will be

automatically imported to the job, and also automatically the created GPS observation will be processed:



F7 (GPS+ PostProcessing)



Note that the vector (GPS observation) was processed from some (not-fixed) coordinates of the imported points. We recommend that the user specify these values:

- enter their correct values into the *Points* tab,
- fix these coordinates (in the *Control* column)
- click F8 (*Adjustment*).

Then the user obtains the coordinates for the given points from the fixed coordinates of the imported reference station:

Icon	Name	Latitude	Longitude	Ell.Height ...	Control
●	CPS	40°06'07.20956N	82°59'06.50947W	811.978	None
▲	colb	39°57'35.08471N	83°02'44.73229W	615.683	Both

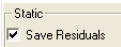
About Vector and Point Coordinates

On the post processing stage Topcon Tools determines coordinates of GPS observations (vectors) only, rather than the final coordinates of the points.

We strongly recommend performing an adjustment of the network (closed or unclosed) to obtain the final coordinates of the network points from Fixed Control Point(s).

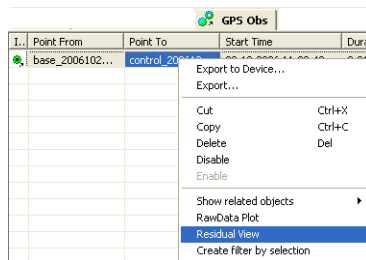
How to See Satellites Used in Post-processing of GPS Observation

If the user wants to see satellites used in post-processing of static GPS - observation(s), the user has to select the checkbox



in the *General* tab (of the *GPS+ PostProcess* group in

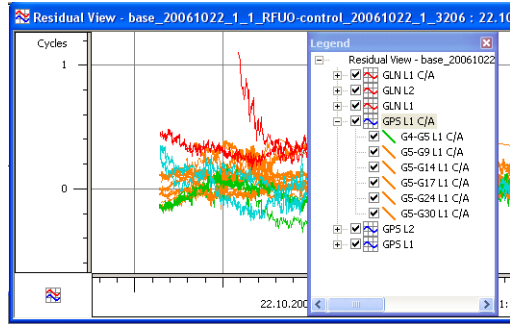
the *Process Properties* dialog box). This option will be enabled, if the *Advanced* module of Topcon Tools is activated. After processing all or selected GPS observations, Topcon Tools creates the residuals plot for each processed static GPS observation. To view this plot, right click on a desired GPS observation in the corresponding tab and select *Residuals View* from the pop-up menu:



Then the *Residual View* dialog box displays diagrams of the residuals resulting from GPS-observation computation for each double difference satellite pair used in processing

- The X-axis represents the duration of GPS-observation.

- The Y-axis represents the residuals in carrier cycles for all measurement types which were collected in the two occupations.



The *Legend* window displays a list of all satellites (and measurement types for each satellite) which were used in post-processing.

Adjusting the Network

Adjustment of the network - is a final procedure for obtaining the coordinates of the network points in the pre-defined system of coordinates (i.e., in the coordinate system defined in the Topcon Tools Database) with estimation of errors.

Only adjustment allows obtaining point coordinates of network from Fixed Control points.

Only after the adjustment of the network, which consists of closed figures, it is possible to obtain not statistical evaluations but realistic errors of coordinates for the given network.

Topcon Tools performs separate adjustments for the plane coordinates and for the heights of the network.

The user can independently select in which plane(s) to perform the adjustment using the appropriate type of control points.

- If the user does not fix points of the network, the free (inner) adjustment will be performed in the both planes:

Icon	Name	Control
●	BASE2	None
●	CP2	None
●	CP4	None
●	CP5	None
●	CP6	None

Subnetwork CP2_CP6_BASE2... (Horz + Vert)
No Vertical and Horizontal Control

- If the user sets ONE point as fixed in the horizontal and vertical planes (set *Both* in the *Control* field), the adjustment of this network in plane and by height is performed with minimal constraint. The plane adjustment uses the horizontal coordinates of this point, and the vertical adjustment uses the elevation of this point:

Icon	Name	Control
▲	BASE2	Both
▲	CP2	None
▲	CP4	None
▲	CP5	None
▲	CP6	None

Control Tie Analysis: Success
Subnetwork CP2_CP6_BASE2... (Horizontal Minimal Constraint + Vertical Minimal Constraint)

