

ProGeoOffice

User Manual Version 1.84.3 2024



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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: <u>support@progeo.online</u> The site of the company:<u>https://progeo.online</u>

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:

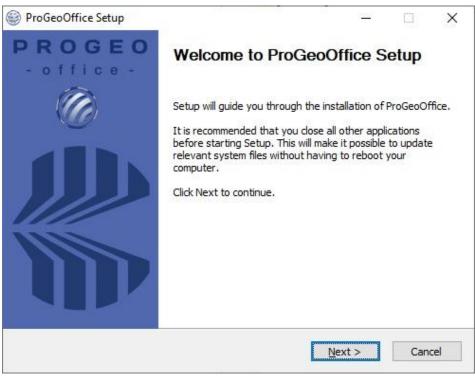


Figure 1 – Product information window

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

| ProGeoOffice Setup | _ | | \times |
|----------------------------------------------------------------------------------------------------------------------------------------|------------|----------|----------|
| Installing Please wait while ProGeoOffice is being installed. | | | ۲ |
| Extract: C:\Users\av.boikov\AppData\Local\Progress\ProGeoOffice\ | Reports\Ge | oData\ga | ao 20 1 |
| Show details | | | |
| | | | |
| | | | |
| Nullsoft Install System v3.09 Kelfacture.com Back | lext > | Car | ncel |

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.

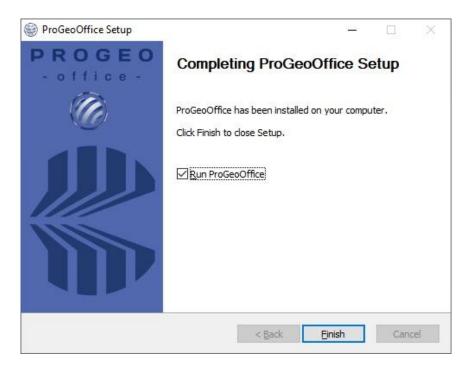


Figure 3 – Corresponding window will be displayed

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.

| Online | | | | \sim |
|-----------|------------------------------|---|---|--------|
| 8 | Activate a new license | | | |
| <u>®</u> | Activate an unlinked license | • | | |
| lon-perso | nalized license (1131363083) | | | |
| ProGeoC | | | | |
| | Activating a new license - | | × | |
| | Кеу | | | |
| | OK Cancel | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

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 XXXXX-XXXXX-XXXXX-XXXXX.

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:

| Non-personalized | license (390545 | 0077) | 0 |
|---------------------|-----------------|---------------------|---|
| ProGeoOffice | | | |
| Q 12 Q | Reports | 31.12.2024 23:59:59 | |
| 9 <u>2</u> <u>8</u> | StaticProcess | 31.12.2024 23:59:59 | |

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".

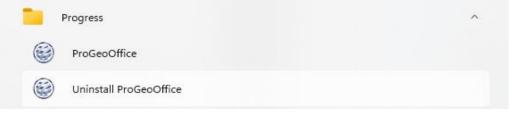


Figure 6 – Window with the installed program

Also through the "Installed applications" menu:

| Apps > Installed apps | | |
|---------------------------------------------------------------------|-----------------|------------|
| ProGeoOffice | × | = 88 @ |
| Filter by: All drives → All Sort by: | Name (A to Z) 🗸 | |
| app found | | |
| ProGeoOffice 1.84.8 Progress 8/2/2024 | | 908 KB ••• |

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:

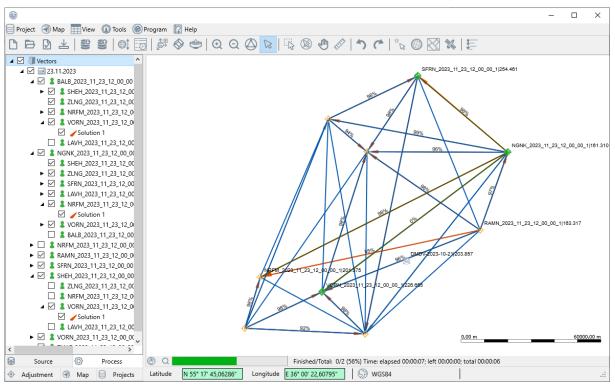


Figure 8 – Main window

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:

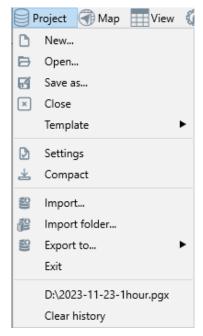


Figure 10 – Project menu item

| 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 |
| Exit | |

Note: some project menu items are duplicated in the toolbar

Мар

The Map menu contains the following items:

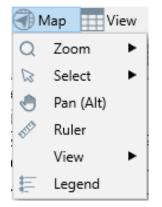


Figure 11 – Map menu item

Zoom contains the following items:

| € | ZoomIn | |
|------------|----------|------------|
| Q | ZoomOut | |
| \bigcirc | Show all | Ctrl+Space |
| | | |

