PROGRESS

microelectronic research **institute**

ProGeoOffice

User Manual

Version 1.84.3

2024

TABLE OF CONTENTS

PREFACE

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SCREEN CAPTURES – This manual includes sample screen captures. Your actual screen can look slightly different from the sample screen due to the receiver you have connected, operating system used and settings you have specified. This is normal and not a cause for concern

TECHNICAL ASSISTANCE – If you have a problem and cannot find the information you need in the product documentation, contact your local dealer. Alternatively, request technical support using the NIIMA PROGRESS World Wide Web site at: https://progeo.expert/en/

CHAPTER 1. SYSTEM ADMINISTRATOR'S GUIDE

This document contains instructions for installing ProGeoOffice software.
The document describes the system administrator's operations for installing new products and servicing already installed products (correcting, changing, deleting). The document is also suitable for use by untrained users.

SYSTEM REQUIREMENTS:

1. Processor: Intel or AMD dual or multi-core
2. RAM: not less than 8 GB
3. Operating system: 64-bit Microsoft Windows 7 – 11 versions
4. ROM: not less than 500 MB

TECHNICAL SUPPORT CONTACTS AND WEBSITE:

E-mail: support@progeo.online
The site of the company: https://progeo.online

1.1 Installation

To install ProGeoOffice execute the ProGeoOffice_X.XX.XXX_Installer.exe installation file. The name of the installation file contains the program version. The program version consists of three integer values. The first indicates the main version of the program. The second indicates the version of the project with which the program works. The third indicates the build number. Newer versions contain higher values. New versions support opening and updating older version projects. When the installation file is executed, the previously installed version of the program is uninstalled automatically. Installation does not require administrator rights and is performed in "%LocalAppData%\Progress\ProGeoOffice\"(C:\Users\username\AppData\Local\Progress\ProGeoOffice\).

1.2 Installation steps

A welcome window with information about the product and installation tips will appear after launching:

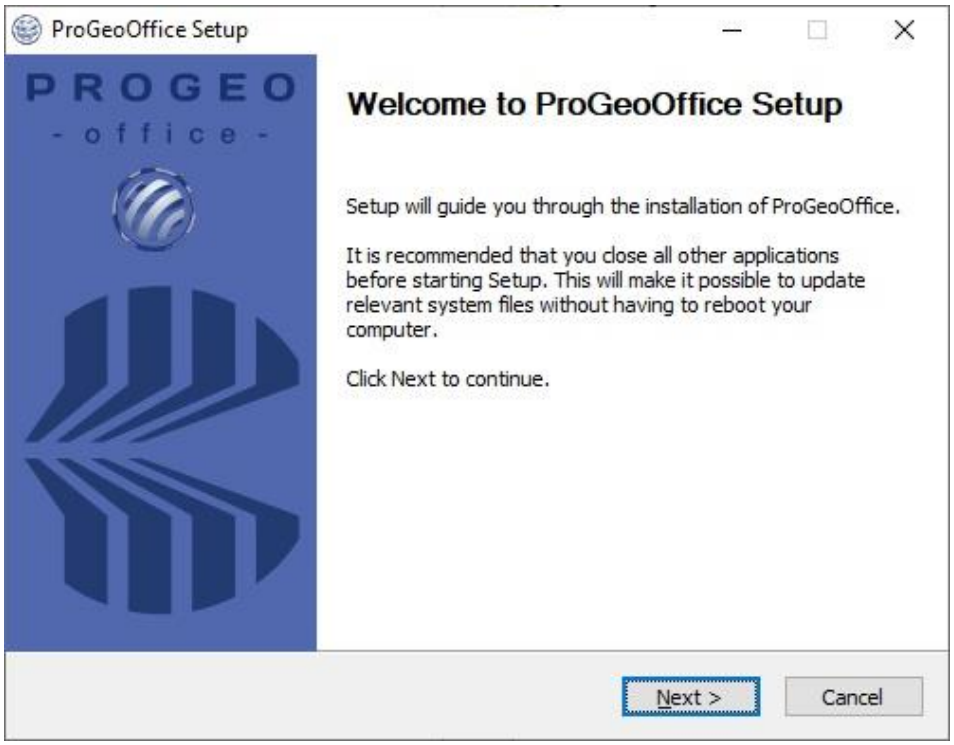


Figure 1 – Product information window

After clicking the "Next >" button the program will uninstall previous version of application, if any, and install a new one.

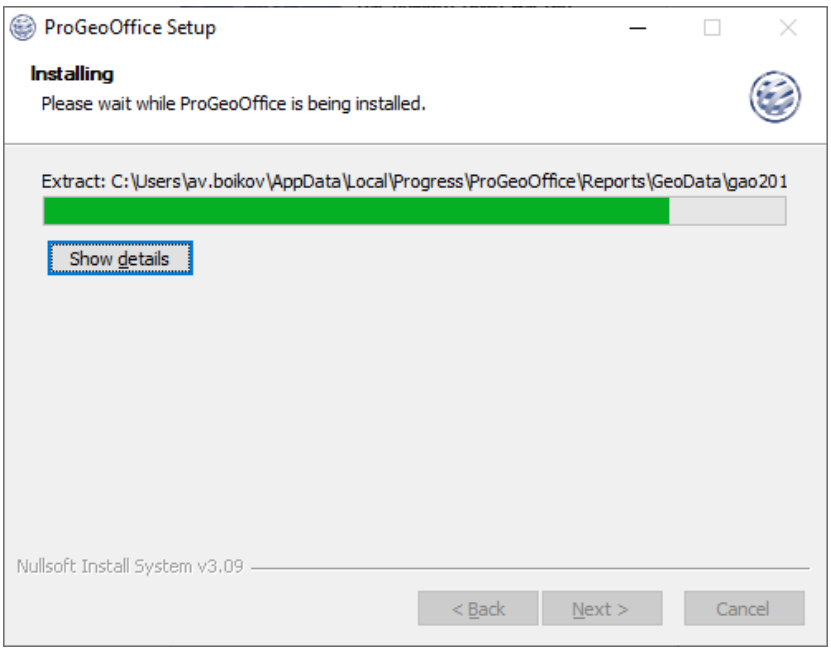


Figure 2 – Uninstall previous version of application window

Once the installation is complete, a corresponding window will be displayed with the option to launch the newly installed software.

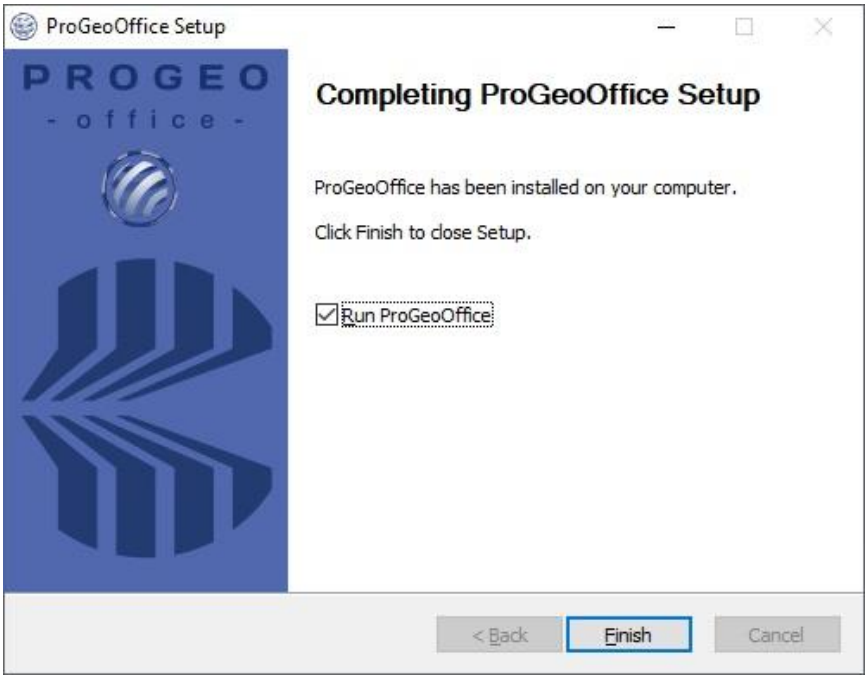


Figure 3 – Corresponding window will be displayed

After clicking the “Done” button, the presence of a license will be automatically checked, and if it is not present, the license manager will be opened.

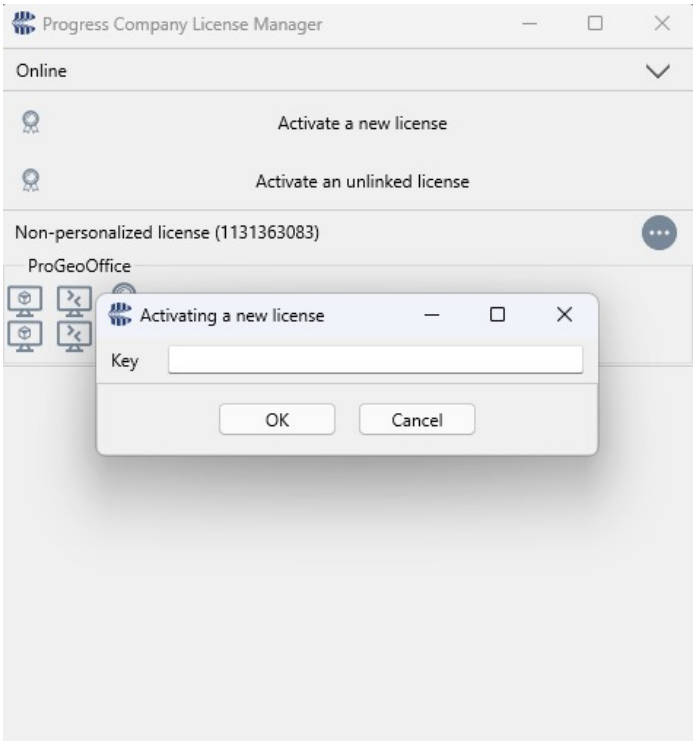


Figure 4 – License manager window

1.3 Progress company license manager

The license manager is installed and supplied with the software and serves to activate, deactivate, transfer and update software licenses. An Internet connection is required for activation. Offline activation is possible via another computer with Internet access.

To activate a new license, you need to click the “Activate new license” button, then in the window that opens, in the “Key” field, enter the 34-character key value in the format XXXXXX-XXXXXX-XXXXXX-XXXXXX-XXXXXX.

After clicking “OK”, a request will be made with information about the PC on which the software is installed to the activation server and if the key matches the license, then the PC data will be linked to this license. After which the license will be installed and will appear in the list below:

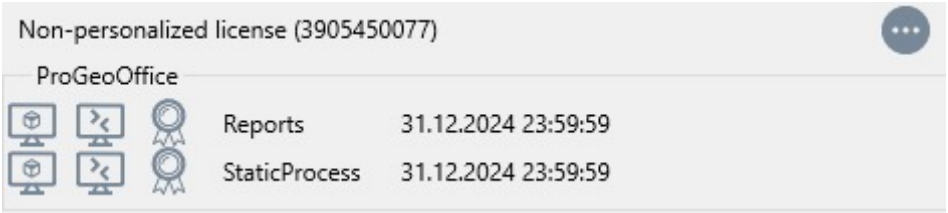


Figure 5 – License activation window

The license will be displayed with the buyer's information, if this information is not specified, "Unnamed license" is displayed. The unique license identifier is indicated in brackets next.

 icon indicates that the software can be run on virtual machines under this license. If the icon is crossed out, this option is prohibited.

 icon indicates that the software can be used via Remote Desktop Protocol (RDP) under this license. If the icon is crossed out, this option is prohibited.

 icon indicates that the license is not active, or activation has not been completed, or the license has expired. If the icon is not crossed out, the license is active.

For each software component, a separate entry indicating the current permissions, component name, and license term or number of launches.

Clicking the button  will provide the “Update” menu, allowing you to update the set of components or permissions.

1.4 Uninstallation

To uninstall the software execute the Uninstall.exe program. It is located in the folder with the installed program. It is possible to execute it using the shortcut in the menu “Start” -> “All Applications” -> “Progress” -> “Uninstall ProGeoOffice”.

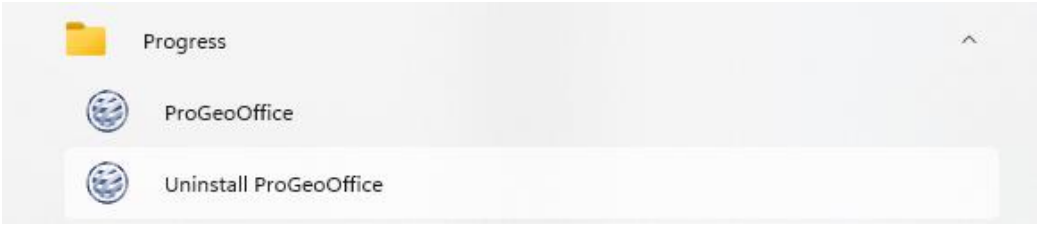


Figure 6 – Window with the installed program

Also through the “Installed applications” menu:

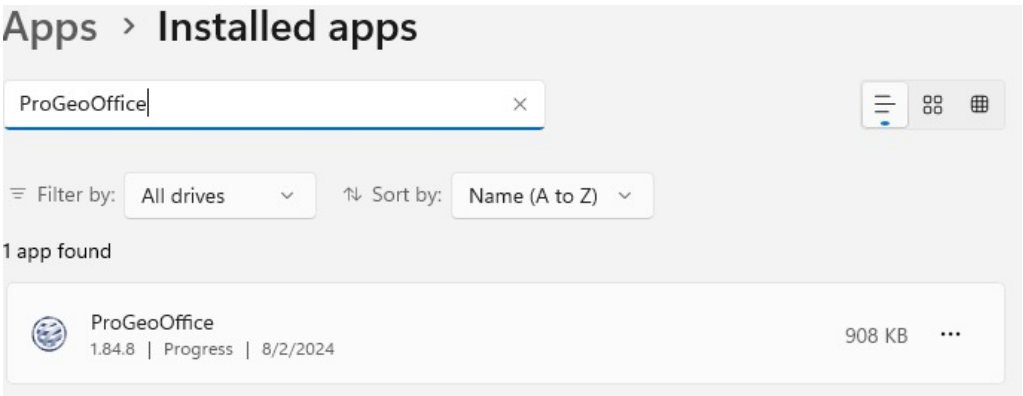


Figure 7 – Menu Installed applications

1.5 Updating

To update the software, you need to download the new version of the program from the company's website specified in the introduction. Then install it in accordance with the section "Installing ProGeoOffice".

1.6 Settings

User settings store items: coordinate systems, reference points, lists of open projects, etc. When reinstalling the program, these settings are saved and updated as needed to work with the new version of the program. If you need to delete, save or move to another computer or for another user, you must copy or delete the %USERPROFILE%\Documents\ProGeoOffice folder (C:\Users\username\Documents\ProGeoOffice) and all its contents.

CHAPTER 2. MAIN WINDOW

When ProGeoOffice is starting the *Main* program window appears. This window contains *Main menu*, *Tool* and *Status bar*, a project and map panes as well:

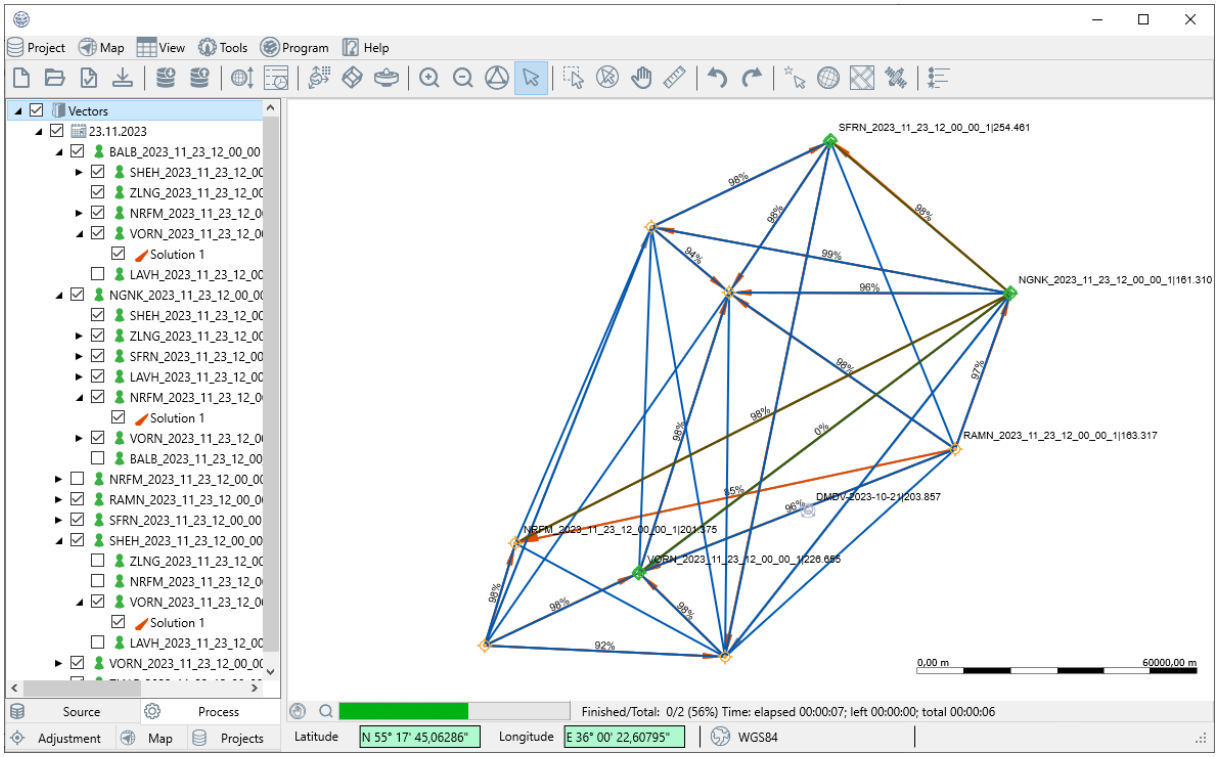


Figure 8 – Main window

Below are the terms used in this manual:

Project	SQLite database
Epoch	a set of data sufficient to calculate coordinates at a single point in time
Position	map point object corresponding to the Epoch
Dataset	project table that contains data for unique receiver and antenna pair
Point	a point object based on (1) a navigation solution when importing a GNSS static data file, (2) coordinates calculated by a satellite receiver, (3) RINEX header coordinates, (4) a tag in an RTCM message
Recordset	a query from dataset. Static and kinematic recordsets
Vector	an object corresponding to the common part of two overlapping recordsets. A pair of static recordsets form a linear object. Otherwise, a collection of point objects - Positions
Solution	a result of Vector post-processing
Edge	network element, result of static solution adjustment
Site	an object created by import raw data file according to standalone, DGPS, RTK solutions, header of RINEX, tag in RTCM message

2.1 MAIN MENU

Main menu contains the following items:

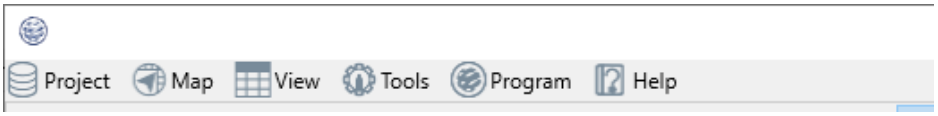


Figure 9 – Main menu

Project

The *Project* menu contains the following items:

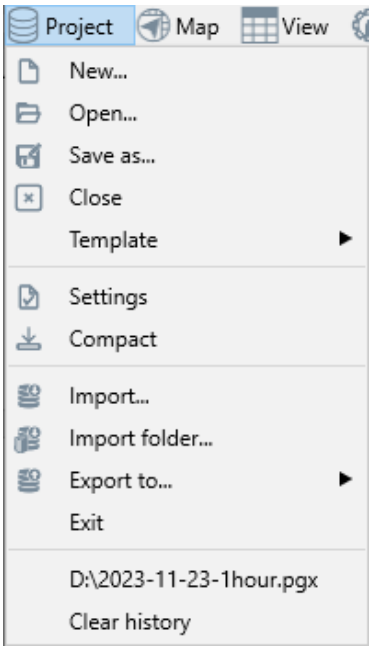


Figure 10 – Project menu item

New…	create a new project
Open…	open an existing project
Save as…	save the project with a new name
Close	save and close the project
Template	select a project settings template
Settings	parameters and settings of the current project
Compact	remove empty database entries
Import…	import data files
Import folder…	import a folder containing data files
Import to…	export project data to one of the exchange formats
Exit	exit program
History list of five recently opened projects	

Note: some project menu items are duplicated in the toolbar

Map

The *Map* menu contains the following items:

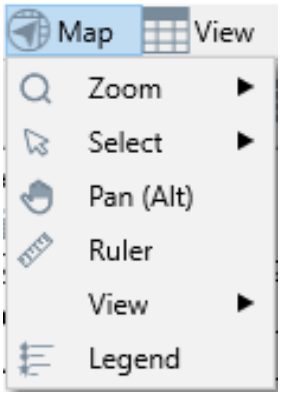


Figure 11 – Map menu item

Zoom contains the following items:

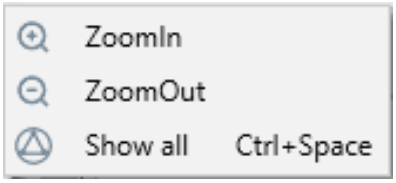


Figure 12 – Menu item *Zoom*

ZoomIn	increases map scale
ZoomOut	decreases map scale
Show all	all objects on program layer will be shown

Select contains the following items:

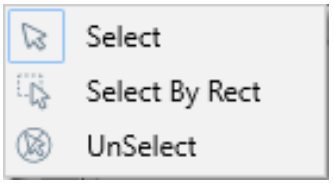


Figure 13 – Menu item *Select*

Select	select object
Select By Rect	select all objects in the area limited by the frame
Unselect	cancel previously made selection

Move – panning a map.

Ruler – invokes a tool for distance and azimuth measurement.

View contains the following items:

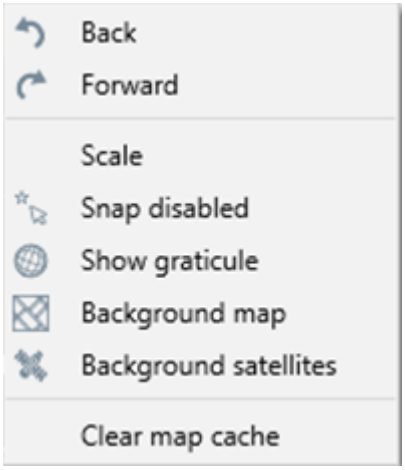


Figure 14 – View menu item

Back	return to previous map scale
Forward	return to next map scale
Scale	setup map scale

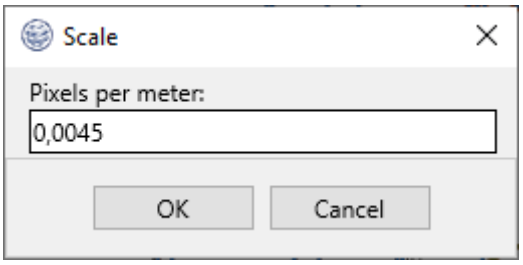


Figure 15 – Map scale

Snap disabled	enable/disable the mode of cursor snapping to point objects
Show graticule	show/hide grid
Background map	show background as a map
Background satellites	show background as a photo
Clear map cache	clear map cache
Legend	list of map signs

View

View contains the following items:

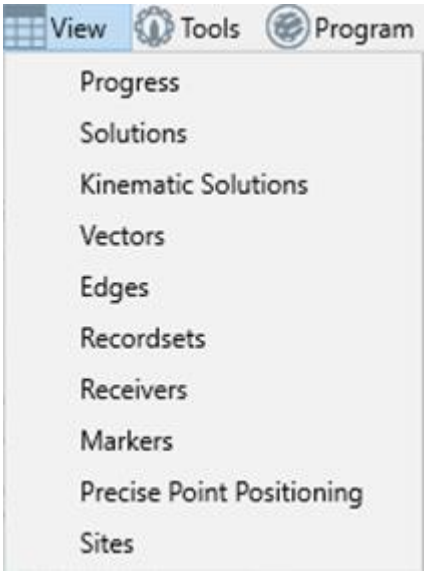
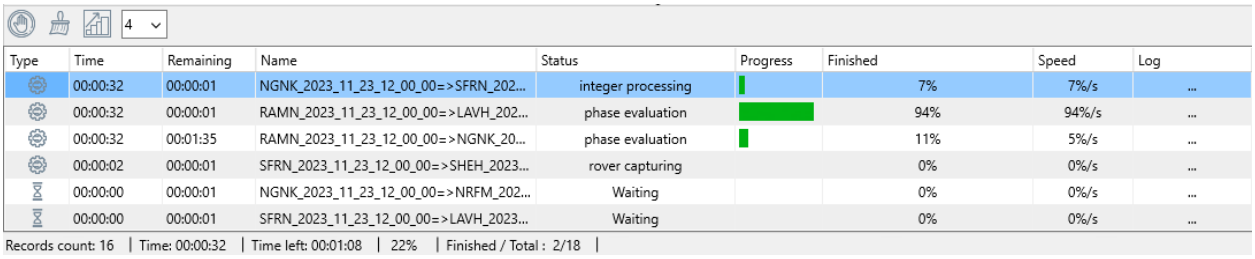


Figure 16 – View menu item

Progress - data processing progress information

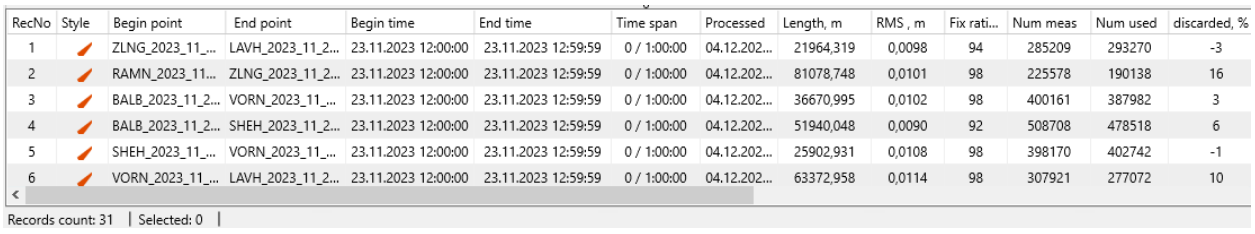


Type	Time	Remaining	Name	Status	Progress	Finished	Speed	Log
	00:00:32	00:00:01	NGNK_2023_11_23_12_00_00=>SFRN_202...	integer processing		7%	7%/s	...
	00:00:32	00:00:01	RAMN_2023_11_23_12_00_00=>LAVH_202...	phase evaluation		94%	94%/s	...
	00:00:32	00:01:35	RAMN_2023_11_23_12_00_00=>NGNK_20...	phase evaluation		11%	5%/s	...
	00:00:02	00:00:01	SFRN_2023_11_23_12_00_00=>SHEH_2023...	rover capturing		0%	0%/s	...
	00:00:00	00:00:01	NGNK_2023_11_23_12_00_00=>NRFM_202...	Waiting		0%	0%/s	...
	00:00:00	00:00:01	SFRN_2023_11_23_12_00_00=>LAVH_2023...	Waiting		0%	0%/s	...

Records count: 16 | Time: 00:00:32 | Time left: 00:01:08 | 22% | Finished / Total : 2/18 |

Figure 17 – Progress

Solutions - solutions table

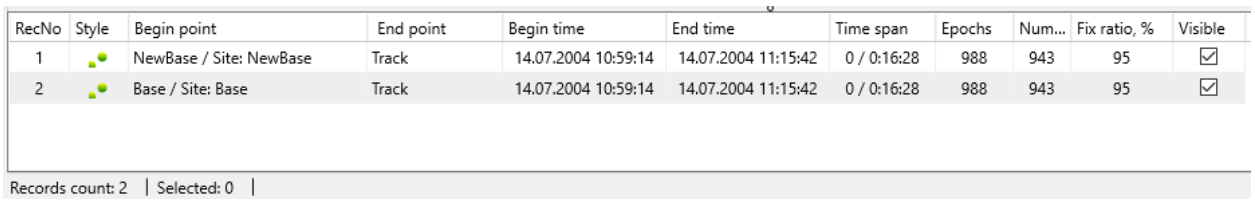


RecNo	Style	Begin point	End point	Begin time	End time	Time span	Processed	Length, m	RMS , m	Fix rati...	Num meas	Num used	discarded, %
1		ZLNG_2023_11_...	LAVH_2023_11_2...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	04.12.202...	21964,319	0,0098	94	285209	293270	-3
2		RAMN_2023_11...	ZLNG_2023_11_2...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	04.12.202...	81078,748	0,0101	98	225578	190138	16
3		BALB_2023_11_2...	VORN_2023_11_...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	04.12.202...	36670,995	0,0102	98	400161	387982	3
4		BALB_2023_11_2...	SHEH_2023_11_2...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	04.12.202...	51940,048	0,0090	92	508708	478518	6
5		SHEH_2023_11_...	VORN_2023_11_...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	04.12.202...	25902,931	0,0108	98	398170	402742	-1
6		VORN_2023_11_...	LAVH_2023_11_2...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	04.12.202...	63372,958	0,0114	98	307921	277072	10

Records count: 31 | Selected: 0 |

Figure 18 – Solutions

Kinematic Solutions - kinematic solutions table

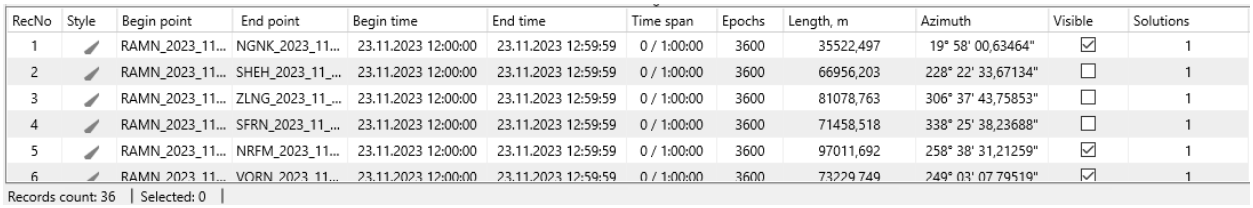


RecNo	Style	Begin point	End point	Begin time	End time	Time span	Epochs	Num...	Fix ratio, %	Visible
1		NewBase / Site: NewBase	Track	14.07.2004 10:59:14	14.07.2004 11:15:42	0 / 0:16:28	988	943	95	☑
2		Base / Site: Base	Track	14.07.2004 10:59:14	14.07.2004 11:15:42	0 / 0:16:28	988	943	95	☑

Records count: 2 | Selected: 0 |

Figure 19 – Kinematic Solutions

Vectors - vectors table

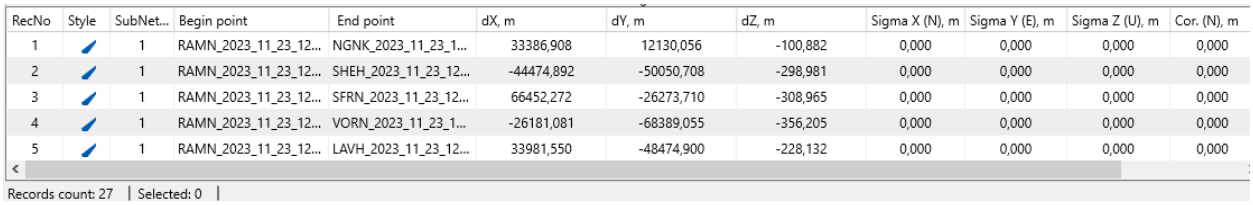


RecNo	Style	Begin point	End point	Begin time	End time	Time span	Epochs	Length, m	Azimuth	Visible	Solutions
1		RAMN_2023_11...	NGNK_2023_11...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	3600	35522,497	19° 58' 00,63464"	☑	1
2		RAMN_2023_11...	SHEH_2023_11_...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	3600	66956,203	228° 22' 33,67134"	☐	1
3		RAMN_2023_11...	ZLNG_2023_11_...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	3600	81078,763	306° 37' 43,75853"	☐	1
4		RAMN_2023_11...	SFRN_2023_11_...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	3600	71458,518	338° 25' 38,23688"	☐	1
5		RAMN_2023_11...	NRFM_2023_11...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	3600	97011,692	258° 38' 31,21259"	☑	1
6		RAMN_2023_11...	VORN_2023_11...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	3600	73229,749	249° 03' 07,79519"	☑	1

Records count: 36 | Selected: 0 |

Figure 20 – Vectors

Edges - adjustment results table

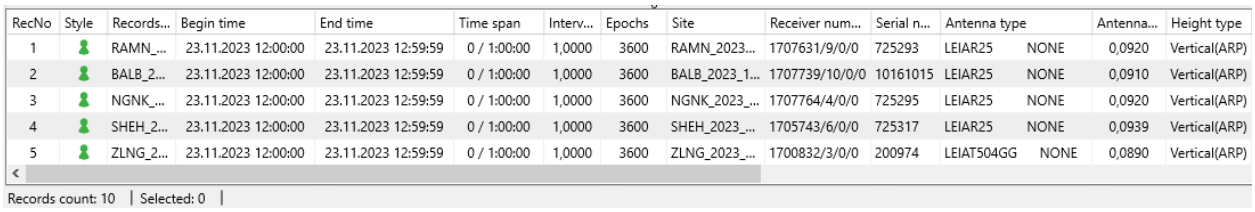


RecNo	Style	SubNet...	Begin point	End point	dX, m	dY, m	dZ, m	Sigma X (N), m	Sigma Y (E), m	Sigma Z (U), m	Cor. (N), m
1		1	RAMN_2023_11_23_12...	NGNK_2023_11_23_1...	33386,908	12130,056	-100,882	0,000	0,000	0,000	0,000
2		1	RAMN_2023_11_23_12...	SHEH_2023_11_23_12...	-44474,892	-50050,708	-298,981	0,000	0,000	0,000	0,000
3		1	RAMN_2023_11_23_12...	SFRN_2023_11_23_12...	66452,272	-26273,710	-308,965	0,000	0,000	0,000	0,000
4		1	RAMN_2023_11_23_12...	VORN_2023_11_23_1...	-26181,081	-68389,055	-356,205	0,000	0,000	0,000	0,000
5		1	RAMN_2023_11_23_12...	LAVH_2023_11_23_12...	33981,550	-48474,900	-228,132	0,000	0,000	0,000	0,000

Records count: 27 | Selected: 0 |

Figure 21 – Edges

Recordsets - recordsets table

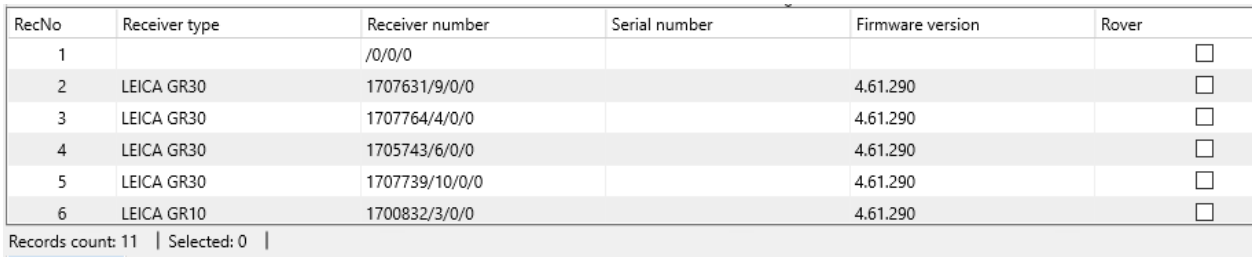


RecNo	Style	Records...	Begin time	End time	Time span	Interv...	Epochs	Site	Receiver num...	Serial n...	Antenna type	Antenna...	Height type
1		RAMN_...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	1,0000	3600	RAMN_2023...	1707631/9/0/0	725293	LEIAR25 NONE	0,0920	Vertical(ARP)
2		BALB_2...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	1,0000	3600	BALB_2023_1...	1707739/10/0/0	10161015	LEIAR25 NONE	0,0910	Vertical(ARP)
3		NGNK_...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	1,0000	3600	NGNK_2023_...	1707764/4/0/0	725295	LEIAR25 NONE	0,0920	Vertical(ARP)
4		SHEH_2...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	1,0000	3600	SHEH_2023_...	1705743/6/0/0	725317	LEIAR25 NONE	0,0939	Vertical(ARP)
5		ZLNG_2...	23.11.2023 12:00:00	23.11.2023 12:59:59	0 / 1:00:00	1,0000	3600	ZLNG_2023_...	1700832/3/0/0	200974	LEIAT504GG NONE	0,0890	Vertical(ARP)

Records count: 10 | Selected: 0 |

Figure 22 – Recordsets

Receivers - information and control. PGO does not creates vectors between data provided by receivers announced as a rovers (rover to rover).



RecNo	Receiver type	Receiver number	Serial number	Firmware version	Rover
1		/0/0/0			☐
2	LEICA GR30	1707631/9/0/0		4.61.290	☐
3	LEICA GR30	1707764/4/0/0		4.61.290	☐
4	LEICA GR30	1705743/6/0/0		4.61.290	☐
5	LEICA GR30	1707739/10/0/0		4.61.290	☐
6	LEICA GR10	1700832/3/0/0		4.61.290	☐

Records count: 11 | Selected: 0 |

Figure 23 – Receivers

Markers - markers and orientation of the aircraft relative to the trajectory

RecNo	Time	Marker	Markers type	Latitude	Longitude	Height, m	DX (N), m	DY (E), m	DZ (U), m	Azimuth	RMS , m
1	15.02.2019 12:42:...		_XA	N 51° 26' 51,29162"	E 7° 16' 10,97936"	267,6125	-3,294	2,061	-0,142	147° 57' 55,18969"	0,0124
2	15.02.2019 12:42:...		_XA	N 51° 26' 50,88776"	E 7° 16' 11,36944"	267,3218	-3,810	2,215	-0,030	149° 49' 36,48357"	0,0114
3	15.02.2019 12:42:...		_XA	N 51° 26' 50,45443"	E 7° 16' 11,76701"	267,5478	-4,142	2,547	0,135	148° 24' 19,15428"	0,0109
4	15.02.2019 12:42:...		_XA	N 51° 26' 50,03992"	E 7° 16' 12,15386"	267,4095	-4,072	2,259	-0,153	150° 58' 52,71321"	0,0106
5	15.02.2019 12:42:...		_XA	N 51° 26' 49,59662"	E 7° 16' 12,53231"	267,1409	-4,074	2,042	0,333	153° 23' 00,95705"	0,0101
6	15.02.2019 12:42:...		_XA	N 51° 26' 49,16394"	E 7° 16' 12,87820"	267,5886	-4,249	2,171	-0,052	152° 56' 16,07913"	0,0101

Records count: 246 | Selected: 0 |

Figure 24 – Markers

Precise point positioning - PPP results table

RecNo	Style	Name	Begin time	End time	Time span	Processed	Latitude	Longitude	Height, m	RMS , m	Fix ratio, %	Num meas	Num used
1		ZLNG	24.01.2024	24.01.2024 23:59:00	0 / 23:59:30	13.02.2024 13:48:55	N 55° 59' 26,...	E 37° 12' 53,...	245,7314	0,0140	0	109068	101712
2		NGNK	24.01.2024	24.01.2024 23:59:00	0 / 23:59:30	13.02.2024 13:48:56	N 55° 51' 36,...	E 38° 27' 04,...	161,3137	0,0150	0	109530	107442
3		VORN	24.01.2024	24.01.2024 23:59:00	0 / 23:59:30	13.02.2024 13:48:55	N 55° 19' 14,...	E 37° 10' 48,...	226,6671	0,0157	0	110006	109922
4		PT02	24.01.2024	24.01.2024 23:59:00	0 / 23:59:30	13.02.2024 13:49:12	N 55° 50' 36,...	E 37° 32' 15,...	203,6199	0,0131	0	179724	170292
5		NRFM	24.01.2024	24.01.2024 23:59:00	0 / 23:59:30	13.02.2024 13:49:21	N 55° 22' 46,...	E 36° 45' 24,...	201,3616	0,0158	0	109282	109048

Records count: 12 | Selected: 0 |

Figure 25 – Precise point positioning

Sites - sites table

RecNo	Style	Sites	Snaped to	Latitude	Longitude	Height, m	Sigma X (N), m	Sigma Y (E), m	Sigma Z (U), m	RMS , m
1		BALB_2023_1...	Adjust	N 55° 10' 50,50778"	E 36° 39' 29,04777"	191,7792	0,000	0,000	0,000	0,0055
2		DMDV-2023...	Navigation	N 55° 26' 31,04373"	E 37° 45' 06,79231"	203,8568	0,293	0,385	0,506	1,0879
3		LAVH_2023_...	Adjust	N 55° 51' 47,81284"	E 37° 28' 59,57810"	209,4778	0,000	0,000	0,000	0,0043
4		NGNK_2023_...	Plane and height snapped	N 55° 51' 36,78096"	E 38° 27' 04,05336"	161,3103	0,000	0,000	0,000	0,0003
5		NRFM_2023_...	Adjust	N 55° 22' 46,82804"	E 36° 45' 24,72323"	201,3750	0,000	0,000	0,000	0,0093
6		RAMN_2023...	Adjust	N 55° 33' 37,80466"	E 38° 15' 26,69327"	163,3169	0,000	0,000	0,000	0,0056

Records count: 10 | Selected: 0 |

Figure 26 – Sites

Tools

Tools contains the following items:

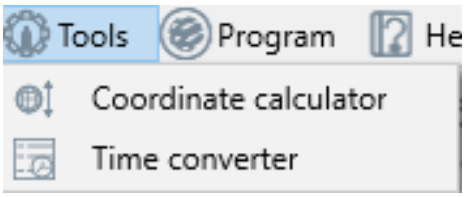


Figure 27 – Tools menu item

Coordinate calculator	coordinate calculator is described in chapter Coordinate calculator
Time converter	time converter

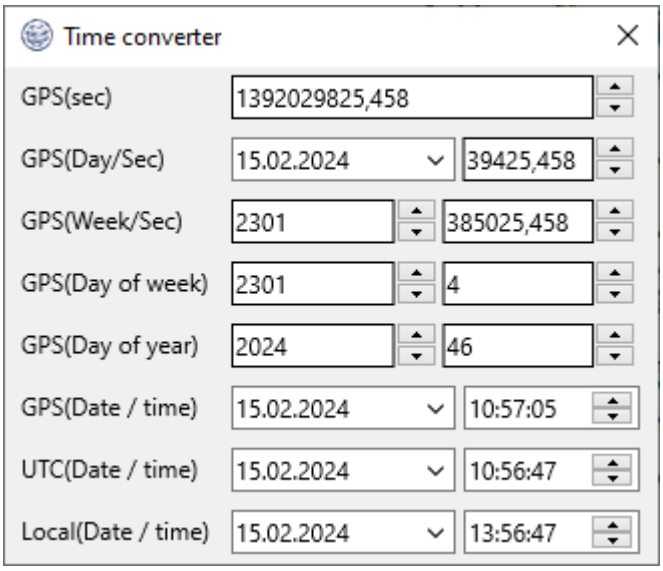


Figure 28 – Time converter window

GPS	Global Positioning System time, is the atomic time scale implemented by the atomic clocks in the GPS ground control stations and the GPS satellites themselves. GPS time was zero at 0h 6-Jan-1980 and since it is not perturbed by leap seconds. GPS is now ahead of UTC by 22 seconds.
UTC	Coordinated Universal Time, popularly known as GMT (Greenwich Mean Time), or Zulu time.
Local	Local time differs from UTC by the number of hours of your time zone.

Program

Program contains the following items:

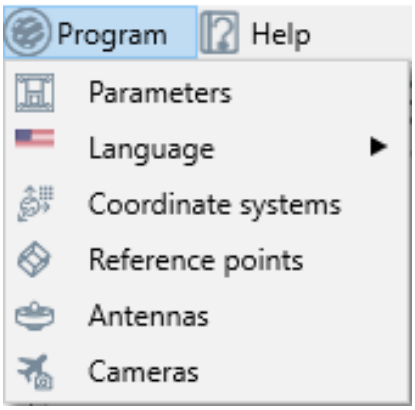


Figure 29 – Program menu item

Common tab

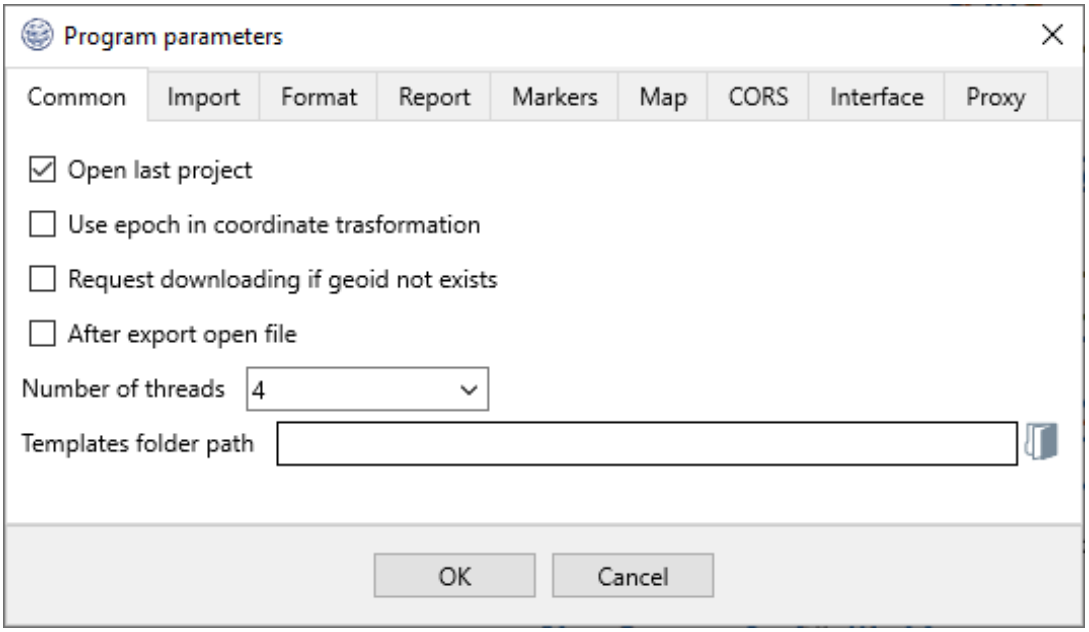


Figure 30 – Program parameters. Common tab

Open last project	open last used project when a program is starting
Use epoch in coordinate transformation	apply time depending coordinate transformations
Request for downloading if geoid is exists	asks confirmation about geoid model file downloading from coordinate transformation repository
After export open file	open export settings file
Number of threads	set the number of threads used during export and processing
Templates folder path	path to the folder with saved templates

Import tab

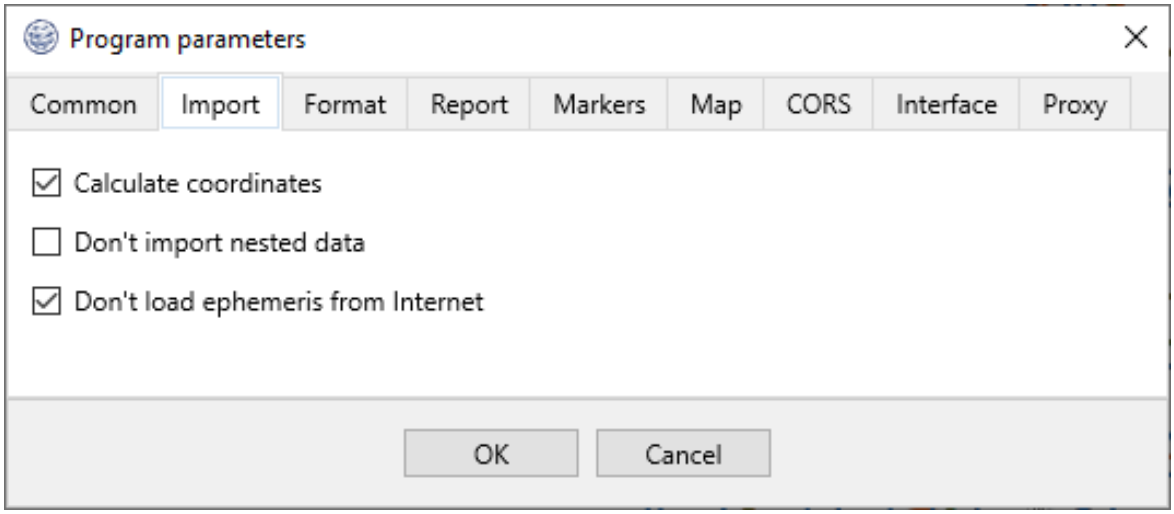


Figure 31 – Program parameters. Import tab

Calculate coordinates	calculate coordinates for each sampling epoch using the measurement information contained in it. Otherwise, for each epoch, the coordinates written in the file are taken, and if they are absent, they are calculated even if the checkbox is switched off
Don't import nested data	do not import any data attached to the imported file (RTCM, meteo)
Don't load ephemeris from Internet	do not download ephemeris from the Internet automatically

Format tab

Setting the units of measurement used in the program.