The user can use TWO different points as control: one only in vertical and another only in horizontal plane. In this case Topcon Tools will also perform the minimal constraint adjustment for each plane:

Icon	Name	Control
□	BASE2	Vertical
▲	CP2	None
▲	CP4	None
▲	CP5	None
▲	CP6	Horizontal

Control Tie Analysis: Success
Subnetwork CP2_CP6_BASE2... (Horizontal Minimal Constraint + Vertical Minimal Constraint)

If the user sets some point as fixed in the horizontal only, the adjustment of this network is performed in plane only. Vertical adjustment will not be done for such setting:

Icon	Name	Control
▲	BASE2	Horizontal
●	CP2	None
●	CP4	None
●	CP5	None
●	CP6	None

Subnetwork CP2_CP6_BASE2... (Horz + Vert)
No Vertical Control
Horz Control Points: 1
Vertical Adjustment will NOT be done

Settings for Adjustment

- To evaluate quality of the adjusted network, the user can select either Quality Control or Tau Criterion tests. To do it, click *Process-Process Properties-Adjustment* tab and select the desired radio button in the *Rejection Criterion* field:

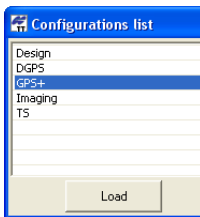
Rejection Criterion

By Quality Control

Tau Criterion

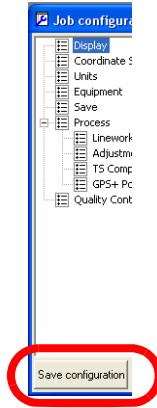
If the user selects “*By Quality Control*”, Topcon Tools will reject those horizontal or /and vertical components of GPS observation from adjustment which have residuals worse than the value set for the current job (**Job - Job Configuration - Quality Control- GPS Obs Precision** tab). The residuals for GPS observation are calculated in the adjustment process for the closed figures of the network.

Note that the values in tab of *Quality Control* block are assigned by the current configuration of the given job. If you are going to adjust the network with centimeter-order-precision, load the *GPS+* configuration before the adjustment. In this case the *GPS Obs Precision* tab will have the following values (an example for meters)



GPS Obs Precisions	
RTK Horizontal Precision (m)	0.02
RTK Vertical Precision (m)	0.05
PP Static Horizontal Precision (m)	0.02
PP Static Vertical Precision (m)	0.05
PP Kinematic Horizontal Precision (m)	0.02
PP Kinematic Vertical Precision (m)	0.05

To load the desired configuration, click the *Save configuration* button on the *Job Configuration* window:



If the user selects “*Tau Criterion*” test, Topcon Tools will reject the horizontal or /and vertical components of GPS observation from adjustment with a Tau value more than $Tau_{critical}$. These residuals are calculated in the adjustment process for the closed figures and/or for repeated observations in the network.

The formula for calculating Tau is: $Tau = RES / \delta_{res}$,

where

“RES” designates the residual calculated for the corresponding component of the observation;

δ_{res} is the RMS residual error.

Note that $Tau_{critical}$ depends on the number of degrees of freedom and the selected level of confidence

- Before the first adjustment, we recommend the user disable the option of rejection of bad component(s) GPS observations from the network adjustment. To do that, double click in the *Autoreject* column for the desired GPS observation and select *Not Allowed*.




In this case ALL GPS observations with any values of residuals will be used in the adjustment of the network. In the

given case, Topcon Tools will display the maximum possible value of UWE for the whole network.

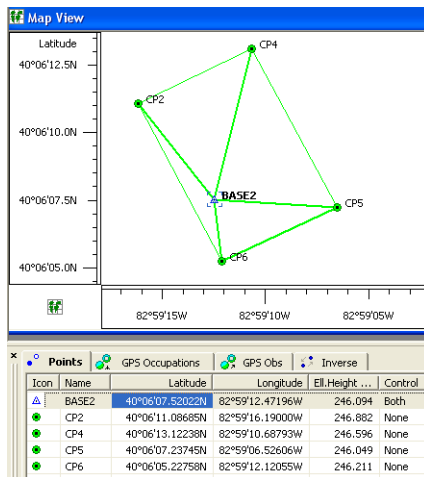
How to Run Adjustment

To adjust all observations in the current job, do one of the following:

- Click **Process->Adjustment**
- Press **F8** on the keyboard
- Click  (*Adjust Network*) button

Let's adjust a network which contains:

- 5 points, one point is fixed in plane and by height,
- 16 GPS observations (together with repeated GPS - observations)



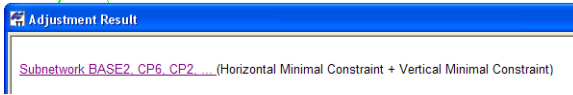
“By Quality Control” is selected for this Topcon Tools job.