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:

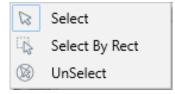


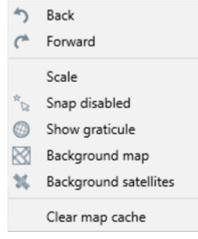
Figure 13 – Menu item Select

| 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:





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

| 🎯 Scale | | × |
|-----------------|-----|-----|
| Pixels per mete | r: | |
| 0,0045 | | |
| OK | Can | cel |

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:

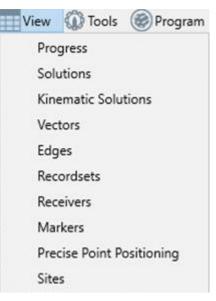


Figure 16 – View menu item

Progress - data processing progress information

| Туре | 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 | | | | | |
| X | 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 | 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 | 1 | 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 | 1 | 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 | 1 | 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 | 1 | 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 | 1 | 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

| | | | | 1 | U | | | | | |
|---------|----------|-------------------------|-----------|---------------------|---------------------|-------------|--------|-----|--------------|--------------|
| 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 | \checkmark |
| 2 | | Base / Site: Base | Track | 14.07.2004 10:59:14 | 14.07.2004 11:15:42 | 0 / 0:16:28 | 988 | 943 | 95 | \checkmark |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| Records | count: 2 | 2 Selected: 0 | | | | | | | | |



Vectors - vectors table

| RecNo | Style | Begin point | End point | Begin time | End time | Time span | Epochs | Length, m | Azimuth | Visible | Solutions |
|-------|-------|--------------|--------------|---------------------|---------------------|-------------|--------|-----------|--------------------|--------------|-----------|
| 1 | 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" | \checkmark | 1 |
| 2 | 1 | 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 | 1 | 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 | 1 | 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 | 1 | 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" | \checkmark | 1 |
| 6 | 1 | 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 |

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 | 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 | 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 | 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 | 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 | 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 | 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 typ | e | Antenna | Height type |
|-------|-------|---------|---------------------|---------------------|-------------|--------|--------|-------------|----------------|----------|-------------|------|---------|---------------|
| 1 | 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 | 1 | 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 | 1 | 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 | 1 | 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 | 1 | 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 | |

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" | F 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 | ٠ | 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 | ٠ | 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 | 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 | 0 | 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 | 6 | RAMN 2023 | Adjust | N 55° 33' 37 80466" | F 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:

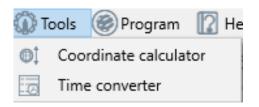


Figure 27 – Tools menu item

Coordinate calculator coordinate calculator is described in chapter Coordinate calculator

Time converter time converter

| le Time converter | | × |
|--------------------|--------------|----------------|
| GPS(sec) | 1392029825,4 | 458 |
| GPS(Day/Sec) | 15.02.2024 | → 39425,458 + |
| GPS(Week/Sec) | 2301 | ▲ 385025,458 ▲ |
| GPS(Day of week) | 2301 | ▲ 4 ▲ |
| GPS(Day of year) | 2024 | ▲ 46 ▲ |
| GPS(Date / time) | 15.02.2024 | ✓ 10:57:05 ÷ |
| UTC(Date / time) | 15.02.2024 | ∽ 10:56:47 🛟 |
| Local(Date / time) | 15.02.2024 | ∽ 13:56:47 🔹 |

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:

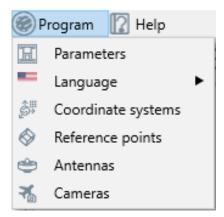


Figure 29 – Program menu item

Common tab

| Program parameters × | | | | | | | | | | | | |
|-----------------------------------------|------------|--------|--------|---------|-------|------|-----------|-------|--|--|--|--|
| Common | Import | Format | Report | Markers | Map | CORS | Interface | Proxy | | | | |
| Open last project | | | | | | | | | | | | |
| Use epoch in coordinate trasformation | | | | | | | | | | | | |
| Request downloading if geoid not exists | | | | | | | | | | | | |
| After ex | oport open | file | | | | | | | | | | |
| Number of | threads | 4 | ~ | | | | | | | | | |
| Templates fo | older path | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | OK | Ca | ancel | | | | | | | |

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

| Program parameters | | | | | | | | | | | | |
|-------------------------------------------------------------------------------------------------------------------------------|--------|--------|--------|---------|-----|------|-----------|-------|--|--|--|--|
| Common | Import | Format | Report | Markers | Map | CORS | Interface | Proxy | | | | |
| ✓ Calculate coordinates ☐ Don't import nested data ✓ Don't load ephemeris from Internet | | | | | | | | | | | | |
| OK Cancel | | | | | | | | | | | | |
| | Cancel | | | | | | | | | | | |

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.