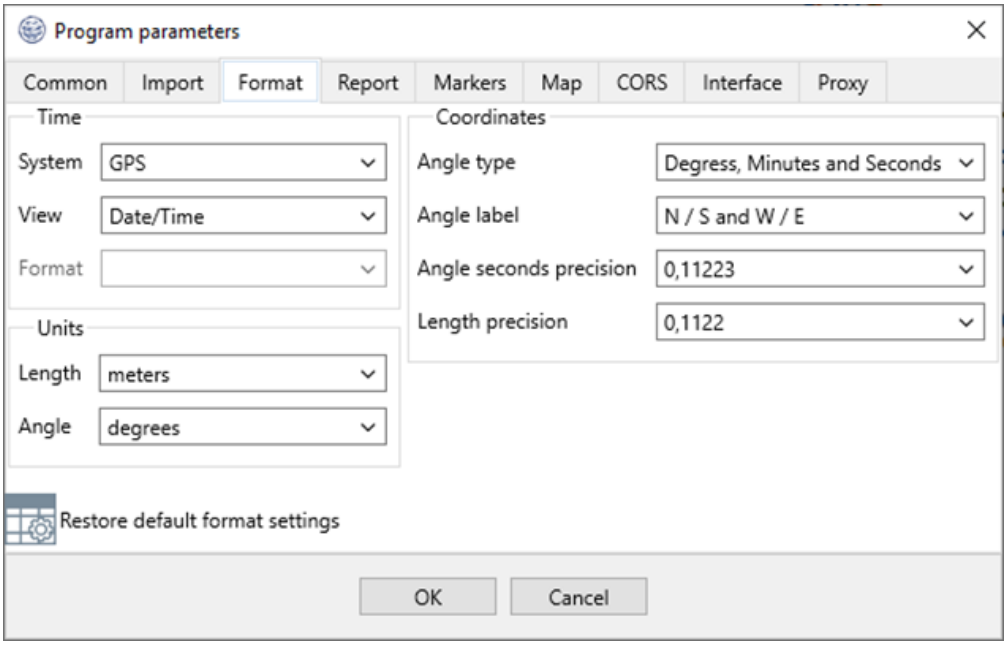


Figure 32 – Program parameters. Format tab

Report tab

This tab shows the list of the supported report types formats.

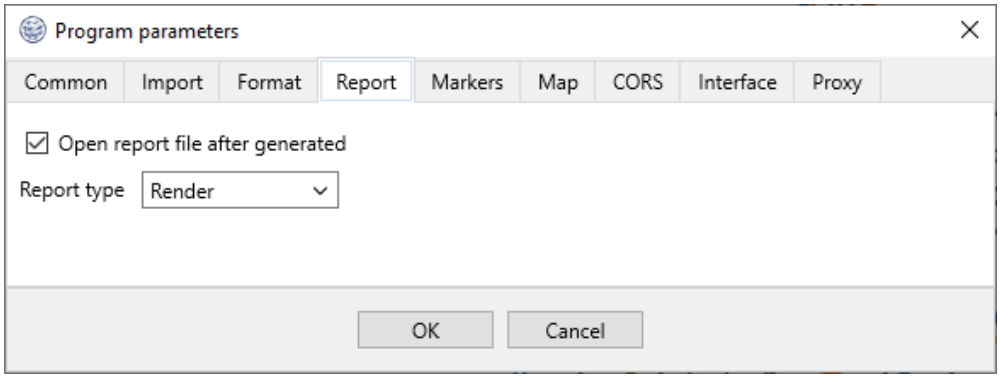


Figure 33 – Program parameters. Report tab

Markers tab

Type of epoch coordinates interpolation.

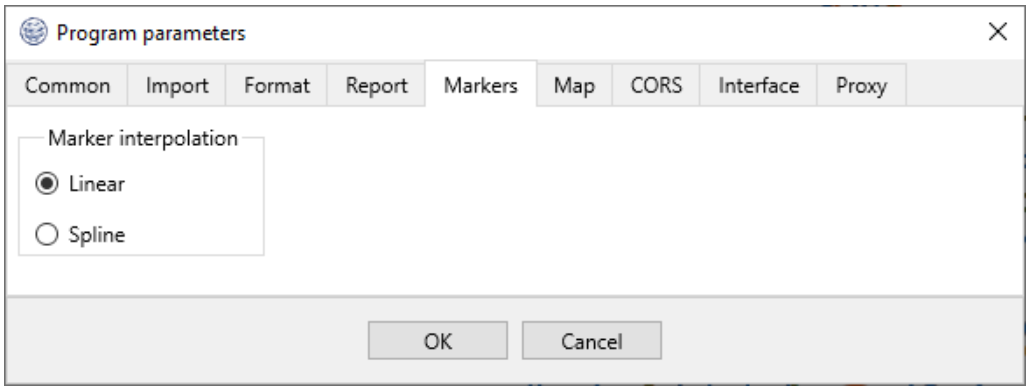


Figure 34 – Program parameters. Markers tab

Map tab

This tab contents the cartographic data source. *Alternative* means that program starts searching for maps at most popular Internet map repositories.
The check box *Show grid* shows grid on a map pane.

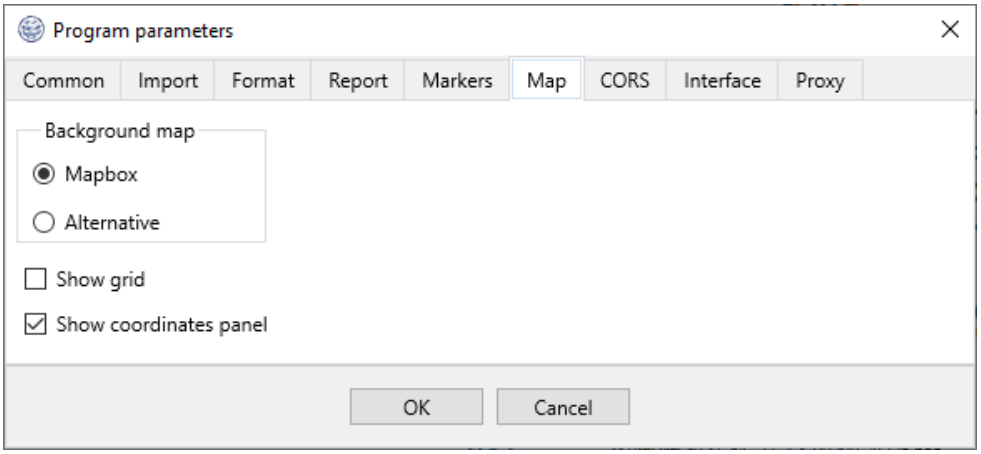


Figure 35 – Program parameters. Map tab

CORS tab

The check box hides/shows the vectors created using CORS data.

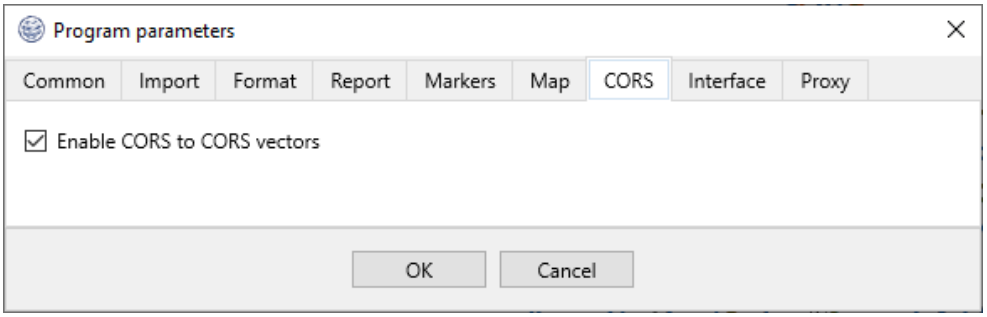


Figure 36 – Program parameters. CORS tab

Interface tab

Setting up interface elements.

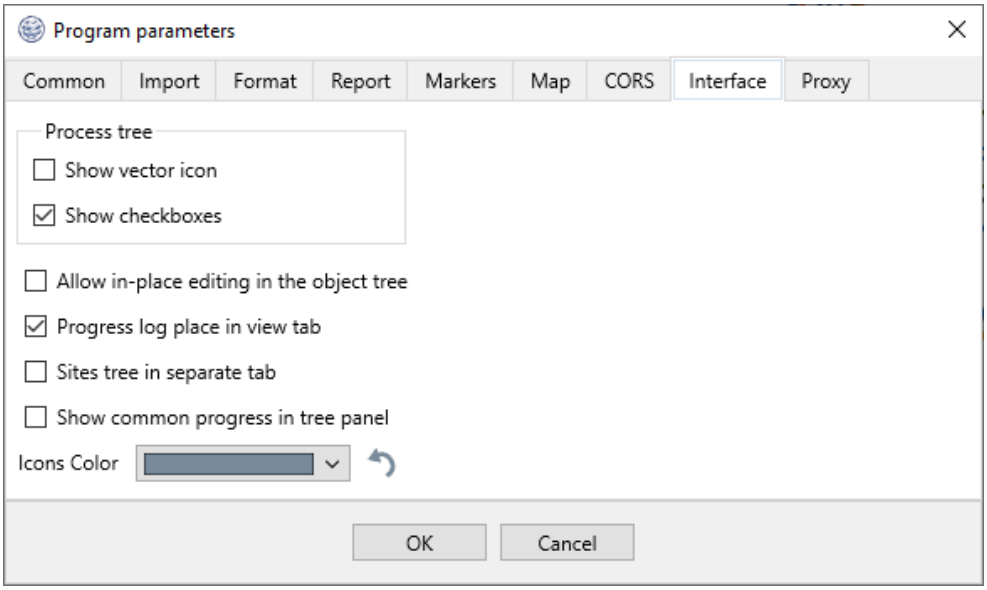


Figure 37 – Program parameters. Interface tab

Proxy tab

Selecting the type of proxy and protocol to use when connecting to the Internet when downloading ephemeris, downloading geoid model files, or updating the antenna database.

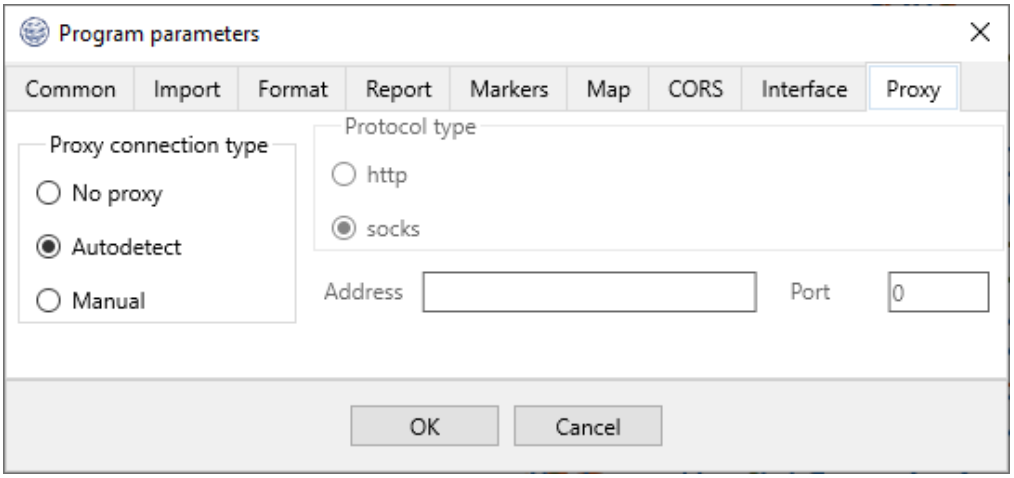


Figure 38 – Program parameters. Proxy tab

The item *Language* is selecting the interface language.

The item is described in the section *Coordinate system manager*.

The item is described in the section *Reference points manager*.

The item is described in the section *Antennas manager*.

The item is described in the section *Aerial camera manager*.

Help

Help contains the following items:

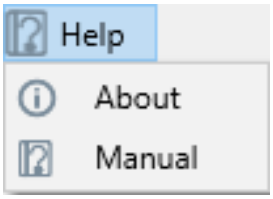


Figure 39 – HELP menu item

About

Program version information.

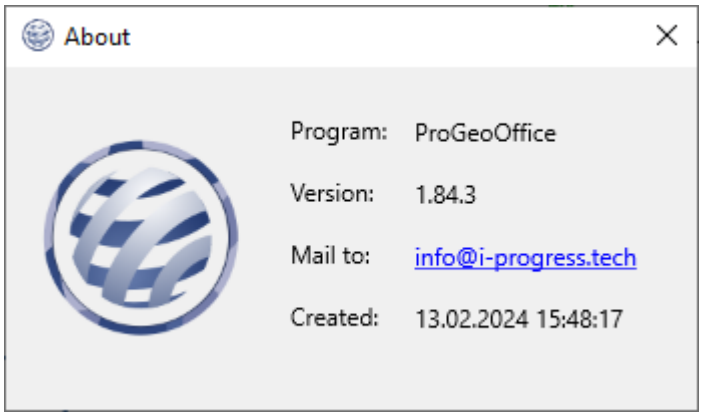


Figure 40 – About

Manual

Opens the online program manual located on the website.

2.2 Toolbar

The toolbar is located at the top of the main window and contains icons with which the user can access the program's functions. Clicking the left mouse button on the icon will open a menu displaying a list of menu items. Point your pointing device at the desired menu item, press and release the left mouse button, and this function will be called.

	dialog window *New project*
	dialog window *Open project*
	dialog window *Project setting*
	compact project
	dialog window *Import files*
	dialog window *Export project data*
	*Coordinate calculator*
	*Time converter*
	*Coordinate system manager*
	*Reference points manager*
	*Antennas manager*
	increases map scale
	decreases map scale
	shows entire program layers
	sets cursor in *Selection in point* mode
	sets cursor in *Selection in rectangle* mode
	unselect

	panning the map
	sets the cursor in ruler mode for distance and azimuth measurement
	returns the map in previous position and scale
	returns the map to initial position and scale after
	sets the snapping mode for the ruler
	show/hide grid
	show/hide raster map
	shows/hides space images
	show *Legend*
WGS84	selects project map coordinate system

2.3 Status bar

Status designed for information about processes progress. It is active during data import/export and post-processing:

Figure 41 – Status bar

Click to stop the process.

Click to activate Progress table:

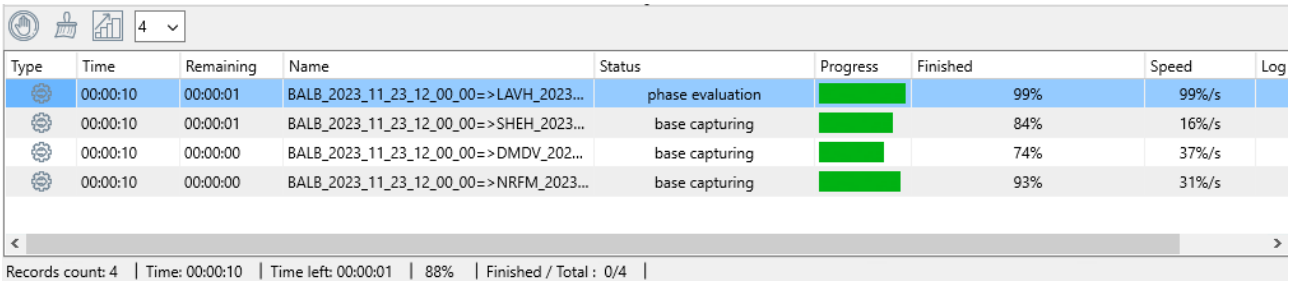


Figure 42 – Progress table

The table toolbar contains the following icons:

	to stop the process
	to clear the window
	switch to log tab for process summary

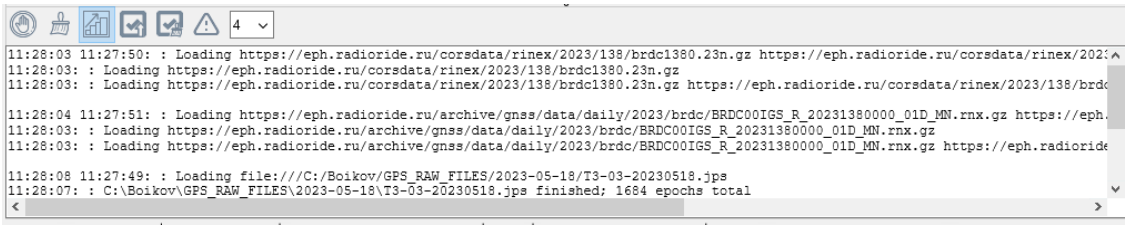


Figure 43 – log-file

	lift completed processes up
	remove terminated processes messages
	number of threads

2.4 Project pane

The *Project* pane is designed to provide full access to program functions. There are five operational tabs: *Source*, *Process*, *Adjustment*, *Map* and *Projects*:

Figure 44 – Project panel tabs

Source tab tree structure depends on *Project* and *Sort* options described below.

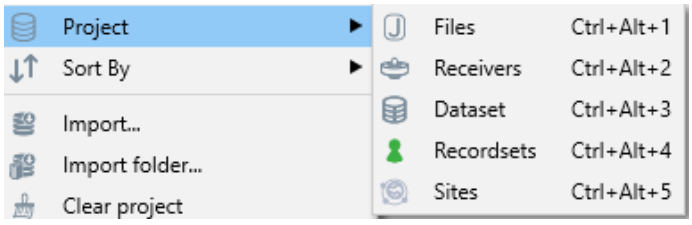


Figure 45 – Source tab

The Process tab is described in *Chapter 5. Post processing.*

The Adjustment tab is described in *Chapter 6. Adjustment.*

The Map panel is described in *Chapter 3. Map.*

CHAPTER 3. MAP

The *Map* tab provides several predefined layers using for control of the principal objects view. Click the *Map* tab to have access to the layer settings:

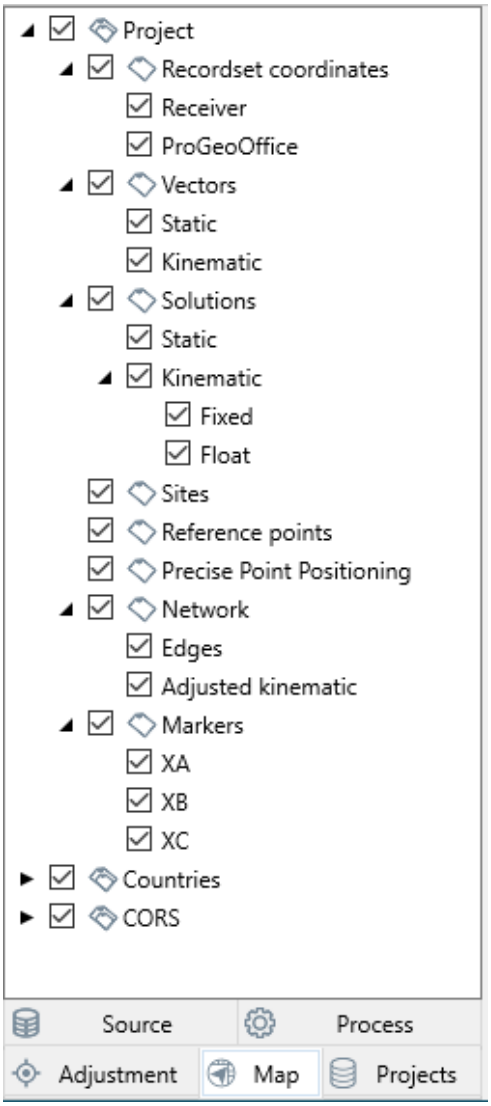


Figure 46 – Layers

Below the notification of signs:

	epochs whose coordinates were calculated by the receiver software
	epochs whose coordinates were calculated by the PGO when importing the measurement file
	static vector
	kinematic vector
	static solution - custom colored line
	fixed kinematic solution (object velocity < 0.1 m/sec)

	fixed kinematic solution (object velocity > 0.1 m/sec)
	float kinematic solution
	site on standalone coordinates
	site on post-processed coordinates
	site on adjusted coordinates
	site snapped to reference point
	reference point
	Precise Point Positioning solution
	common edge
	adjusted kinematic
	events

Layers of administrative boundaries and continuously operated reference station regions boundaries:

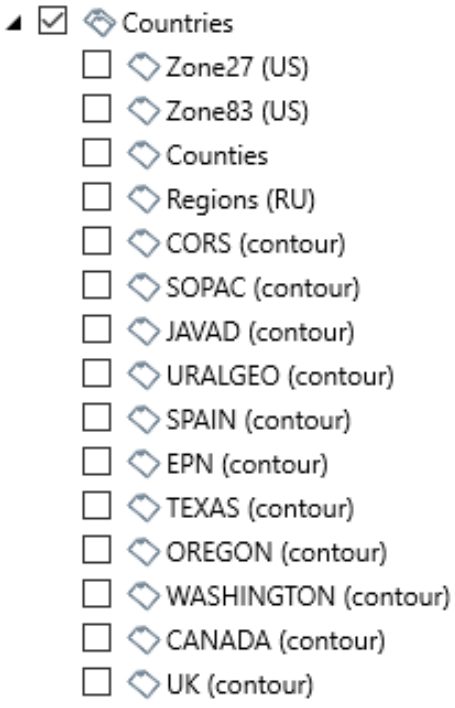


Figure 47 – Contours

Continuously operated reference station layers:

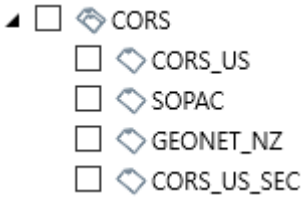


Figure 48 – CORS

Check-box next to the item makes the layer visible or invisible.

Some layers have style settings. Click the right mouse button on the item and select *Style*:

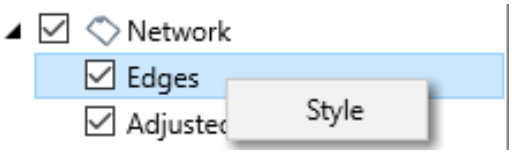


Figure 49 – Layer style

In the *Lines*, *Label*, *Track* tabs (depending on the layer) it is possible to set the required image style:

Figure 50 – Style settings for line object

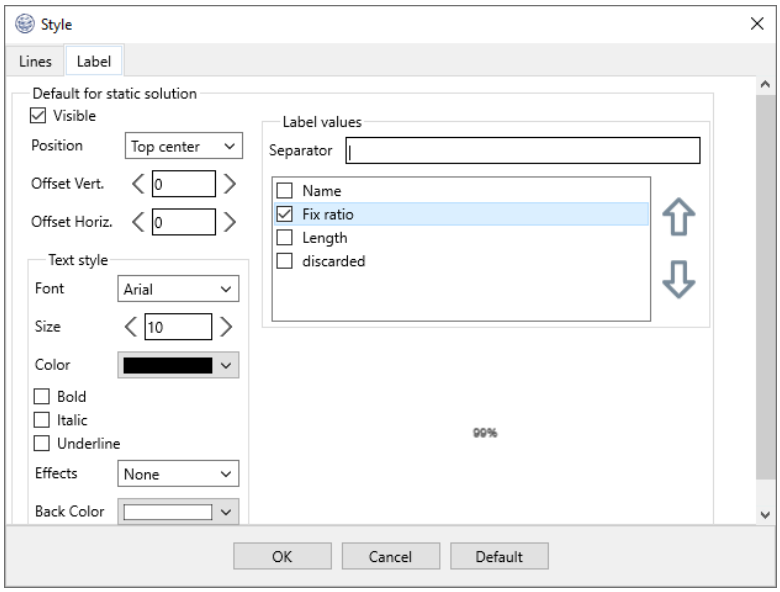


Figure 51 – Label tab

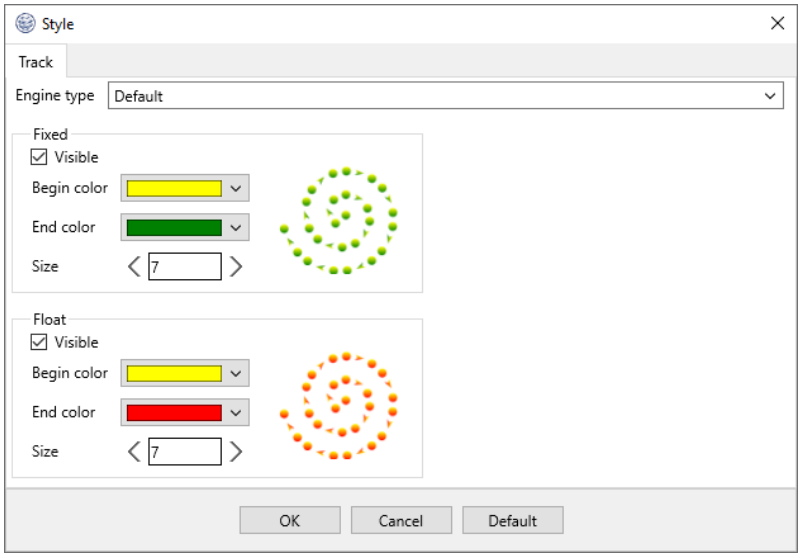


Figure 52 – Track tab

CHAPTER 4. SOURCE

The *Source* tab is active when a program is starting. This tab is a main for data management – import/export, view, modification data imported into the project.

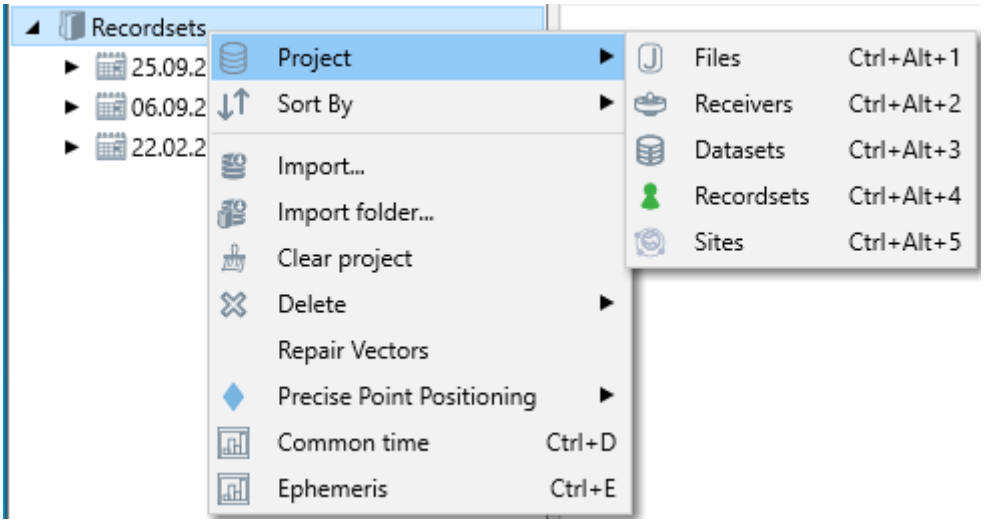


Figure 53 – Project

The root item may vary depending on *Project* option. By clicking on it user may organize main project tree according with *Files*, *Receivers*, *Datasets*, *Recordsets* and *Sites* options. The *Files* option shows items with regard to imported files.

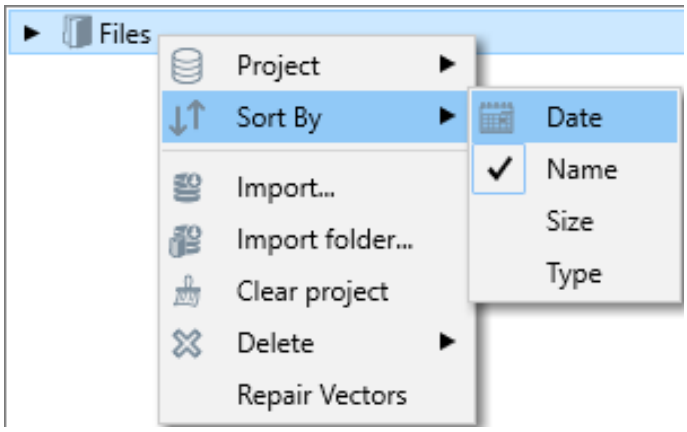


Figure 54 – Files, Sort by

Files, recordsets and datsasets sorted by date has *Common time* option:

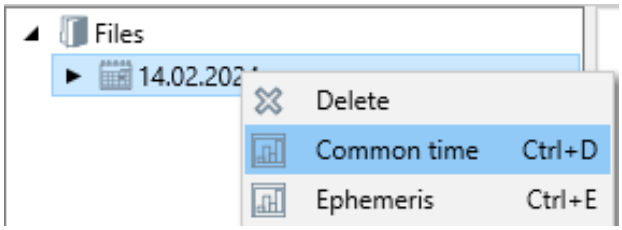


Figure 55 – Common Time

When this option is selected, *Common Time* window displays a graph of the observation time for all recordsets in the project:

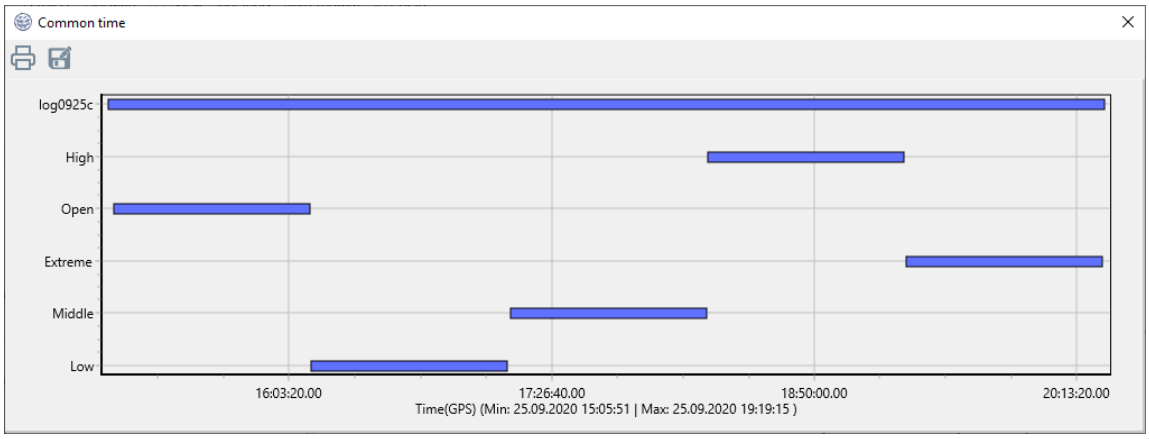


Figure 56 – Common Time diagram

Receiver item shows a list of receivers that provide raw data files:

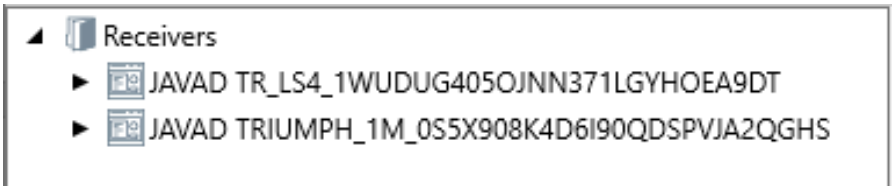


Figure 57 – Receivers

Receivers are sorted by name and type.

As well as a raw data file may contain GNSS data captured from multiple receivers and antennas (rover file with wrapped bases RTCM corrections, multi-antenna receiver file). We introduce *Dataset* that is a corresponding receiver/antenna pair.

File may be represented in a project by multiple datasets. From the database point of view, *Dataset* is a set of consecutive in time records in the project database table that contains raw GNSS data. *Datasets* are created from files during import GNSS files according to program settings. The file may be represented in the project by multiple datasets.

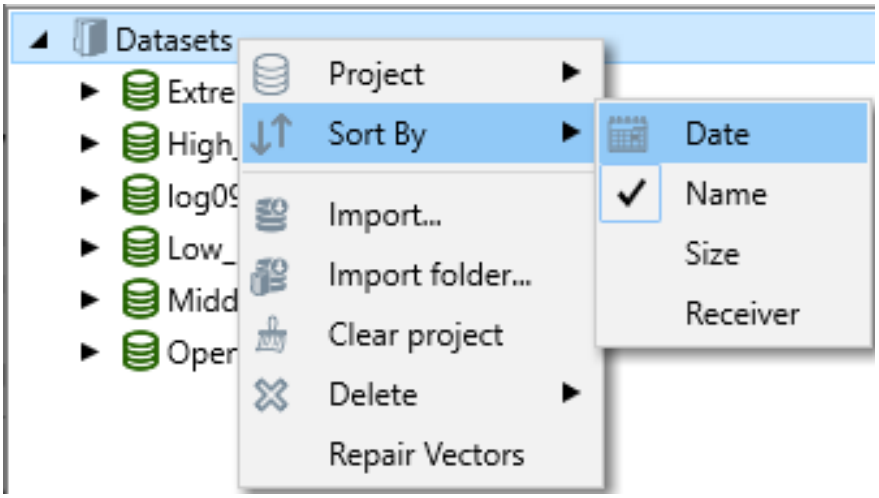


Figure 58 – Datasets, sort by

Recordset is a query from *Dataset*. By default, every dataset produces at least one recordset linked to the parent object. User may modify recordsets with no risk to corrupt original data because of the opportunity to recover it at any time from the parent *Dataset*. In the meantime, the Dataset automatically produces multiple recordsets in a case of *STATIC/DYNAMIC* events marker, epoch gaps, record interval changing inside raw data file and so on.

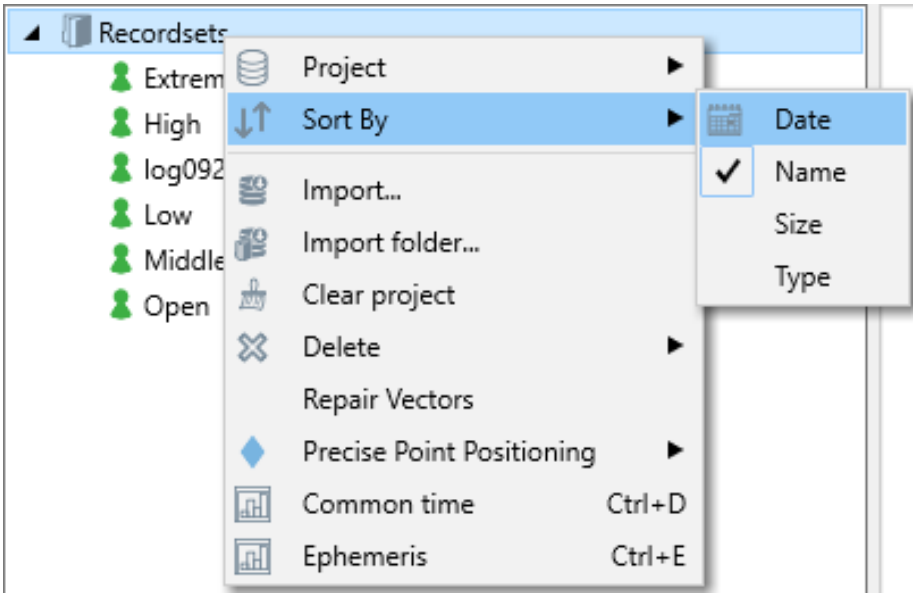


Figure 59 – Recordsets, sort by

Site is an object created by import procedure and being used as point GIS feature:

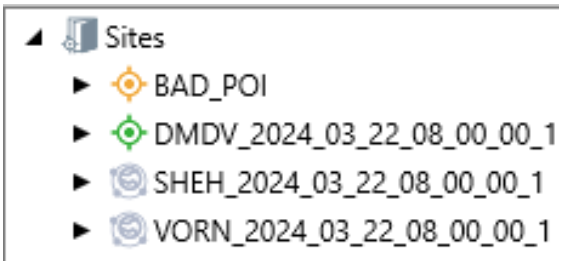


Figure 60 – Sites

Coordinates of Site are the standalone solution or provided by the receiver. A *Dataset* and a *Recordset* are associated with a *Site*. *PGO* creates site using the *Tolerance* for site criterion. If the distance between the existing and newly created *Sites* is less than the established Tolerance, then a new *Site* is not created.

All above-mentioned items may be sorted by some parameters depending on the selected item. Sorting options also depends on the selected item.

Import - import different types of GNSS data as follow.

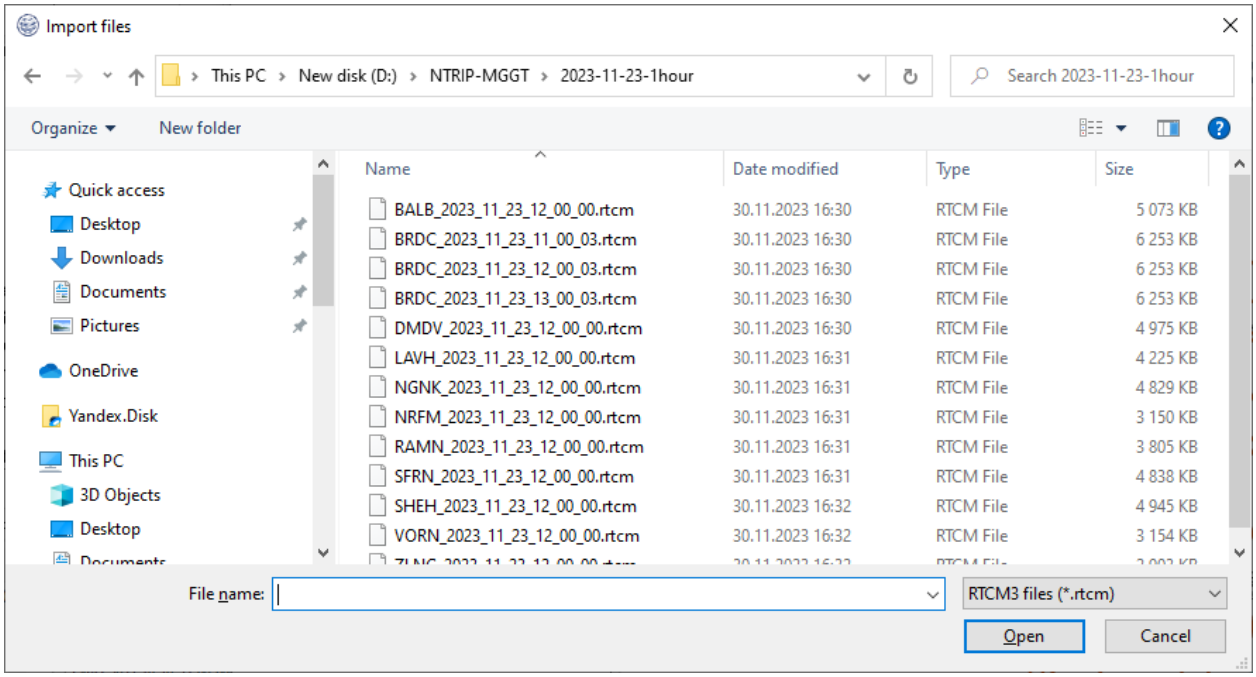


Figure 61 – Import observation files

Import folder	option may be used for batch process of import all valid GNSS data
Clear project	option used to remove all GNSS data from a project. Program asks about a confirmation:

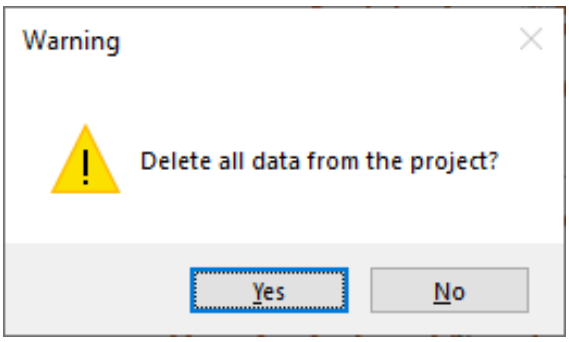


Figure 62 – Delete confirmation

Delete	delete selected data from the project: • Delete epochs - delete data that is not used when creating vectors • Residuals - remove residuals that were saved during vector post-processing

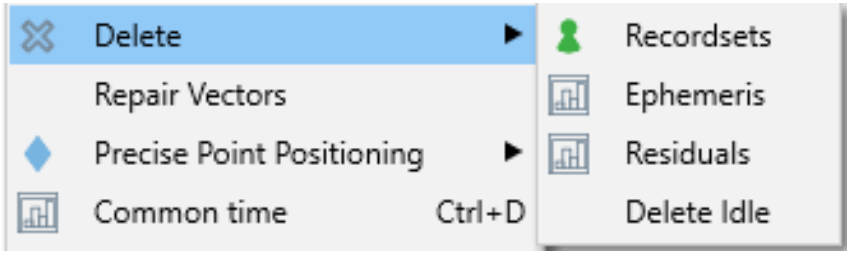


Figure 63 – Delete selected data

Repair Vectors	restores vectors. Option may be helpful in case of program crash by some reasons.
Precise Point Positioning	calculation of coordinates by PPP:

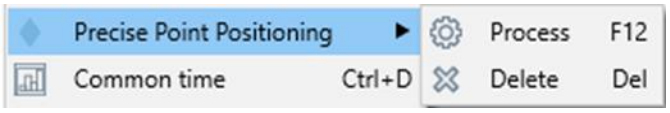


Figure 64 – Menu for PPP solutions

Common time	time diagram for all project recordsets
Ephemeris	satellite ephemeris diagram: • Green - data available • Yellow - unhealthy satellite • Blue - no data available

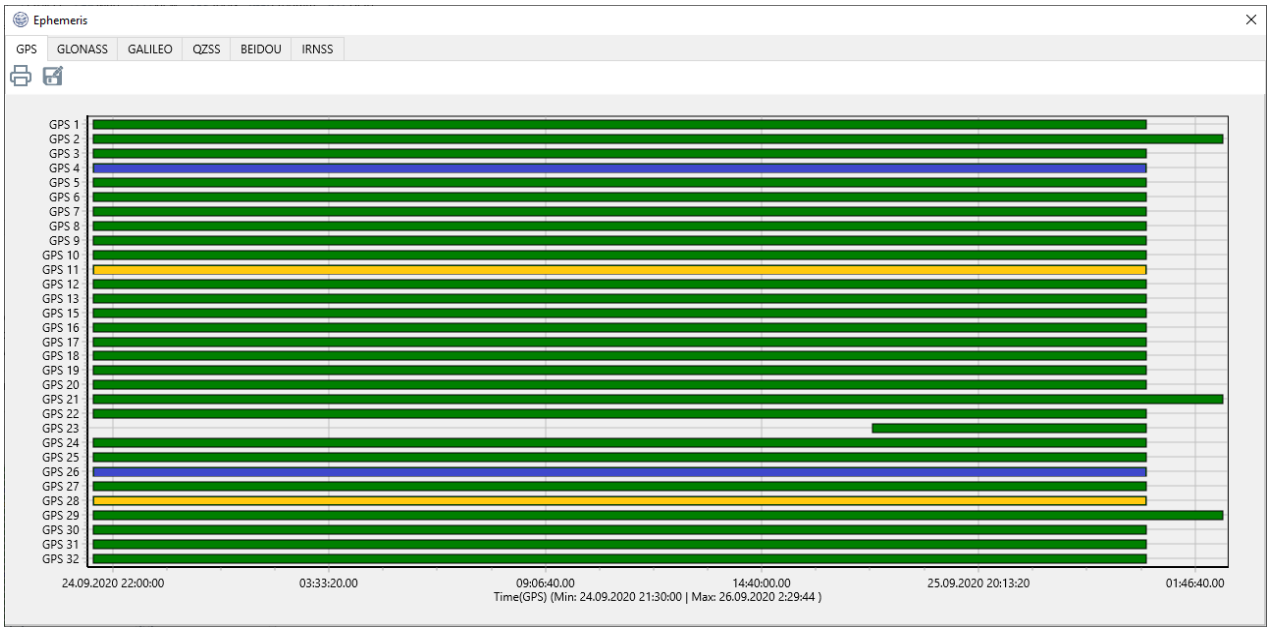


Figure 65 – Satellite ephemeris diagram

4.1 Files

The menu designed for the file objects management looks as follow:

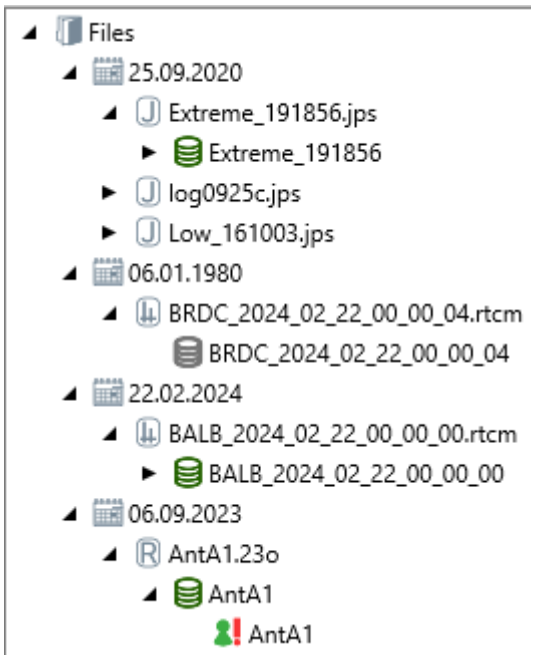


Figure 66 – Files

Letters or simbols above the icons indicates files origin (B, J, R, - broadcasted ephemeris, jps, RINEX, RTCM). The *File* item contains related *Datasets* and *Recordsets* items. A red exclamation mark before the recordset name is shown if antenna type has not been specified.

4.2 Receivers

The menu designed for the receiver objects management looks as follow:

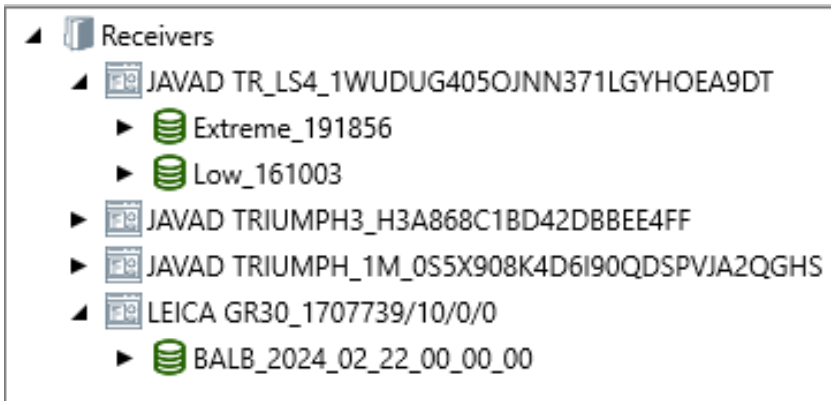


Figure 67 – Receivers

The *Receiver* item contains related *Datasets* and *Recordsets* items.