What Adjustment Result Window Displays

After starting the adjustment procedure, the network is analyzed.

If every test is performed successfully, the *Adjustment Result* window displays:

- a) The type of the network adjustment. For the given example the adjustment was performed in both planes with minimal constraints:



b) The table contains information about:

- the quantity of adjusted points,
- the quantity of fixed points and weighted points,
- the quantity of used and rejected observations,
- errors of unit weight (UWE) and UWE bounds:

Type	Adjusted Points	Fixed Points	Weighted Points	Equations (Used/Rejected)	UWE	UWE Bounds
				GPS		
Horz	5	1	0	16	2.36	[0.72,1.28]
Vert	5	1	0	16	4.94	[0.61,1.39]

Note that auto rejected observations are absent, because *Not Allowed* was selected in *Autoreject* column for all GPS observations of the network

c) The component in red is a GPS observation with precisions worse than the values set for the current job in the *Job*

QC fail Observations

Configuration tab:

Name	Type	Residual N(m)	Residual E(m)	Residual H(m)
BASE2-CP5	GPS	-0.015	0.002	-0.113

What is UWE

UWE is a coefficient which displays HOW the precision of the network points (closed figure) changes after adjustment with respect to the precision obtained after processing the baselines (GPS observations). If the user got UWE close to 1, the average precision of each GPS observation (vector) in the network after

adjustment is not worse than the average precision after processing. The following formula can be used for calculation:

$$\text{Precision_of_Vector_after_Adjustment} = \text{UWE} * \text{Average_Precision_of_Vector_after_Processing.}$$

UWE bounds are the min/max values of UWE for the given network with successful result of adjustment (only for closed figure(s)).

Note that most reliable results of the network adjustment are obtained when UWE is within the bounds. Therefore, to achieve centimeter precision for the network points, the user has to try to get UWE whose value does not exceed the upper bound.

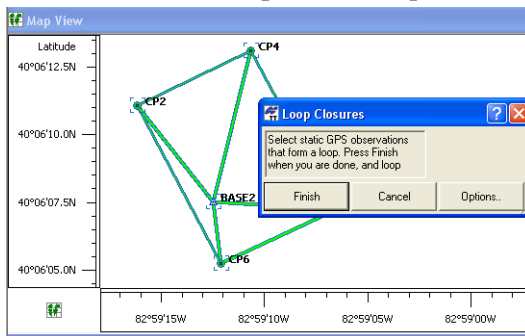
How to Decrease the UWE Value

Usually, to change the UWE value for the adjusted network, you can search out a figure (triangle or rectangular) or several figures, which shows maximum values of misclosures in regard to other figures. After such figures are found out, the “worst“vector is detected. That vector (or maybe the vectors) is disabled from the adjustment, and the adjustment is performed again.

After the adjustment of our example network, the value of UWE for horizontal plane is 2,36, and the value of UWE for vertical plane is 4,94.

All these values overrun UWE bounds for this network.

Select all GPS observations and click **Process->Loop Closure**. Click the **Finish** button to create the loop closures report:



The maximum values of loop closures in horizontal and vertical planes are as follows:

in plane

in vertical

Loop Closures

Loop	dHz (m)
BASE2-CP2(16.05.2006 19:29:30) BASE2-CP4(16.05.2006 15:53:00) CP2-CP4(16.05.2006 15:59:00)	0.0343
BASE2-CP2(16.05.2006 19:29:30) BASE2-CP4(16.05.2006 16:36:30) CP2-CP4(16.05.2006 15:59:00)	0.0342

Loop Closures

Loop	dHz (m)	dU (m)
BASE2-CP4(16.05.2006 15:53:00) BASE2-CP5(16.05.2006 19:38:00) CP4-CP5(16.05.2006 16:43:30)	0.0205	0.1475
BASE2-CP4(16.05.2006 16:36:30) BASE2-CP5(16.05.2006 16:43:30) CP4-CP5(16.05.2006 16:43:30)	0.0131	0.0238
BASE2-CP4(16.05.2006 16:36:30) BASE2-CP5(16.05.2006 17:18:30) CP4-CP5(16.05.2006 16:43:30)	0.0114	0.0313
BASE2-CP4(16.05.2006 16:36:30) BASE2-CP5(16.05.2006 19:38:00) CP4-CP5(16.05.2006 16:43:30)	0.0263	0.1503

After the triangles with maximum misclosure are detected, let's deal with the task of finding out the "worst" vector in these triangles.