| Common | Import | Format | Report | Markers | Map | CORS | Interface | Proxy | | | |
|----------|---------------|-------------|--------|-------------------------|-----|------|---------------------------------|-------|--|--|--|
| Time | | | | Coordina | tes | | | | | | |
| System G | iPS | | ~ | Angle type | | [| Degress, Minutes and Seconds $$ | | | | |
| View D | w Date/Time ~ | | | | | | N / S and W / E 🗸 | | | | |
| Format | | | ~ | Angle seconds precision | | | 0,11223 | | | | |
| Units | | | | Length precision | | | 0,1122 | | | | |
| Length m | neters | | ~ | | | | | | | | |
| Angle d | egrees | | ~ | | | | | | | | |
| _ | | | | | | | | | | | |
| Restor | e default fo | rmat settin | gs | | | | | | | | |

Figure 32 – Program parameters. Format tab

Report tab

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

| Program parameters × | | | | | | | | | | | |
|-----------------------------------------------------------------|--------|--------|--------|---------|-------|------|-----------|-------|--|--|--|
| Common | Import | Format | Report | Markers | Map | CORS | Interface | Proxy | | | |
| ✓ Open report file after generated Report type Render ✓ | | | | | | | | | | | |
| | | | | OK | Cance | el | | | | | |

Figure 33 – Program parameters. Report tab

Markers tab

Type of epoch coordinates interpolation.

| Common | Import | Format | Report | Markers | Map | CORS | Interface | Proxy | |
|--------|--------|--------|--------|---------|-----|------|-----------|-------|--|
| Marker | | n | | | | | | | |
| 0 -p | | | | | | | | | |

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.

| 🛞 Program | n paramete | ers | | | | | | | × |
|------------------------------|------------|--------|--------|---------|-------|------|-----------|-------|---|
| Common | Import | Format | Report | Markers | Map | CORS | Interface | Proxy | |
| Backgrou Mapbo Alterna | х | | | | | | | | |
| ☐ Show g ☑ Show c | | panel | | | | | | | |
| | | | | OK | Cance | el | | | |

Figure 35 – Program parameters. Map tab

CORS tab

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

| Program parameters | | | | | | | | | | | |
|-------------------------------|--------|--------|--------|---------|-------|------|-----------|-------|--|--|--|
| Common | Import | Format | Report | Markers | Map | CORS | Interface | Proxy | | | |
| ☑ Enable CORS to CORS vectors | | | | | | | | | | | |
| | | | | OK | Cance | el | | | | | |

Figure 36 – Program parameters. CORS tab

Interface tab

Setting up interface elements.

| 🎯 Progran | Program parameters | | | | | | × | | |
|----------------------------|-------------------------------------------|--------------|------------|---------|-------|------|-----------|-------|--|
| Common | Import | Format | Report | Markers | Мар | CORS | Interface | Proxy | |
| | vector icon | | | | | | | | |
| Allow ir | Allow in-place editing in the object tree | | | | | | | | |
| Sites tree in separate tab | | | | | | | | | |
| Show c | ommon pr | ogress in tr | ee panel | | | | | | |
| Icons Color | | | ~ ^ | | | | | | |
| | | | | OK | Cance | el | | | |

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.

| Program | n paramete | ers | | | | | | | × |
|---------------------------------------|------------|--------|--------------------------------------------|---------|--------|------|-----------|-------|---|
| Common | Import | Format | Report | Markers | Map | CORS | Interface | Proxy | |
| Proxy co No pro Autode Manua | etect | /pe (| Protocol ty) http) socks ddress | /pe | | | Port | 0 | |
| | | | | | | | | | |
| | | | OK | (| Cancel | | | | |

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:

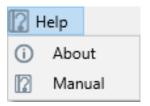


Figure 39 – HELP menu item

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.

| C | dialog window New project |
|--------------|---------------------------------------------------|
| ₿ | dialog window <i>Open project</i> |
| | dialog window Project setting |
| + | compact project |
| S | dialog window Import files |
| <u>9</u>)) | dialog window Export project data |
| € | Coordinate calculator |
| Ø | Time converter |
| <u>,</u> | Coordinate system manager |
| \bigotimes | Reference points manager |
| ٢ | Antennas manager |
| • | increases map scale |
| Q | decreases map scale |
| \bigcirc | shows entire program layers |
| \square | sets cursor in <i>Selection in point</i> mode |
| | sets cursor in <i>Selection in rectangle</i> mode |
| | unselect |