4.3 Datasets

The menu designed for the dataset objects management looks as follow:

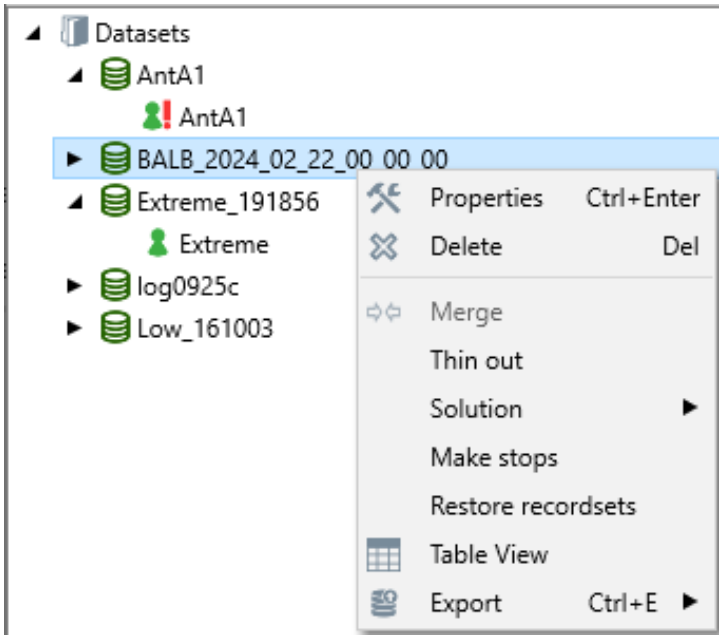


Figure 68 – Datasets

Properties

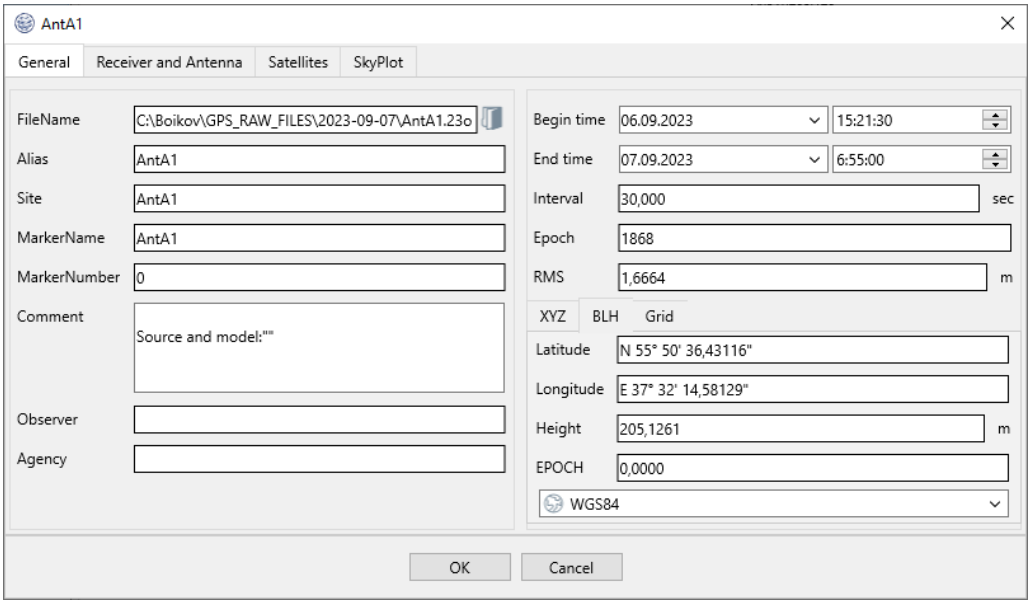


Figure 69 – General tab

General tab contains information about the file name and path to the file, the begin and end time and interval of the recording, the number of epochs, standard deviation and standalone coordinates of the site. Here it is possible to change the start and end times of the recordset.

Receiver and Antenna

The Receiver and Antenna tab is used to select the antenna type, view and edit antenna parameters:

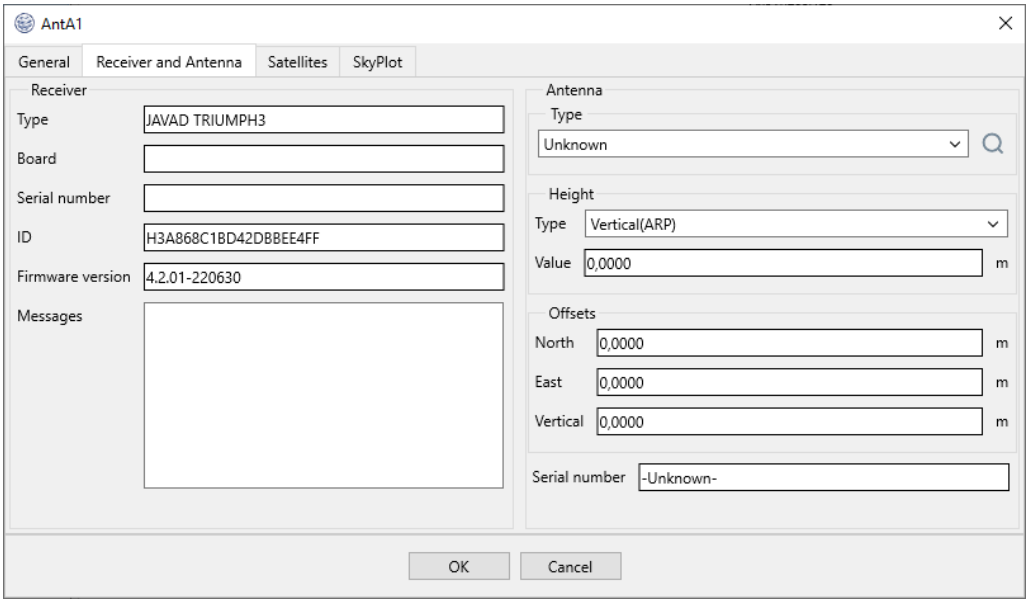


Figure 70 – Receiver and Antenna tab

Click  button for antenna list.

Types of measured antenna height:

- Vertical(ARP) - vertical, ARP (Antenna Reference Point)
- Slant(ARP) - slant, ARP
- Slant(SHMP) - slant, SHMP (Slant Height Measurement Point)

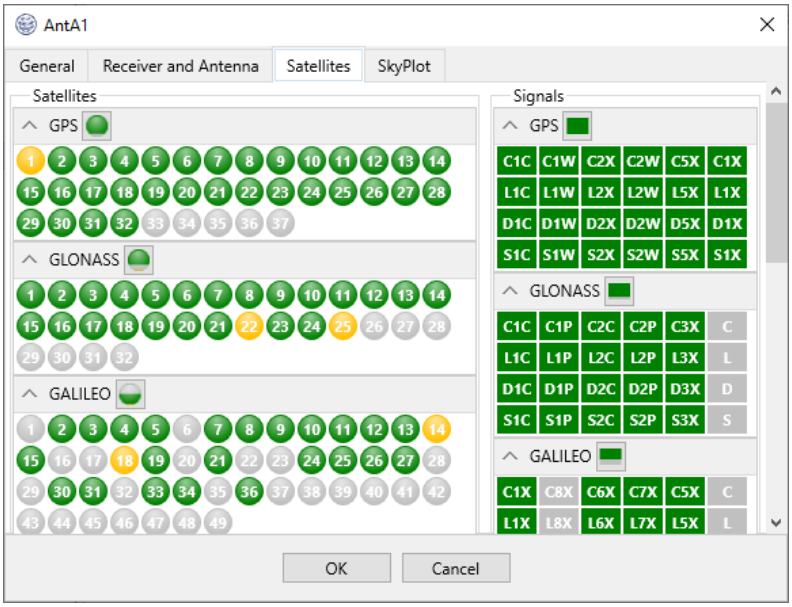


Figure 71 – Satellites tab

Information about GNSS satellites and signals. Yellow colored circles mark unhealthy satellites. Field  indicates ratio of exist/absent signals.

Green, red, blue, yellow colored circles means GPS, GLONASS, Galileo, Beidou satellites respectively. Use scroll control to see picture in dynamic.

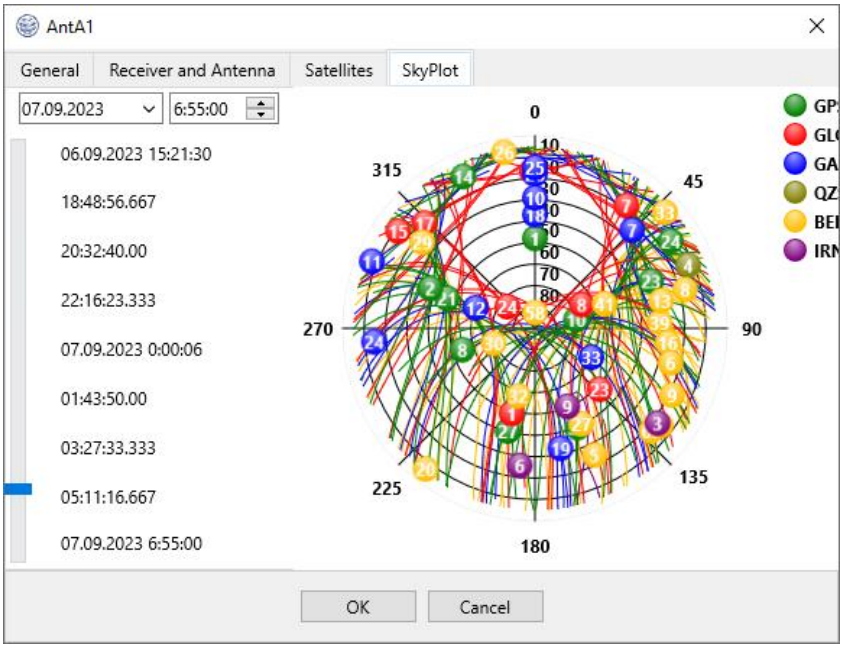


Figure 72 – Sky Plot tab

Delete	deleting from the project. Restoration is impossible, data is deleted permanently
Merge	combines two datasets into one. Only possible if the datasets were written by the same receiver
Thin out	bring the recording interval to the value selected from the list

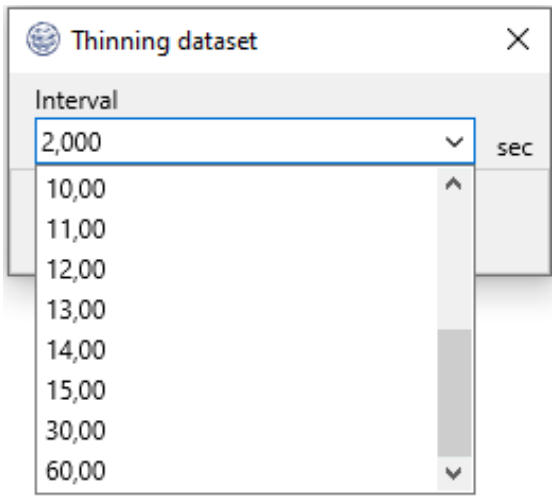


Figure 73 – Recording interval

A thinned dataset cannot be restored, the data is deleted permanently.

Solution	is to set the coordinates of the dataset corresponding to the coordinates taken from the receiver or calculated in the PGO
Make stops	bring the recording interval to the one selected from the list
Restore recordsets	restore recordset to its original form after deleting or editing
Table view	data by epoch in tabular form

RecNo	Enable	Time	Latitude	Longitude	Height, m	Sigma N, m	Sigma E, m	Sigma U, m	Satellites	Satellites...	RMS , m	PDOP,...	GDOP,...	HDOP, m	TDOP, m
1	☑	23.11.2023 12:00...	N 55° 10' 50,53260"	E 36° 39' 29,08002"	186,3554	0,1400	0,1038	0,4517	37	37	0,9956	0,8377	0,0000	0,0000	0,0000
2	☑	23.11.2023 12:00...	N 55° 10' 50,53217"	E 36° 39' 29,08020"	186,3358	0,1400	0,1038	0,4518	37	37	0,9957	0,8377	0,0000	0,0000	0,0000
3	☑	23.11.2023 12:00...	N 55° 10' 50,53238"	E 36° 39' 29,08005"	186,3558	0,1405	0,1042	0,4534	37	37	0,9975	0,8377	0,0000	0,0000	0,0000
4	☑	23.11.2023 12:00...	N 55° 10' 50,53246"	E 36° 39' 29,08021"	186,3680	0,1401	0,1039	0,4520	38	37	0,9959	0,8377	0,0000	0,0000	0,0000
5	☑	23.11.2023 12:00...	N 55° 10' 50,53276"	E 36° 39' 29,07998"	186,3524	0,1402	0,1040	0,4525	37	37	0,9965	0,8377	0,0000	0,0000	0,0000
6	☑	23.11.2023 12:00...	N 55° 10' 50,53255"	E 36° 39' 29,07972"	186,3580	0,1405	0,1042	0,4534	37	37	0,9974	0,8377	0,0000	0,0000	0,0000
7	☑	23.11.2023 12:00...	N 55° 10' 50,53267"	E 36° 39' 29,08000"	186,3734	0,1404	0,1042	0,4534	37	37	0,9974	0,8377	0,0000	0,0000	0,0000
8	☑	23.11.2023 12:00...	N 55° 10' 50,53270"	E 36° 39' 29,07989"	186,3828	0,1406	0,1043	0,4540	37	37	0,9980	0,8377	0,0000	0,0000	0,0000

Figure 74 – Table

Export	export dataset to jps or RINEX files

4.4 Recordsets

The menu designed for recordset objects management looks as follow:

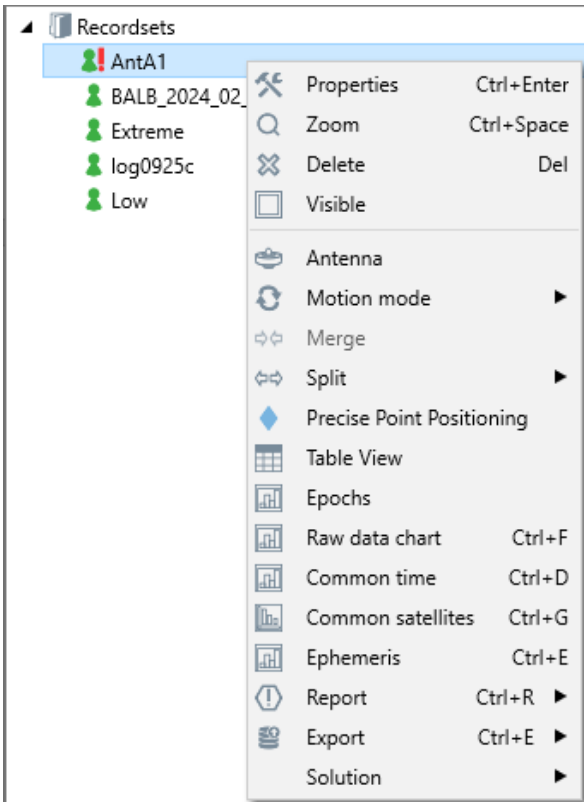


Figure 75 – Recordsets

Properties	a set of tabs and the information are similar to those described in the *DATASET* section
Zoom	show the point corresponding to the recordset on an enlarged scale in the center of the cartographic window
Delete	delete a recordset
Visible	display of solutions by epoch (receiver and PGO) in the cartographic window
Antenna	selection of the antenna type, determination the type of height, height value and offsets.

Activating the window for editing antenna parameters:

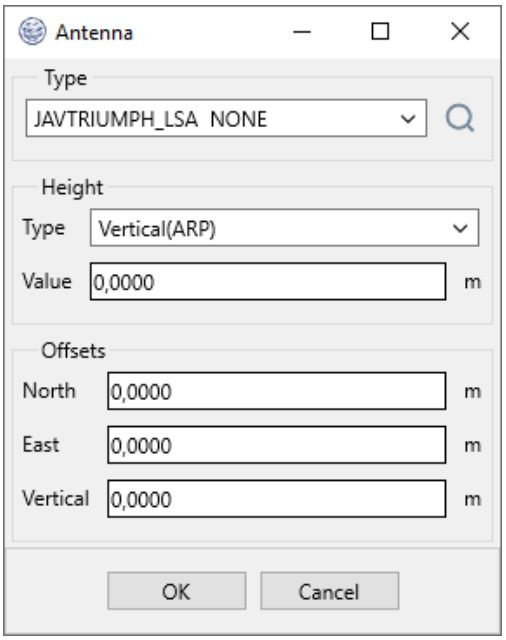


Figure 76 – Antenna type selection

Motion mode	select the motion mode for recordset

Figure 77 – Motion mode

PGO detects the recordset type automatically upon import. The criterion for type determination as static is set in the project properties settings and *Static/Dynamic* tags/events inside the file. The default value of criterion is 5 meters, which means that positions for all epochs for statics are expected to be within 3*5 = 15 meters. Recordset type can be changed manually.

Merge	merging two or more recordsets. Possible only for recordsets belonging to the same dataset
Split	divide the recordset into two or more parts by time interval or number of parts

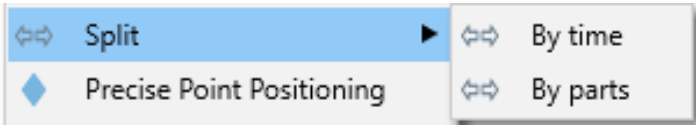


Figure 78 – Split recordset

Precise Point Positioning	determination of coordinates by method PPP
Table view	data in tabular form

RecNo	Enable	Time	Latitude	Longitude	Height, m	Sigma N, m	Sigma E, m	Sigma U, m	Satellites	Satellites...	RMS , m	PDOP,...	GDOP,...	HDOP, m
1	☑	22.02.2024	N 55° 10' 50,54678"	E 36° 39' 29,04667"	194,4132	0,0949	0,0803	0,2404	39	39	0,9337	0,6905	0,0000	0,0000
2	☑	22.02.2024 0:00:01	N 55° 10' 50,54696"	E 36° 39' 29,04693"	194,4136	0,0952	0,0806	0,2414	39	39	0,9356	0,6905	0,0000	0,0000
3	☑	22.02.2024 0:00:02	N 55° 10' 50,54678"	E 36° 39' 29,04686"	194,4069	0,0947	0,0802	0,2400	39	39	0,9329	0,6905	0,0000	0,0000
4	☑	22.02.2024 0:00:03	N 55° 10' 50,54702"	E 36° 39' 29,04688"	194,4024	0,0944	0,0800	0,2395	39	39	0,9317	0,6905	0,0000	0,0000
5	☑	22.02.2024 0:00:04	N 55° 10' 50,54688"	E 36° 39' 29,04678"	194,4080	0,0944	0,0799	0,2394	39	39	0,9315	0,6905	0,0000	0,0000
6	☑	22.02.2024 0:00:05	N 55° 10' 50,54705"	E 36° 39' 29,04715"	194,4122	0,0944	0,0800	0,2396	39	39	0,9317	0,6906	0,0000	0,0000
7	☑	22.02.2024 0:00:06	N 55° 10' 50,54702"	E 36° 39' 29,04700"	194,4113	0,0946	0,0801	0,2400	39	39	0,9325	0,6906	0,0000	0,0000

Records count: 3600 | Selected: 1 |

Figure 79 – Table

Epochs	data by epoch in tabular form

RecNo	Dataset	Solution type	Engine mode	Time	Status	Latitude	Longitude	Height, m	RMS , m	Satellite
1	Extreme_191856	Nav	Receiver	25.09.2020 19:19:15	code	N 55° 39' 17,32245"	E 38° 06' 11,48603"	147,4649	17,7396	
2	Extreme_191856	Nav	Receiver	25.09.2020 19:19:16	code	N 55° 39' 17,32017"	E 38° 06' 11,48633"	147,2707	17,5289	
3	Extreme_191856	Nav	Receiver	25.09.2020 19:19:17	code	N 55° 39' 17,32509"	E 38° 06' 11,49181"	147,1898	17,9174	
4	Extreme_191856	Nav	Receiver	25.09.2020 19:19:18	code	N 55° 39' 17,33060"	E 38° 06' 11,49803"	147,1517	18,0027	
5	Extreme_191856	Nav	Receiver	25.09.2020 19:19:19	code	N 55° 39' 17,32691"	E 38° 06' 11,49800"	147,0732	17,5189	
6	Extreme_191856	Nav	Receiver	25.09.2020 19:19:20	code	N 55° 39' 17,32612"	E 38° 06' 11,49900"	146,9787	17,2008	

Records count: 60178 | Selected: 0 |

Figure 80 – Table

- Solution type - navigation, floating, fixed.
- Engine mode - coordinates calculated by the receiver or PGO
- Status - depends on the receiver or PGO solution

Raw data chart	measurement charts.

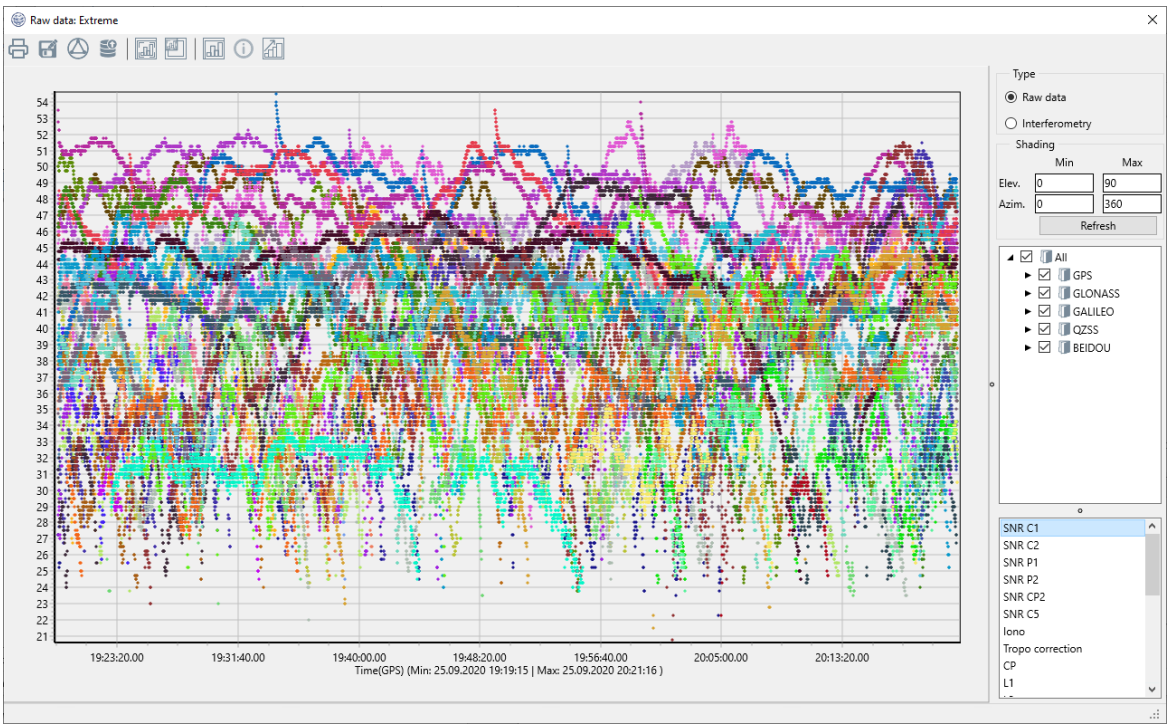


Figure 81– Measurement charts

The raw data shows base to rover single differenced GNSS signals values. Interferometry shows satellite to satellite single differenced GNSS signals values. Statistics are displayed both on the screen and exported to a text file.

Common time	chart for recordsets time (CTRL+ select recordsets)
Common satellites	diagram of common satellites for recordsets (CTRL+ select recordsets)

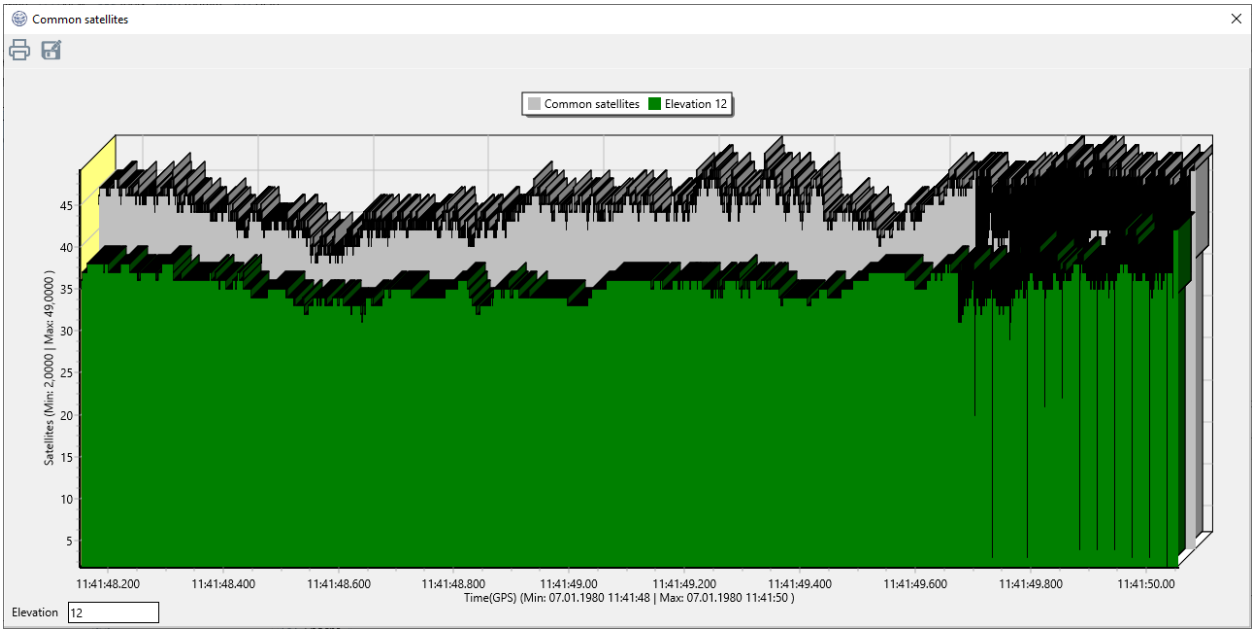


Figure 82 – Common satellites diagram

Ephemeris	diagram for ephemerides loaded into the project
Report	generate a report

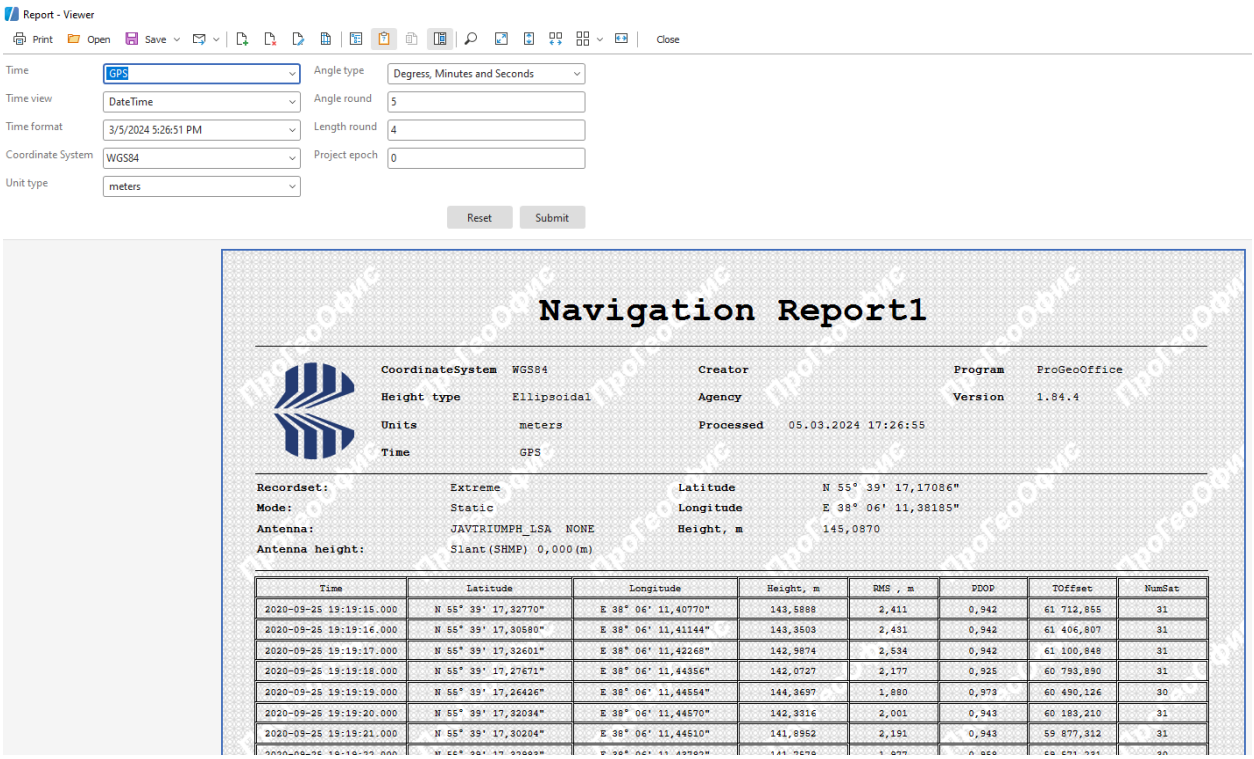


Figure 83 – Report

Export	export recordset data to jps or RINEX files
Solution	set the recordset coordinates corresponding to the coordinates taken from the receiver or calculated in the PGO

4.5 Sites

PGO creates object *Site* using the source data and the *Tolerance* criterion for sites. Several recordsets can be assigned to one site, depending on the distance between the positions corresponding to the coordinates of recordsets. The criterion for creating individual sites is set in the project settings. Recordsets that overlap in time create a vector that can be processed.
The menu designed for the site objects management looks as follow:

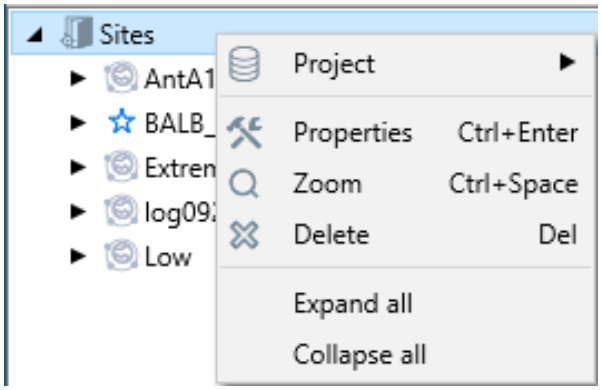


Figure 84 – Sites

Properties

The site properties window contains information about the site coordinates and coordinate errors:

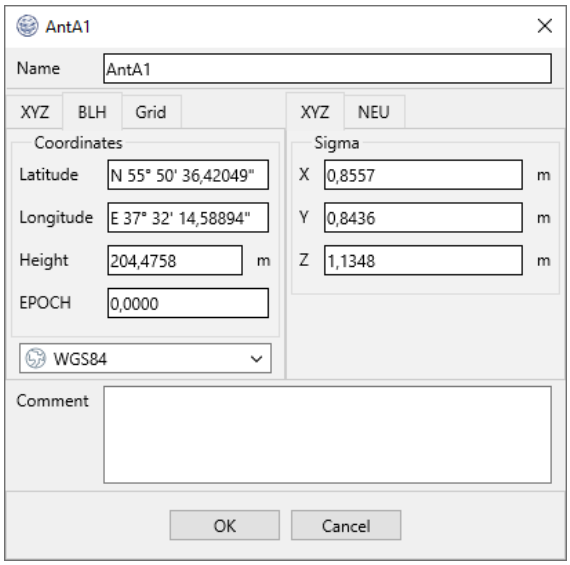


Figure 85 – Site properties

Zoom	show the site on an enlarged scale in the center of the cartographic window
Delete	the item is deleted as an object, but the recordset and dataset are not deleted. Can be restored by selecting the menu item *Restore recordset*
Expand all	expand all nodes in the tab

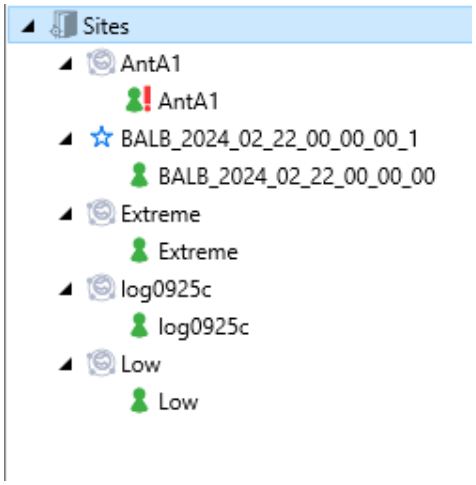


Figure 86 – Expand all

Collapse all	collapse all nodes in the tab:

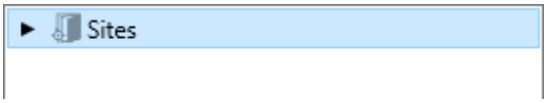


Figure 87 – Collapse all

Change vectors direction	set the direction of the vectors (all from the selected site or all to the selected site)

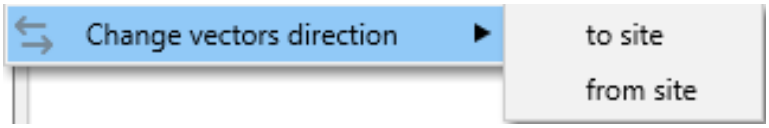


Figure 88 – Change vectors direction

When sites operating in the cartographic window, additional options are available. To access the corresponding menu, select an item by hovering the cursor over it and clicking the mouse, and then press the right mouse button:

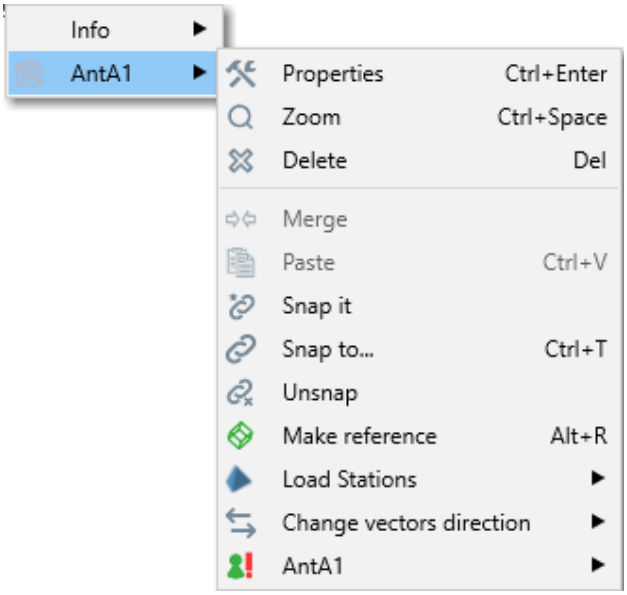


Figure 89 – Site operating

Snap it	snap a site to a reference point. After selecting this menu item, select the reference point, right-click on it and in the menu that appear
Snap here	snap to selected reference site

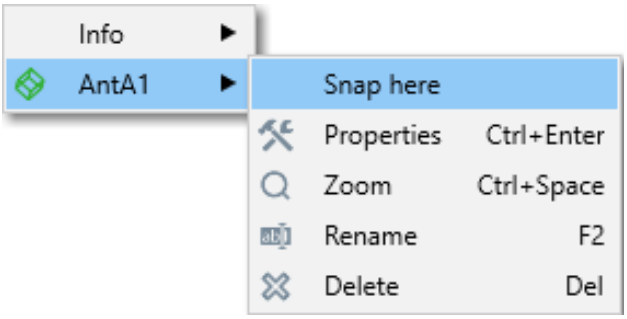


Figure 90 – Snap to selected reference site

Snap to…	snap site to the reference point selected in the list

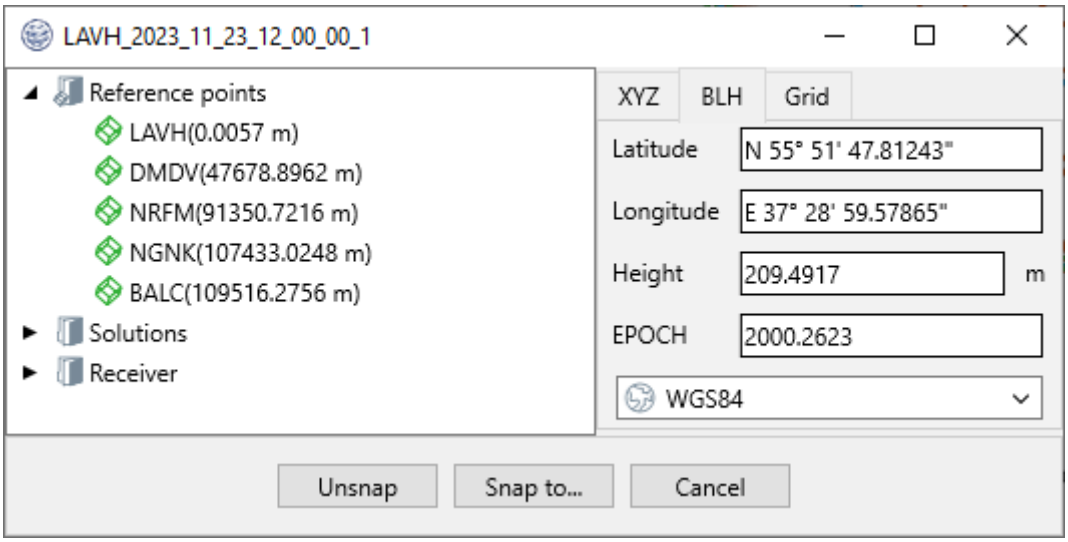


Figure 91 – Snap to…

Unsnap	unsnap a site from a reference point
Make reference	create a reference point with the coordinates of the site
Load stations	import Continuously Operating Reference Stations data

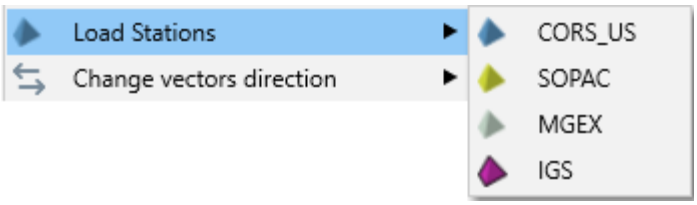


Figure 92 – CORS networks

CHAPTER 5. POST PROCESSING

Post-processing is a *Vector* option. Recall that recordsets which have time overlapped GNSS observation sessions yield a *Vector*. A goal of post-processing is a *Solution*. Depending on a type of rover *Recordset* we distinguish static or kinematic modes of post-processing. Type of recordset is figured out just after importg GNSS data relative to *Criterion for static* in a project settings. *PGO* offers type editing through recordset properties dialog.
Activate *Process* tab in a project pane to get access to post-processing.
Post-processing could be run in a batch mode via *Vectors* item in a *Process* tab of project pane.

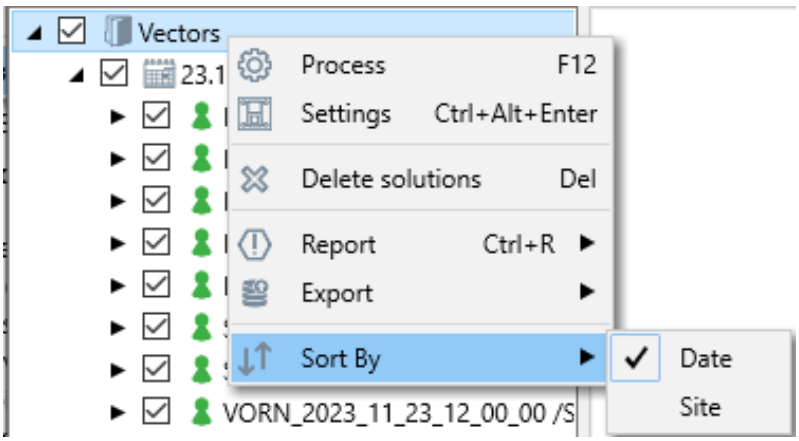


Figure 93 – Sorting vectors

Otherwise, use *Selection by point/rectangle* tool in the main toolbar for post-processing through the map. The post-processing of static data yields the increments of coordinates from base to rover in the geocentric coordinate system. The static *Solution* is shown on the solution layer as a line object. The post-processing of kinematic data yields a set of solution vectors so-called fan. The kinematic solution is shown on the map as a collection of point objects. The point positions are the end of solution vectors. We use *base* and *rover* indications for terminal points of Vector
The static engine, as well as kinematic one, use so-called single differences of GNSS data.

Vectors options:

Process	post-processing of all unprocessed vectors
Settings	open process settings window (described below)
Delete Solutions	delete all solutions from a project
Report	create a vectors processing report
Export	export to exchange formats
Sort by	sort vectors by date or site name. Initially Vectors tree is structured by date of the beginning of time span

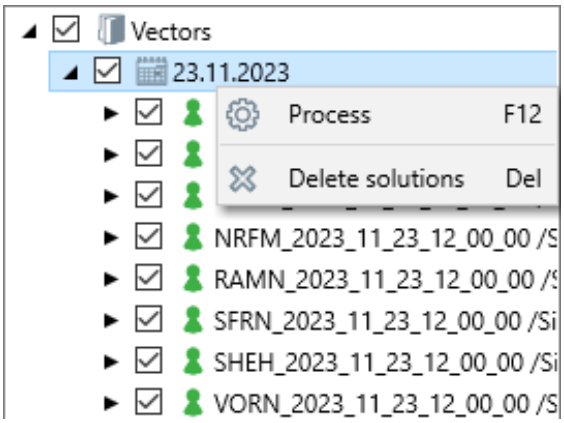


Figure 94 – Date node options

Data item options:

Process	post-processing for all associated vectors
Delete solutions	delete all solutions

The next level of *Vectors* tree corresponds to base object. Sublevels are rovers.

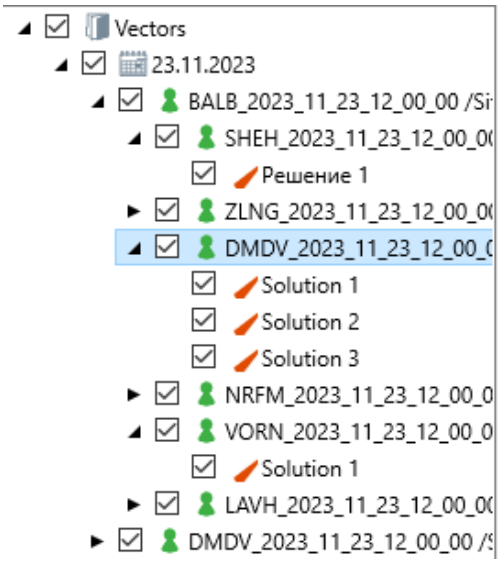


Figure 95 – Vectors tree

Both base site *BALB* and rover site *DMDV* are signed by static recordset icon.

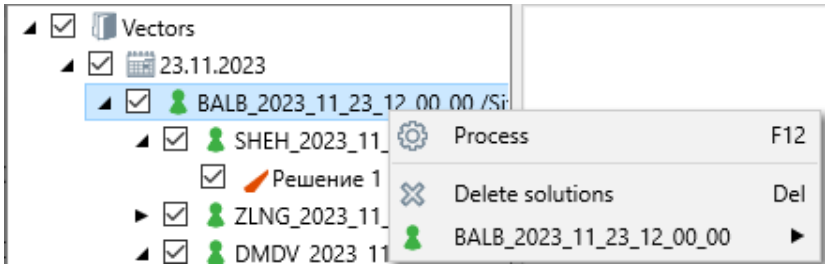


Figure 96 – Base tree options

Base node options:

Process	post-processing for all unprocessed *Vectors*
Delete Solutions	delete all solutions related to the base node

The last level of vectors tree is intended for solutions that appear under rover node after post-processing. Initially the rover node is empty. Processing adds a *Solution* to an item.

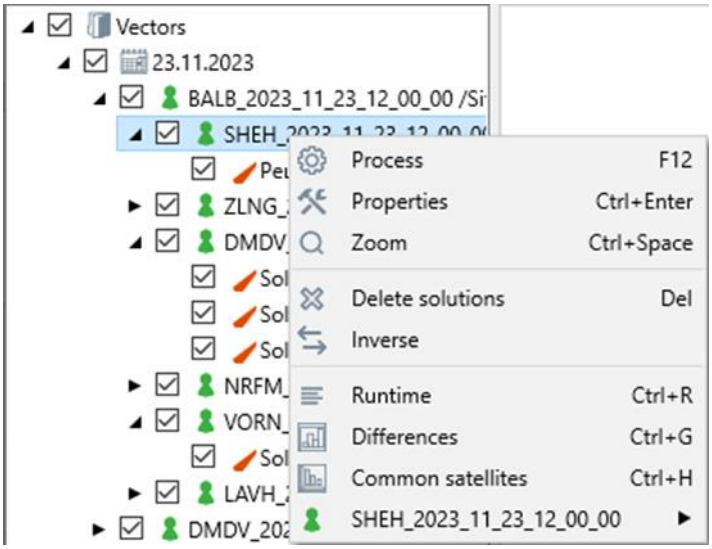


Figure 97 – Rover tree options

Rover node options:

Process	post-processing if no solution exists
Properties	open vector properties window:

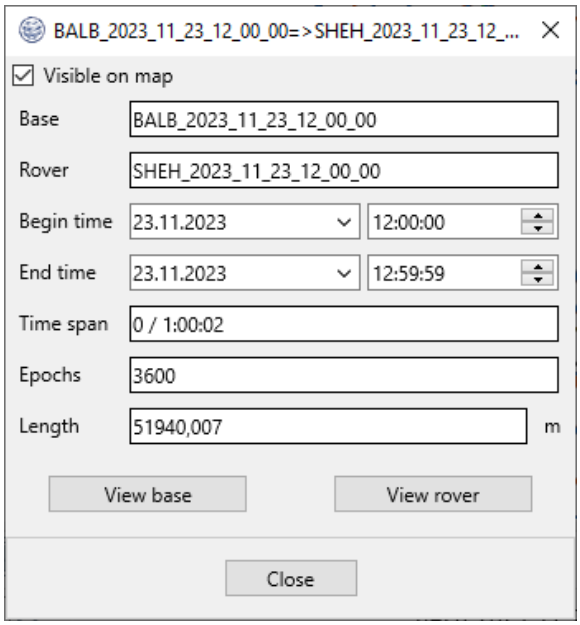


Figure 98 – Vector properties

View base and *View rover* buttons open relative recordset properties window.