The triangle Base2-CP2-CP4 has the worst residuals in the horizontal plane. Highlight this triangle and perform the *Loop Closure* test again. As we see from the report, the figure contains the repeated GPS observations:

Loop Closures

Loop	dHz (m)
BASE2-CP2(16.05.2006 15:13:15) BASE2-CP4(16.05.2006 15:53:00) CP2-CP4(16.05.2006 15:59:00)	0.0082
BASE2-CP2(16.05.2006 15:13:15) BASE2-CP4(16.05.2006 16:36:30) CP2-CP4(16.05.2006 15:59:00)	0.0028
BASE2-CP2(16.05.2006 15:59:00) BASE2-CP4(16.05.2006 15:53:00) CP2-CP4(16.05.2006 15:59:00)	0.0025
BASE2-CP2(16.05.2006 15:59:00) BASE2-CP4(16.05.2006 16:36:30) CP2-CP4(16.05.2006 15:59:00)	0.0106
BASE2-CP2(16.05.2006 19:29:30) BASE2-CP4(16.05.2006 15:53:00) CP2-CP4(16.05.2006 15:59:00)	0.0343
BASE2-CP2(16.05.2006 19:29:30) BASE2-CP4(16.05.2006 16:36:30) CP2-CP4(16.05.2006 15:59:00)	0.0342

The sessions, where the vector Base2-CP2 with start time 16.05.2006; 19:29:30 is present, have the maximum residuals in plane.

We see that the plane component (dN) of the vector does not go with other observations of vector Base2-CP2:

I...	Point F...	P...	Start Time	dN (m)	dE (m)	dHt (m)
	BASE2	CP2	16.05.2006 15:59:00	110.018	-88.057	0.811
	BASE2	CP2	16.05.2006 19:29:30	109.994	-88.078	0.803
	BASE2	CP2	16.05.2006 15:13:15	110.022	-88.065	0.771

We can disable this vector. Then let's continue to analyse the network.

The triangle Base2-CP4-CP5 has the worst residuals in vertical plane. Highlight this triangle and perform the *Loop Closure* test again. As we see from the report, the figure contains the repeated GPS observations.

The sessions, where the vector Base2-CP5 with start time 16.05.2006; 19:38:00 is present, have the maximum residuals in plane.

Loop Closures

Loop	dHz (m)	dU (m)
BASE2-CP4(16.05.2006 15:53:00) BASE2-CP5(16.05.2006 16:43:30) CP4-CP5(16.05.2006 16:43:30)	0.0057	0.021
BASE2-CP4(16.05.2006 15:53:00) BASE2-CP5(16.05.2006 17:18:30) CP4-CP5(16.05.2006 16:43:30)	0.0043	0.0284
BASE2-CP4(16.05.2006 15:53:00) BASE2-CP5(16.05.2006 19:38:00) CP4-CP5(16.05.2006 16:43:30)	0.0205	0.1475
BASE2-CP4(16.05.2006 16:36:30) BASE2-CP5(16.05.2006 16:43:30) CP4-CP5(16.05.2006 16:43:30)	0.0131	0.0238
BASE2-CP4(16.05.2006 16:36:30) BASE2-CP5(16.05.2006 17:18:30) CP4-CP5(16.05.2006 16:43:30)	0.0114	0.0313
BASE2-CP4(16.05.2006 16:36:30) BASE2-CP5(16.05.2006 19:38:00) CP4-CP5(16.05.2006 16:43:30)	0.0263	0.1503

We see that the vertical component (dU) of the vector does not go with other observations of vector Base2-CP5:

	BASE2	CP5	16.05.2006 19:38:00	-8.736	140.837	-0.160
	BASE2	CP5	16.05.2006 16:43:30	-8.721	140.837	-0.033
	BASE2	CP5	16.05.2006 17:18:30	-8.720	140.836	-0.041

We can disable this vector.