Chapter 2. Main window

| ٩ | panning the map | | | |
|--------------|--------------------------------------------------------------------|--|--|--|
| ALE - | sets the cursor in ruler mode for distance and azimuth measurement | | | |
| 5 | returns the map in previous position and scale | | | |
| C | returns the map to initial position and scale after | | | |
| | sets the snapping mode for the ruler | | | |
| | show/hide grid | | | |
| \bigotimes | show/hide raster map | | | |
| tela, | shows/hides space images | | | |
| * | show Legend | | | |
| 69 v | vGS84 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:

| 3 | 2 | | Fin | ished/Total: 0/1 (25%) |) Time: elap | osed 00:00:01; left 00: | 00:05; total 00:0 | 0:07 |
|----------------|---------------|-------------------|----------------------------------------------|------------------------|--------------|-------------------------|-------------------|------|
| Click Click | () to | stop the activate | Figure e process. Progress table: | 41 – Status bar | | | | |
| | 4 | ~ | | - | | | | |
| Туре | Time | Remaining | Name | Status | Progress | Finished | Speed | Log |
| \$ | 00:00:10 | 00:00:01 | BALB_2023_11_23_12_00_00=>LAVH_2023 | phase evaluation | | 99% | 99%/s | |
| \$ | 00:00:10 | 00:00:01 | BALB_2023_11_23_12_00_00=>SHEH_2023 | base capturing | | 84% | 16%/s | |
| \$ | 00:00:10 | 00:00:00 | BALB_2023_11_23_12_00_00=>DMDV_202 | base capturing | | 74% | 37%/s | |
| \$ | 00:00:10 | 00:00:00 | BALB_2023_11_23_12_00_00=>NRFM_2023 | base capturing | | 93% | 31%/s | |
| | | | | | | | | |
| < | | | | | | | | > |
| Records o | ount: 4 Tin | ne: 00:00:10 | Time left: 00:00:01 88% Finished / Total | : 0/4 | | | | |

Figure 42 – Progress table

The table toolbar contains the following icons:

| ۲ | to stop the process |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | to clear the window |
| <u></u> | switch to log tab for process summary |
| 11:: 11:: 11:: 11:: | 28:03 11:27:50: : Loading https://eph.radioride.ru/corsdata/rinex/2023/138/brdc1380.23n.gz https://eph.radioride.ru/corsdata/rinex/2023/138/brdc1380.23n.gz 28:03: : Loading https://eph.radioride.ru/corsdata/rinex/2023/138/brdc1380.23n.gz 20231380000_01D_MN.rnx.gz 2023/138/brdc1380:03: : Loading https://eph.radioride.ru/archive/gnas/data/daily/2023/brdc/BRDC00165_R_20231380000_01D_MN.rnx.gz 20231380000_01D_MN.rnx.gz 2023138000_01D_MN.rnx.gz 202300_01D_MN.rnx.gz 202300_MN.rnx.gz 202300_01D_MN.rnx.gz 202300_01D_MN.rnx.gz 202300_01D_MN.rnx.gz 202300_01D_MN.rnx.gz 202300_01D |

11:28:08 11:27:49: : Loading file:///C:/Boikov/GFS_RAW_FILES/2023-05-18/T3-03-20230518.jps 11:28:07: : C:\Boikov\GFS_RAW_FILES\2023-05-18\T3-03-20230518.jps finished; 1684 epochs total

Figure 43 – log-file

| | lift completed processes up |
|-----|--------------------------------------|
| | remove terminated processes messages |
| 4 ~ | 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*:





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

| 8 | Project | ► | J | Files | Ctrl+Alt+1 |
|---------------------------------------|---------------|---|---|------------|------------|
| ¢↓ | Sort By | ► | ۲ | Receivers | Ctrl+Alt+2 |
| go | Import | | | Dataset | Ctrl+Alt+3 |
| i i i i i i i i i i i i i i i i i i i | Import folder | | 1 | Recordsets | Ctrl+Alt+4 |
| | Clear project | | 0 | Sites | Ctrl+Alt+5 |

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:

| 🔺 🗹 🗇 Project |
|-------------------------------|
| 🔺 🗹 🛇 Recordset coordinates |
| Receiver |
| ProGeoOffice |
| 🔺 🗹 🛇 Vectors |
| Static |
| 🗹 Kinematic |
| 🔺 🗹 🔿 Solutions |
| Static |
| 🔺 🗹 Kinematic |
| Fixed |
| 🗹 Float |
| 🗹 🔿 Sites |
| 🗹 🔿 Reference points |
| 🗹 🔿 Precise Point Positioning |
| 🔺 🗹 🔿 Network |
| ✓ Edges |
| Adjusted kinematic |
| Markers |
| 🗹 XA |
| ⊠ XB |
| ⊠ xc |
| 🕨 🖉 🗞 Countries |
| ► 🗹 🗞 CORS |
| |
| Source 💮 Process |
| ♦ Adjustment ④ Map 	Projects |

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 |
| °00 0 00 | 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) |
|----------------------------------------|--------------------------------------------------------|
| 1000 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | float kinematic solution |
| 9 | site on standalone coordinates |
| \sim | site on post-processed coordinates |
| - | site on adjusted coordinates |
| ب | site snapped to reference point |
| \$ | reference point |
| • | Precise Point Positioning solution |
| | common edge |
| 1000001 | adjusted kinematic |
| YNY. | events |