Zoom	scales the map by the length of the corresponding vector
Delete solutions	delete all solutions rover node related
Inverse	change the direction of the vector (which will lead to corresponding changes in the vector tree)
Runtime	opens the *Runtime* tab, which allows to process a single vector and obtain two or more solutions for it with different settings (described below in the section *Processing a Single Vector*)
Differences	chart of GNSS signal differences used in post-processing

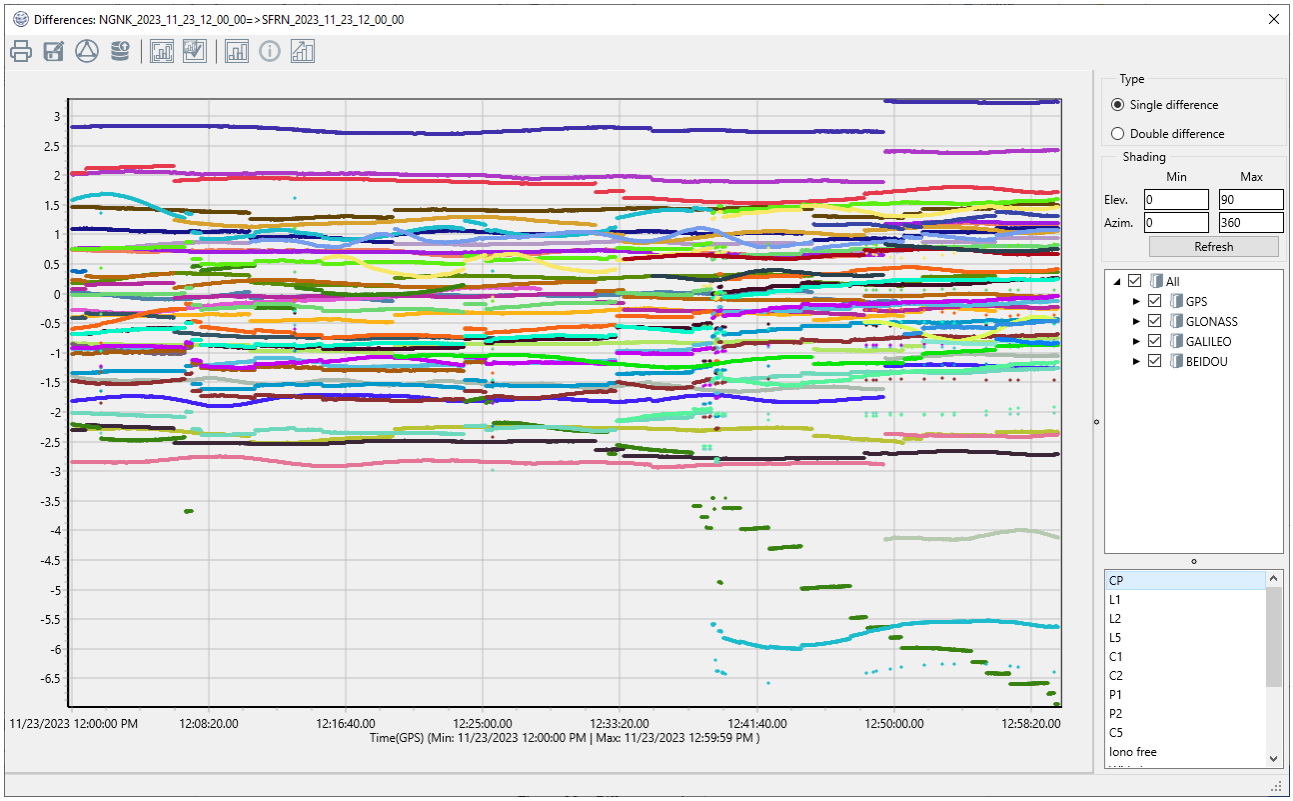


Figure 99 – Differences chart

Common satellites	open the visibility of common satellites for the base and rover chart

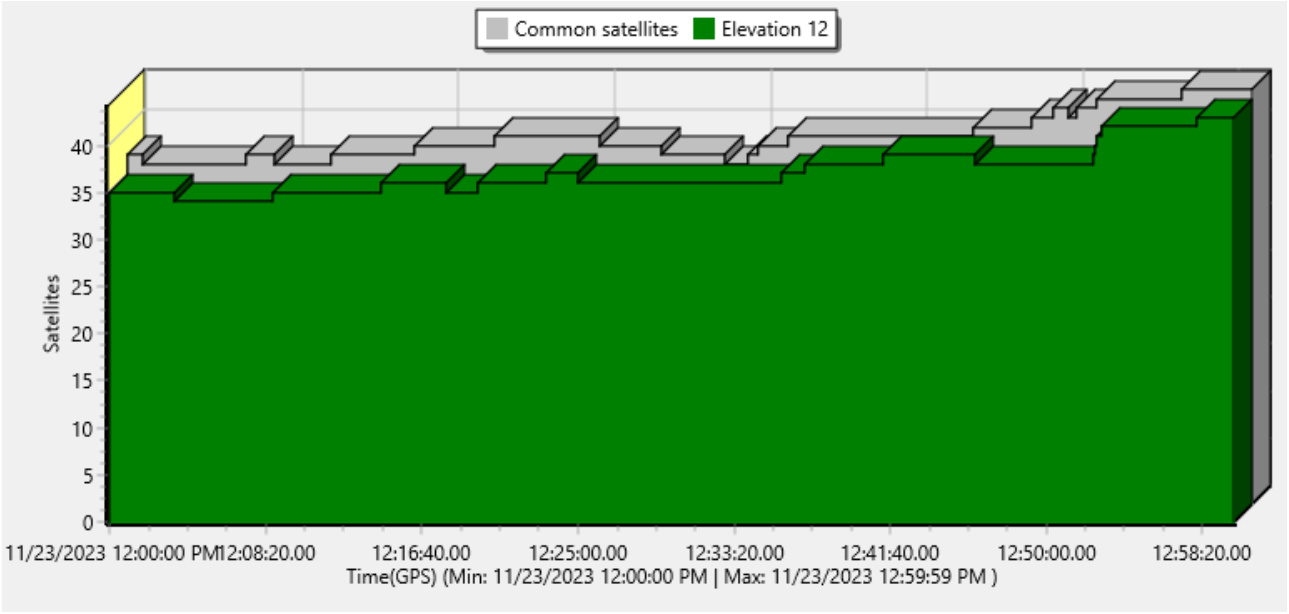


Figure 100 – Common satellites chart

5.1 Settings

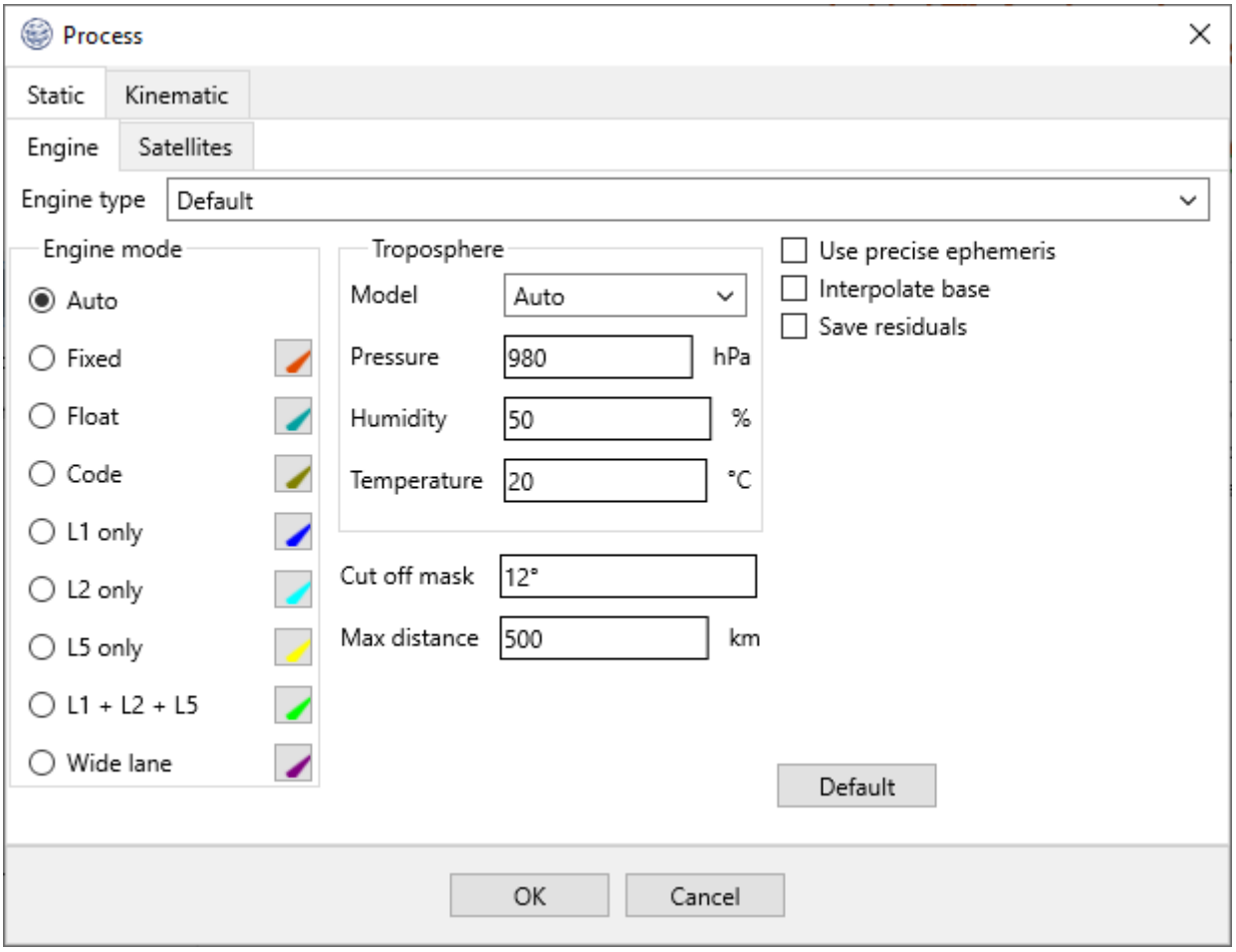


Figure 101 – Process properties

5.2 Static

Engine tab

Regular PGO software is delivered with one default engine. By request additional engines may be activated.

Engine mode options:

Auto	auto detect best combination of base and rover overlapped data
Fixed	automatic mode processing, get a fixed solution only
L1 only, L2 only, L5 only	process L1, L2, L5 data respectively
L1+L2+L5	process L1, L2, L5 all together
Wide lane	process L1 and L2 data in Wide lane combination
Float	not integer processing in Auto mode
Code	обработка по кодовым измерениям

Troposphere tab

Model	a list of most popular modern models

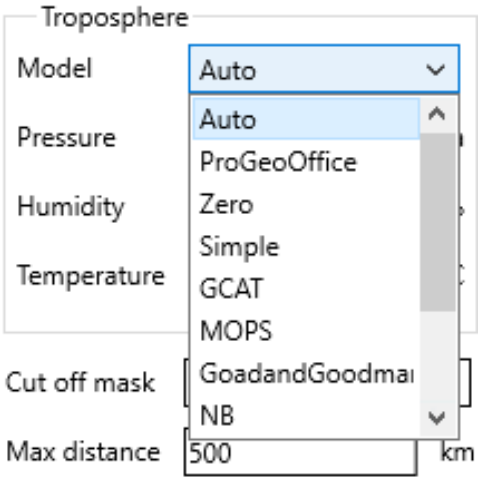


Figure 102 – Troposphere models

Pressure, Humidity, Temperature	input of meteo parameters, *Humidity* value extremely affects to altitude
Cut off mask	rejection satellites data by elevation angle
Max distance	maximum baselines length (in km). Focus on this parameter in batch processing. Some vectors may be skipped/
Use precise ephemeris	process vectors using precise ephemeris if those are available on the date of processing. PGO can automatically download ephemeris from Internet.

Interpolate base	interpolate base GNSS data if rover data sampling is different
Save residuals	store residuals in a project database. Residual is result of subtraction measured code or carrier phases values (depending on processing mode) and a distance between final receiver position and satellite. Storage of residuals make post-processing slower. In the meantime residuals chart is a main tool to control post-processing result for data captured in a bad environment.

Click  button to customize Solution object style on a map:

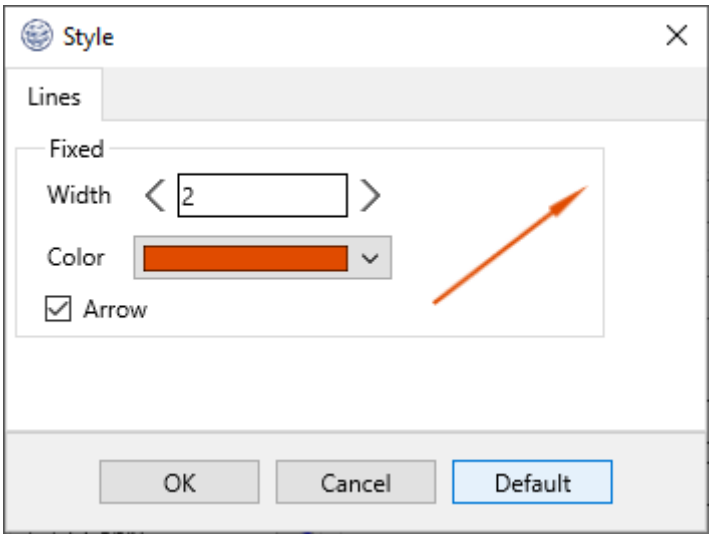


Figure 103 – Object style

Satellites tab

Use this option to unable/disable satellites.

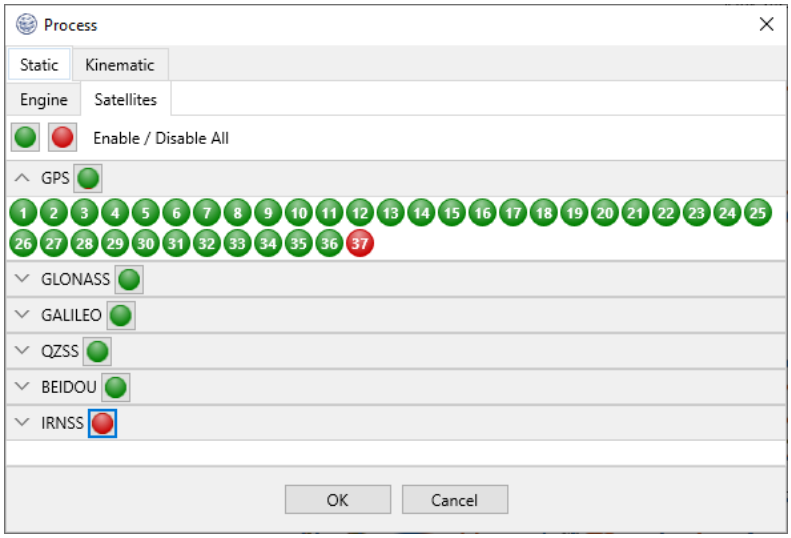


Figure 104 – Process properties. Satellites tab

5.3 Batch processing

Continuous vectors post-processing could be run by Vectors tree item or using selection Vectors on a map by  or  tools:

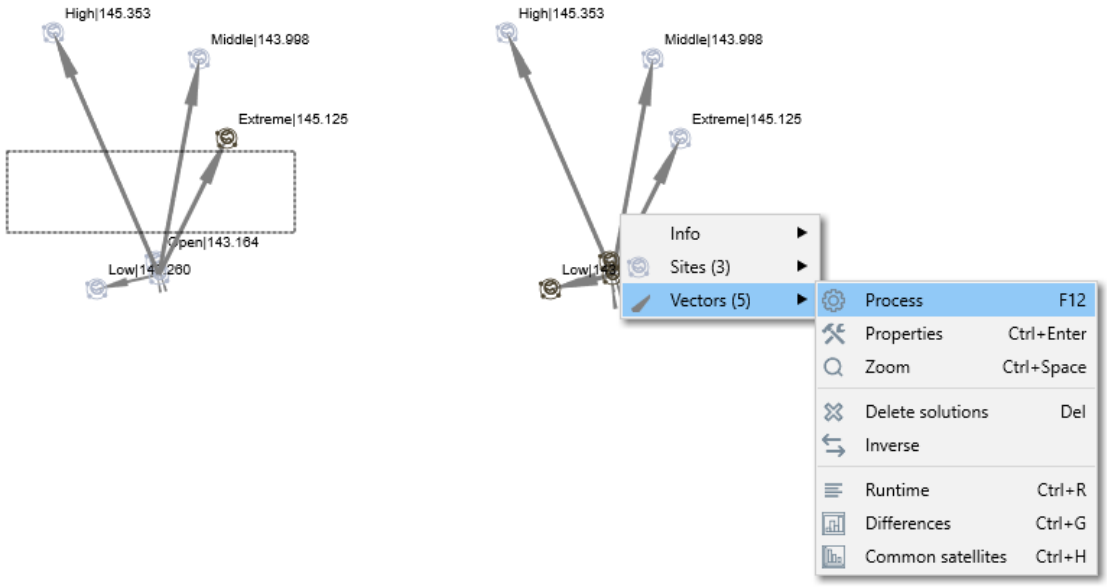


Figure 105 – Vectors selection for processing

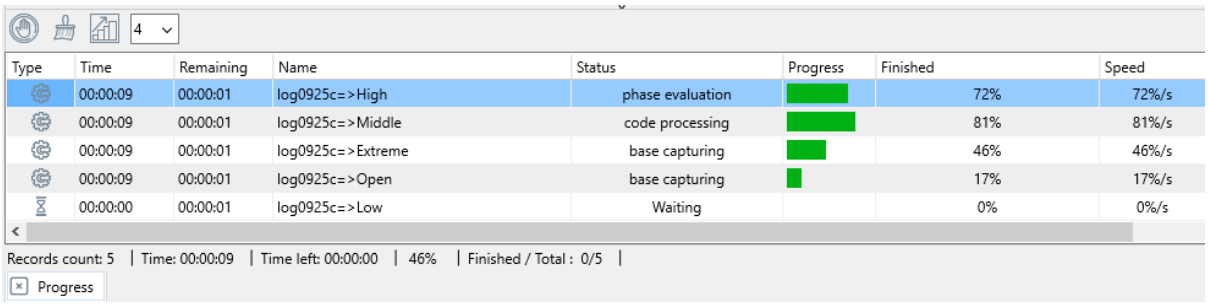


Figure 106 – Processing progress

Processing progress is shown in a Progress window. Click  to abort processing. Log tab looks like this:

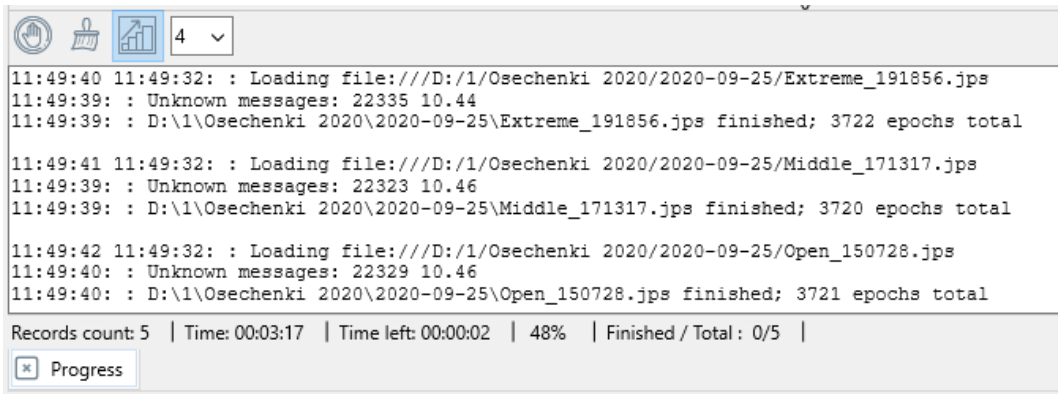


Figure 107 – Log tab

Below an information about elapsed processing time and statistics of solutions.

5.4 Single vector processing

This approach makes sense if user wants to refine solution yielded by batch processing or to process vector with different processing settings.
Select the rover node in the vector tree or the vector on the map, right-click and select the vector, then select the *Runtime* menu item:

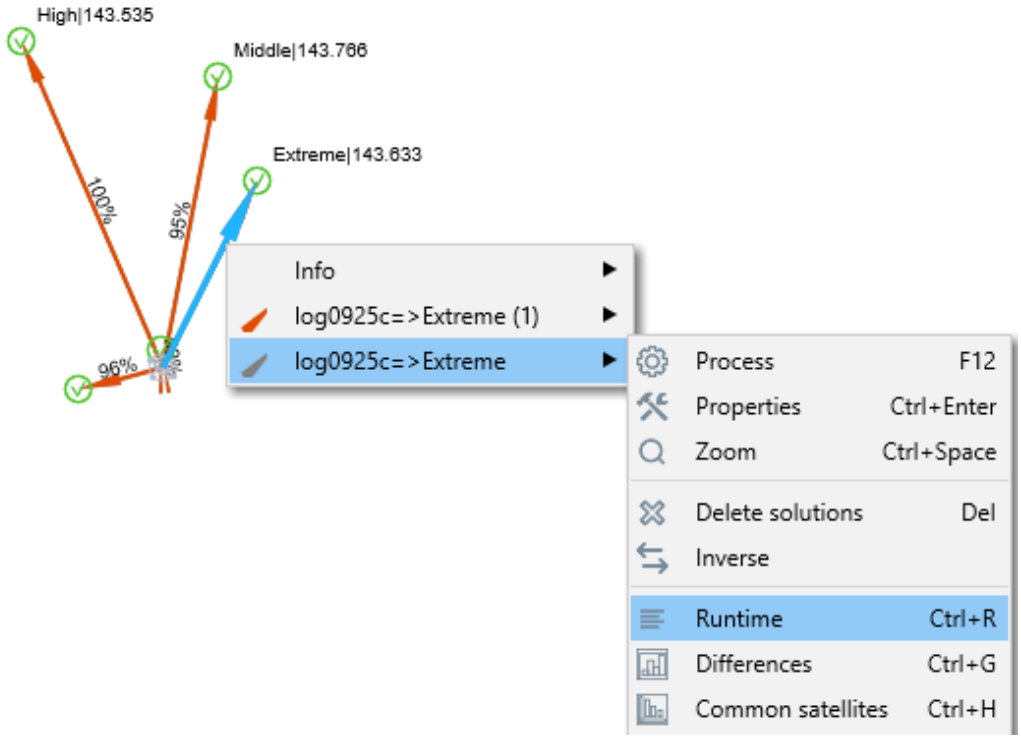


Figure 108 – Runtime

Bottom pane appears:

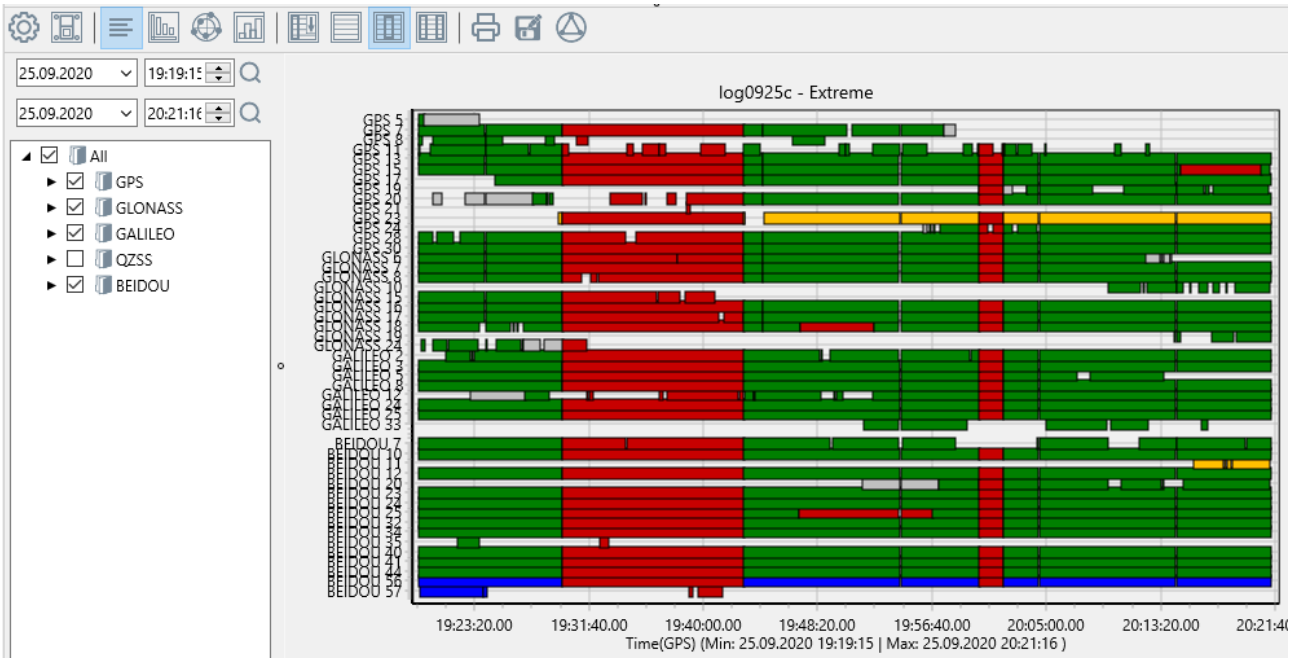


Figure 109 – Bottom pane

	run post-processing
	post-processing options
	diagram *Runtime*
	diagram *Common satellites*
	diagram *SkyPlot*
	*Differences* chart
	select all satellites
	clear chart
	disable satellites
	enable satellites
	print

	save as…
	show all

The left pane is intended for satellites disabling and *Start/End* time may be edit. *Settings, Common satellites, Differences* and *SkyPlot* windows were described above

Solution

The item is accessible as through map and from project pane as well.

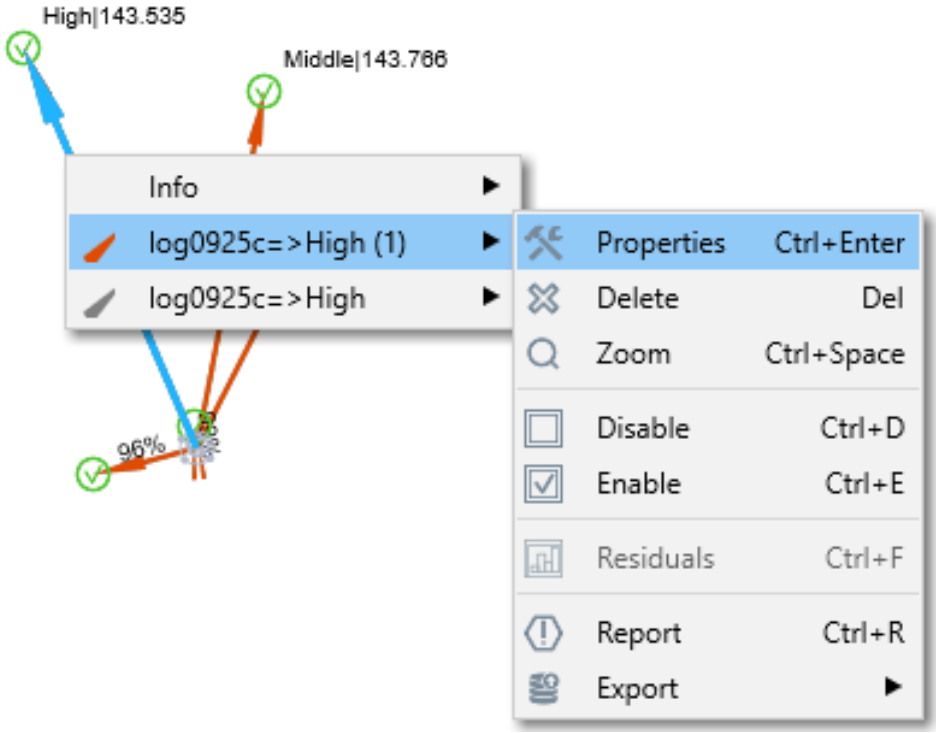


Figure 110 – Solution menu item

Properties

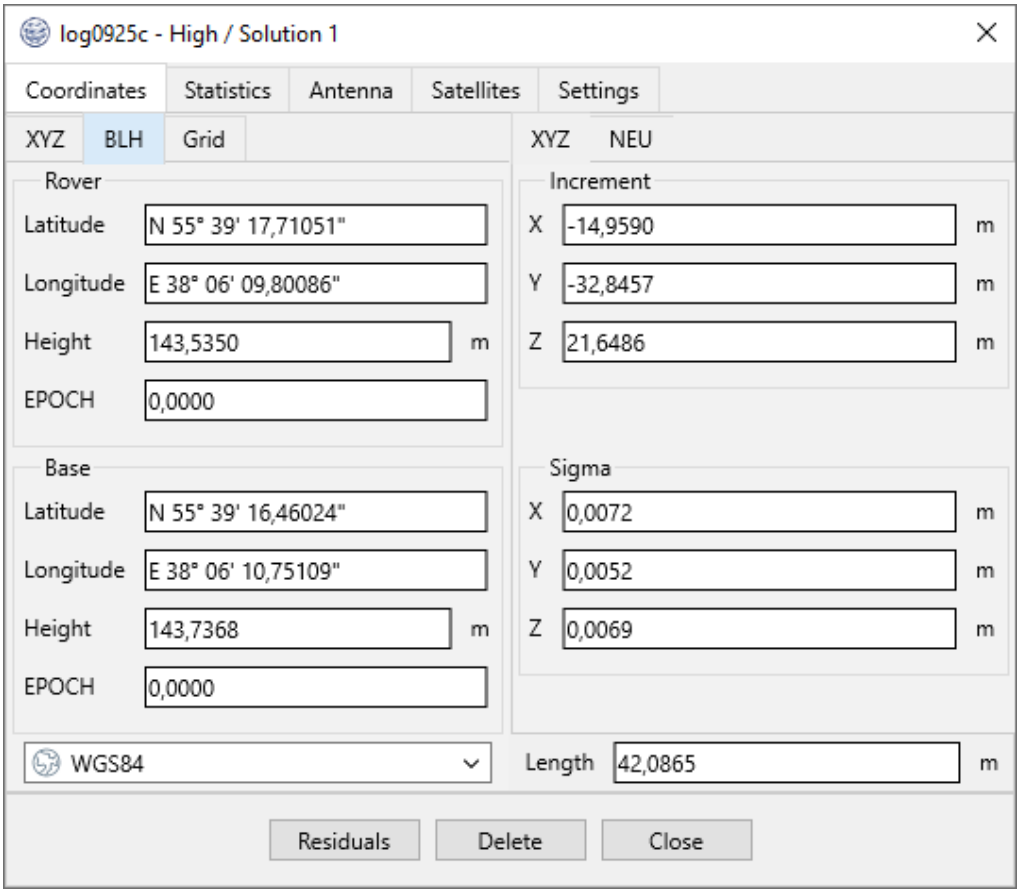


Figure 111 – Coordinates tab

Coordinates tab

- *Rover* and *Base* coordinates on epoch date of the project
- Solution components in XYZ
- Sigmas are diagonal elements of correlation matrix. Only coordinates systems announced in a project are available.

Statistics tab

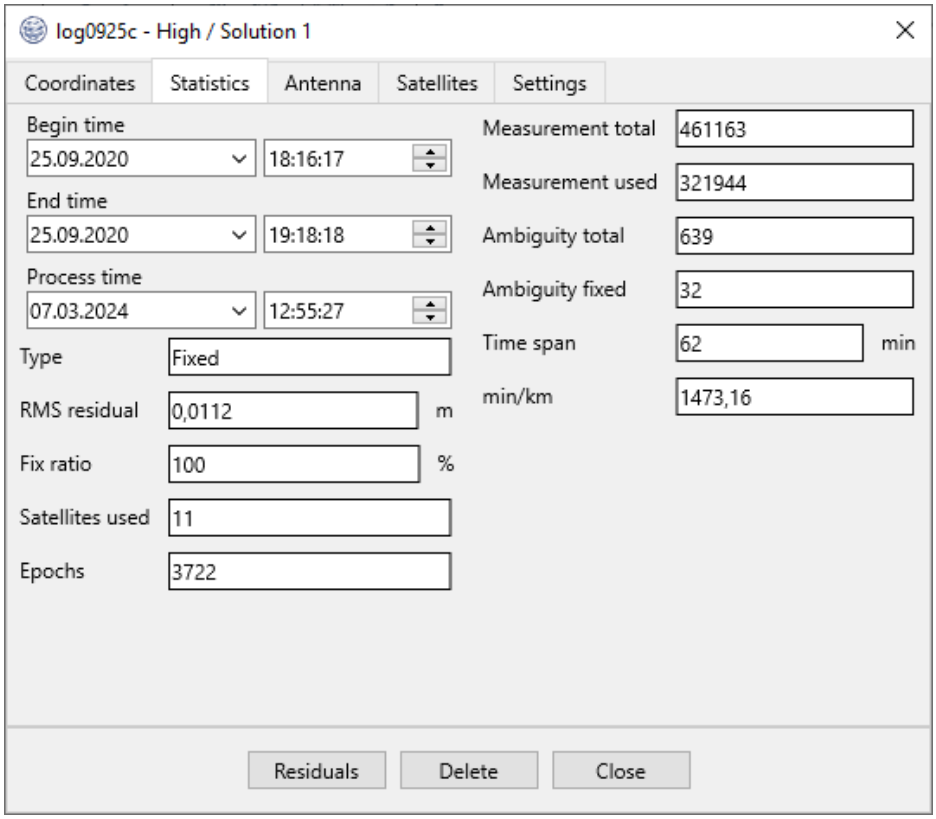


Figure 112 – Statistics tab

- Total and left code and phase data in *Solution*
- Number of total and left phase ambiguities
- Time span equals epoch number multiplied by record interval
- RMS residuals = sqrt(sum(sqr(v)) / n), v – residual, n – epoch number
- Fix ratio - Fisher statistics
- Left satellites used
- Min/km - time span divided by length
- Begin, End time shows time tag of observation session
- Process time - post-processing time and date

Antenna tab

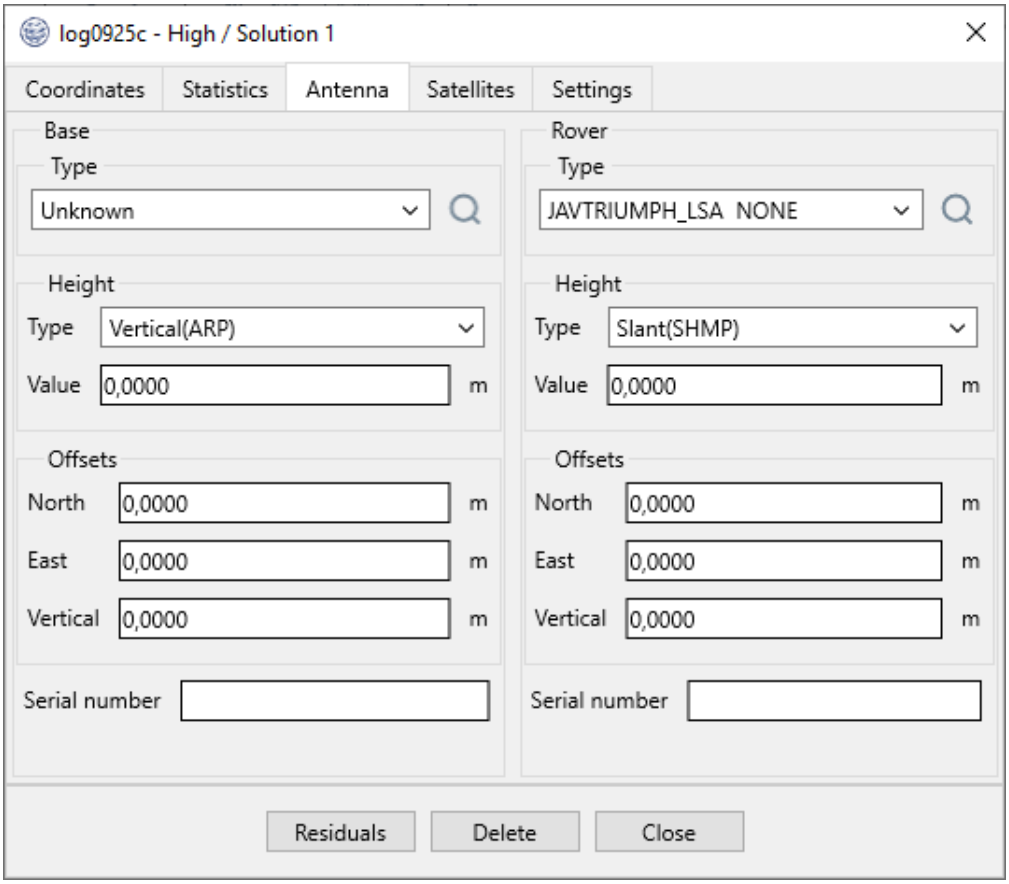


Figure 113 – Antenna tab

Type	antenna model (NGS US convention)
Height Type	antenna measurement point
Height Value	direct distance between measurement point and ground point
Offsets	distances between ground point and point of interest
Serial number	antenna serial number

Satellites tab

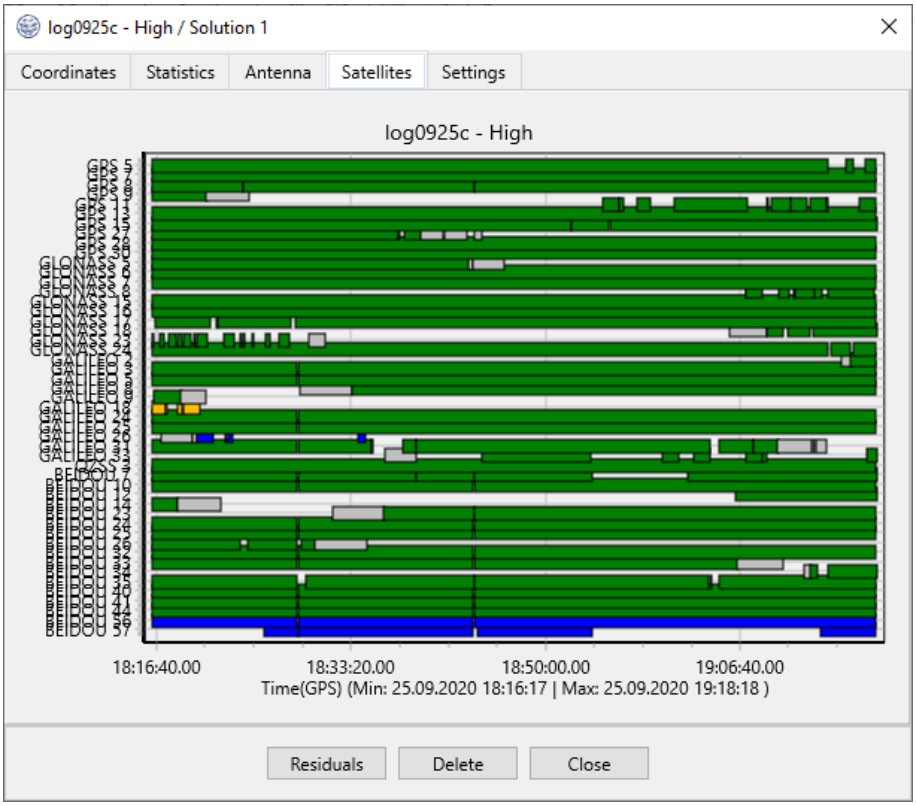


Figure 114 – Satellities tab

Snapshot of Timeline chart.

Settings tab

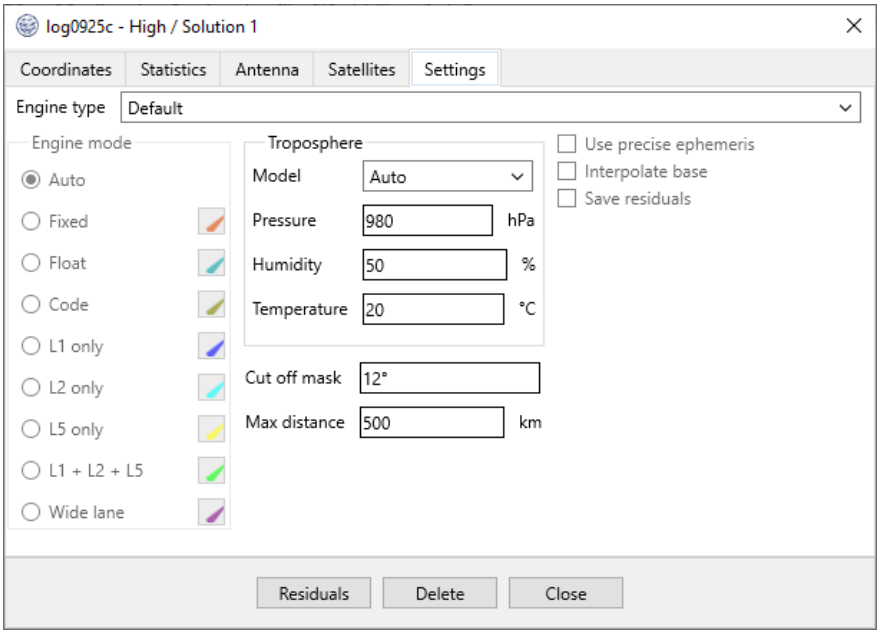


Figure 115 – Settings tab

Snapshot of post-processing settings window.

5.5 Kinematic solution

Kinematic solution

Get access to solution option by selection Vector item on a left pane or Vector object on a map:

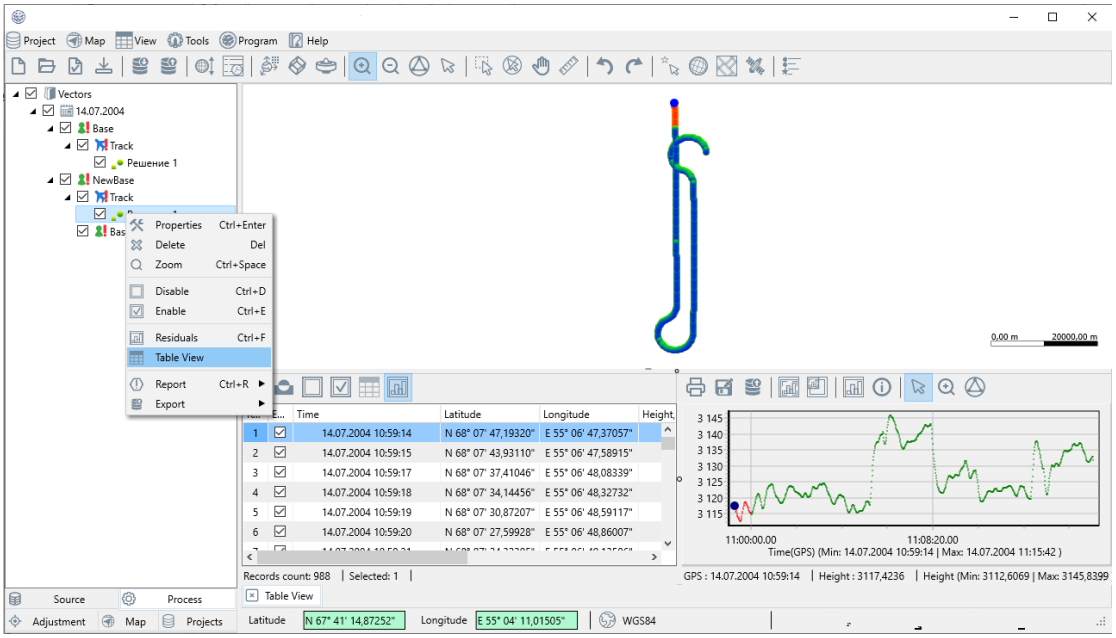


Figure 116 – Table view

In fact, almost all options are similar to above mentioned with exception of Table View. The option opens new bottom pane with a table of coordinates with statistics and a chart of vertical profile. By selection on a table or on a chart relative objects on map being selected also and vice versa.

Residuals

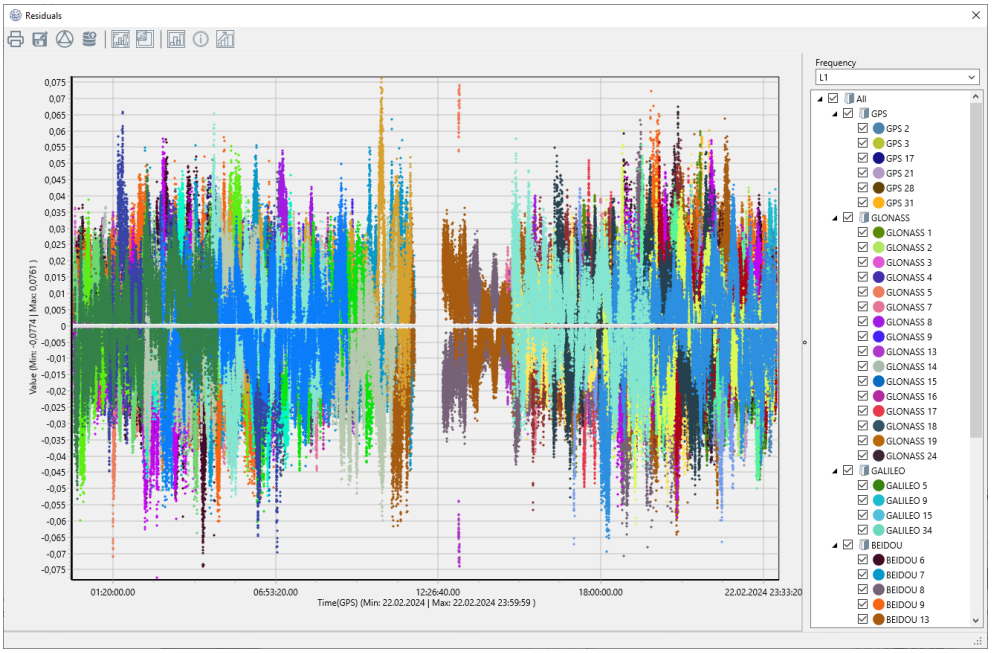


Figure 117 – Residuals

Statistics are shown in status bar. Otherwise, to reach statistics for single satellite right click on it on a right pane and get Info window or export to *.csv file:

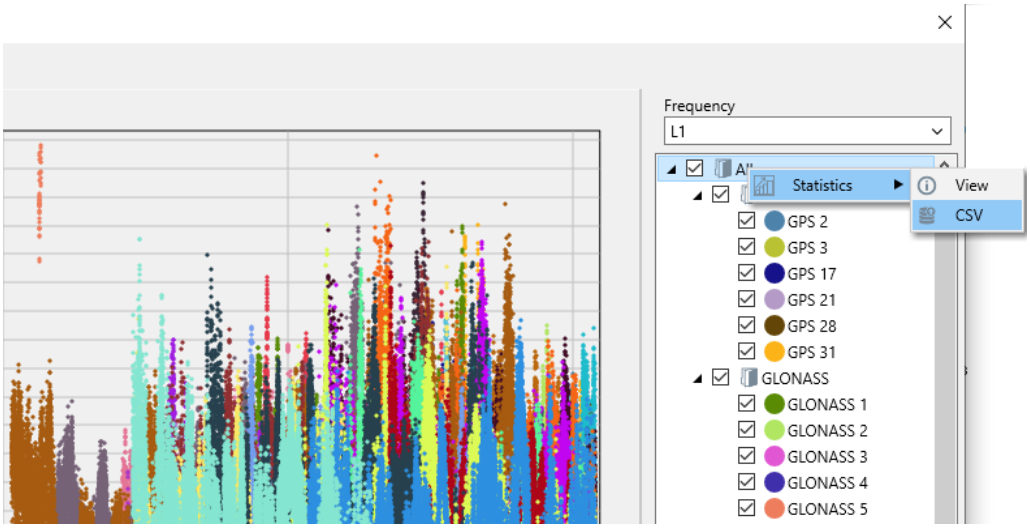
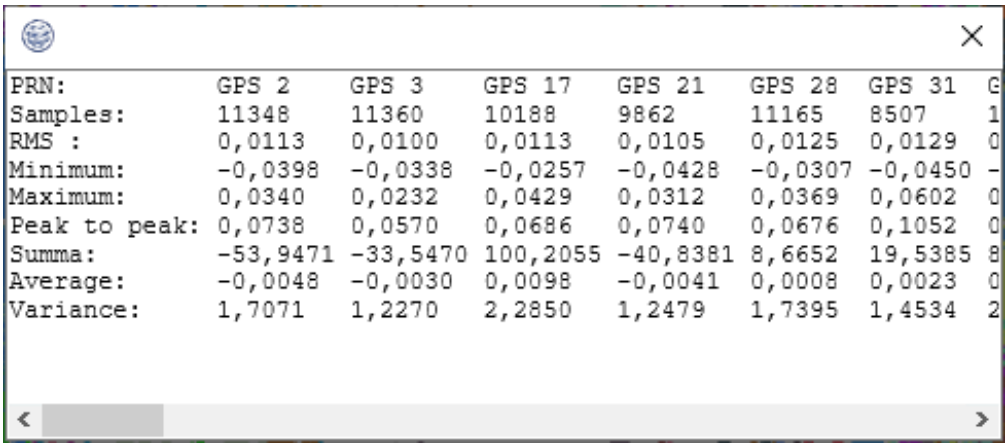


Figure 118 – Save residuals

or select View to display statistics on the screen.