Then adjust the network again. In this case, without two manually rejected vectors, we obtain the following results:

Subnetwork BASE2, CP6, CP2....(Horizontal Minimal Constraint + Vertical Minimal Constraint)

Type	Adjusted Points	Fixed Points	Weighted Points	Equations (Used/Rejected)	UWE	UWE Bounds
				GPS		
Horz	5	1	0	14	1.32	[0.69,1.31]
Vert	5	1	0	14	2.35	[0.57,1.43]

Using the above method of searching triangles with maximum misclosures, and manual rejecting the “worst” vectors from the found triangles, you can further decrease the UWE value. But even for such values of UWE, being out the UWE bounds, the result of *Loop Closure* test for the 14 GPS observations shows that the maximal residuals do not exceed 0.013m in horizontal and 0.042 m in vertical plane.

Loop Closures

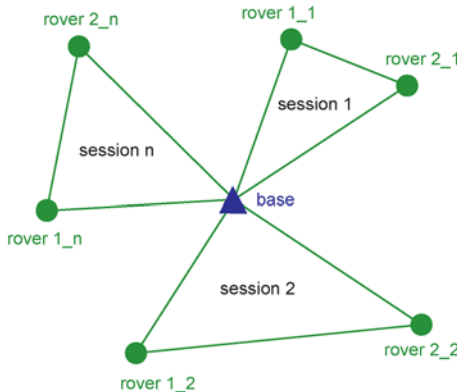
Loop	dHz (m)
BASE2-CP4(16.05.2006 16:36:30) BASE2-CP5(16.05.2006 16:43:30) CP4-CP5(16.05.2006 16:43:30)	0.0131

Loop Closures


Loop	dHz (m)	dU (m)
BASE2-CP2(16.05.2006 15:13:15) BASE2-CP4(16.05.2006 15:53:00) CP2-CP4(16.05.2006 15:59:00)	0.0082	0.0396
BASE2-CP2(16.05.2006 15:13:15) BASE2-CP4(16.05.2006 16:36:30) CP2-CP4(16.05.2006 15:59:00)	0.0028	0.0425

Reject with Care

When using three receivers, which simultaneously collect data at three different sites, each of sessions represents a “trivial” triangle. Such a triangle has three simultaneously measured vectors.



If after performing *Loop Closure* test for this network, there will be a triangle with the misclosure greater than the value set in the *Job Configuration* window, we do not recommend using automatic rejection of bad GPS observations for adjustment of such a network.

We recommend selecting *Not Allowed*  for all GPS observations of the given network.

In this case we recommend evaluating the misclosure, and if the obtained values are worse than the desired accuracy, analysing the processed vectors to try to find out the cause of low accuracy. There may be the following causes: insufficient common time of data collection, too little number of observed satellites for the given time of data collection, collecting raw data in conditions of external interference or multipath.

Try re-processing all vectors or one of them with different values of elevation mask and do the *Loop Closure* test again.

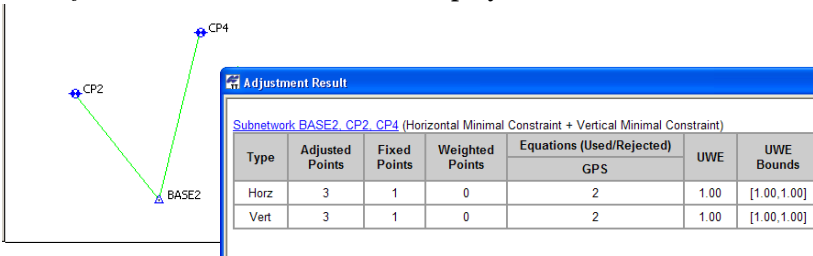
If the repeated the *Loop Closure* test does not show decreasing the misclosures, we recommend you re-measure the triangle in different survey conditions:

- with greater time of data collection, or with the antenna mounted higher over the site, or with using a new site for raw data collection, and measuring the desired point as offset by TS or tape.

Adjustment of Unclosed Figures

Topcon Tools allows one to perform adjustment for unclosed figures. When the network is not closed, the adjustment procedure is simply the calculation of coordinates of network points from a fixed base

station. If the user sets a control point with fixed vertical coordinate, the *Adjustment Result* window will display:



The plane and vertical coordinates of the points will be calculated from the coordinates of the base station.



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