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

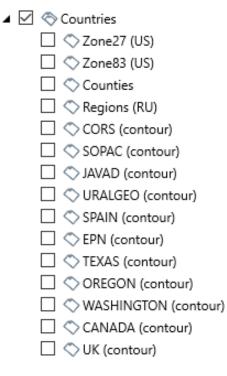


Figure 47 – Contours

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:

| 4 | \checkmark | 🔿 Network | : |
|---|--------------|------------|-------|
| | | 🗹 Edges 👔 | |
| | | 🗹 Adjusted | Style |

Figure 49 – Layer style

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

| le Style | × |
|-----------------------------------|---------------------------------------------|
| Lines Label | |
| Width < 2 > Color v | L1 + L2 + L5 Width < 2 Color Arrow |
| L1 only Width < 2 > Color ~ | L2 only Width < 2 > Color / Arrow |
| L5 only Width < 2 > Color ~ | Wide lane Width < 2 > Color |
| ОК | Cancel Default |

Figure 50 – Style settings for line object

| Lines | Label | | | |
|--------------------------------------------------------------|-------------------------------------------------------------|--------|-----------------------------------------------------------------------------|--|
| ∨ V Posit Offse Offse Colc E E I | ′isible tion et Vert. et Horiz. xxt style− t | Arial | Label values Separator Name Fix ratio Length discarded 0% | |
| Effe | cts k Color | None ~ | | |

Figure 51 – Label tab

| 🖗 Style 🛛 🗙 |
|------------------------|
| Track |
| ngine type Default ~ |
| Fixed Visible |
| Begin color |
| End color |
| Size < 7 |
| Float |
| Visible Begin color |
| End color |
| Size < 7 |
| OK Cancel Default |

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.

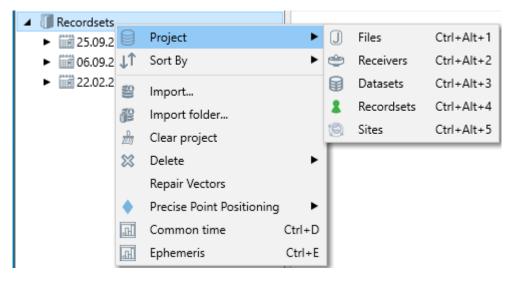


Figure 53 – Project

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.

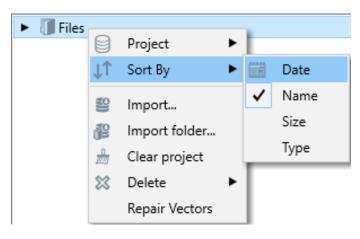


Figure 54 - Files, Sort by

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

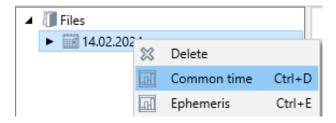


Figure 55 – Common Time

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

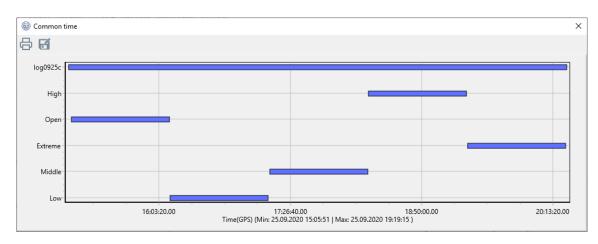


Figure 56 – Common Time diagram

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.

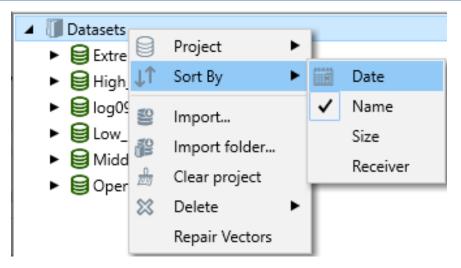


Figure 58 – Datasets, sort by

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.

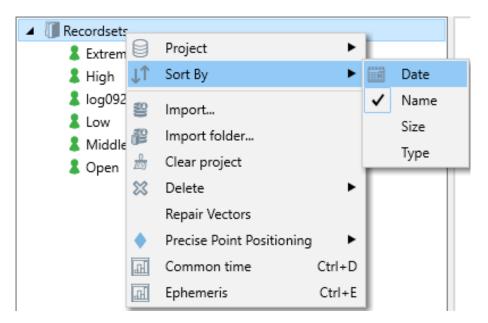
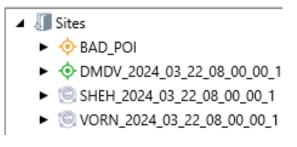


Figure 59 – Recordsets, sort by

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





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.