PRN:	GPS 2	GPS 3	GPS 17	GPS 21	GPS 28	GPS 31	G
Samples:	11348	11360	10188	9862	11165	8507	1
RMS :	0,0113	0,0100	0,0113	0,0105	0,0125	0,0129	0
Minimum:	-0,0398	-0,0338	-0,0257	-0,0428	-0,0307	-0,0450	-
Maximum:	0,0340	0,0232	0,0429	0,0312	0,0369	0,0602	0
Peak to peak:	0,0738	0,0570	0,0686	0,0740	0,0676	0,1052	0
Summa:	-53,9471	-33,5470	100,2055	-40,8381	8,6652	19,5385	8
Average:	-0,0048	-0,0030	0,0098	-0,0041	0,0008	0,0023	0
Variance:	1,7071	1,2270	2,2850	1,2479	1,7395	1,4534	2

Figure 119 – Statistics

Report

To generate a report for all solutions select the *Vectors* node, right-click and select *Report*. To generate a single solution report do the same steps for this solution:

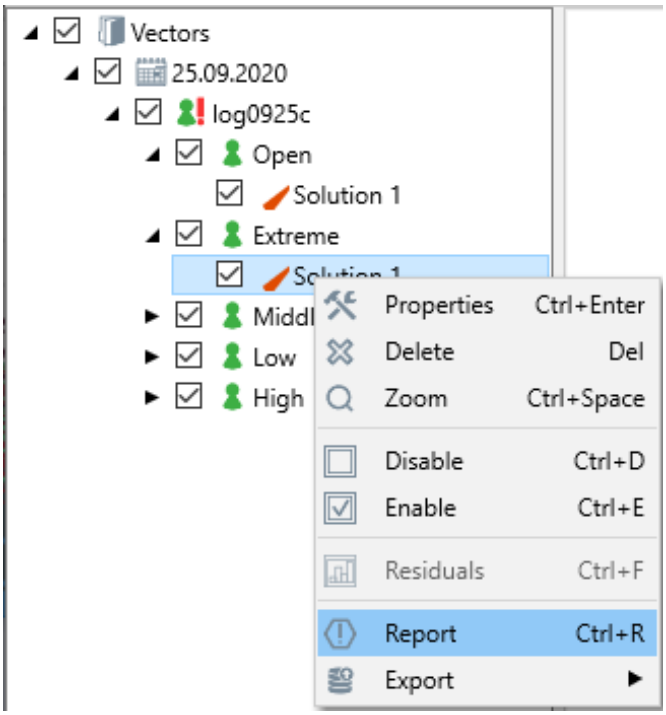


Figure 120 – Single solution repor

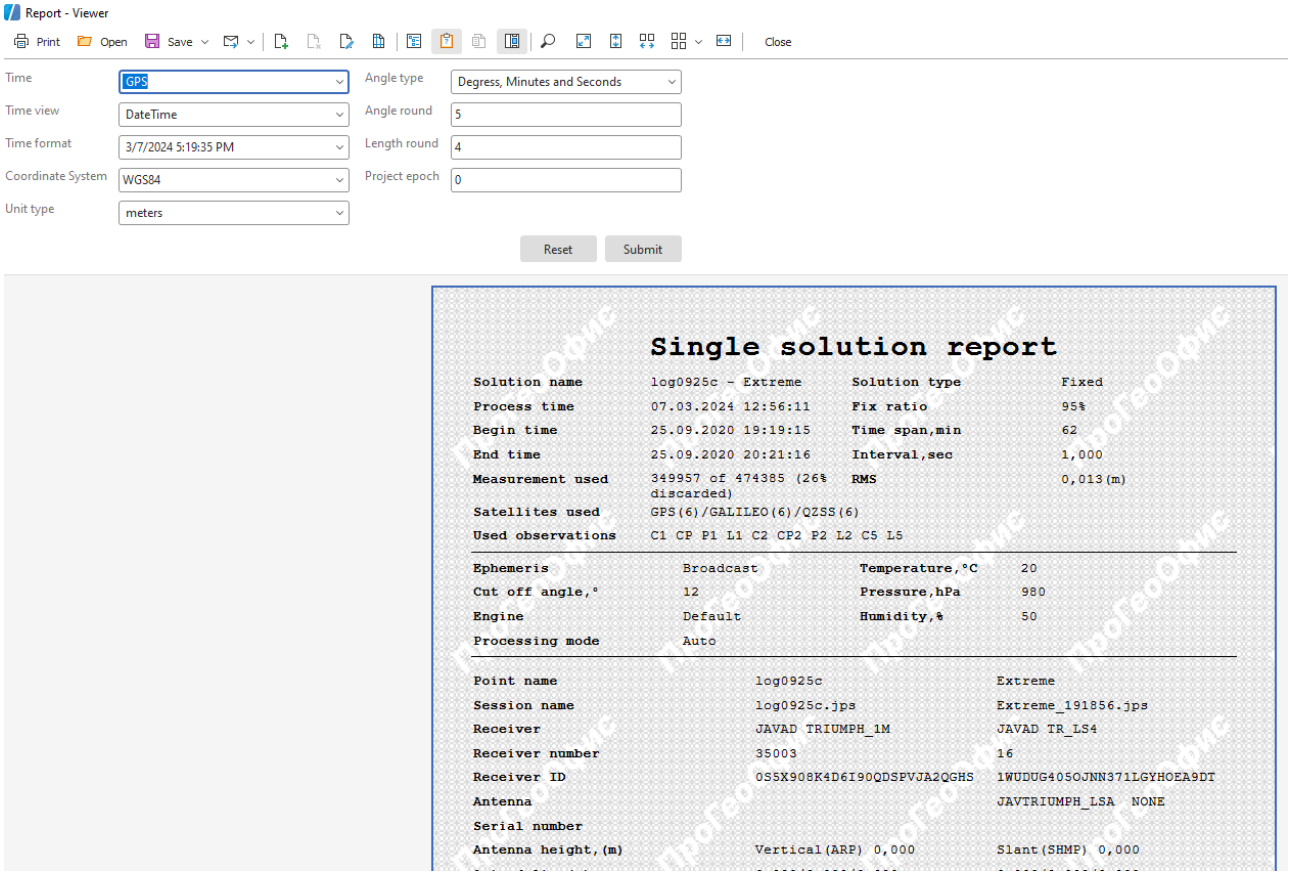


Figure 121 – Single solution report

CHAPTER 6. ADJUSTMENT

Geodetic network adjustment uses Weighted Least Squares method for solving over-determined linear system:

$$AX = L\ , \tag{6.1}$$

Depend on 3D/2D adjustment mode the design matrix A has 3*n or 2*n rows (n - number of solutions) and a structure comprising +1 and -1. X is a matrix of unknown node coordinates. The number of unknowns m equals the number of network nodes multiplied by 3 or 2 also. L is an array of Solution components dX, dY, dZ. In the case of adjustment in geocentric linear equations system is:

$$\begin{aligned} X_M - X_N &= dX; \\ Y_M - Y_N &= dY; \\ Z_M - Z_N &= dZ \end{aligned} \tag{6.2}$$

where $X,\ Y,\ Z$ are unknown coordinates of M and N network points.

The redundancy of the network adjustment problem is a number of rows minus the number of columns. Subject to a weight matrix W solution of [6.1] is given by solving:

$$A^T W A X = A^T W L \tag{6.3}$$

Weight matrix W is a block diagonal matrix formed using Solution covariance matrixes.
Network adjustment solves two main problems:

1. Get post-processing solution accuracy estimation, outlier and blunder detection.
2. Calculation of final point coordinates tied to reference points and statistics.

As much as coordinates are not a goal of the first problem it runs as inner constrained mode. To overpass the singularity of normal matrix we use singular value decomposition (SVD) method. The research of network adjusted in inner constraints mode is intended for detection and making odd from final adjustment results blunders and estimation of systematic errors impact. The detection of blunder is treated using Pope's τ -test.

$$u_i = \frac{v_i}{\sqrt{q_{ii}}}\ , \tag{6.4}$$

q_{ii} are diagonal elements of the cofactor matrix.

This method computes standardized residuals detect blunders in iterations and remove suspicious data from design matrix. The iterations continue until blunders have been disable and χ^2 test passed depend upon the significance level and the degree of freedom.

$$Q_{vv} = Q_u - AQ_{xx}A^T, \tag{6.5}$$

where Q_u is a block diagonal matrix of 3x3 dimension solution covariance matrixes, Q_{xx} is inverse of A^TWA matrix.

τ- test treats solution as a blunder if a residual exceed τ - value.

$\frac{\tau\alpha_0}{2}$, $n-m$ is determined in τ- distribution $\alpha_0 = 1-(1-\alpha)^{\frac{1}{n}}$.

α is user defined significance level (68%, 95%,99%).

Level 99% corresponds to the most soft restriction and 68% level is the most strong.

Note that τ -test uses standardized residuals for blunder detection instead of its absolute value so small residuals could be treated as blunders also.

Least Squares method deals optimal results in geodetic adjustment if GNSS data post-processing solution errors are normally distributed. χ^2-test checks if solutions errors are normally distributed. It compares so-called unit weight error μ and χ^2 statistics.

$$\chi_L^2 < \mu^2 = \frac{1}{n-k} \times V^T PV < \chi_H^2 \tag{6.6}$$

In fact χ^2- test estimates consistency of solution covariance matrix Q_u relative to a posteriori statistic.

In the case of geodetic adjustment failed χ^2- test it indicates that some observation sessions were too short. Due to time correlation of GNSS data solution accuracy is overrated. In the meantime loop closure are often big and μ is out of limits.

Inner constraints adjustment runs in relative coordinate systems. To show inner adjustment result in a cartographic window we snap relative coordinated network to first listed reference point (if it exists) or to first listed site. Second goal of adjustment are coordinates of measured ground points. To reach it the network must be snapped to ground reference points and final adjustment should be running under external constraints.

6.1 Net

To start adjustment switch to *Adjustment* tab in *Project* pane. As well as a subject of adjustment are *Solutions* than complete *Process* procedure in advance. The objective are *Sites*. First step of adjustment (Inner constraints) evaluates Loops closure. We use *Edge* category to show loops. In fact *Edge* appears as a result of *Solutions* adjustment. Remember that *Solution* is a result of *Vector* post-processing. There is a special layer to represent *Edges* in a map pane. Loops closure deals simple additional estimation of post-processing data accuracy. It is the sum of solutions components along with a *Loop*. Loops detection is running during network adjustment procedure.

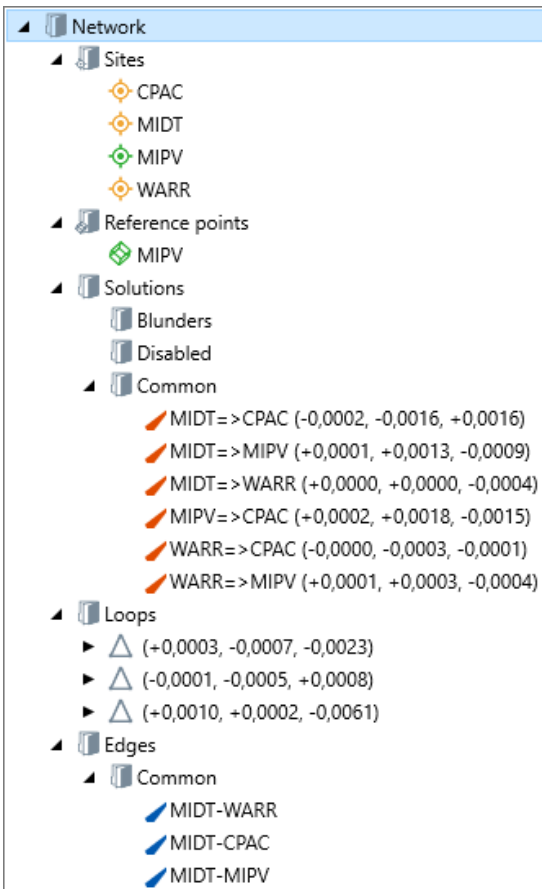


Figure 122 – Net tab

Upper items in *Adjustment* tab:

Net	main adjustment item
Sites	list of adjustment objects
Reference points	list of control ground points with postulated coordinates, external constraints
Solutions	subjects of adjustment • *Blunders* - not passing tau-test *Solutions* • *Disabled* - solutions excluded in interactive mode • *Common* - solutions passed all test and affected to final result
Loops	a closed circuit for which the non-closure values are calculated
Edges	result of equalization of *Solutions* • *Common* - in a closed loop with a passed τ-test • *Single ended* - - having only one common point with the network • *Bridges* - connecting groups of closed loops • *Blunders* - failed τ-test
Kinematic	kinematic solutions
Precise Point Positioning	site precise positions

Introduce a terminology of other items:

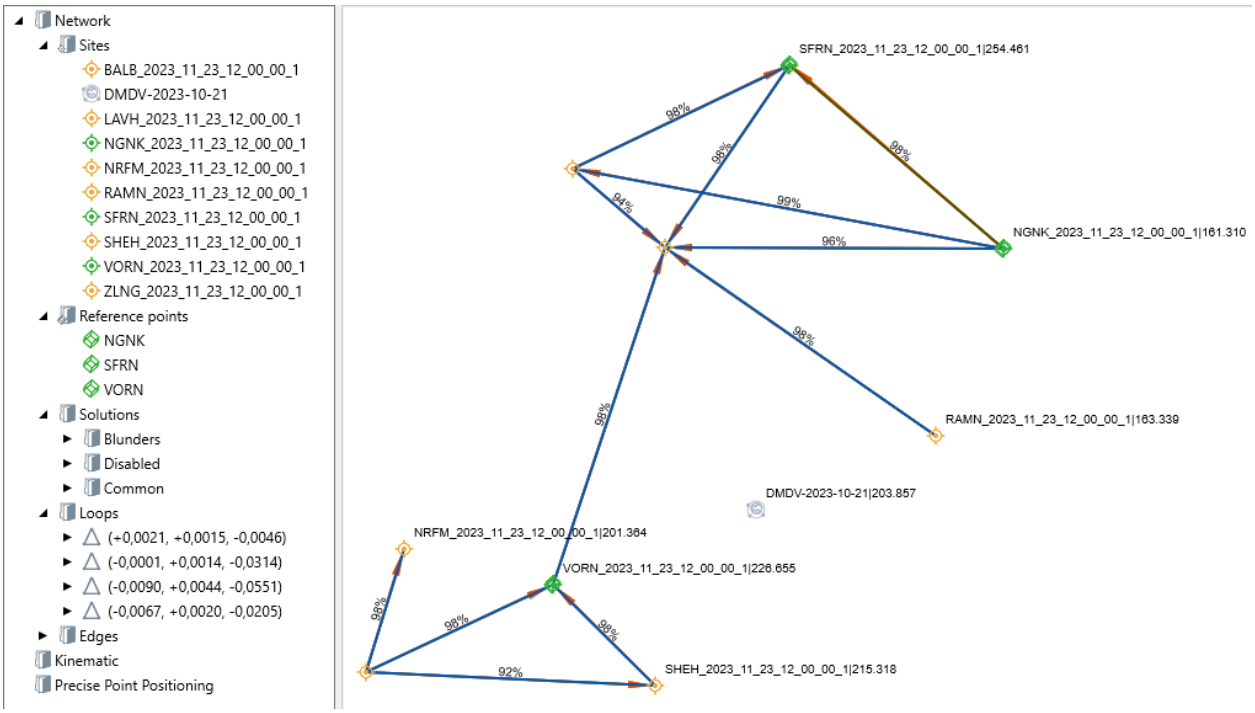


Figure 123 – Adjusted network

Sites	point objects shown on the map with cartographic sign relative to *Legend*. Initially, sites are generated for raw data recordsets upon standalone solution. Cartographic sign of *Site* reflects its origin - receiver calculated, standalone, post-processed, adjusted. The snapped sites are colored by green. For example, site DMDV is on a standalone position, NFRM is on post-processing solution, VORN snapped to reference.
Edge	linear object created through adjustment. Edge connects two adjusted sites and forms a network structure. The edges are shown on a special map layer. There is *Edge* table in adjustment report. It is used for residuals and relative error publishing. Edge types:
Single-ended	edge that shares with a network one site only
Bridge	edge that connects loops. It does not form itself any loop
Blunder	edge that has not passed τ-test. By default blunders are colored brown
Common	others edges
Loops	a list of independent loops generated under restriction of minimum edges quantity in a loop

Loop closure residuals are indicated depending on adjustment mode (XYZ/NEU).
To get access to *Net* items point on it and right-click mouse button:

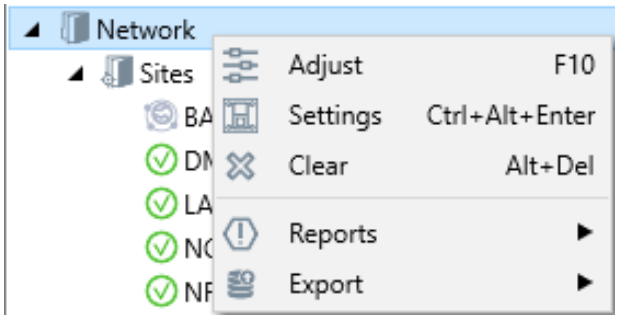


Figure 124 – Right-click menu items

Adjust	run network adjustment. Last adjustment will be dropped automatically
Settings	involves a dialog window showed on Figure 125. Adjustment settings
Clear	drops the last adjustment
Report	generates standard report
Exports	output files in most popular format

6.2 Adjustment settings

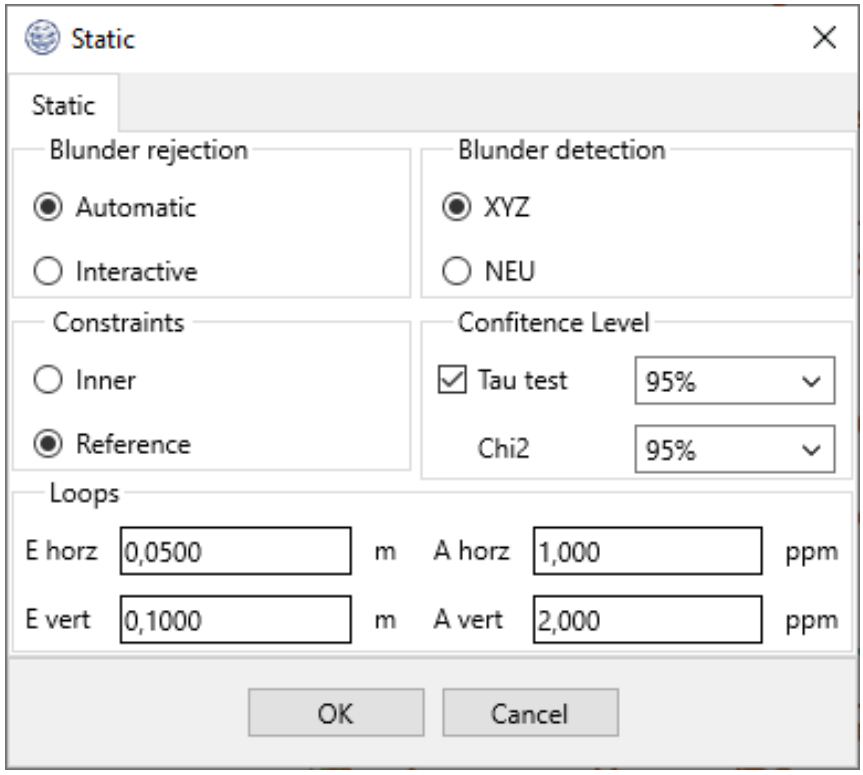


Figure 125 – Adjustment settings

Blunder rejection

Blunder rejection	scenario of blunders processing • *Automatic rejection* - adjustment is running in iteration. Blunders are excluded step by step until they are canceled • *Interactive* - adjustment with a dialog. This allows to cancel a solution at each iteration step instead of batch blunder processing in above mentioned automatic mode.

Blunder detection

Blunder detection	blunders qualification in inner constraints adjustment: • *XYZ* - residuals are calculated in a geocentric coordinate system • *NEU* - residuals are calculated in the topocentric coordinate system (Northing, Easting, Up). There is additional specification 2D/3D to separate plane and vertical sources of errors. If an edge was marked as a blunder in NEU 3D-mode then it makes sense to readjust network as 2D to exclude error in vertical components which happens due to wrong antenna height or type input.

Confidence level

Post-processed solutions that based on GNSS data obtained in a short session of observation may have low absolute accuracy and a good statistics - small standard deviation errors (sigmas - square route of diagonal elements of cofactor matrix). Thus its impact in adjustment is overvalued due to big values of weight matrixes. In the meantime, edge residuals mustn't exceed sigma more than in 2-5 times in the case of the normal distribution of errors. Otherwise, the Solution should be detected as a blunder. The settings of confidence level limit allow to control blunder detection procedure.
From the other hand value of unit weight error must correspond to Solution accuracies. Regular μ value varies from 0.4 to 1.6. Formula [5.6] computes more accurate these limits using number degrees of freedom and confidence level value. 99% level is the widest limit.
Blunder detection procedure affects to χ^2-test. Control of confidence levels for both tests allows to passχ^2- test well.

Constraints

Inner	adjustment of free network with no constraints. Residuals depend on network geometry and solution quality. It is a significant preliminary network adjustment which is running automatically for constrained network also. We recommend run it in advance separately as it is a best way for post-processing cancellation of outliers. Inner constraints adjustment computes site positions in a relative coordinate system. Meantime results might be similar to those of a case of fixed constraints adjustment with one reference point.

Fixed	adjustment which could be completed if a network Sites were snapped minimum to one reference point. Otherwise, a warning appears. Snapped Sites position left steady. Reference points accuracy statistic does not affect to residuals and computation but used for accuracy estimation.

Loops

Constant *E* (in meters) and linear parameter A (in ppm) define an acceptable limit for loop closure. An equation is:

$$\Delta L = E \times \sqrt{N} + A \times L \ , \tag{6.7}$$

where *N* - edges quantity in a loop, *L* - length of loop.

Loops with overpassed closure of are colored in red in the left project pane.

Interactive

This dialog window appears if interactive adjustment mode was selected:

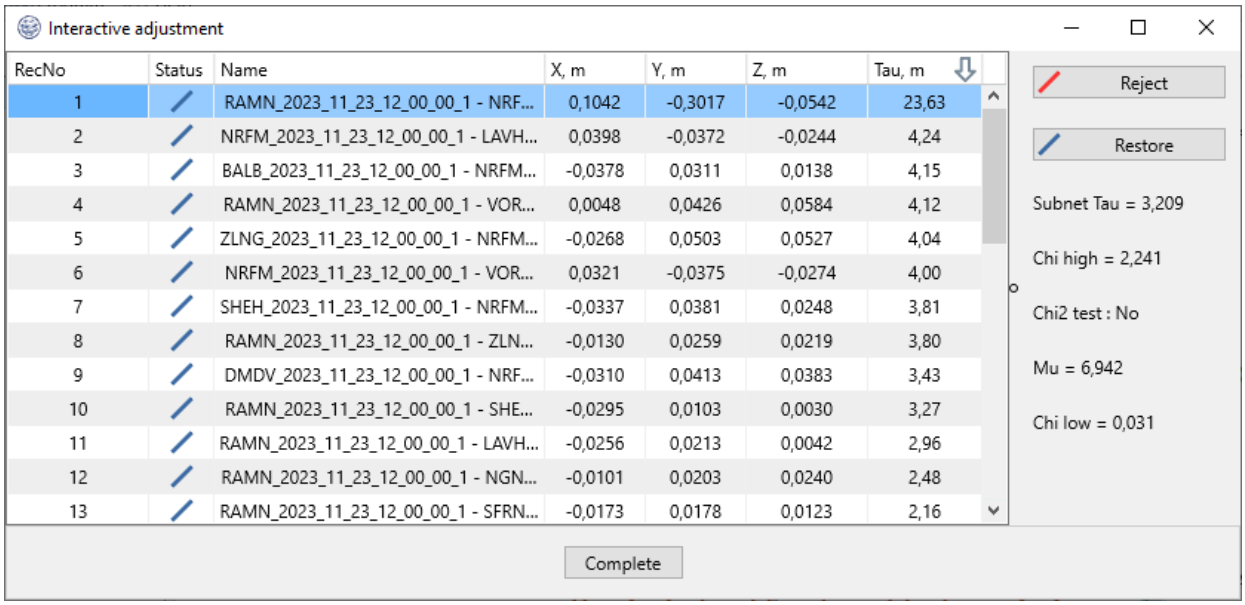


Figure 126 – Adjust interactive

There are a list network edges residuals and τ-statistics in a table. X, Y, Z are components of edge residuals. *Tau* column includes maximum components of standardized residuals along X, Y, Z / NEU axes. Right from the table shown common net statistics: common τ value, unit weight error (UWE), low and high limits of χ^2-test for UWE.

To exclude an edge from adjustment, select a row in a table and click *Reject*. Press and hold *Ctrl* or *Shift* button to exclude more edges at once. By clicking *Reject*, the *Restore* button reruns the adjustment. The dialog window *Adjust* interactive appears once more. The *Complete* button is intended to cancel iterations.

The main goal of interactive mode is a χ^2-test achievement. To reach it we recommend to consequentially reject edges with maximum value in a Tau column. It is not possible to reject *Bridge* edge as it will split net in two subnets! In this case a warning appears. A network could be adjusted

in subnets by disabling edge solution in advance before start an adjustment. Rejected edge is kept in a table but corresponding row shown in gray. For restoring it select row and click *Restore*.

6.3 Kinematic solution adjustment

Multiple bases kinematic data processing generates new trajectory object in the Kinematic node with options.

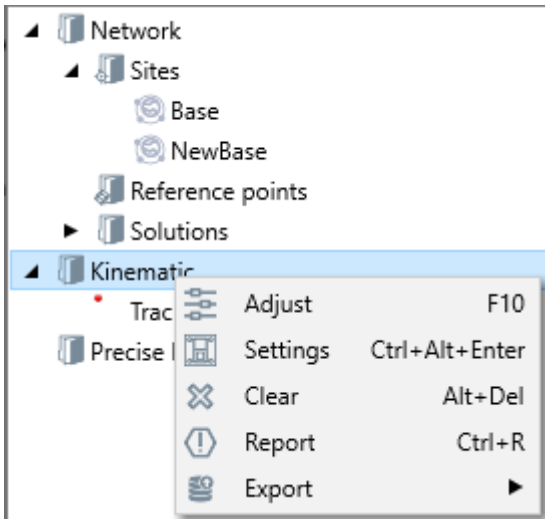


Figure 127 – Kinematic node

Adjust	running kinematic solutions adjustment

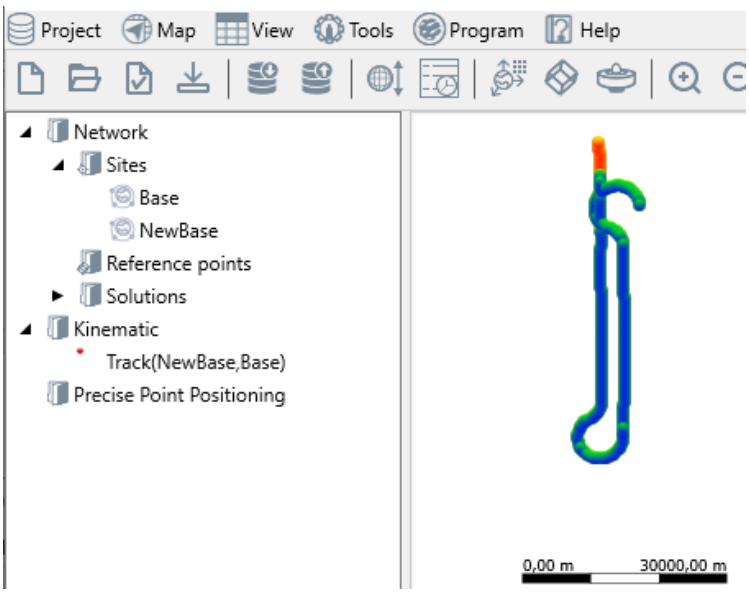


Figure 128 – Adjusted kinematic

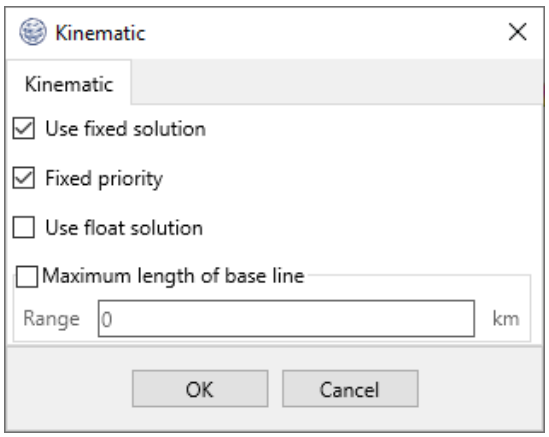


Figure 129 – Adjustment settings

Settings	adjustment settings • *Use fixed solution* - only fixed solutions are taken in account • *Fixed priority* - ignore float solution if fixed one exists • *Use float solution* - both float and fixed solutions will be adjusted using epoch solution covariance matrixes • *Maximum length of base line* range parameter sets maximum acceptable in adjustment distance between base and rover epoch positions ю эпоху
Clear	remove the last adjustment from the project
Report	report generation:
Export	export to exchange formats

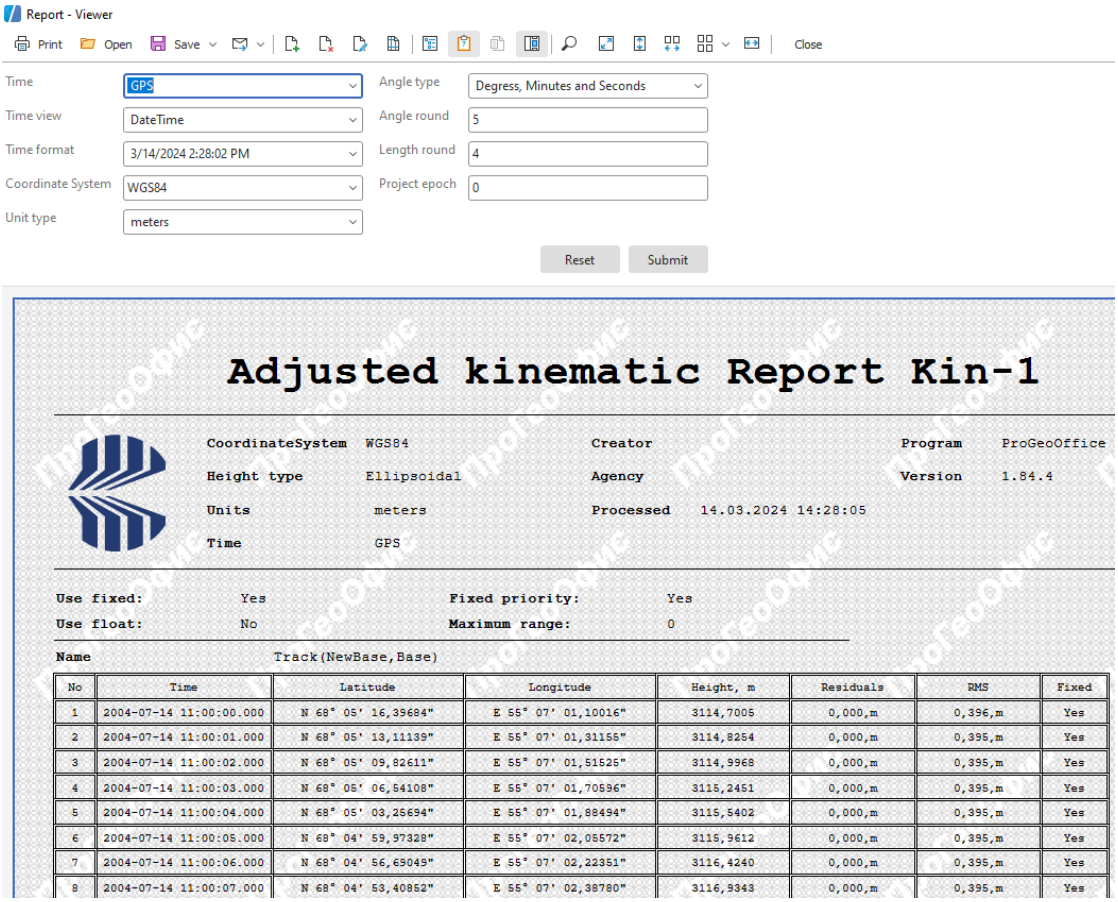


Figure 130 – Adjusted kinematic report

The adjustment of kinematic solutions is performed both for trajectories that have several solutions from different base points, and for trajectories that have one solution. In the latter case, the adjusted coordinates will coincide with the coordinates obtained from processing.

CHAPTER 7. PROJECT SETTINGS

Use the main program menu to get access to the *Settings* option:

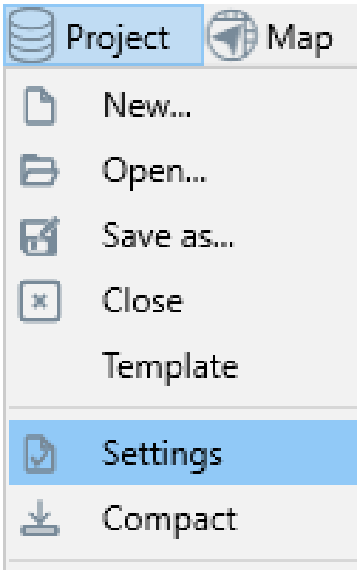


Figure 131 – Project menu item

Open the *Project Properties* window, select *Project*, then *Settings* in the main menu. The left side of the *Project Properties* window contains information about the location of the project file and the date it was created:

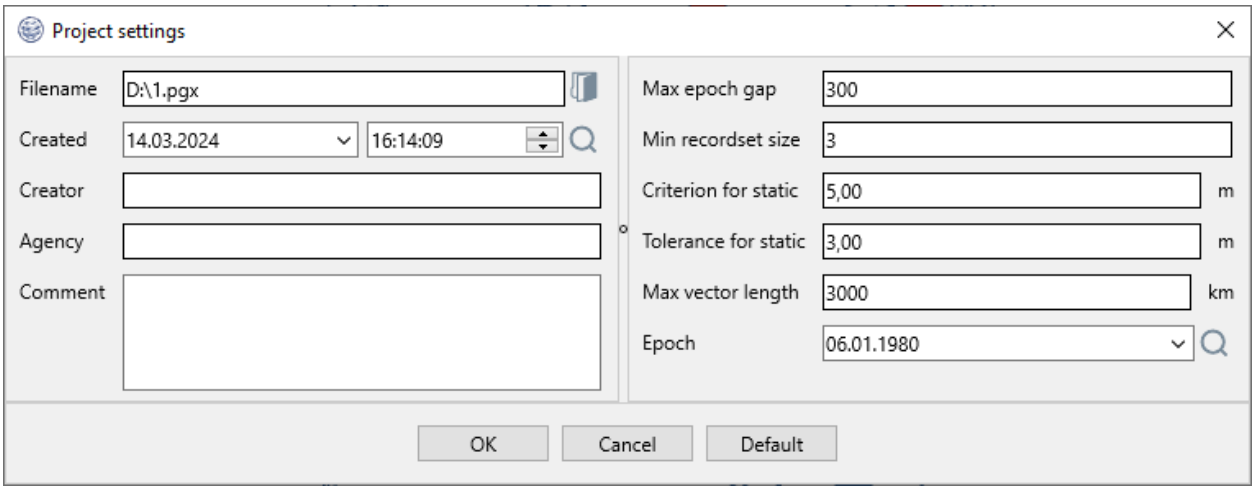


Figure 132 – Project settings

When creating a project, the *Creator* and *Agency* fields are filled automatically following the example of the previous project.

On the right of the window, you can set the following parameters:

Max epoch gap	the maximum number of skipped epochs between any two adjacent epochs in the sample

Min sample size	minimum number of epochs to process the sample
The criterion for static	is the coefficient multiplied by the standard error of the epoch for the sample. If the coordinates calculated for all epochs are inside a circle with a radius equal to the criterion, the sample is determined by the program as static. Otherwise, the sample is defined as kinematic
Tolerance for static	The maximum distance at which the record sets refer to the same point
Max vector length	maximum length of processed vectors
Epoch	the date of the project
The Default button	restores the default window settings

CHAPTER 8. COORDINATE SYSTEMS MANAGER

The tool is available through main menu *Program* item:

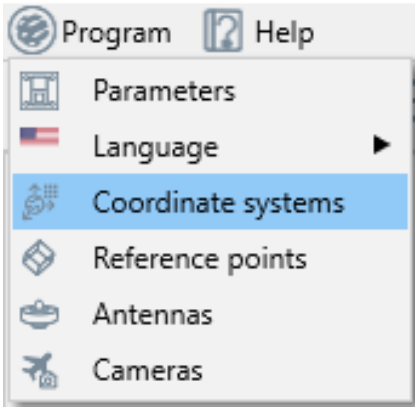


Figure 133 – Coordinate systems item

or by clicking  button on a toolbar:

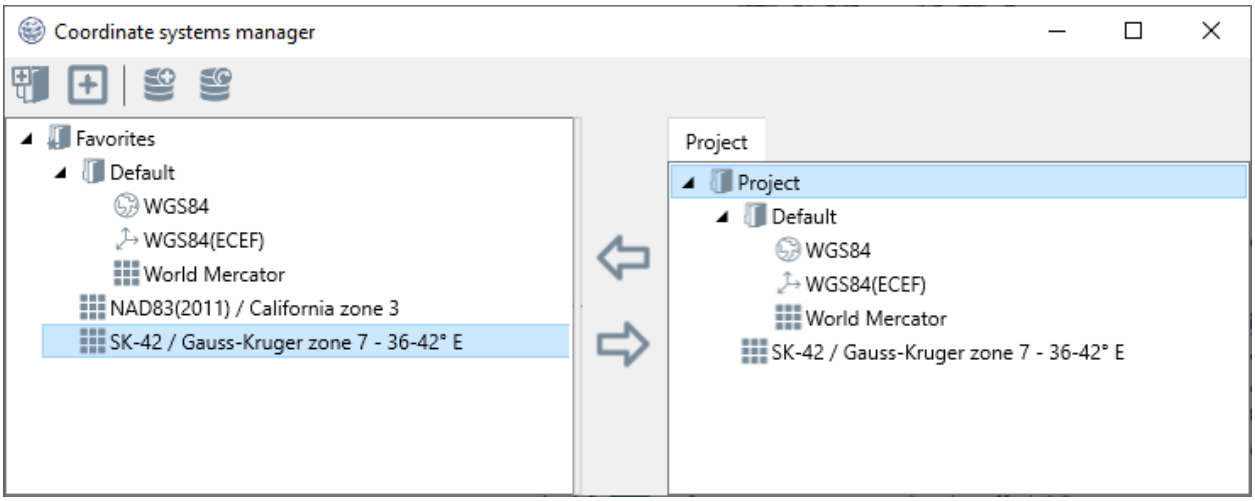


Figure 134 – Coordinate system manager

Default coordinate systems are:

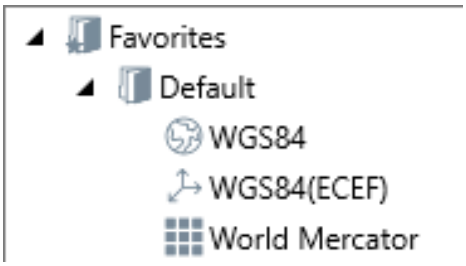


Figure 135 – Default coordinate systems

Click  button to add a subfolder Favorites root item:

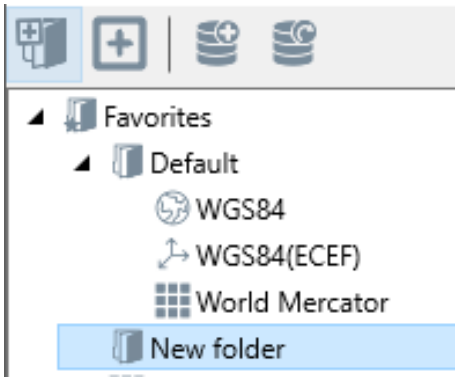


Figure 136 – Adding the new subfolder

To edit subfolder's name double click on it.

Click  button to customize a list of preferable coordinate systems:

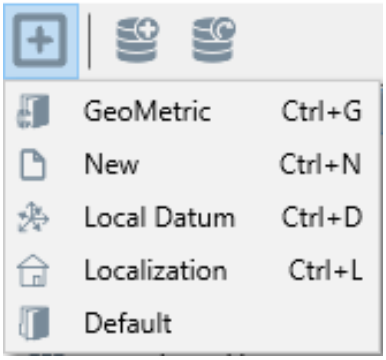


Figure 137 – Coordinate system creation way

and choose way to add a new coordinate system:

GeoMetric	copy the coordinate system from the *GeoMetric* database
New	create a new coordinate system
Local datum	create a coordinate system by datum calculation
Localization	create a coordinate system by localization
Default	create a standard coordinate systems folder

8.1 GeoMetric database

Select GeoMetric for searching coordinate system in *GeoMetric* database,

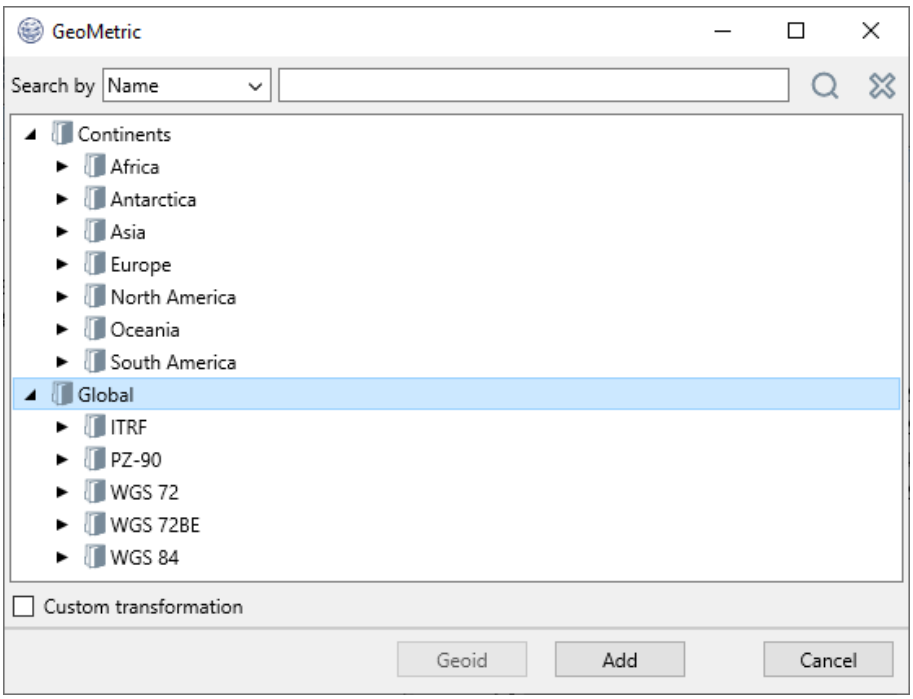


Figure 138 – Node selection

select *Continents* to select coordinate systems by continent name or *Global* to open a list of global coordinate systems, select the country and the required coordinate system:

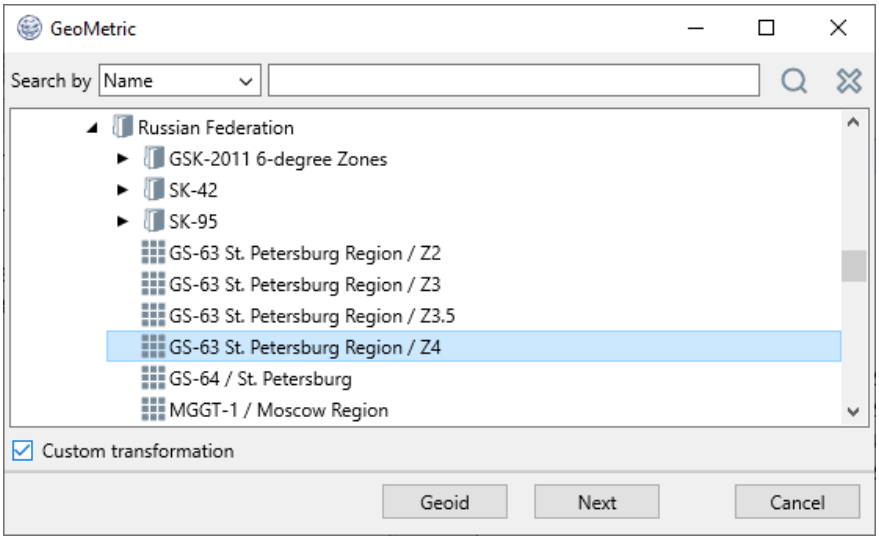


Figure 139 – Coordinate system selection

If there are several transformations for a coordinate system, you should select the *Custom transformation* checkbox, then click the *Next* button, and select transformation in the valid transformations list for selected coordinate system:

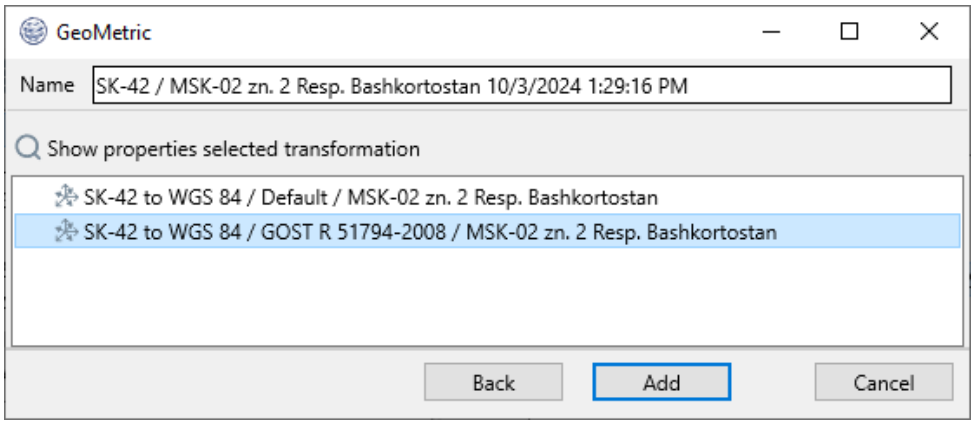
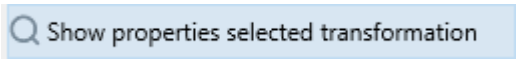


Figure 140 – Transformation selection

Select a transformation and click 

to view transformation parameters:

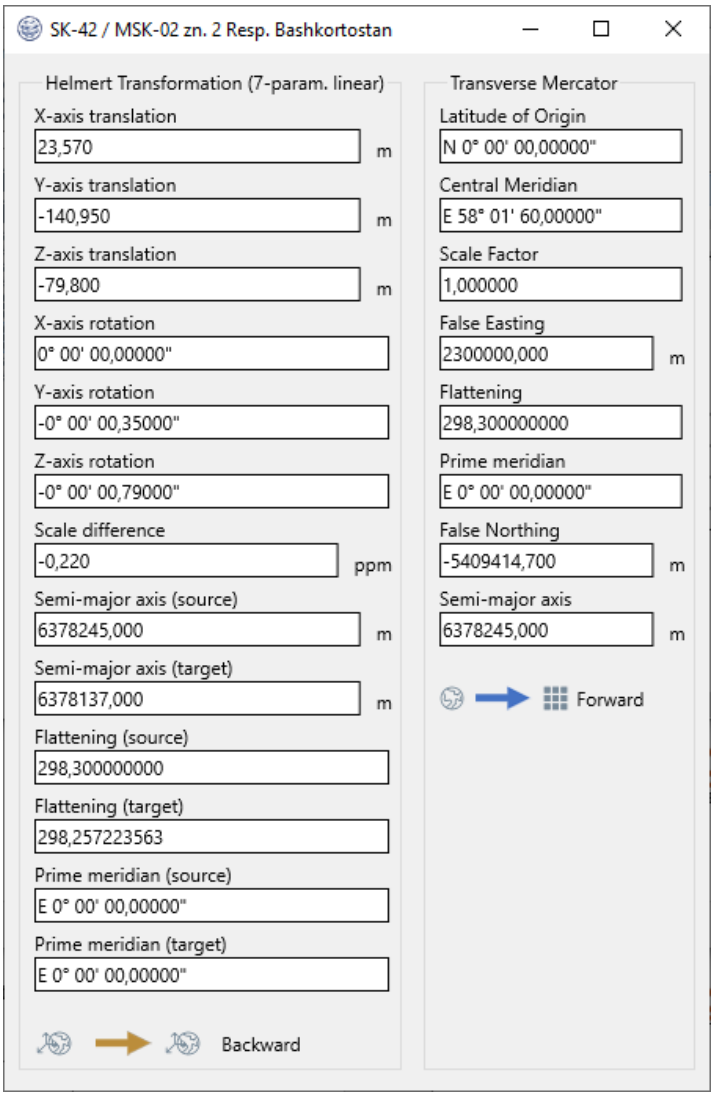


Figure 141 – Transformation parameters

then click the *Add* button to add a coordinate system to the list or the *Back* button. To select a geoid model click the *Geoid* button and select the required geoid model:

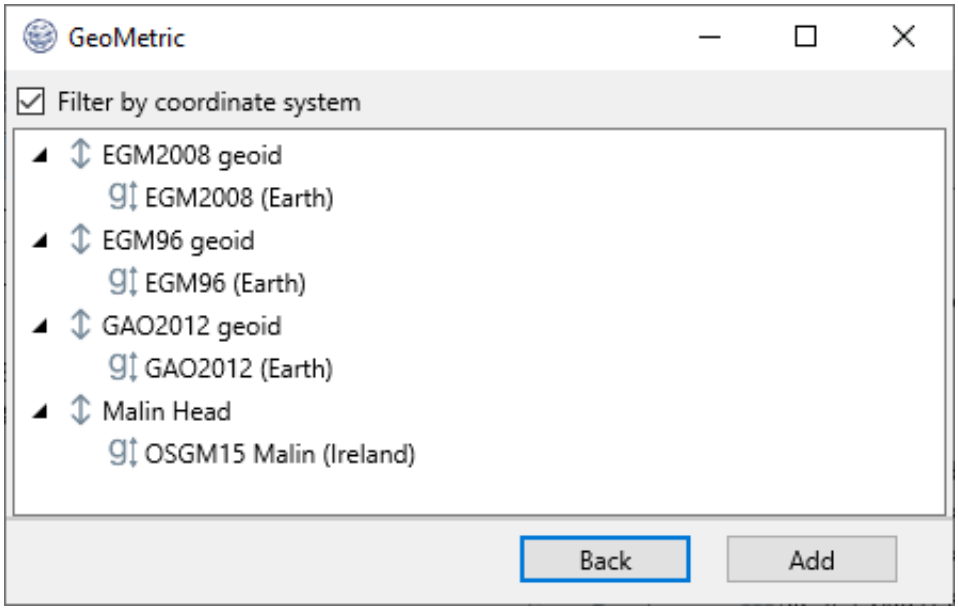


Figure 142 – Geoid model selection

then click the *Add* button to add a coordinate system to the list or the *Next* button to return to the transformation selection window (if the *Custom transformation* switch was selected), then click the *Add* button. The selected coordinate system will be added to the selected folder of the *Favorites* node.