| | C ≯ New d | lisk (D:) > NTRIP-MGGT > 2023-11-23-1hou | ır 🗸 | ن 🔎 Search | 2023-11-23-1hour |
|---------------------|-----------|------------------------------------------|------------------|---------------------------------|---------------------------------------|
| ganize 🔻 New folder | | | | | · · · · · · · · · · · · · · · · · · · |
| | ^ | Name | Date modified | Туре | Size |
| Quick access | | BALB_2023_11_23_12_00_00.rtcm | 30.11.2023 16:30 | RTCM File | 5 073 KB |
| E Desktop | * | BRDC_2023_11_23_11_00_03.rtcm | 30.11.2023 16:30 | RTCM File | 6 253 KB |
| 🕂 Downloads | * | BRDC_2023_11_23_12_00_03.rtcm | 30.11.2023 16:30 | RTCM File | 6 253 KB |
| 🔮 Documents | * | BRDC_2023_11_23_13_00_03.rtcm | 30.11.2023 16:30 | RTCM File | 6 253 KB |
| Pictures | * | DMDV_2023_11_23_12_00_00.rtcm | 30.11.2023 16:30 | RTCM File | 4 975 KB |
| 0.0 | | LAVH_2023_11_23_12_00_00.rtcm | 30.11.2023 16:31 | RTCM File | 4 225 KB |
| OneDrive | | NGNK_2023_11_23_12_00_00.rtcm | 30.11.2023 16:31 | RTCM File | 4 829 KB |
| 🛃 Yandex.Disk | | NRFM_2023_11_23_12_00_00.rtcm | 30.11.2023 16:31 | RTCM File | 3 150 KB |
| This DC | | RAMN_2023_11_23_12_00_00.rtcm | 30.11.2023 16:31 | RTCM File | 3 805 KB |
| This PC | | SFRN_2023_11_23_12_00_00.rtcm | 30.11.2023 16:31 | RTCM File | 4 838 KB |
| 🧊 3D Objects | | SHEH_2023_11_23_12_00_00.rtcm | 30.11.2023 16:32 | RTCM File | 4 945 KB |
| 📃 Desktop | | VORN_2023_11_23_12_00_00.rtcm | 30.11.2023 16:32 | RTCM File | 3 154 KB |
| A Documents | × | TINC 2022 11 22 12 00 00 | 20 11 2022 16:22 | DTCNA FOL | 2 002 KB |
| File <u>n</u> ame | s | | | RTCM3 files | (*.rtcm) |

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: |

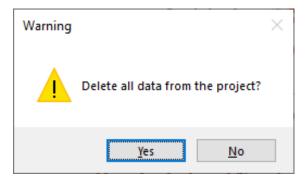


Figure 62 – Delete confirmation

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 postprocessing

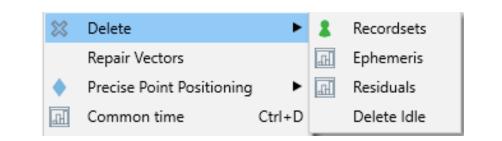


Figure 63 – Delete selected data

| Repair Vectors | restores vectors. Optic | restores vectors. Option may be helpful in case of program crash | | | | | | |
|---------------------------|---------------------------|------------------------------------------------------------------|---------|-----|--|--|--|--|
| | by some reasons. | | | | | | | |
| Precise Point Positioning | calculation of coordina | ates | by PPP: | | | | | |
| • | Precise Point Positioning | ŝ | Process | F12 | | | | |
| æ | Common time Ctrl+D | 8 | Delete | Del | | | | |

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 | | | | | |

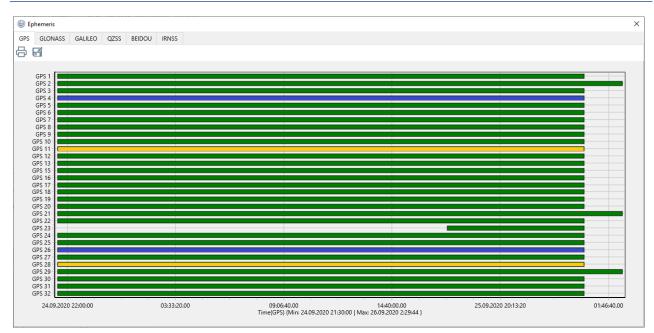


Figure 65 – Satellite ephemeris diagram

4.1 Files

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

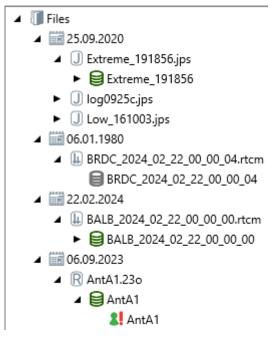


Figure 66 – Files

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:

| Receivers |
|---------------------------------------------|
| JAVAD TR_LS4_1WUDUG405OJNN371LGYHOEA9DT |
| Extreme_191856 |
| Elsow_161003 |
| IAVAD TRIUMPH3_H3A868C1BD42DBBEE4FF |
| JAVAD TRIUMPH_1M_0S5X908K4D6I90QDSPVJA2QGHS |
| LEICA GR30_1707739/10/0/0 |
| BALB_2024_02_22_00_00_00 |
| |

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:

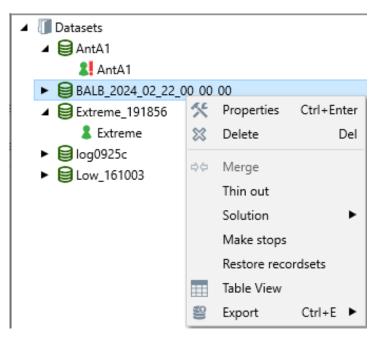


Figure 68 – Datasets

Properties

| le AntA1 | | | | > |
|--------------|----------------------------------------------|------------|---------------------|----------|
| General Rece | iver and Antenna Satellites SkyPlot | | | |
| FileName | C:\Boikov\GPS_RAW_FILES\2023-09-07\AntA1.230 | Begin time | 06.09.2023 ~ | 15:21:30 |
| Alias | AntA1 | End time | 07.09.2023 ~ | 6:55:00 |
| Site | AntA1 | Interval | 30,000 | se |
| MarkerName | AntA1 | Epoch | 1868 | |
| MarkerNumber | 0 | RMS | 1,6664 | n |
| Comment | | XYZ BL | H Grid | |
| | Source and model:"" | Latitude | N 55° 50' 36,43116" | |
| | | Longitude | E 37° 32' 14,58129" | |
| Observer | | Height | 205,1261 | m |
| Agency | | EPOCH | 0,0000 | |
| | | S WGS8 | 14 | ~ |
| | | | | |
| | ОК | Cancel | | |

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:

| 🛞 AntA1 | | × |
|-----------------|--------------------------------------|-------------------------|
| General Rece | eiver and Antenna Satellites SkyPlot | |
| Receiver | | Antenna |
| Туре | JAVAD TRIUMPH3 | Туре |
| Board | | Unknown V Q |
| Serial number | | Height |
| ID | H3A868C1BD42DBBEE4FF | Type Vertical(ARP) ~ |
| Firmware versio | n 4.2.01-220630 | Value 0,0000 m |
| Messages | | Offsets |
| | | North 0,0000 m |
| | | East 0,0000 m |
| | | Vertical 0,0000 m |
| | | Serial number -Unknown- |
| | L | |
| | OK | Cancel |

Figure 70 – Receiver and Antenna tab

Click O 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)

| le AntA1 | | | | | | | | | | | × |
|-----------|----------------------|------------|----------|-------|-----|-------------|-----|-----|-----|-----|---|
| General | Receiver and Antenna | Satellites | SkyPlot | | | | | | | | |
| Satellite | s | | | | Sig | nals | | | | | ^ |
| ∧ GPS | | | | | ~ 0 | SPS 📕 | | | | | |
| 12 | 345678 | 91011 | 12 13 14 | | C1C | C1W | C2X | C2W | C5X | C1X | |
| 1516(| 789222 | 23 24 25 | 26 27 28 | | L1C | L1W | L2X | L2W | L5X | L1X | |
| 29 30 3 | ;1 32 33 34 35 36 (| 37 | | | D1C | D1W | D2X | D2W | D5X | D1X | |
| ∧ GLON | IASS 🦲 | | | | S1C | S1W | S2X | S2W | S5X | S1X | |
| 12 | 345678 | 900 | 12 13 14 | | ~ 0 | ∧ GLONASS ■ | | | | | |
| 15160 | 089020 | 23 24 25 | 26 27 28 | | C1C | C1P | C2C | C2P | C3X | С | |
| 29 80 8 | 31 32 | | | | L1C | L1P | L2C | L2P | L3X | L | |
| ∧ GALIL | eo 🥌 | | | | D1C | D1P | D2C | D2P | D3X | D | |
| 02 | 345678 | 900 | 121314 | | S1C | S1P | S2C | S2P | S3X | S | |
| 600 | 713192222 | 3225 | 26 27 28 | | ~ 0 | GALILE | 0 | | | | |
| 29 30 8 | 3 3 3 3 3 3 3 6 | 789 | 40 41 42 | | C1X | C8X | C6X | C7X | C5X | С | |
| 4344 | 15 46 47 48 49 | | | | L1X | L8X | L6X | L7X | L5X | L | ~ |
| | | OK | Ca | ancel | | | | | | | |

Figure 71 – Satellites tab

Information about GNSS satellites and signals. Yellow colored circles mark unhealthy satellites.

Field ^ GALILEO

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.