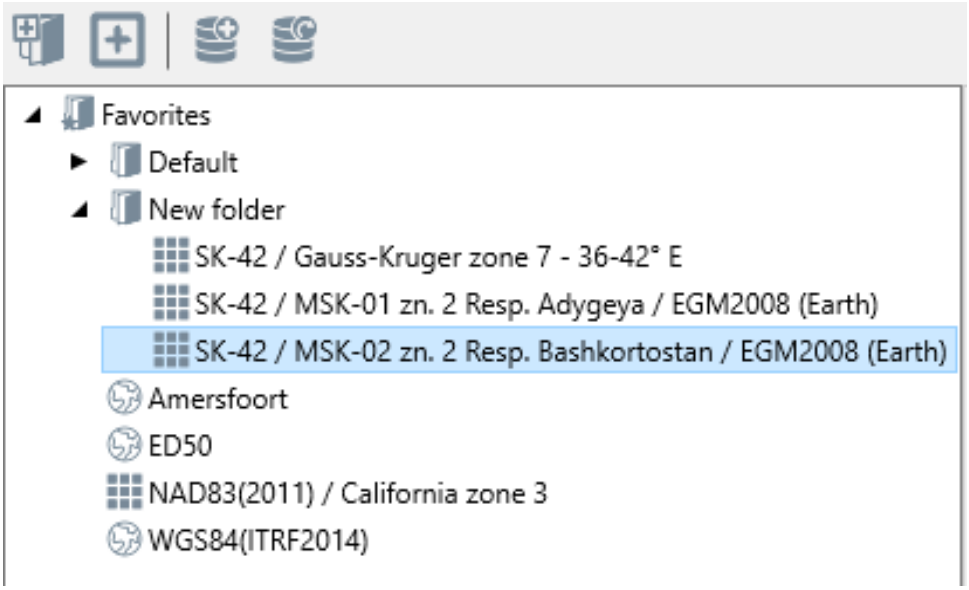


Figure 143 – Created coordinate system

8.2 New coordinate system

Click  button on the toolbar to create a new coordinate system or select the folder where the new coordinate system will be created, right-click, and in the menus that open sequentially, select Add coordinate system and New buttons:

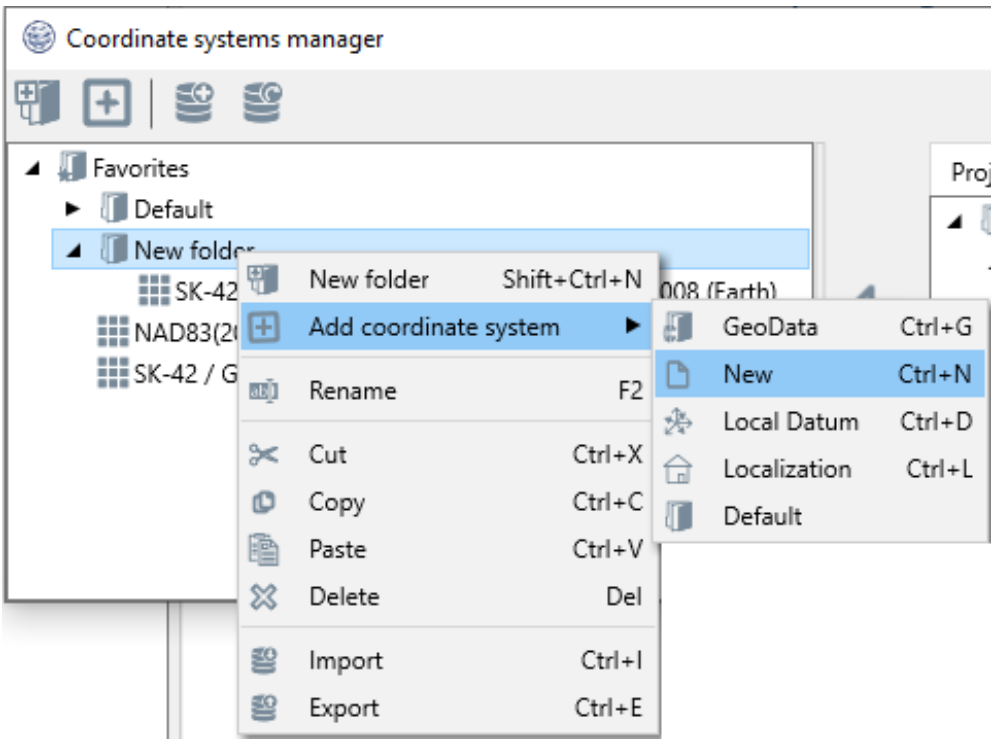


Figure 144 – Creation a coordinate system in a folder

to create a new coordinate system select a new coordinate system type geocentric, ellipsoidal or grid:

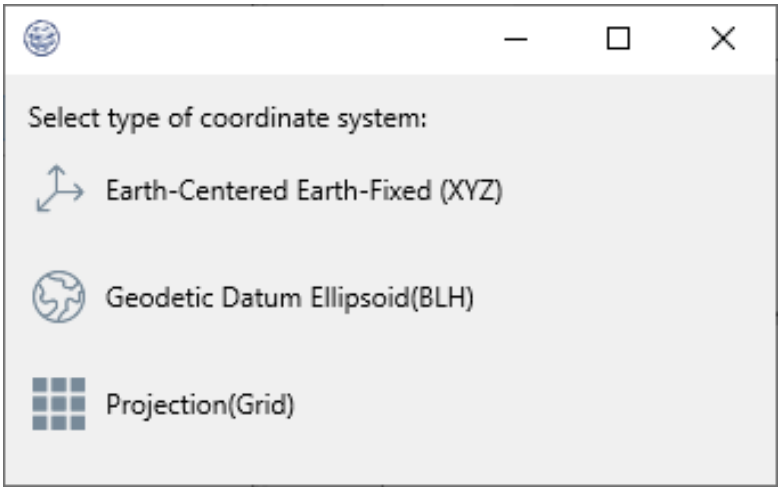


Figure 145 – Coordinate system type

Consider the creation of a grid coordinate system, since this case includes all others.

To do this, select the option 

then select a datum from the list or create a new one, if necessary:

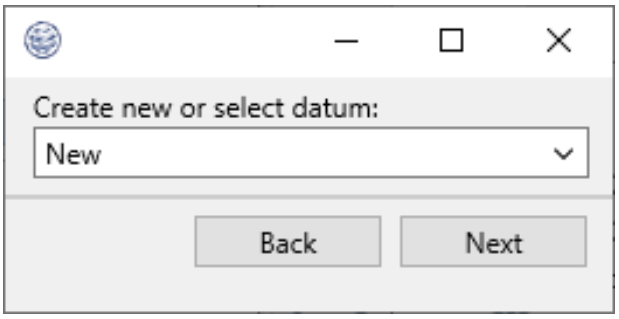


Figure 146 – Datum Selection/Creation

Datum parameters correspond to the transformation from ITRF2008(WGS84), which is the main coordinate system in *PGO*.

8.3 New datum

To create a new datum select ellipsoid in the drop-down menu or type the ellipsoid parameters manually:

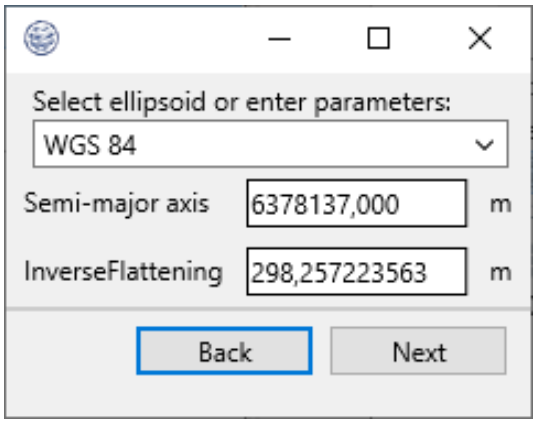


Figure 147 – Datum Selection/Creation

then type 7 Helmert transformation parameters:

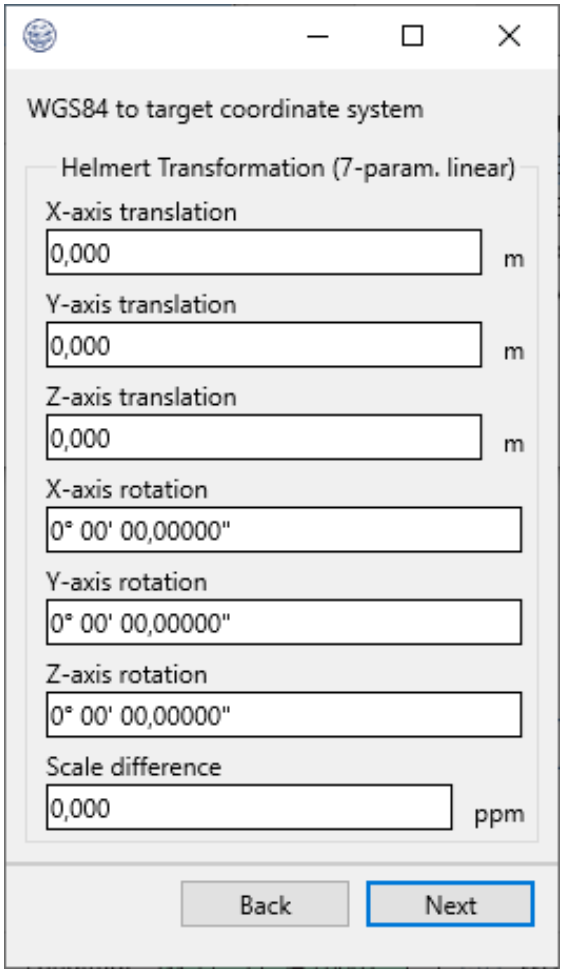


Figure 148 – 7 Helmert parameters

Then select the required geoid model or skip this step:

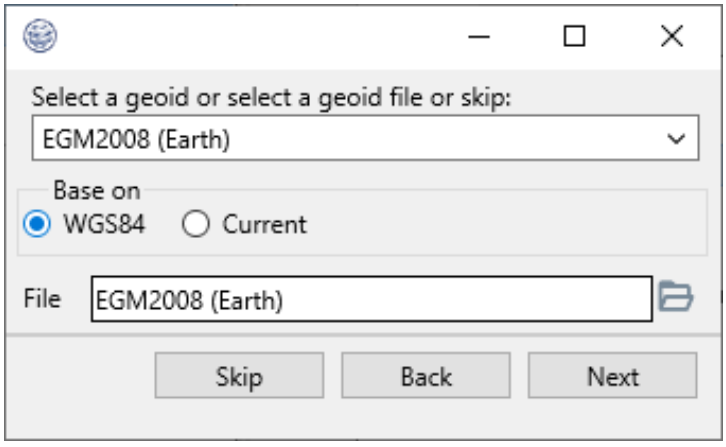


Figure 149 – Geoid model selection

Select projection type in the drop-down list:

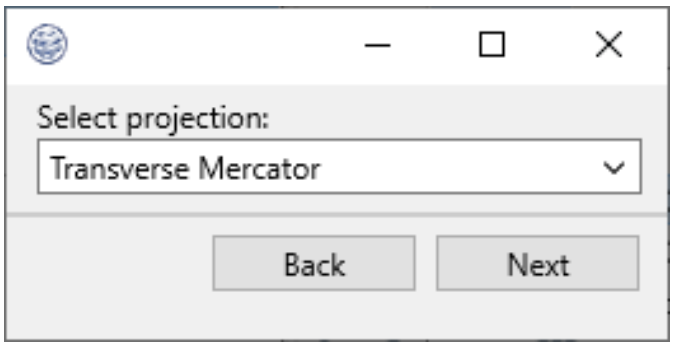


Figure 150 – Projection type selection

And type projection parameters:

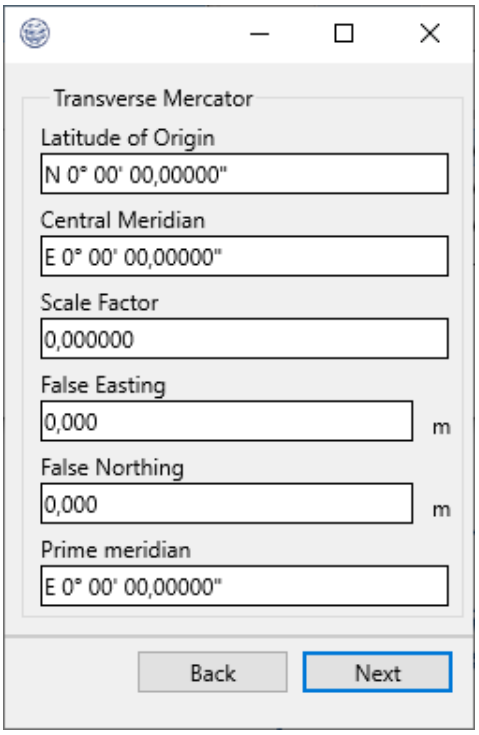


Figure 151 – Projection parameters

then type the name of the coordinate system to be created.

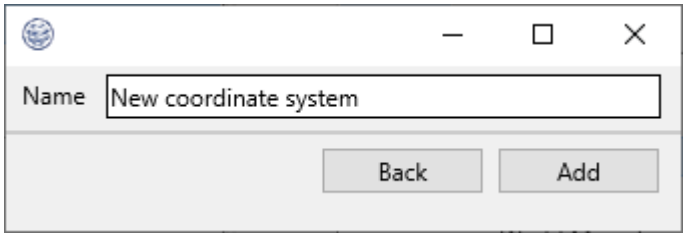


Figure 152 – New coordinate system name

and click *Add*. The coordinate system will be created and its name will be added to the *Favorites* node in the corresponding folder:

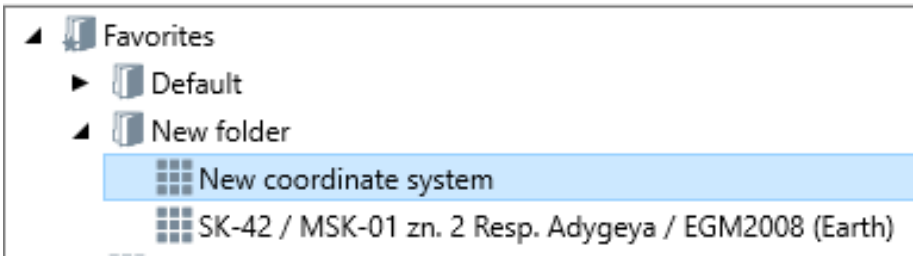


Figure 153 – Created coordinate system

8.4 Select existing datum

To select an existing datum copy it to the Favorites node as follows:

Click  , select 

, type datum name and click Enter:

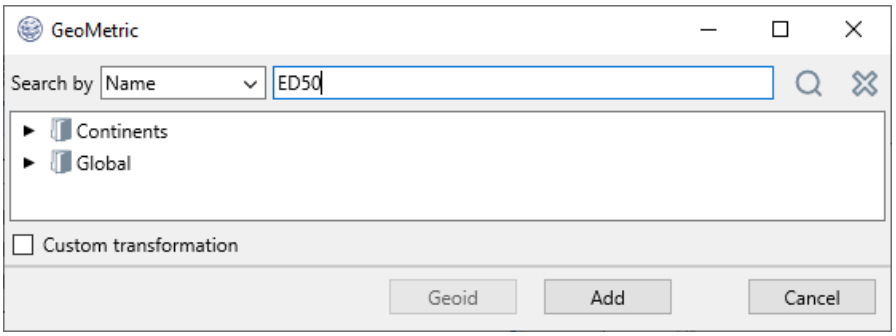


Figure 154 – Datum name

The window that opens will display a list of coordinate systems that reference this datum:

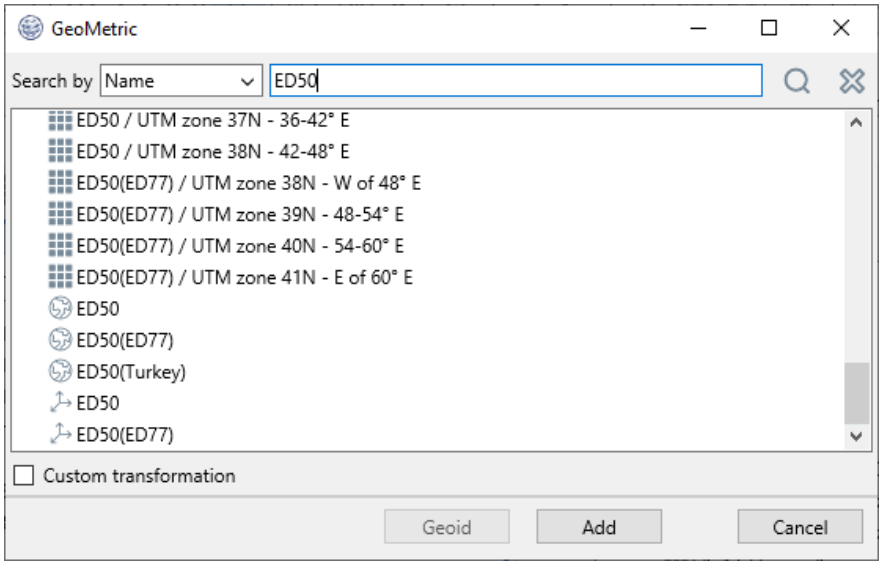


Figure 155 – Datum selection

In this window select a coordinate system with the appropriate name, which is a datum (it is indicated by the icon) and click *Add*. The datum will be added to the *Favorites* node.

The added datum will be available when creating a new coordinate system when using the datum selection mode from the list:

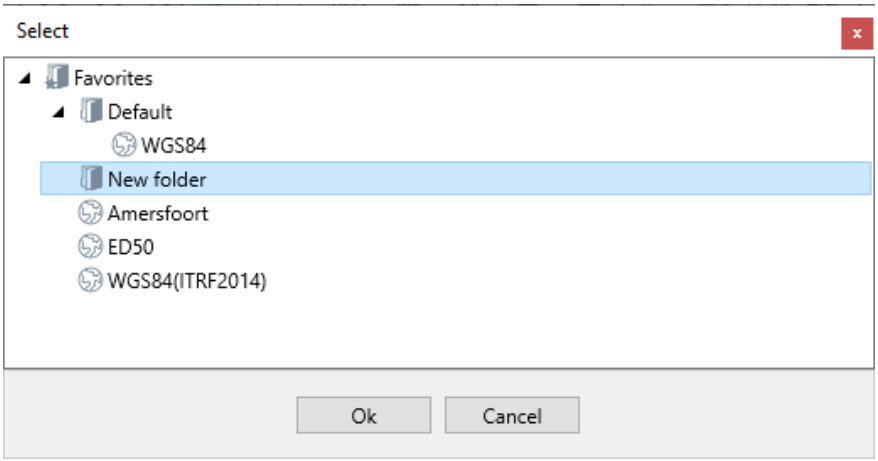


Figure 156 – Datum selection

Select the required datum from the list and click *OK*.

8.5 Coordinate system options

To access coordinate system options select the coordinate system and click the right mouse button:

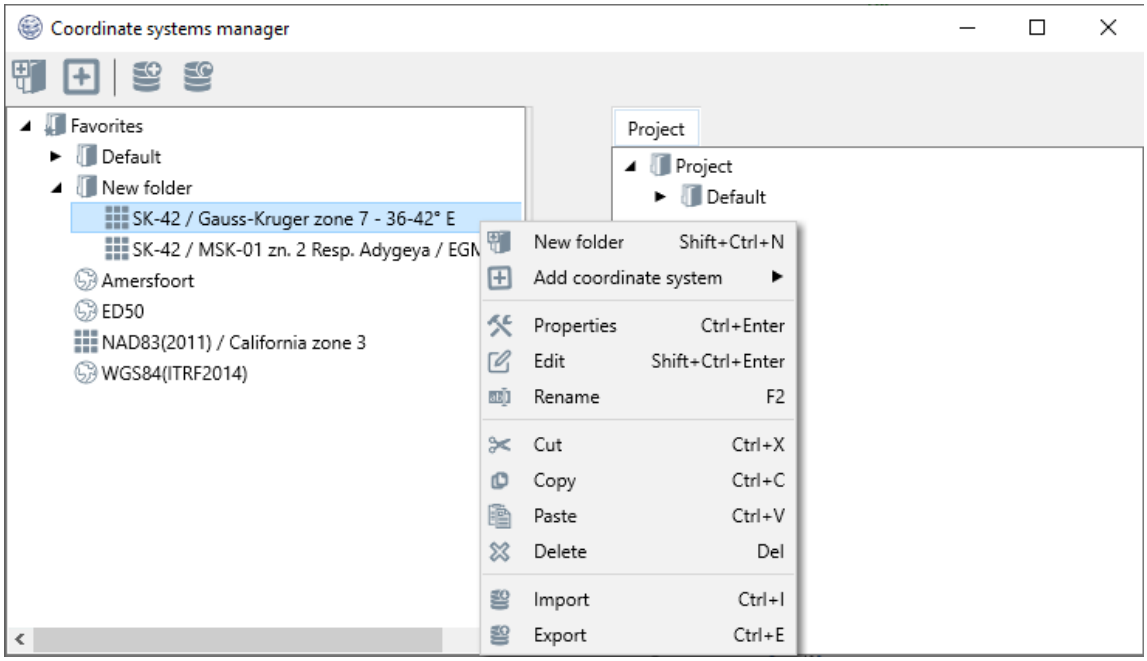


Figure 157 – Coordinate system options

Properties

To get full information about the coordinate system click *Properties*:

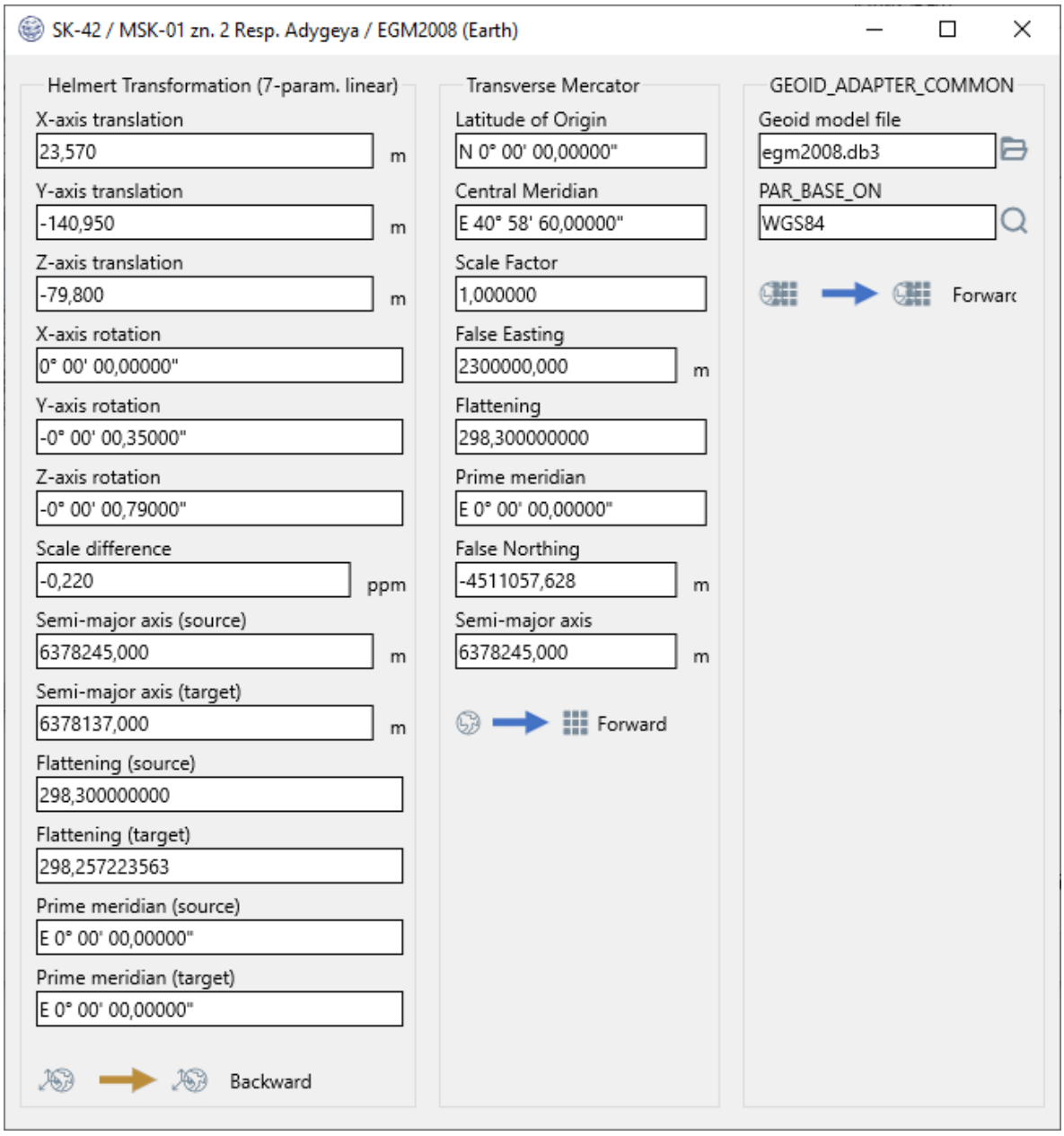


Figure 158 – Coordinate system properties

Edit

Click this option for editing. In fact, every complete coordinate transformation from WGS84(ITRF2008) to target coordinate system is chain of consecutive transformations. It causes following form to edit transformation:

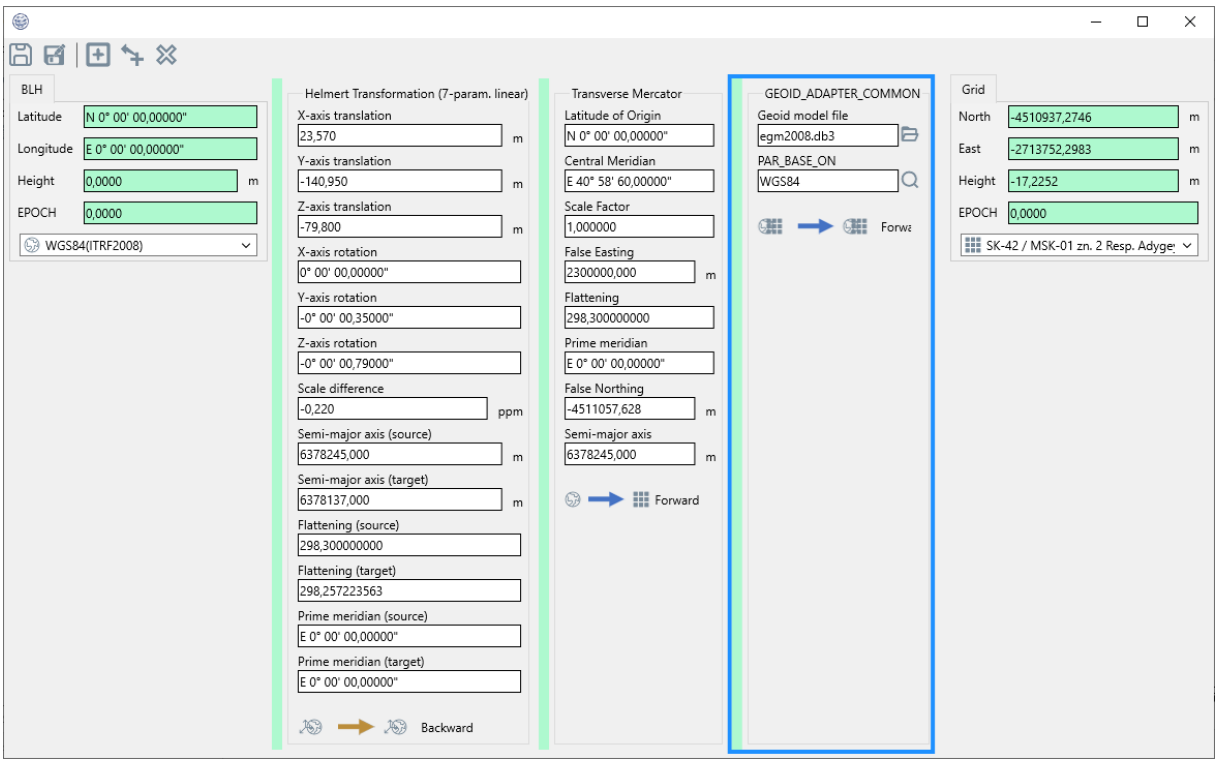


Figure 159 – Edit window

Status bar:

	save transformation
	save transformation under new name
	add transformation
	insert transformation
	delete transformation

Far left panel designed for input/output coordinates in WGS84(ITRF2008). Far right panel designed for input/ output coordinates in target coordinates system. Each panel in middle represents consecutive transformation. These middle panels are highlighted by green or red colors depending on correct/wrong link between output data previous transformation and input data current transformation.

Validation between transformations is detected by coincidence types of in/out data. Check type using icons on the bottom bar:

- ECEF - geodetic - grid

Combined icon means variant types of coordinates.

Transformation types could be forward and backward and indicated by color of icon and signature. Selected transformation is highlighted by blue frame.

Next transformations can be added or inserted:

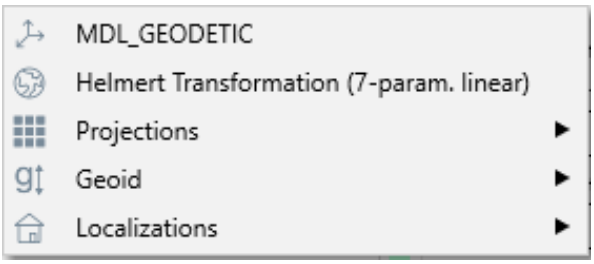


Figure 160 – Transformation types

Allowed projection list, geoid model types and localization types:

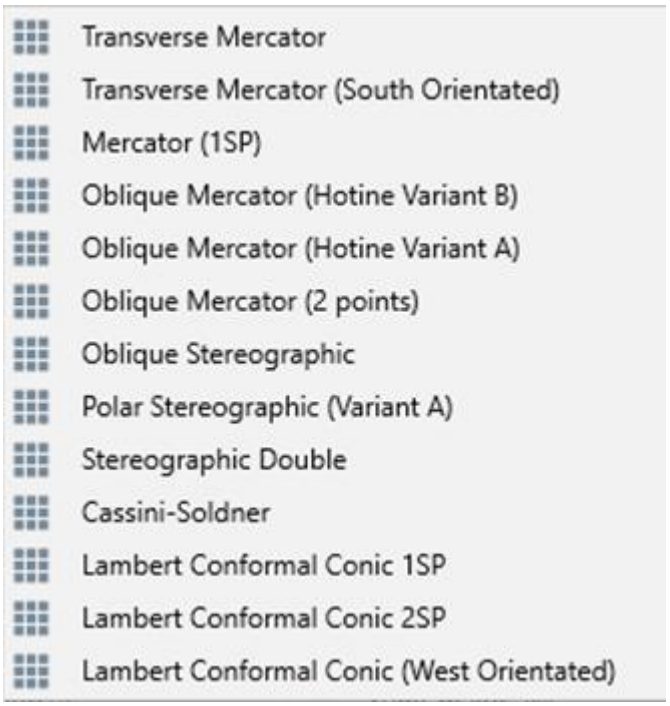


Figure 161 – Projection list

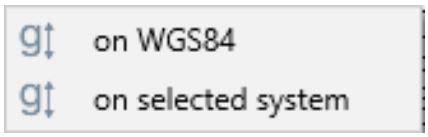


Figure 162 – Geoid model types

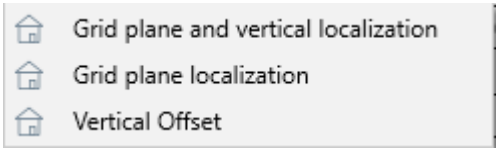


Figure 163 – Localization types

After selecting the option *on the selected system* select the panel that will be used to determine the geoid height and then click the *Accept* button. A panel will be added in the *Editing Coordinate System* window, in which select a geoid file by clicking . Icon serves to obtain information about the reference coordinate system for the selected geoid file. The new geoid file will be copied to the geoid folder of the PGO program. When a conversion is valid, the panel frame is colored green. Only coordinate systems with valid transformations can be saved. Should be pressed to save transformation or to save transformation under a new name. The transformation name must be unique. When saving an existing coordinate system under a new name, enter it in the Name line:

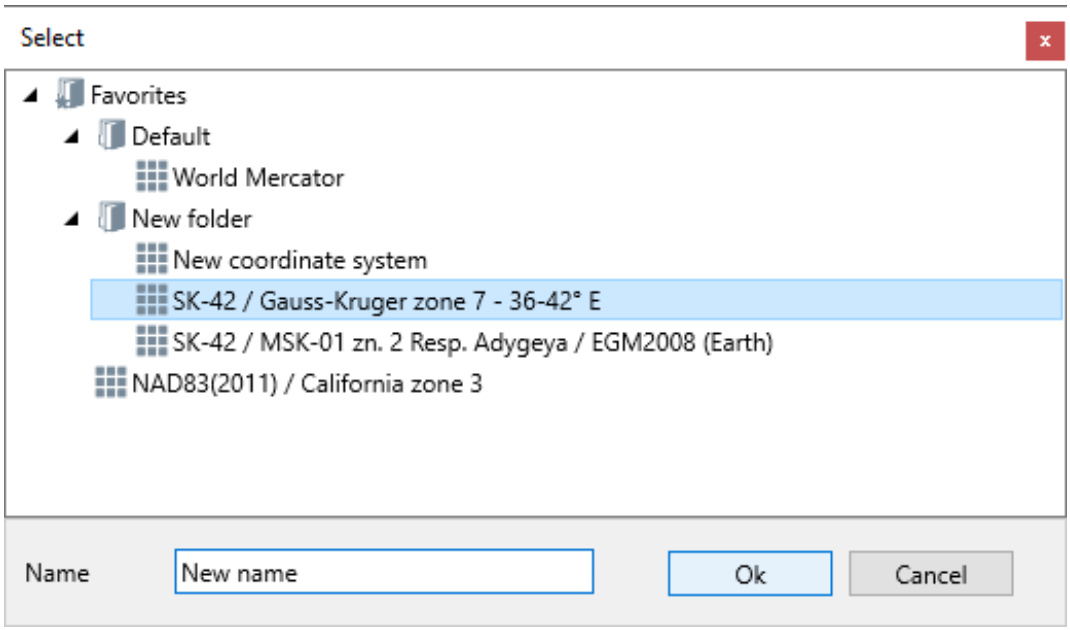


Figure 164 – New name

Rename

Click an option Rename for input and edit the name:

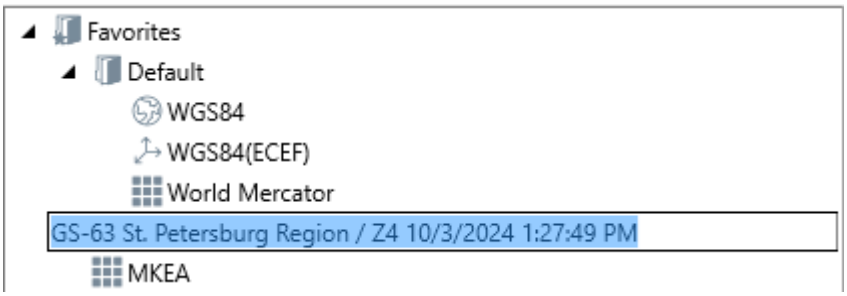


Figure 165 – Rename

Cut	an option for cut and paste
Copy	an option for pasting from buffer
Paste	deletes the item after confirmation

Delete	deletes an object after confirmation
Import	opens standard Save window. Exchange format is *PCS*
Export	opens standard window for export selected coordinate system as PCS file

8.6 Coordinate systems backup

Creat

The option is used to create a backup copy of the Favorites item. This helps when installing a new version of the software or running the software on several PC and is implemented by clicking the icon  (to create a backup file copy named Param_Year-Month-DayTHours_Minutes_SecondsZ.pcs in the folder C:\Users\UserName\Documents\ProGeoOffice\CoordinateSystems).

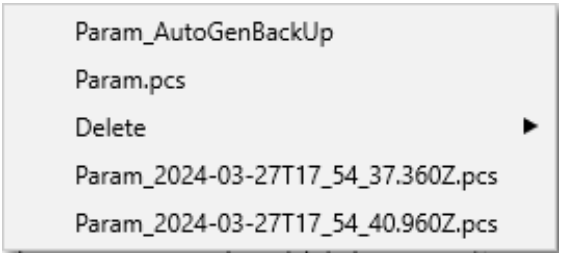


Figure 166 – List of backup files

Exchange of coordinates systems

Use right pane of *Coordinate systems manager* for coordinate systems exchange:

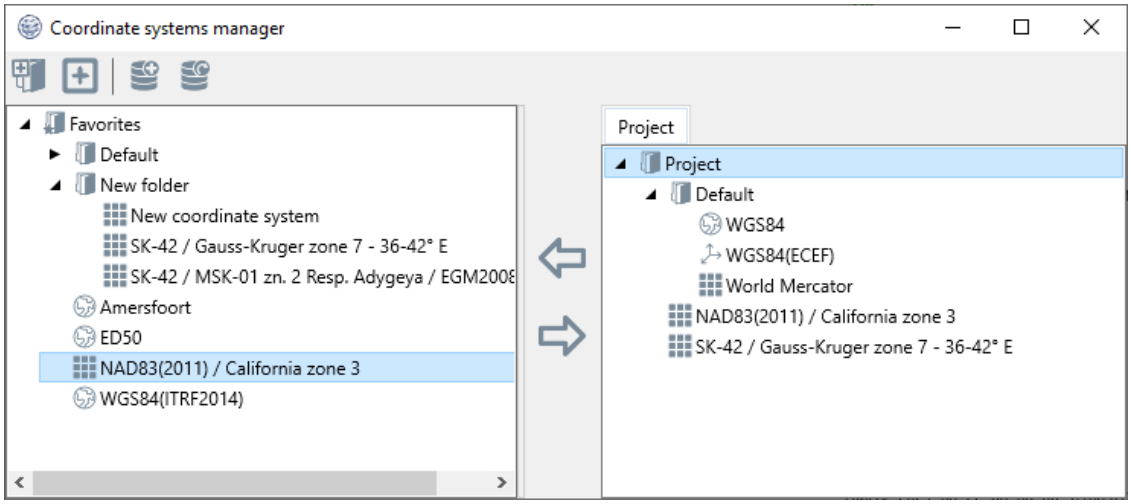


Figure 167 – Coordinate systems exchange

Use  and  buttons to copy coordinate systems from program database to a project vice versa. This makes it convenient to store frequently used coordinate systems and quickly and conveniently exchange coordinate systems between projects.

CHAPTER 9. REFERENCE POINTS

Reference points are point objects which represents a catalog of postulated coordinates. Raw data post-processing deals vector components in XYZ. To get shooting point position in some coordinate system we need first of all at least one reference point in this coordinate system. Set base receiver above reference point, set rover receiver above survey point in the field. Getting raw data from both, snap the beginning of processed vector to reference point and adjust. After post-processing and network adjustment, the coordinates of network points are obtained in the coordinate system of reference/origin points.

Click  *toolbar button or Program and Reference points in the main menu:*

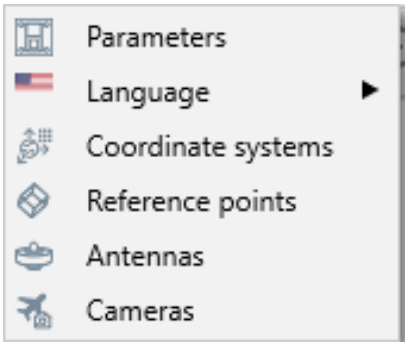


Figure 168 – Reference points

to open *Reference points manager* window:

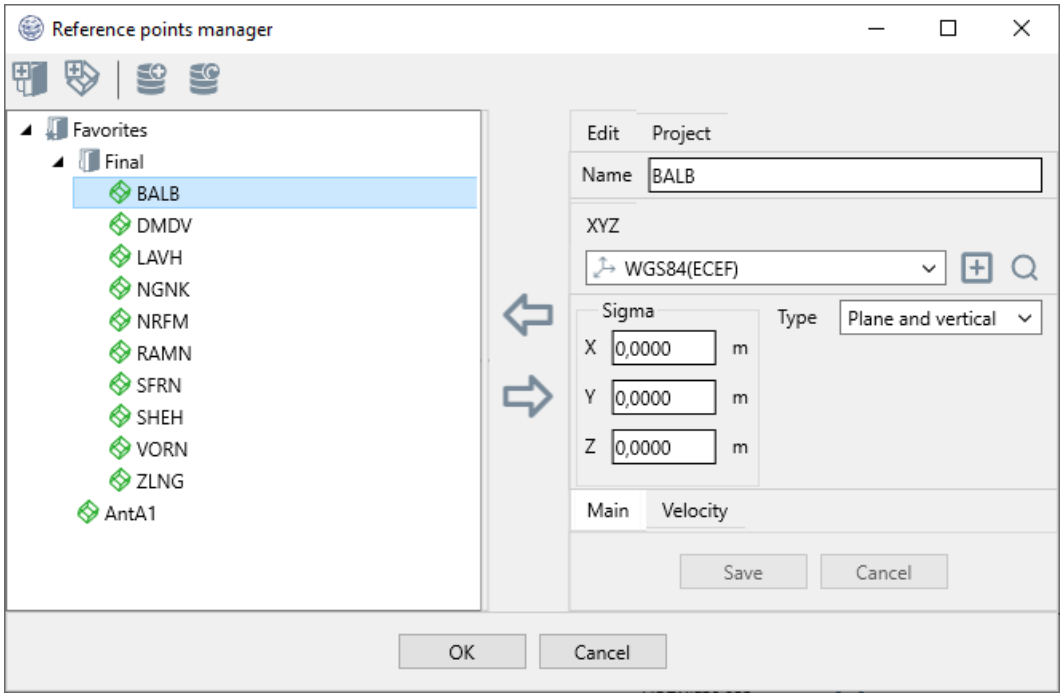


Figure 169 – Reference points manager

Toolbar items:

	create a new folder in the *Favorites* node
	create a new reference point
	create a backup file
	restore backup file

9.1 Left panel

The root element is the *Favorites* folder, which can contain several subfolders. To access the object menu, select an object (node, folder or item name) and click the right mouse button:

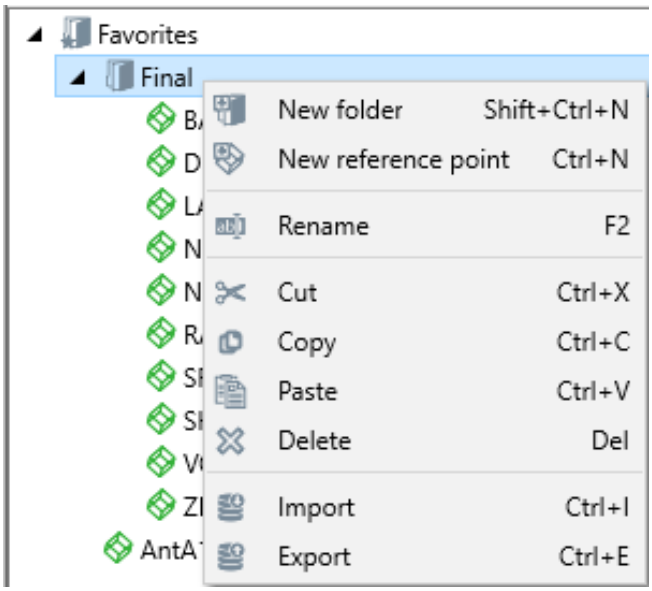
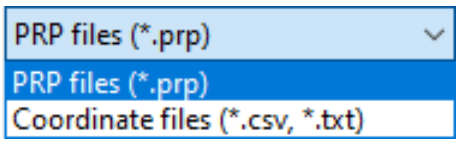


Figure 170 – Menu for left panels objects

New folder	create a new folder
New reference point	create a new reference point
Rename	rename a reference point
Cut	cut out an object
Copy	copy an object
Paste	paste copied or cut
Delete	delete an object
Import	import of reference points from files prp, csv, txt formats:



Export	export of reference points to files prp, csv, txt formats

When importing/exporting from files csv and txt formats, select the coordinate system in the list presented in the Favorites node of the coordinate system editor, since the name of the coordinate system is not saved in files of these formats, and select or create an input/output template.

9.2 Right panel

The panel contains two tabs:

- Edit - ввод, обновление свойств опорного пункта
- Project - repository of programs and projects for exchanging reference points

Edit

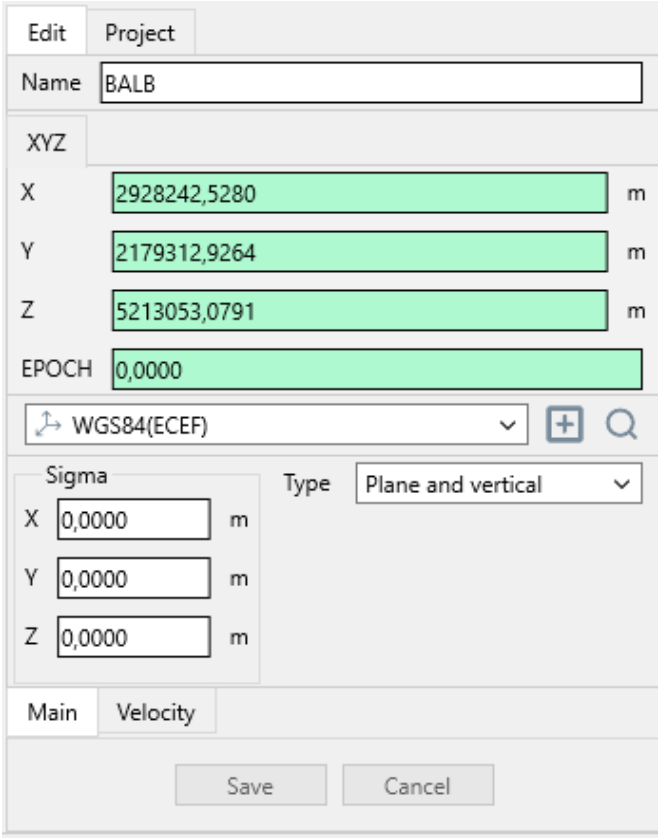


Figure 171 – Edit tab

The panel is active only when the item in the left panel is selected. In the drop-down list select a coordinate system for the coordinates of the point:

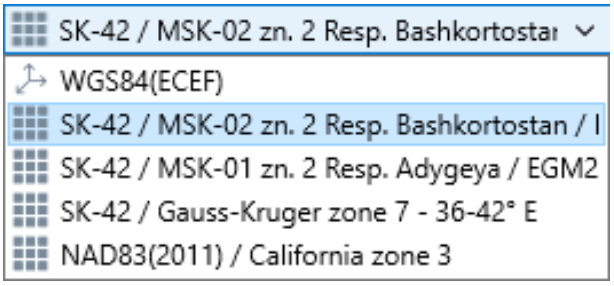


Figure 172 – Coordinate system selection

Click  to add coordinate system from *Favorities* node of *Coordinate Systema Manager* to the coordinate systems list, click  to get coordinate system properties:

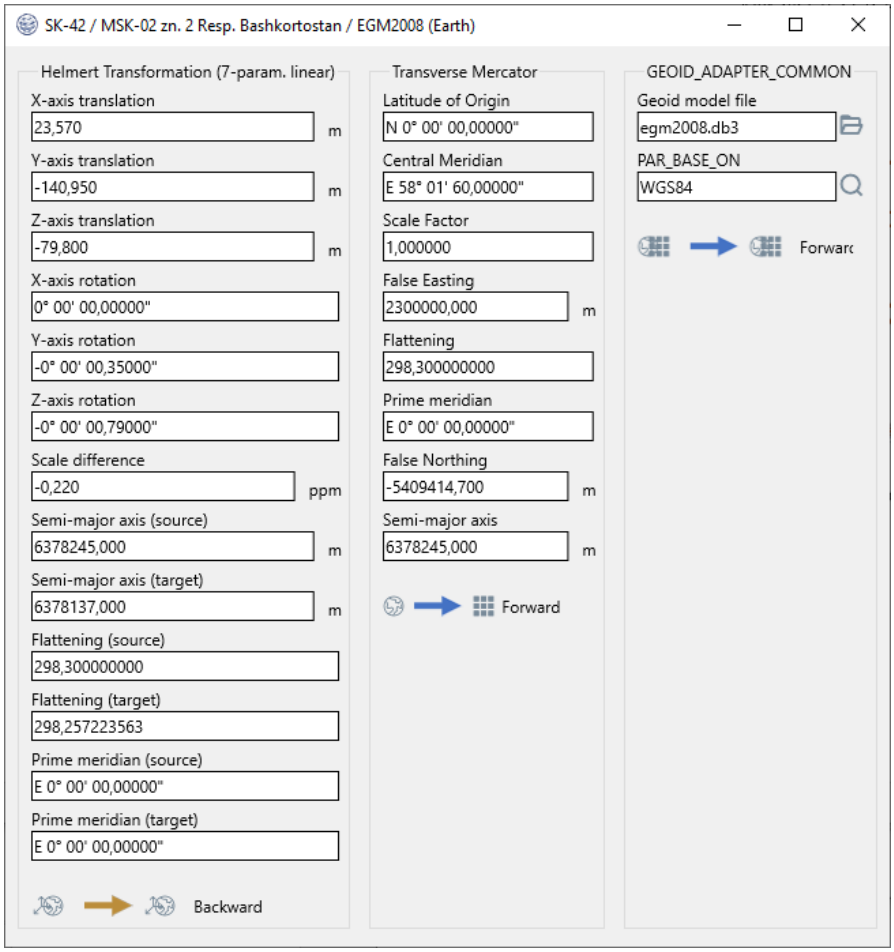


Figure 173 – Coordinate system properties

If necessary, it is also possible to enter the epoch value for coordinates and coordinates velocities. Time-dependent coordinate systems use predefined rates (e.g. HTTP conversion). In this case type the velocities values:

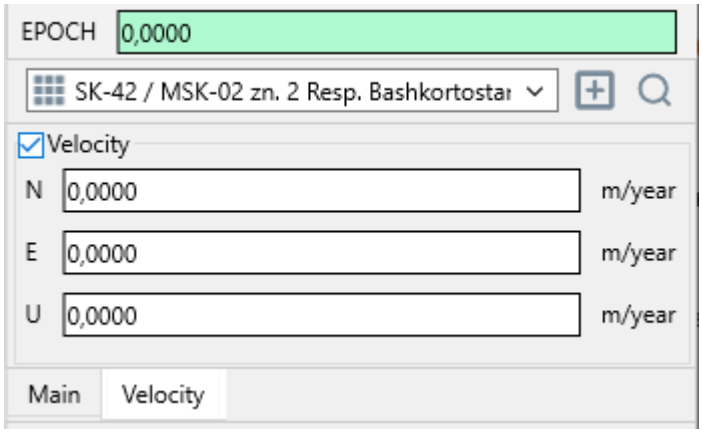


Figure 174 – Epoch and velocities

9.3 Project

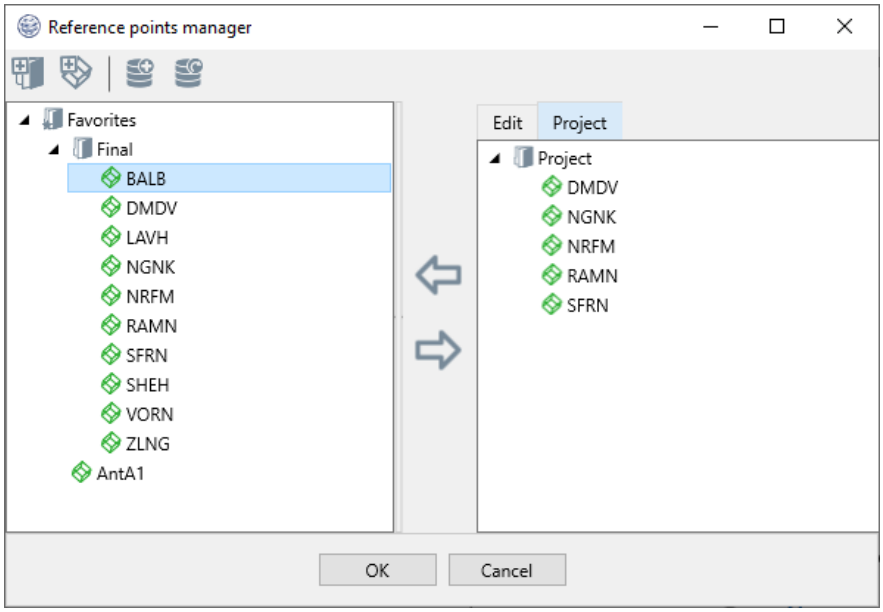


Figure 175 – Exchange reference points

The Project tab is intended to exchange entire folders and individual reference points between the program and project databases. Buttons  and  are used to copy folders and items.

CHAPTER 10. LOCALIZATION

To convert the coordinates obtained by the satellite data (GNSS) processing from WGS-84 to a local coordinate system, it is important to have:

- Reference coordinates in local coordinate system.
- Coordinate transformations which connect this coordinate system with WGS-84.

The order, in which coordinates are calculated, is shown on the following chart:

Figure 176 – Transformation steps

Transformation of geocentric coordinate systems is performed by the formula of 7 parametric Helmert transforms (Amendment 2 to RTCM STANDARD 10403.1):

$$\begin{bmatrix} X_T \\ Y_T \\ Z_T \end{bmatrix} = \begin{bmatrix} dX \\ dY \\ dZ \end{bmatrix} + M \times R \times \begin{bmatrix} X_S \\ Y_S \\ Z_S \end{bmatrix} \quad (10.1)$$

where (X_S, Y_S, Z_S) and (X_T, Y_T, Z_T) are WGS-84 geocentric coordinates and reference coordinate system accordingly (S - Source, T - Target)

dX, dY, dZ are translations along the axes *(X, Y, Z)*

M is the scale factor, $M = (1 + dS \times 10^{-6})$.

The size of *dS* is indicated in the list of datum Justin parameters in ppm, which means parts per millionths *(1 ppm* = 1×10^{-6}).

In rotation matrix $R = R_x \times R_y \times R_z$, where

$$R_X = \begin{bmatrix} \cos R_1 & \sin R_1 & 0 \\ -\sin R_1 & \cos R_1 & 0 \\ 0 & 0 & 1 \end{bmatrix}; R_Y = \begin{bmatrix} \cos R_2 & 0 & -\sin R_2 \\ 0 & 1 & 0 \\ \sin R_2 & 0 & \cos R_2 \end{bmatrix}; R_Z = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos R_3 & \sin R_3 \\ 0 & -\sin R_3 & \cos R_3 \end{bmatrix} \quad (10.2)$$

where R_1, R_2, R_3 are angles between axes of source and target coordinate systems. Axes are counted in the clockwise direction.

The formula of inverse transformation:

$$\begin{bmatrix} X_S \\ Y_S \\ Z_S \end{bmatrix} = \frac{R^{-1}}{M} \left[\begin{bmatrix} X_T \\ Y_T \\ Z_T \end{bmatrix} - \begin{bmatrix} dX \\ dY \\ dZ \end{bmatrix} \right] \quad (10.3)$$

The Helmert transformation is a similarity transform in which the scale factor is the same for each coordinate. Combination of 7 parameters for transformation (*dX, dY, dZ, dS, R_1, R_2, R_3*) and ellipsoid is called datum. In the list of Justin datums the signs of parameters correspond to the transition from WGS-84 to the reference system.
Example. *d*X = +10 метров. *XR = XWGS 84 + 10.*
Calculation of geodetic coordinates (B - latitude, L - longitude, H - height) with the use of geocentric coordinates (item 2 of the transformation scheme) is performed by iterations using the formulas:

$$\tan L = \frac{Y}{X} \ldots. \ \tan B = \frac{Z}{\sqrt{X^2+Y^2}} + \frac{e^2 \times N \times \sin B}{\sqrt{X^2+Y^2}} \ldots \ldots H = \frac{\sqrt{X^2+Y^2}}{\cos B} - N \quad (10.4)$$

where
N is the radius of curvature of the first vertical;
e^2 is the square of the first eccentricity of the ellipsoid.

The reverse transition to rectangular coordinates *X, Y, Z* from geodetic coordinates (stage 2 of the transformation scheme) *B, L, H* is described by the formulas:

$$\begin{aligned} X &= (N + H) \times \cos B \times \cos L \\ L &= (N + H) \times \cos B \times \sin L \\ Z &= (N + H - e^2 \times N) \times \sin B \end{aligned} \quad (10.5)$$

where
e is eccentricity;
N is the radius of curvature of the first vertical.
To calculate geodetic coordinates, there is need to specify an ellipsoid — semi-major axis and eccentricity.

The transformation of geodetic coordinates *B, L* into rectangular coordinates on a plane is performed based on the type and parameters of the map projection. The transition from H_{geod}, geodetic (ellipsoidal) height, which is measured along the normal to the ellipsoid, to H_{ortho} orthometric height is performed by the formula:

$$H_{geod} = H_{ortho} + \zeta \quad (10.6)$$

where ζ is the height of the geoid above the ellipsoid.
Geoid heights are determined from geodetic coordinates based on a geoid model that is defined relative to the same ellipsoid for which the geodetic height is calculated.

Stage 4 of the transformation scheme is performed between two rectangular coordinate systems specified on the plane. Finding the parameters of such a transformation in geodesy is usually called localization or calibration.

Planned transformation formulas are similar to (10.1):

$$\begin{bmatrix} N_T \\ E_T \end{bmatrix} = \begin{bmatrix} dN \\ dE \end{bmatrix} + M \times R \times \begin{bmatrix} N_S \\ E_S \end{bmatrix} \tag{10.7}$$

where

$$R = \begin{bmatrix} \cos\alpha & -\sin\alpha \\ \sin\alpha & \cos\alpha \end{bmatrix}$$

The formulas are:

$$\begin{aligned} N_T &= dN + M \times (N_S \times \cos\alpha - E_S \times \sin\alpha) \\ E_T &= dE + M \times (N_S \times \sin\alpha + E_S \times \cos\alpha) \end{aligned} \tag{10.8}$$

where *dN, dE* are offsets along the coordinate axes.;
N_S, E_S, N_T, E_T are Northing and Easting rectangular coordinates on a plane;
α is the turning angle, counted clockwise;
M is the scale factor.
The formula for inverse transformation for coordinates on a plane:

$$\begin{bmatrix} N_S \\ E_S \end{bmatrix} = \frac{R^{-1}}{M} \left[\begin{bmatrix} N_T \\ E_T \end{bmatrix} - \begin{bmatrix} dN \\ dE \end{bmatrix} \right] \tag{10.9}$$

The formula of altitude transformation:

$$H_T = H_S + dH + \alpha_N \times N_S + \alpha_E \times E_S \tag{10.10}$$

where H_S is height in the original coordinate system,
dH is height increment,
α_N, α_E are slope angles along the Northing, Easting axes.

The determination of the transformation parameters of coordinate systems on the plane is performed by the ordinary least mean squares method (LMS) by comparing the resulting transformation chain 1 - 4 and the original (from the catalog) coordinates of the points.
The parameters of the horizontal and vertical transformation are calculated independently. The minimum number of points required for calculation is two points for plane localization and three points for vertical localization.
Local datum includes 4 parameters of plane transformation plus 3 parameters of vertical transformation. Sometimes, this set of parameters is called 4+3 datum. This highlights the difference between it and datum with 7 parameters, which is used for calculation of geocentric coordinates transformations.
The calculation of the transformation parameters of rectangular coordinate systems on a plane and vertical coordinate systems is performed in the Localization window.

To activate this window, select the main menu item *Program*, then *Coordinate systems* (or click the  icon). In the opened window click the icon  and choose *Localization*:

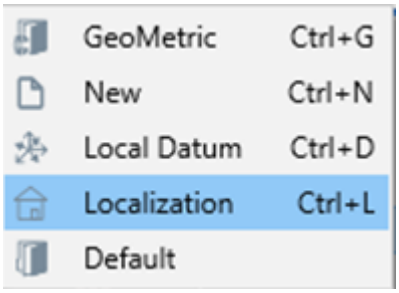


Figure 177 – Localization

The main elements of the *Localization* window are the bar of icons, the settings panel and the coordinate entry table:

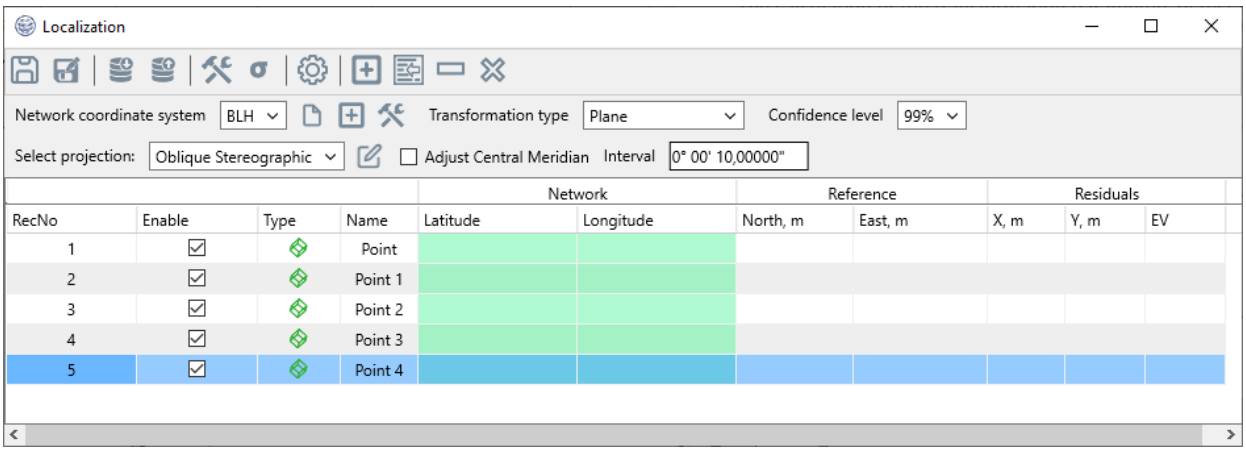


Figure 178 – Localization window

10.1 Icon bar

The bar of icons functionally corresponds to all localization commands:

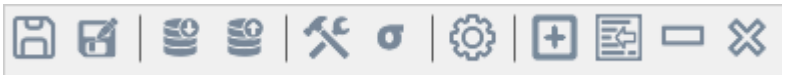
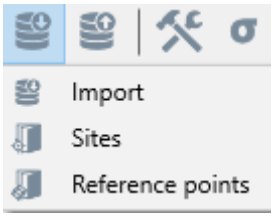
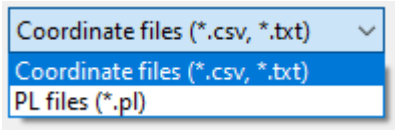


Figure 179 – The icon bar

	save new localization
	save localization as…
	import the following objects:



Import - import coordinate files (csv, txt) and saved localizations (pl):



Sites - import point coordinates for any point type from the current project:

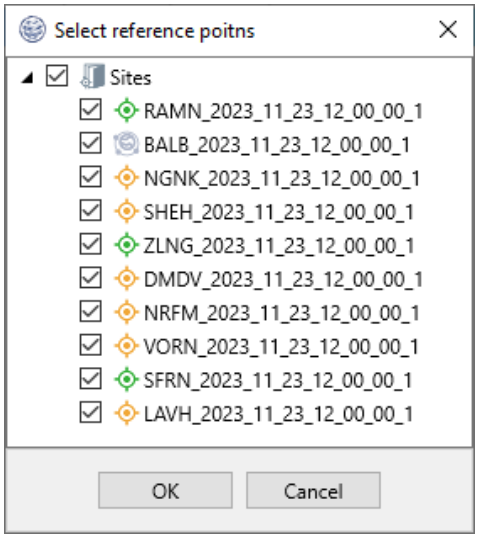


Figure 180 – Import site coordinates

Reference points - import reference points coordinates

	export of coordinate files (csv,txt) and localizations files (PL)
	activate / deactivate a bookmark, which contains a list of calculated parameters of horizontal and vertical transformations
	add columns to enter estimates of the accuracy of the coordinates of points
	perform localization calculation
	add a new row to the end of the table
	add a new row to the table before the selected one
	remove selected row from table
	delete all rows in table

Select from a list or create an input template when importing coordinate file:

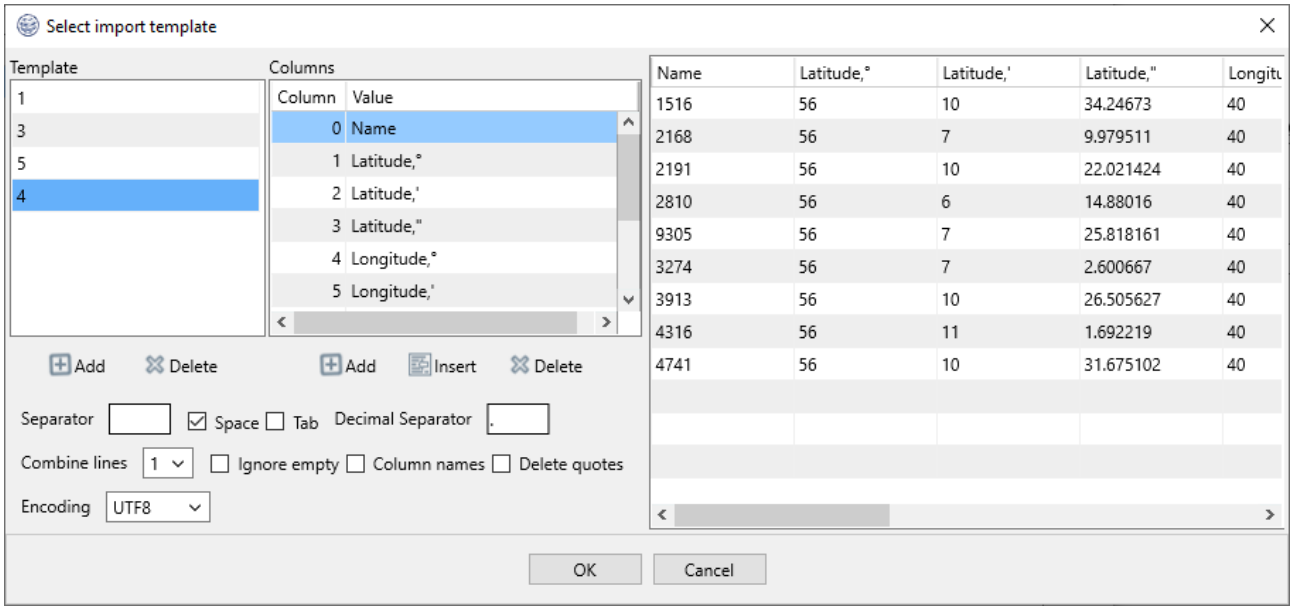


Figure 181 – Template for coordinates importing

To save the localization in the program database click  or  and select or create a new folder in the *Favorites* node of the *Coordinate System Editor*:

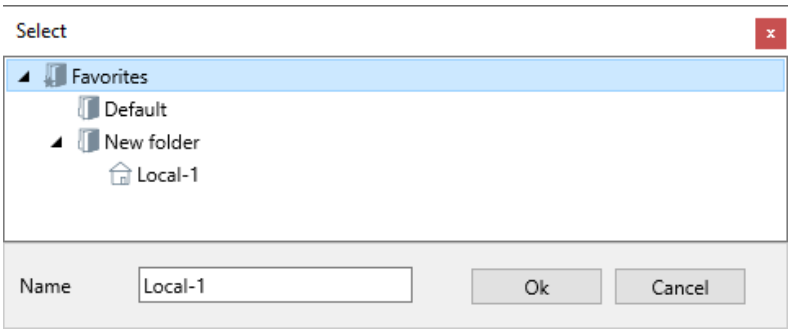


Figure 182 – Save localization

The localization file stores not only the conversion parameters, but also all table data, including if no processing was performed and the parameters were not received.

10.2 Main window

Data table

The data table is used to display the coordinates of points and to estimate the accuracy of the transformation calculation. Accuracy estimation is based on residuals. It depends both on the coordinate quality of the satellite network points and the mutual consistency of the reference points, and on the reliability of the user-specified projection parameters of the local coordinate system of the *Reference*. The columns of the table are combined into blocks - *Network, Reference, Residuals*. The *Network* block contains coordinates of points in the selected coordinate system. As a rule, these are the coordinates of points obtained from adjusting of the free GNSS network. *Reference*

block - coordinates of points in the local rectangular coordinate system on the plane. The residuals obtained from adjustment are shown in the right part of the table:

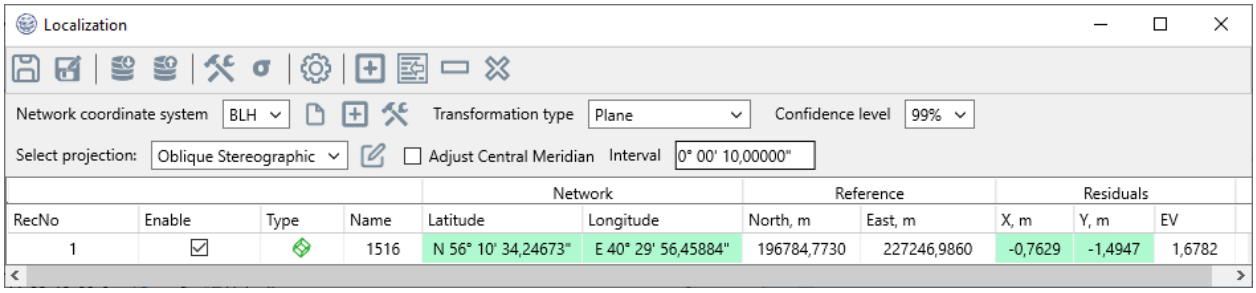


Figure 183 – Table blocks

In the input window, each line contains information about one item and contains the following columns:

RecNo	line number in order
Enable	the selected check-box means that the coordinates of the point will be used when calculating the parameters. Otherwise, the point is excluded from the calculation process. In this case, the corresponding row in the table is shaded, residuals are not calculated.
Type	sets the type of transformations in which a specific item can be used:

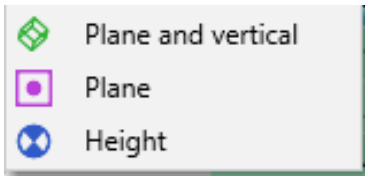


Figure 184 – Transformation types

It is possible to set one of three types of typing to control points:

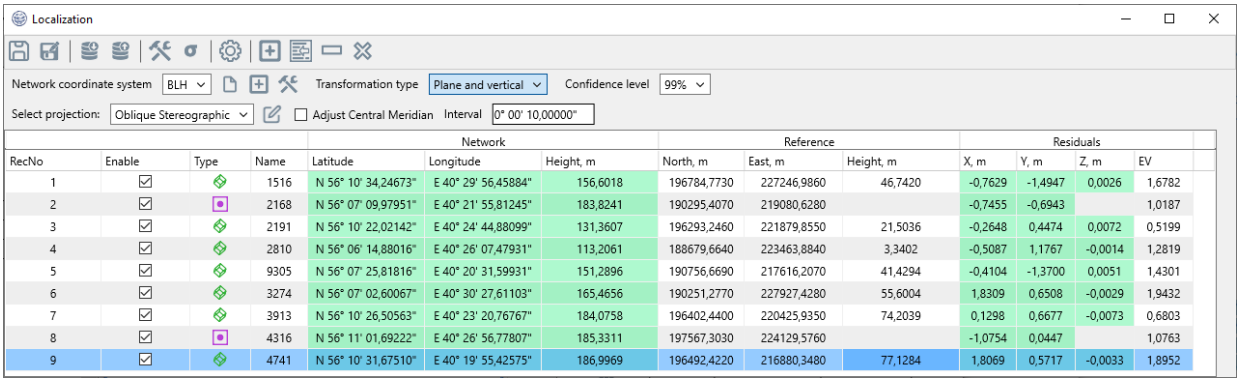
- Plane and vertical. The coordinates of the points will be used to calculate the parameters for the horizontal transformation (Latitude / Longitude or North / East) and the vertical transformation (Height)
- Plane. The coordinates of the points will be used to calculate the parameters for the horizontal transformation (Latitude / Longitude or North / East)
- Height. The coordinates of the points will be used to calculate the parameters of the vertical transformation (Height) (Высота).

Name	item name
Latitude, Longitude, (Height - if parameters for vertical transformation are also calculated) from the Network block	coordinates of points in the reference coordinate system. Depending on the type of coordinates which were entered into these columns (ellipsoidal or rectangular on a plane), there may be options BLH or North / East)

North, East, (Height - if parameters for height transformation are also calculated)	from the Reference block - coordinates of points in the local coordinate system
X(м) Y(м) Z(м) EV in Residuals block	residuals of points of the coordinates by the corresponding component and residuals by radius vector

10.3 Working with input fields in a table

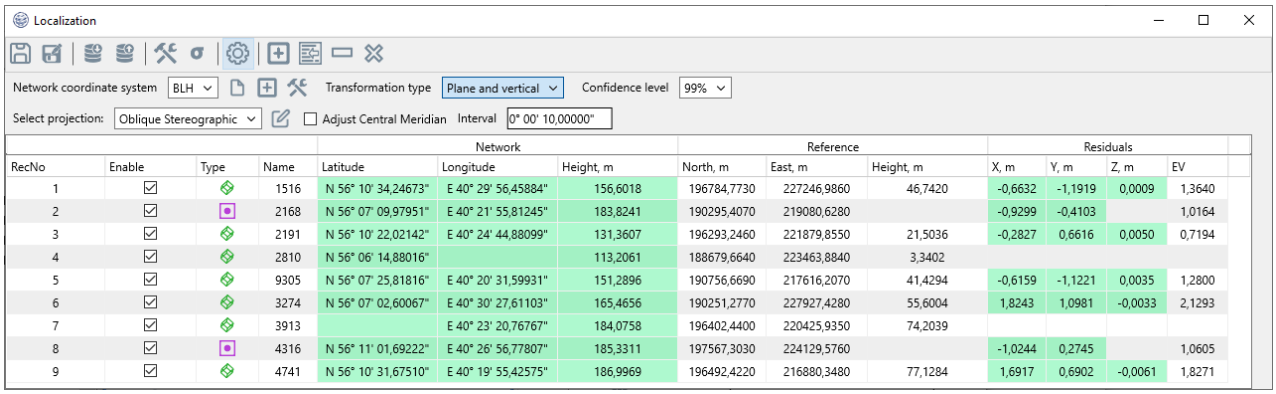
For greater clarity and convenience of work, the table uses color highlighting of fields. The coordinate columns of points in the original coordinate system are highlighted in green. The fields of the residual columns (except for the V column) are highlighted in red before the parameters are calculated. After calculating the parameters, the fields of these columns can be marked in green if the corresponding corrections to the measurements meet the criteria for the τ-test (tau test), or in red if the test is not passed. During the τ-test, the correspondence of corrections to the coordinates of points to the estimate of their accuracy obtained from the adjustment is analyzed. Therefore, sometimes, even relatively small corrections can be marked as not passed the τ-test. In addition to the τ-test, it is important to pay attention to the magnitude of the residuals, while evaluating the results of localization. If the item is excluded from the calculations (the check-box in the *Enable* column is unchecked), the color of the corresponding line changes to pale green. Fields for the value of the corresponding residuals will be empty and will be highlighted in white. To edit the type, names, coordinates of points directly in the table, double-click the corresponding field with the left mouse button. To save the editor in the text information input columns, press *Enter*, or by pressing the left mouse button, move the cursor from the edited field. Empty fields in the *Height* column are not highlighted in another color. The height value for this item will not be considered when calculating the altitude transformation parameters. The corresponding field in the residual columns is highlighted in the line by white color:



				Network			Reference			Residuals			
RecNo	Enable	Type	Name	Latitude	Longitude	Height, m	North, m	East, m	Height, m	X, m	Y, m	Z, m	EV
1	☑		1516	N 56° 10' 34,24673"	E 40° 29' 56,45884"	156,6018	196784,7730	227246,9860	46,7420	-0,7629	-1,4947	0,0026	1,6782
2	☑		2168	N 56° 07' 09,97951"	E 40° 21' 55,81245"	183,8241	190295,4070	219080,6280		-0,7455	-0,6943		1,0187
3	☑		2191	N 56° 10' 22,02142"	E 40° 24' 44,88099"	131,3607	196293,2460	221879,8550	21,5036	-0,2648	0,4474	0,0072	0,5199
4	☑		2810	N 56° 06' 14,88016"	E 40° 26' 07,47931"	113,2061	188679,6640	223463,8840	3,3402	-0,5087	1,1767	-0,0014	1,2819
5	☑		9305	N 56° 07' 25,81816"	E 40° 20' 31,59931"	151,2896	190756,6690	217616,2070	41,4294	-0,4104	-1,3700	0,0051	1,4301
6	☑		3274	N 56° 07' 02,60067"	E 40° 30' 27,61103"	165,4656	190251,2770	227927,4280	55,6004	1,8309	0,6508	-0,0029	1,9432
7	☑		3913	N 56° 10' 26,50563"	E 40° 23' 20,76767"	184,0758	196402,4400	220425,9350	74,2039	0,1298	0,6677	-0,0073	0,6803
8	☑		4316	N 56° 11' 01,69222"	E 40° 26' 56,77807"	185,3311	197567,3030	224129,5760		-1,0754	0,0447		1,0763
9	☑		4741	N 56° 10' 31,67510"	E 40° 19' 55,42575"	186,9969	196492,4220	216880,3480	77,1284	1,8069	0,5717	-0,0033	1,8952

Figure 185 – Data in the Height column

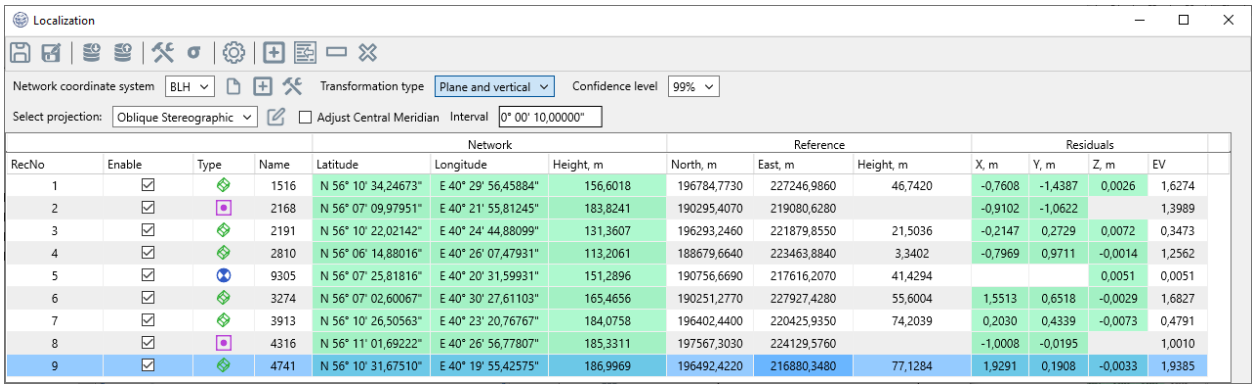
When coordinates are entered in the table in the columns of the *Network* block and there is no value of any plane coordinate (deleted from the table by the operator, omitted in the imported file), then the input line is not taken into account in the calculation (sites 2810, 3913). The result will be similar to deleting item information from the table or unchecking the check-box in the *Enable* column). The residuals of the row will be zero, and their fields in the table are highlighted in white:



				Network			Reference			Residuals			
RecNo	Enable	Type	Name	Latitude	Longitude	Height, m	North, m	East, m	Height, m	X, m	Y, m	Z, m	EV
1	☑		1516	N 56° 10' 34,24673"	E 40° 29' 56,45884"	156,6018	196784,7730	227246,9860	46,7420	-0,6632	-1,1919	0,0009	1,3640
2	☑		2168	N 56° 07' 09,97951"	E 40° 21' 55,81245"	183,8241	190295,4070	219080,6280		-0,9299	-0,4103		1,0164
3	☑		2191	N 56° 10' 22,02142"	E 40° 24' 44,88099"	131,3607	196293,2460	221879,8550	21,5036	-0,2827	0,6616	0,0050	0,7194
4	☑		2810	N 56° 06' 14,88016"		113,2061	188679,6640	223463,8840	3,3402				
5	☑		9305	N 56° 07' 25,81816"	E 40° 20' 31,59931"	151,2896	190756,6690	217616,2070	41,4294	-0,6159	-1,1221	0,0035	1,2800
6	☑		3274	N 56° 07' 02,60067"	E 40° 30' 27,61103"	165,4656	190251,2770	227927,4280	55,6004	1,8243	1,0981	-0,0033	2,1293
7	☑		3913		E 40° 23' 20,76767"	184,0758	196402,4400	220425,9350	74,2039				
8	☑		4316	N 56° 11' 01,69222"	E 40° 26' 56,77807"	185,3311	197567,3030	224129,5760		-1,0244	0,2745		1,0605
9	☑		4741	N 56° 10' 31,67510"	E 40° 19' 55,42575"	186,9969	196492,4220	216880,3480	77,1284	1,6917	0,6902	-0,0061	1,8271

Figure 186 – Missing data in the fields

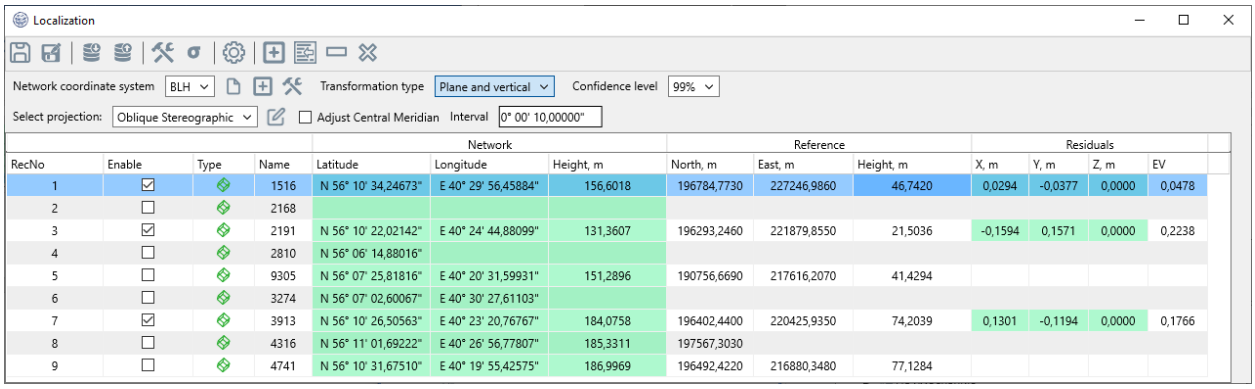
When changing the type of a point, those coordinates that do not belong to this type are excluded from the calculations. The fields in the Residuals columns are highlighted in white. For example, site 4316 does not use elevation, and site 9305 does not use plane coordinates:



				Network			Reference			Residuals			
RecNo	Enable	Type	Name	Latitude	Longitude	Height, m	North, m	East, m	Height, m	X, m	Y, m	Z, m	EV
1	☑		1516	N 56° 10' 34,24673"	E 40° 29' 56,45884"	156,6018	196784,7730	227246,9860	46,7420	-0,7608	-1,4387	0,0026	1,6274
2	☑		2168	N 56° 07' 09,97951"	E 40° 21' 55,81245"	183,8241	190295,4070	219080,6280		-0,9102	-1,0622		1,3989
3	☑		2191	N 56° 10' 22,02142"	E 40° 24' 44,88099"	131,3607	196293,2460	221879,8550	21,5036	-0,2147	0,2729	0,0072	0,3473
4	☑		2810	N 56° 06' 14,88016"	E 40° 26' 07,47931"	113,2061	188679,6640	223463,8840	3,3402	-0,7969	0,9711	-0,0014	1,2562
5	☑		9305	N 56° 07' 25,81816"	E 40° 20' 31,59931"	151,2896	190756,6690	217616,2070	41,4294			0,0051	0,0051
6	☑		3274	N 56° 07' 02,60067"	E 40° 30' 27,61103"	165,4656	190251,2770	227927,4280	55,6004	1,5513	0,6518	-0,0029	1,6827
7	☑		3913	N 56° 10' 26,50563"	E 40° 23' 20,76767"	184,0758	196402,4400	220425,9350	74,2039	0,2030	0,4339	-0,0073	0,4791
8	☑		4316	N 56° 11' 01,69222"	E 40° 26' 56,77807"	185,3311	197567,3030	224129,5760		-1,0008	-0,0195		1,0010
9	☑		4741	N 56° 10' 31,67510"	E 40° 19' 55,42575"	186,9969	196492,4220	216880,3480	77,1284	1,9291	0,1908	-0,0033	1,9385

Figure 187 – Transformation types

Similar rules apply to coordinate columns of the Reference block.
Fields in which coordinates are not entered (for all columns) remain empty, and the following fields of this item also remain empty:



				Network			Reference			Residuals			
RecNo	Enable	Type	Name	Latitude	Longitude	Height, m	North, m	East, m	Height, m	X, m	Y, m	Z, m	EV
1	☑		1516	N 56° 10' 34,24673"	E 40° 29' 56,45884"	156,6018	196784,7730	227246,9860	46,7420	0,0294	-0,0377	0,0000	0,0478
2	☐		2168										
3	☑		2191	N 56° 10' 22,02142"	E 40° 24' 44,88099"	131,3607	196293,2460	221879,8550	21,5036	-0,1594	0,1571	0,0000	0,2238
4	☐		2810	N 56° 06' 14,88016"									
5	☐		9305	N 56° 07' 25,81816"	E 40° 20' 31,59931"	151,2896	190756,6690	217616,2070	41,4294				
6	☐		3274	N 56° 07' 02,60067"	E 40° 30' 27,61103"								
7	☑		3913	N 56° 10' 26,50563"	E 40° 23' 20,76767"	184,0758	196402,4400	220425,9350	74,2039	0,1301	-0,1194	0,0000	0,1766
8	☐		4316	N 56° 11' 01,69222"	E 40° 26' 56,77807"	185,3311	197567,3030						
9	☐		4741	N 56° 10' 31,67510"	E 40° 19' 55,42575"	186,9969	196492,4220	216880,3480	77,1284				

Figure 188 – Missing data

10.4 Localization window tabs

In addition to the coordinate table, a tab can be activated in the window, in which four parameters of the plane transformation (if calculated) and three parameters of the vertical transformation (if calculated) are displayed:

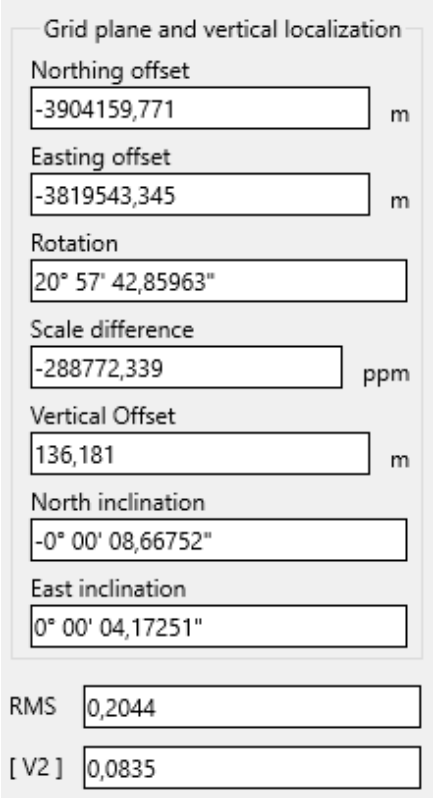


Figure 189 – Transformation parameters

Also, the sum of the squares of the residuals (by the radius vector, the Input table section, the description of the Residuals column) and the mean square error.

10.5 Settings panel

The settings panel is designed to select various settings and parameters when calculating localization parameters:

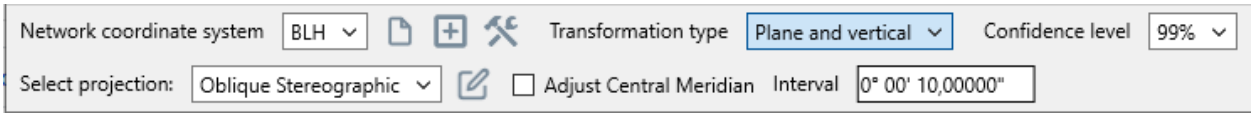


Figure 190 – Settings panel

10.6 Network coordinate system

The *Network coordinates* drop-down list is used to define the type of coordinate system for the coordinates that will be imported into the *Network* block:

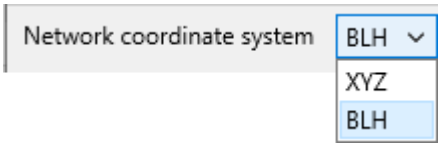


Figure 191 – Network coordinate system type

These can be ellipsoidal (BLH) coordinates (set by default), or rectangular coordinates on a plane (GRID). Depending on the selected type of coordinate system, the table view is configured, settings for the coordinate input template are selected (section Importing coordinates into a table).
Since the main purpose of the localization module is to tie the coordinates of global satellite navigation systems - WGS-84, obtained as a result of processing/post-processing by the *PGO* program - to ground points, then, mainly, the coordinates of the network essentially denote the coordinates of WGS-84. In this case, the BLH/Grid switch only affects the external representation of coordinates since the internal representation of the data in the *PGO* database is WGS-84.
The situation is different when importing grid coordinates from a file, in which coordinates can be specified in any form. Setting the switch allows you to correctly identify the original data, that is, convert it to the internal representation of the WGS-84 program. The list of coordinate systems offered for selection corresponds to the list available when choosing *Program-Coordinate systems* from the main PGO menu.
The reference coordinate system is characterized by a map projection and a global (spatial) 7-parameter datum. The purpose of localization is to calculate the parameters of the local datum required for transformations of coordinates specified on the plane.
The local datum is used in the *PGO* program in addition to the global one, but its calculation may be of interest for use in independent coordinate transformation programs. The parameters of the map projection are not subject to calculation (except for the value of the axial meridian, for those projections where it is available).
The accuracy of the conversion to local coordinates depends on the accuracy of the initial definition of the coordinate system of the reference. The dependence of the accuracy of transformations on the parameters of the global datum is relatively small. In most cases, the main source of calculation errors is the inaccuracy of the choice of the central meridian. Distortions in the coordinates of the item increase with distance from it. Therefore, the parameters of the cartographic projection of a predefined coordinate system of the reference should be as accurate as possible correspond to the real, which are not always known. It is possible to recommend the selection of parameters and type of cartographic projection of the reference to achieve the best result.
If nothing is known about the type and parameters of the cartographic projection of the reference coordinate system, then in the drop-down list of coordinate systems you should select *Oblique Stereographic*, which is equivalent to choosing a stereographic projection with a central point calculated as the average between their maximum and minimum values of latitudes and longitudes for points of the *Network* block, zero shifts along the axes and unit scale.

10.7 Transformation type

The Transformation drop-down list is used to define a set of calculated parameters: Plane (set by default) - 4 parameters:

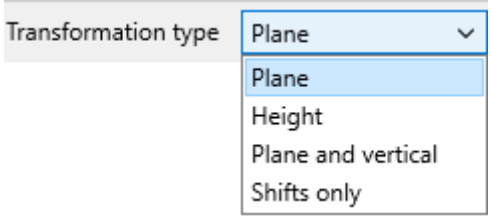


Figure 192 – Transformation type

of the horizontal transformation are calculated, *Height* - three parameters of the vertical transformation, *Plane + Height* - four parameters of the horizontal and three parameters of the vertical transformation, *Offsets only* - 2 parameters of the horizontal transformation (shifts along the *North* and *East* axes). In this case, the roll angle is 0, the scale is 1.

10.8 Auto select central meridian

The *Autoselect CM* check-box is designed to select the central meridian when calculating transformation parameters:

Figure 193 – The Autoselect CM check-box

If the check-box is not selected, the coordinates of the grid points are converted to the reference coordinate system using the preset value of the central meridian, specified by the map projection in the projection list of coordinate systems. If the check-box is checked, the meridian is automatically selected for the six-degree zone with the boundaries shifted by 3 degrees to the left and right relative to the average longitude of the points of the *Network* block. The calculation is performed in a cycle with a longitude step equal to the entered value in the *Interval* window (the preset step value is 10 seconds). The criterion is the estimate of the sum of the squares of the residuals. The value of this sum is reflected in line *[V2]* of the tab with the list of calculated parameters. The value of the central meridian, for which the transformation parameters were obtained, can be viewed by clicking the button  on the settings panel:

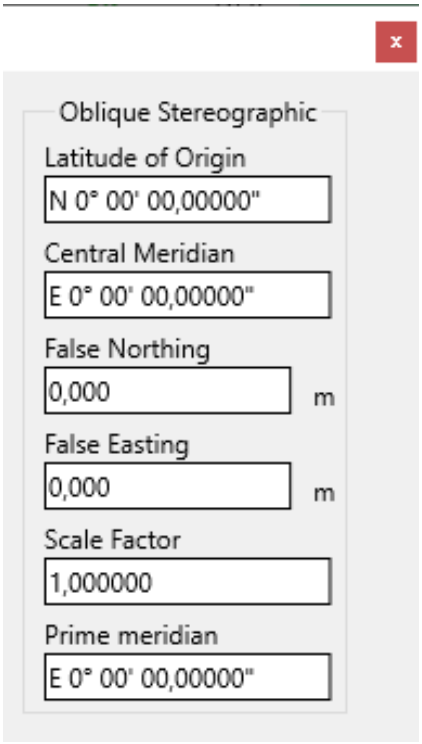


Figure 194 – Plane system parameters for translation into the reference coordinate system

The values of these parameters are updated after each calculation of localization with the *Auto-select CM* check-box checked or at any time can be changed manually in this window. If the *Autoselect CM* check-box is not selected, the values of these parameters are entered only manually and do not change during the calculation. In the course of calculations, the longitude step, the value of the current central meridian for which the calculations are being performed, the value of the central meridian for which the best estimate of the localization accuracy has been obtained at the moment and the sum of the residual squares are displayed in the *Progress* window with a progress bar with the *Auto-select CM* check-box selected:

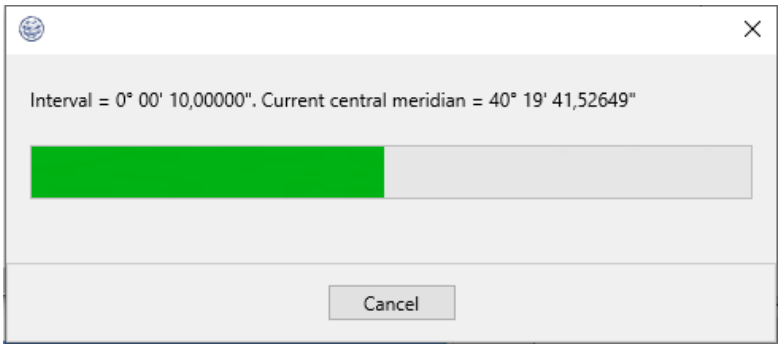


Figure 195 – Progress window

10.9 Progress window

Confidence intervals are set to searching blunders with τ-test:

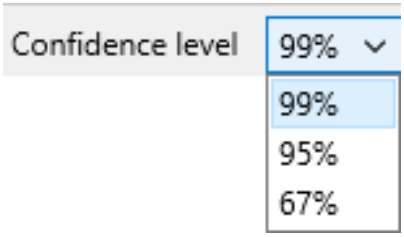


Figure 196 – Choosing a Confidence level

The 95% confidence level corresponds to a narrower confidence interval, that is, the criterion for passing the test will be more stringent. 99% confidence level corresponds more wide error interval.

10.10 Import/export of point coordinates

To import point coordinates, click  on the icon bar of the Localization window.

Import is carried out through a standard dialog from text files of arbitrary format with the extension csv, txt and files previously saved using a template with the extension PL.

To export point coordinates click  . Export is carried out in files of the same formats as import. When importing/exporting files of arbitrary format, you should create a coordinate input/output template. The difference between the template creation windows for import and export is that

during import, the template creation window has an additional panel that shows the contents of the imported file, during export this panel is absent.
After creating a template and clicking *OK*, the coordinates of the points will be imported into the table in accordance with the created template. The set of template fields depends on the type of imported or exported coordinates (XYZ/BLH/Grid). When importing/exporting files with the PL extension created using a standard template, creating or selecting a template is not required.

10.11 Save localization

To save the localization click:

	save current localization
	save current localization as a new one

To avoid data loss select a unique name for the new saved localization. The saved localization file contains not only the transformation parameters, but also a table of coordinates from which these parameters were obtained. Save a coordinate table in a localization file without calculating transformation parameters. In this case, all parameters in the file will be equal to zero. All localizations are stored in the *Favorites* node of the *Coordinate Systems Manager*.

CHAPTER 11. ANTENNA EDITOR

Click  toolbar button or Program and Antennas in the main menu:

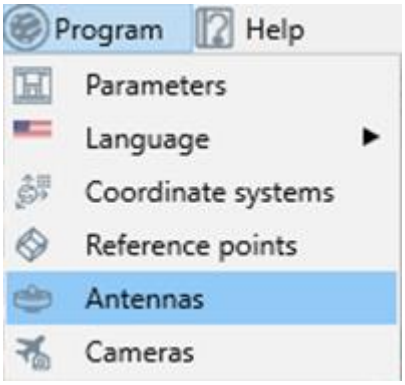


Figure 197 – Antennas item

to open *Antennas* window:

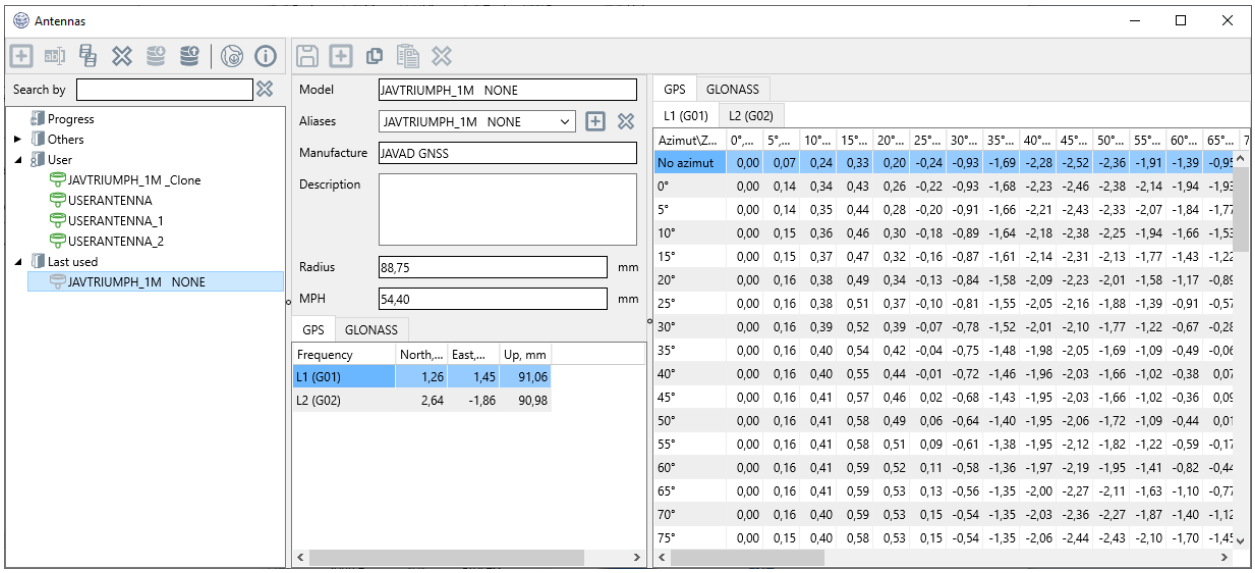


Figure 198 – Antennas window

The panel is divided into 3 panels. The left panel contains 3 antennas items:

- Other - antennas from other manufacturers, grouped by company name
- User - antennas added by the user
- Last used - antennas used in the program

The central panel contains the name, description and parameters of the antenna selected in the lists and is used to edit the antenna parameters and the table of antenna phase center variations for antennas in the User list:

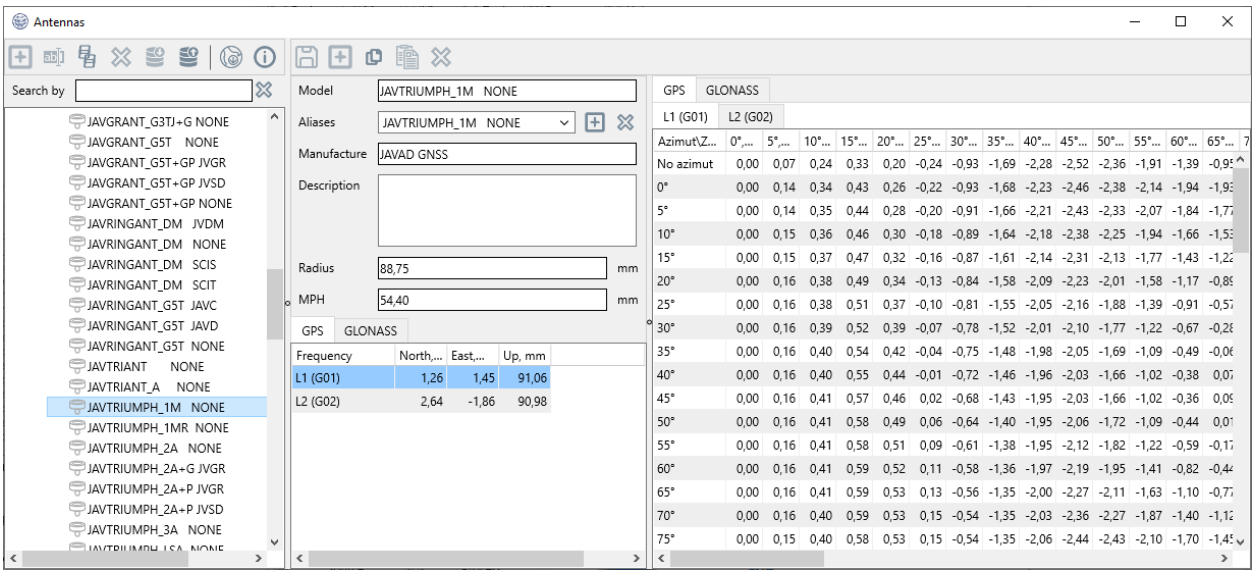


Figure 199 – Antennas parameters

Radius	antenna radius
MPH	is the vertical distance from the antenna reference point (ARP) to the height measurement mark on the antenna
North, East, Up	offsets of the phase center relative to ARP toward north, east and altitude for the selected navigation system and frequency

To update the antenna database click the button on the toolbar. Click on the toolbar to activate *Diagram antenna parameters* window. It displays a diagram of the main geometric parameters of the antenna:

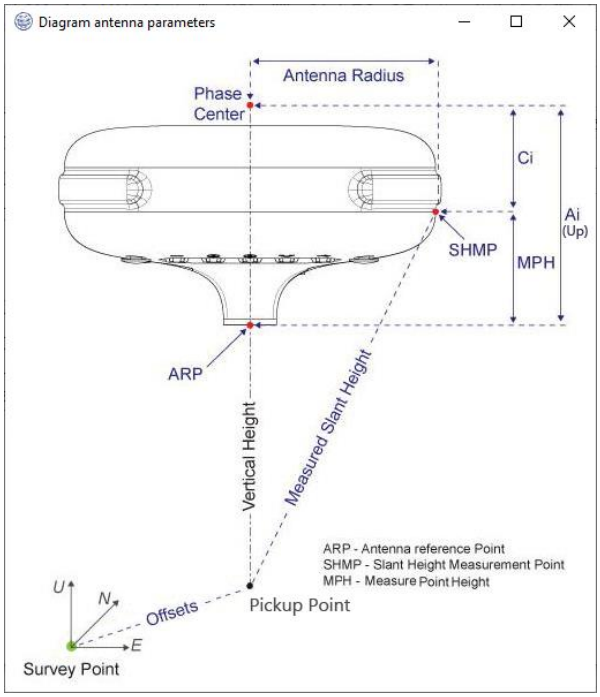


Figure 200 – Antenna geometry diagram

The right panel contains tables of azimuth and zenith distance of phase center variations for the navigation systems and frequencies. Phase center variations for certified by NGS antennas are published on the NGS website and contain data for GPS and GLONASS for L1 and L2 frequencies:

GPS | GLONASS

G1 (R01) | G2 (R02)

Азимут\З...	0°,...	5°,...	10°...	15°...	20°...	25°...	30°...	35°...	40°...	45°...	50°...	55°...	60°...	65°...	70°...	75°...	80°...	85°...	90°...
Без азиму...	0,00	-0,05	-0,16	-0,19	-0,10	0,13	0,34	0,32	-0,03	-0,66	-1,33	-1,70	-1,53	-0,81	0,15	0,85	0,85	-0,01	-1,43
0°	0,00	0,01	-0,05	-0,06	-0,01	0,10	0,11	-0,13	-0,70	-1,48	-2,20	-2,57	-2,38	-1,69	-0,82	-0,19	-0,16	-0,91	-2,40
5°	0,00	0,00	-0,07	-0,08	-0,03	0,08	0,09	-0,14	-0,70	-1,47	-2,20	-2,55	-2,35	-1,63	-0,73	-0,09	-0,03	-0,69	-2,03
10°	0,00	-0,01	-0,08	-0,11	-0,05	0,07	0,08	-0,15	-0,70	-1,47	-2,18	-2,52	-2,27	-1,51	-0,56	0,12	0,24	-0,36	-1,57
15°	0,00	-0,02	-0,11	-0,13	-0,07	0,04	0,08	-0,14	-0,69	-1,44	-2,14	-2,45	-2,16	-1,34	-0,33	0,43	0,60	0,06	-1,04
20°	0,00	-0,04	-0,13	-0,16	-0,10	0,03	0,08	-0,12	-0,66	-1,41	-2,09	-2,38	-2,03	-1,16	-0,04	0,81	1,04	0,56	-0,47
25°	0,00	-0,05	-0,15	-0,19	-0,13	0,01	0,09	-0,10	-0,62	-1,36	-2,03	-2,29	-1,91	-0,96	0,24	1,20	1,52	1,11	0,13
30°	0,00	-0,06	-0,17	-0,22	-0,16	-0,01	0,08	-0,09	-0,58	-1,32	-1,98	-2,22	-1,81	-0,79	0,50	1,57	2,00	1,65	0,73
35°	0,00	-0,06	-0,20	-0,25	-0,19	-0,03	0,07	-0,08	-0,55	-1,27	-1,93	-2,17	-1,73	-0,67	0,71	1,89	2,42	2,15	1,28
40°	0,00	-0,07	-0,21	-0,28	-0,23	-0,06	0,05	-0,07	-0,54	-1,24	-1,89	-2,13	-1,70	-0,59	0,83	2,10	2,74	2,56	1,76
45°	0,00	-0,09	-0,23	-0,31	-0,26	-0,10	0,03	-0,09	-0,53	-1,22	-1,87	-2,13	-1,70	-0,60	0,87	2,20	2,93	2,84	2,11
50°	0,00	-0,10	-0,26	-0,34	-0,29	-0,14	-0,01	-0,11	-0,54	-1,23	-1,88	-2,14	-1,75	-0,67	0,80	2,18	2,98	2,97	2,33
55°	0,00	-0,11	-0,27	-0,37	-0,32	-0,17	-0,05	-0,15	-0,57	-1,24	-1,90	-2,19	-1,83	-0,81	0,63	2,01	2,86	2,94	2,36
60°	0,00	-0,11	-0,28	-0,40	-0,36	-0,22	-0,10	-0,20	-0,62	-1,28	-1,95	-2,26	-1,95	-1,00	0,38	1,74	2,60	2,72	2,22
65°	0,00	-0,12	-0,30	-0,42	-0,40	-0,26	-0,16	-0,26	-0,68	-1,34	-2,00	-2,34	-2,10	-1,21	0,07	1,36	2,20	2,37	1,92
70°	0,00	-0,12	-0,31	-0,44	-0,43	-0,30	-0,21	-0,32	-0,75	-1,40	-2,06	-2,42	-2,23	-1,45	-0,27	0,94	1,74	1,89	1,47
75°	0,00	-0,13	-0,31	-0,44	-0,44	-0,34	-0,26	-0,38	-0,81	-1,46	-2,13	-2,51	-2,37	-1,67	-0,60	0,49	1,22	1,35	0,91
80°	0,00	-0,13	-0,33	-0,46	-0,46	-0,36	-0,30	-0,44	-0,87	-1,52	-2,19	-2,57	-2,48	-1,86	-0,90	0,09	0,72	0,80	0,30
85°	0,00	-0,14	-0,33	-0,46	-0,46	-0,37	-0,33	-0,48	-0,92	-1,57	-2,22	-2,62	-2,55	-2,00	-1,13	-0,25	0,29	0,28	-0,29
90°	0,00	-0,15	-0,33	-0,46	-0,45	-0,37	-0,33	-0,49	-0,93	-1,58	-2,23	-2,63	-2,58	-2,07	-1,26	-0,48	-0,02	-0,11	-0,79
95°	0,00	-0,15	-0,33	-0,44	-0,43	-0,35	-0,31	-0,48	-0,92	-1,57	-2,21	-2,60	-2,55	-2,05	-1,30	-0,56	-0,18	-0,35	-1,14

Figure 201 – Phase Center Variation Table

Standard antennas manufactured by third party companies cannot be edited or deleted. Clone and export operations are available for them:

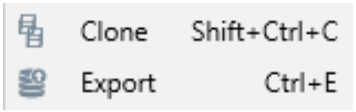


Figure 202 – Standard antennas menu

Clone	an antenna titled with a _Clone addition. It is added to the *User* list
Export	opens window to export antenna to an *ANTEX* file:

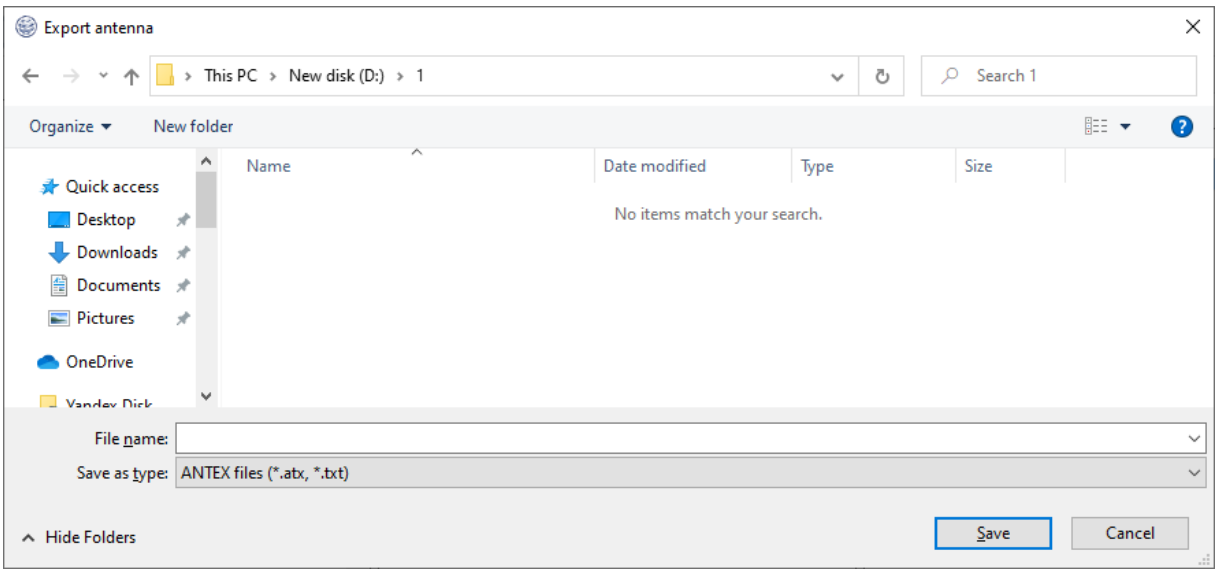


Figure 203 – Export antenna window

For antennas created by the user, the following operations are available:

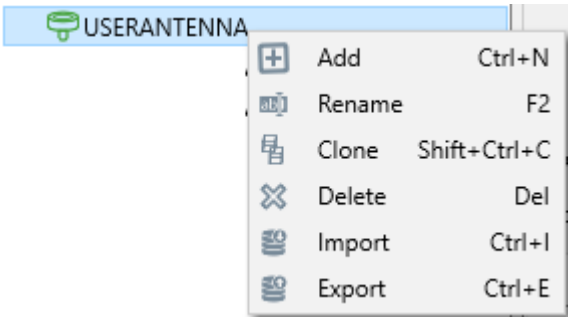


Figure 204 – User antennas menu

Add	add an antenna named USERANTENNA to the User list with the addition to the name _1, if the name USERANTENNA is already in use
Rename	edit the name of the antenna
Clone	clone the antenna name
Delete	remove an antenna from the list
Import	import parameters for the selected antenna from an ANTEX file
Export	export antenna parameters to ANTEX file

For antennas in the Last used list, operations are available for cloning, deleting and exporting to an ANTEX file:

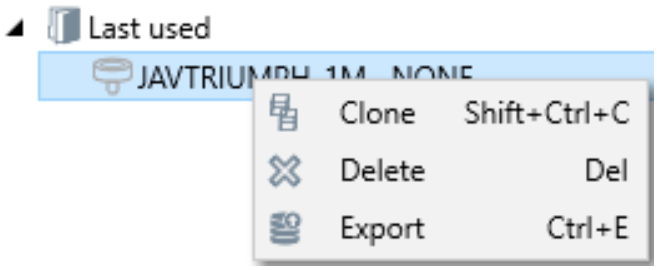


Figure 205 – Last used antennas menu

The ribbon of the left panel contains the following icons:

Figure 206 – Ribbon of icons of the left panel

	adding an antenna named USERANTENNA to the *User* list
	editing antenna name
	clone antenna
	delete antenna
	import of antenna parameters into *ANTEX* file
	export of antenna parameters to *ANTEX* file

For the antennas of *Other* list only the cloning and export icons are active, for the *User* list — all icons, for the *Last used* list - the icons for cloning, deleting and exporting. The central and the right panels for the *Other* and *Last used*, are for informational purposes and are available for viewing only. For antennas selected in the *User* list, the ribbon of icons of the central panel become active. The parameters and variations of the phase center of the selected antenna become available for editing:

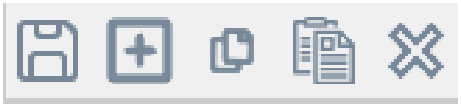


Figure 207 – Ribbon of icons of the central panel

	save changes in parameters
	add a table of phase center variations for a specific navigation system and for a specific signal type
	copy the phase center variation table. The copied table is copied to an Excel or Notepad ++ file, where the values can be edited, then the edited data is copied to PGO
	paste the phase center variation table copied into Excel or Notepad ++
	delete the phase center variation table for a specific navigation system and for a specific signal type. To edit the values of parameters or variations, you need to double-click on the edited value, and then edit it.

CHAPTER 12. AERIAL CAMERA EDITOR

To calculate the coordinates of camera exposure moments (events), it is necessary to set the initial parameters, such as shifts of the center of the film plane of the aerial camera relative to the phase center of the satellite receiver antenna, installed on the aircraft, and the camera parameters.
The aerial cameras editor window can be activated by selecting the *Program* item of the main menu and then the *Cameras* item:

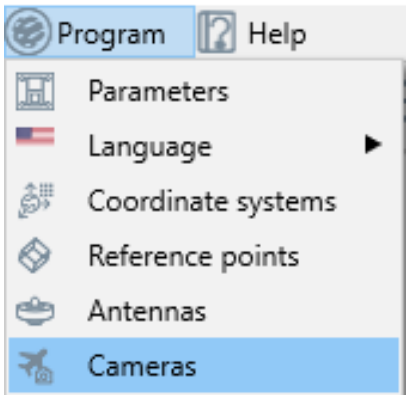


Figure 208 – Cameras

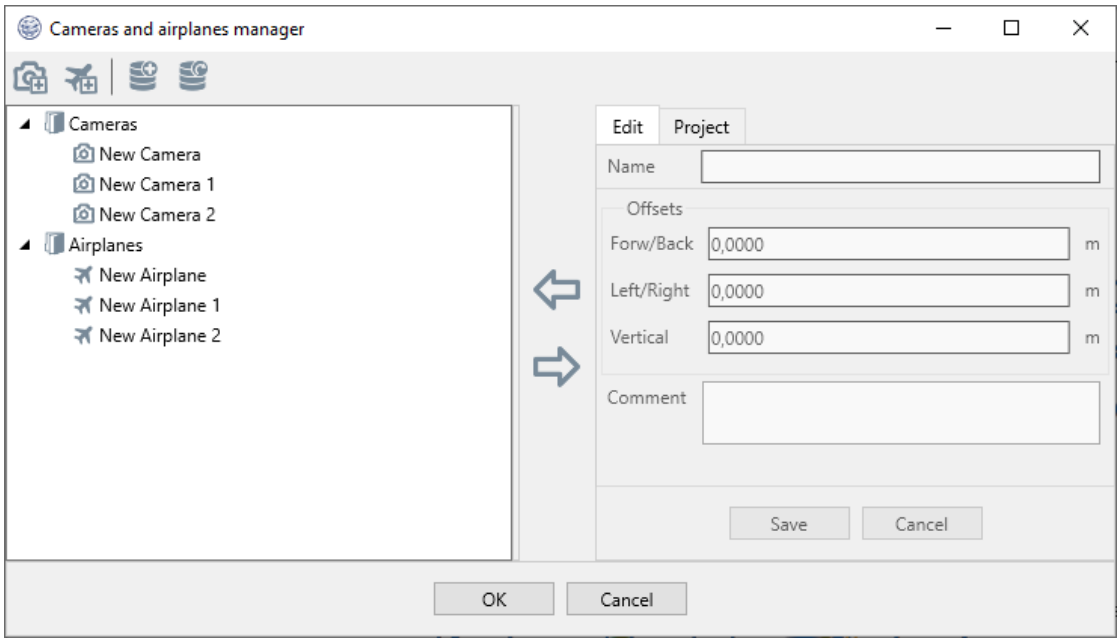


Figure 209 – Cameras and airplane manager

Left panel

The panel of the window has lists of airplanes and cameras, defined in the program. The icon ribbon implements the following functions:

	create an object *New Camera*
	create an object *New Airplane*
	create BackUp File
	restore BackUp File

It is possible to edit names of the aircraft and the camera by double-clicking on the name of the camera or the aircraft.
Right-clicking on any element on the left side of the window opens a menu with the following functions:

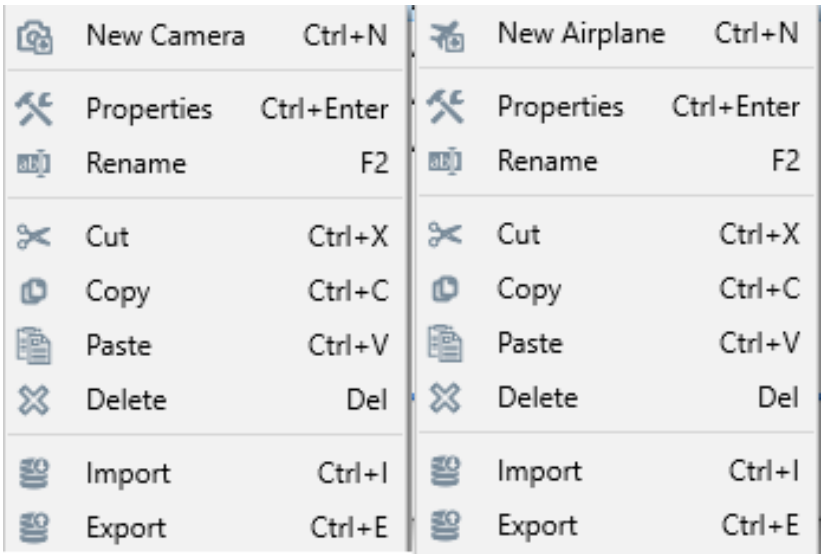


Figure 210 – Program menu

New Camera (Airplane)	create an object *New Camera (New Airplane)*
Propertie	opens windows for entering camera parameters and setting up the receiver:

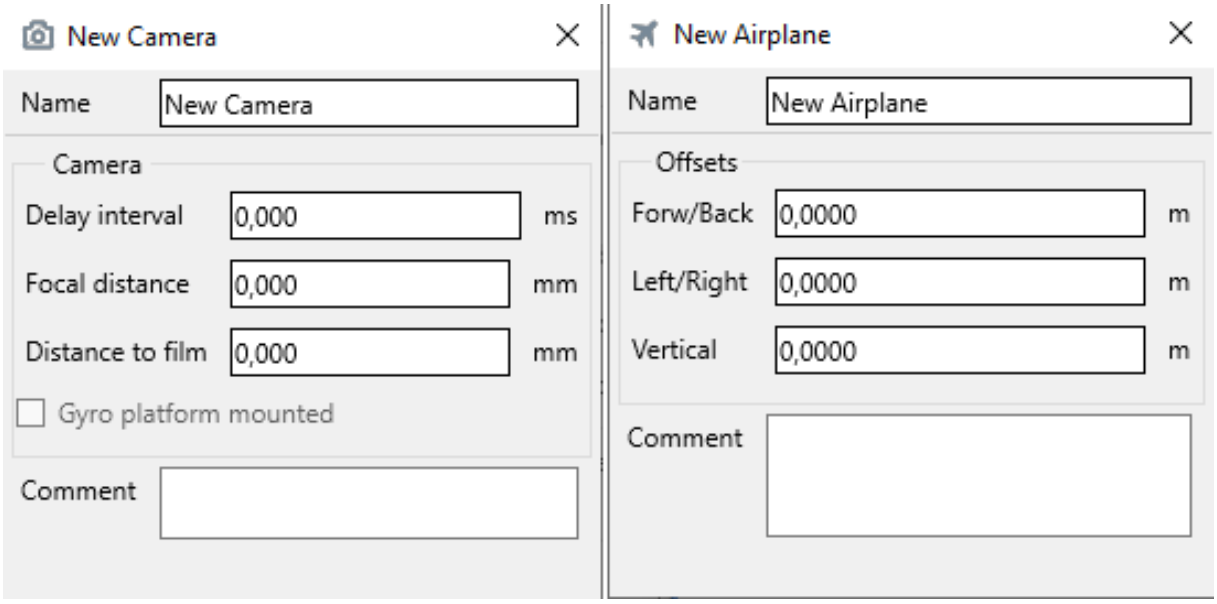


Figure 211 – Shifts and camera parameters

Rename	rename an object
Cut	cut out an object
Copy	copy an object
Paste	paste copied or cut
Delete	delete an object
Import	import of sets of shifts and camera parameters from *. *PAC* files
Export	export of sets of shifts and camera parameters to *. *PAC* files

Parameters related to the aerial camera and the aircraft are automatically recognized when importing from *PAC* files.

Right panel

The *Edit* tab of the right panel contains information about the shifts and camera parameters selected in the left panel and is used to exchange information between the project and the program. The main functions are implemented in a menu that opens when you right-click on an object and are similar to those described above

12.1 Receiver installation parameters

Parameter *Forw/Back* allows to set the offset, which is measured along the aircraft axis from the antenna phase center to the center of the film plane with the corresponding sign:

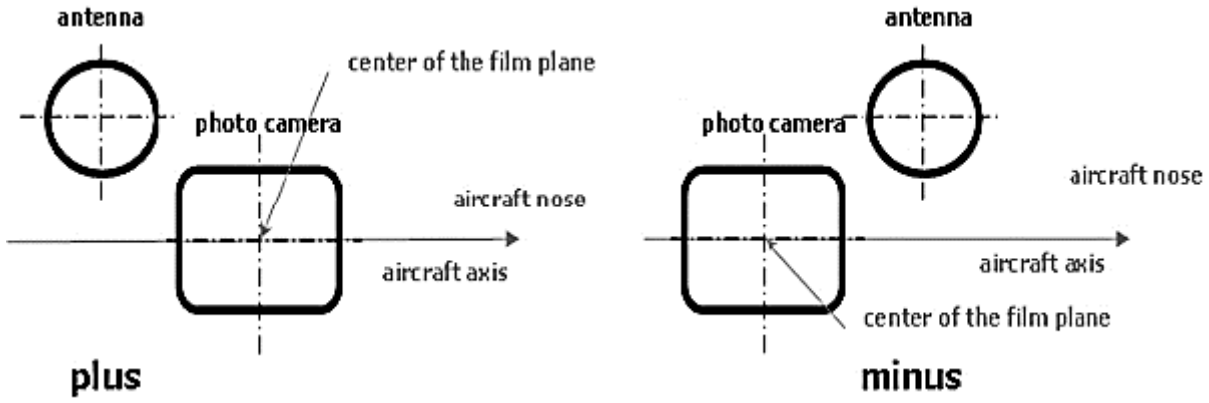


Figure 212 – Forw/Back offset

Parameter *Left/Right* allows to set the offset, which is measured across the aircraft axis from the phase center of the antenna to the center of the film plane with the corresponding sign:

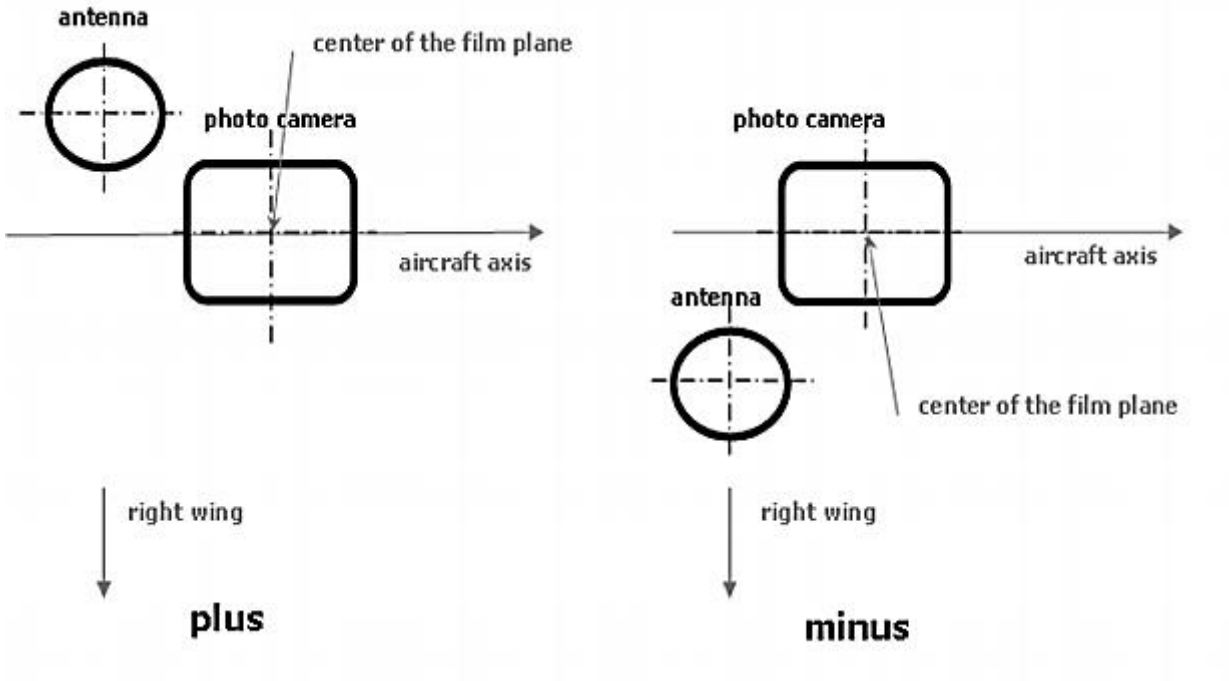


Figure 213 – Left/Right offset

Parameter *Vertical* allows to set distance from the ARP antenna to the film plane, which is measured along the vertical axis.

12.2 Camers parameters

The *Delay interval* (milliseconds) allows to set delay between the moment of camera exposure and the event time measured by the receiver.
Focal length (millimeters) allows to set the focal length of the camera.
Distance to the film (millimeters) allows to set the distance to the film plane, which is measured from the center of rotation of the camera to the film plane. The distance will be positive if the center of rotation of the camera is below the plane of the film.
If *Gyro platform mounted* is checked, the camera was used with a gyro platform, and the camera orientation angles should be used when calculating the coordinates of the events. Otherwise,

aircraft orientation angles should be specified manually in the table *Markers.* To do this, select *View* and *Markers* in the main menu, select the columns in the table that opens, right-click and edit the values of the *Yaw*, *Pitch* and *Roll* parameters.

The *Project* item shows lists of airplanes and cameras in the project database:

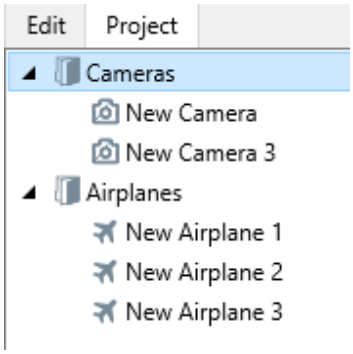


Figure 214– Project tab

To copy from program database to the project database or vice versa, select the element to be copied and click the button  or  .

CHAPTER 13. COORDINATE CALCULATOR

The tool is available through main menu *Tools* item:

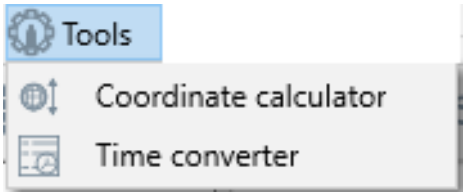


Figure 215 – Coordinate calculator item

or by clicking  button on a toolbar:

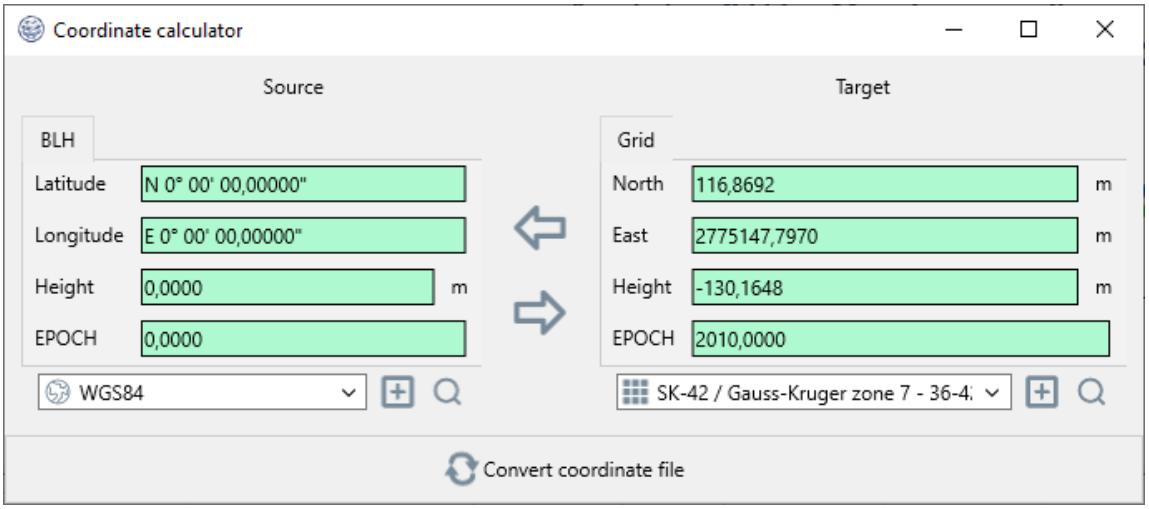


Figure 216 – Coordinate calculator window

The calculator window consists of two panels, where it is possible to select a source and target coordinate systems (in the future CS) from a list. In order for the CS to be in this list, copy the CS from the *Favorites* folder using the button  :

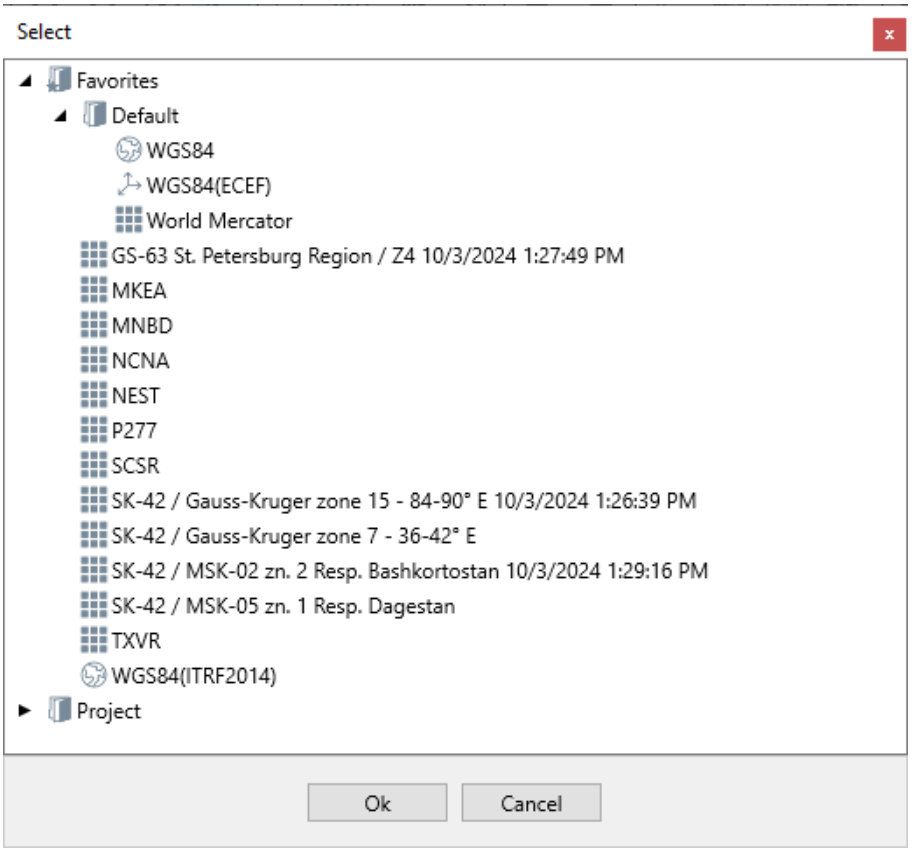


Figure 217 – Favorites folder

The CS selected in this window after pressing the OK button is included to the list of CS of the calculator.

The coordinate system is copied to the Favorites folder from the program database using the Coordinate System Editor. Any number of CS may be copied to this folder.

Coordinates are recalculated by pressing arrows  and  in the direction indicated by the arrows. Both panels are equivalent and the panel selection for entering the initial coordinates does not matter.

The choice of the source and the resulting CS in both panels is carried out in the drop-down list of the CS of the calculator:

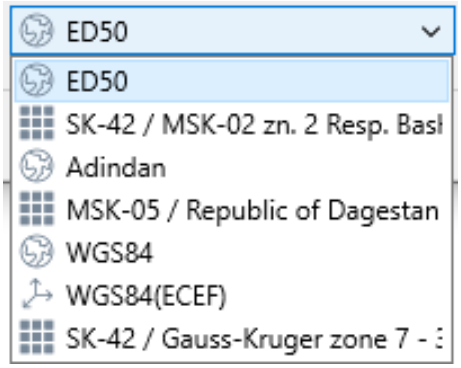


Figure 218 – Choice of CS

By clicking the button  activates the window with the parameters selected CS:

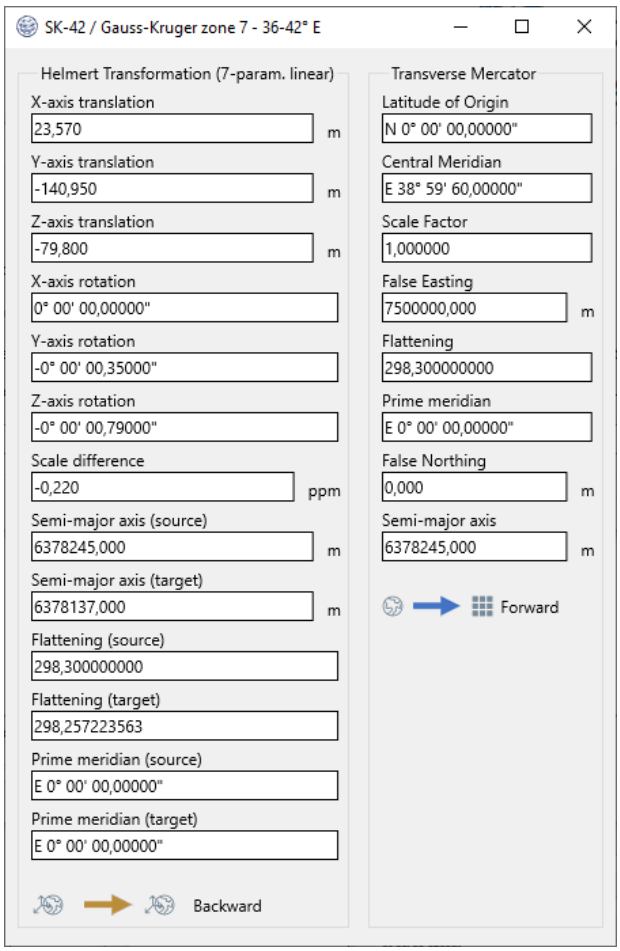
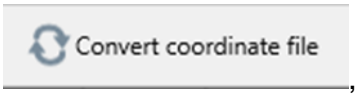


Figure 219 – CS parameters

The color of the arrow and the label show the direction of conversion, for which the parameters are given.

For the batch recalculation of coordinates, click the button 

, select the file containing the coordinates in the window 

select the file, where recalculated coordinates will be placed in the window and then click *Save*.

Define templates

It is necessary to specify templates of formats for input and output of coordinates:

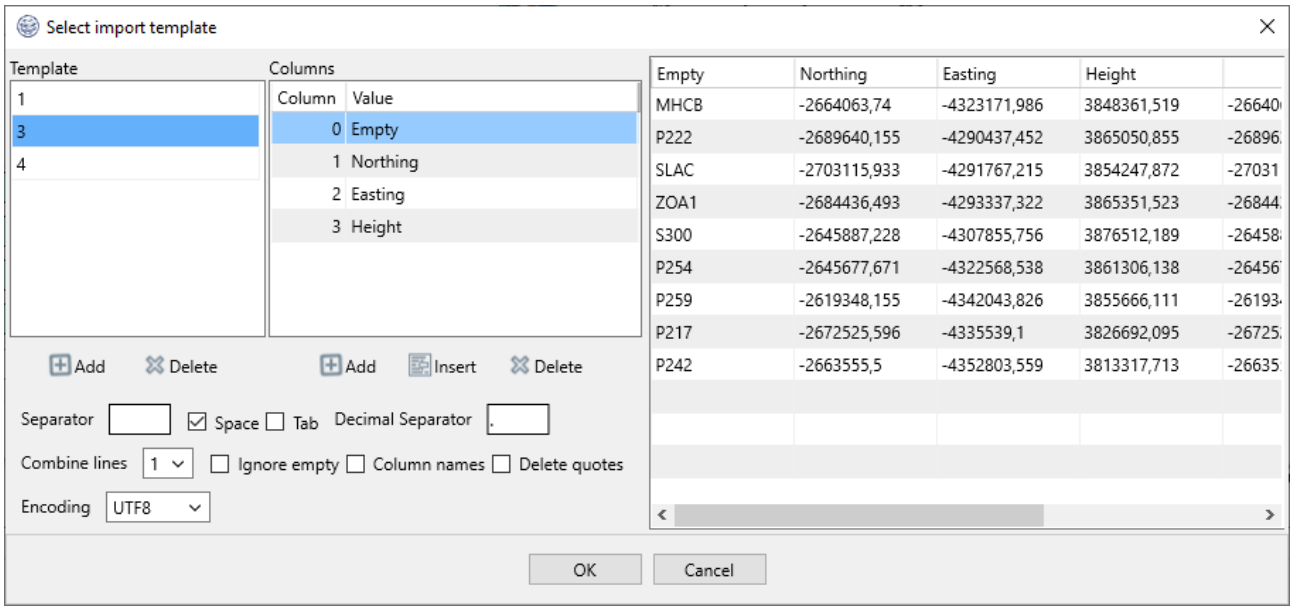


Figure 220 – Coordinate input template