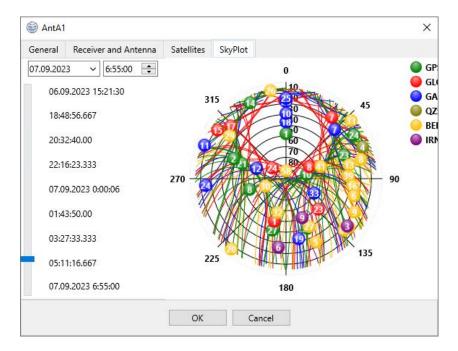


Figure 72 – Sky Plot tab

| 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 |

| _ | | | |
|---|--------------------|---|----------|
| 6 | 🗑 Thinning dataset | | \times |
| | Interval | | |
| | 2,000 | ~ | sec |
| | 10,00 | ^ | |
| | 11,00 | | |
| L | 12,00 | | |
| | 13,00 | | |
| | 14,00 | | |
| | 15,00 | | |
| | 30,00 | | |
| | 60,00 | 4 | |
| | | | |

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 | \checkmark | 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 | \checkmark | 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 | \checkmark | 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 | \checkmark | 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 | \checkmark | 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 | \checkmark | 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 | \checkmark | 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:

| | P20 - | | | |
|---|--------------|-----------------------------------|--------------------|------------|
| 4 | Recordsets | | | |
| | 💦 AntA1 | | | |
| | BALB_2024_02 | * | Properties | Ctrl+Enter |
| | Extreme | Q | Zoom | Ctrl+Space |
| | 8 log0925c | \approx | Delete | Del |
| | 💄 Low | | Visible | |
| | | ۲ | Antenna | |
| | | Ð | Motion mode | • |
| | | $\Leftrightarrow \Leftrightarrow$ | Merge | |
| | | ⇔⇔ | Split | • |
| | | ٠ | Precise Point Posi | tioning |
| | | | Table View | |
| | | 41 | Epochs | |
| | | 41 | Raw data chart | Ctrl+F |
| | | . 1-1 | Common time | Ctrl+D |
| | | h. | Common satellite | s Ctrl+G |
| | | 4 | Ephemeris | Ctrl+E |
| | | (!) | Report | Ctrl+R ► |
| | | 89 | Export | Ctrl+E ► |
| | | | Solution | • |
| | | | | |

Figure 75 – Recordsets

| Properties | a set of tabs and the information are similar to those described in the <i>DATASET</i> 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. |

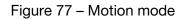
Activating the window for editing antenna parameters:

| 8. | | | _ | ~ | | | |
|----------|---------------|-------|------|---|--|--|--|
| | | | | | | | |
| Туре | | | | | | | |
| JAVTR | UMPH_LSA NONE | | ~ | Q | | | |
| | | | | | | | |
| Heig | ht | | | | | | |
| Туре | Vertical(ARP) | | | ~ | | | |
| Value | 0,0000 | | | | | | |
| | | | | | | | |
| Offse | ts | | | | | | |
| North | 0,0000 | | | m | | | |
| East | 0,0000 | | | m | | | |
| Vertical | 0,0000 | | | | | | |
| | 0,000 | | | | | | |
| | | | | | | | |
| | OK | Cance | el 🛛 | | | | |
| | | | | | | | |

Figure 76 – Antenna type selection

| Motion mode | select the | motion mode for | r recordse | ət | |
|-------------|------------|-----------------|------------|----|-----------|
| | Ð | Motion mode | • | 1 | Static |
| | 00 | Merge | | 75 | Kinematic |

Stop Go



Split

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 same da | | recordsets. Pos | sible | only for reco | ordsets belonging to th |
|--------------|-----------------------------|-----------------|-------------------|-------|----------------|-------------------------|
| Split | divide th | ne recordset in | to two or more | oarts | s by time inte | rval or number of parts |
| | $\langle \Box \Box \rangle$ | Split | • | ⇔⇔ | By time | |
| | • | Precise Point | Positioning | ⇔⇒ | By parts | |
| | | Figure | e 78 – Split reco | rdse | t | |
| Precise Poin | t Positioning | deterr | mination of cool | rdina | tes by metho | od PPP |
| Table view | | data i | n tabular form | | | |

Chapter 4. Source

| 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 | \checkmark | 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 | \checkmark | 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 | \checkmark | 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 | \checkmark | 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 | \checkmark | 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 | \checkmark | 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 |
| < | | | | | | | | | | | | | | > |
| | count: 36 | | 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 | |

Figure 79 – Table

| Epochs data by epoch in t | 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

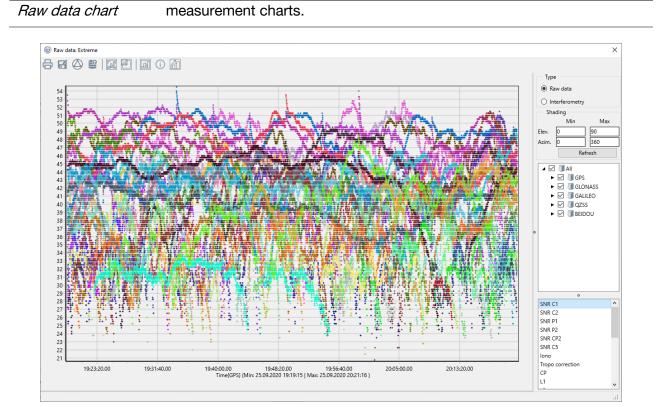


Figure 81– Measurement charts

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)

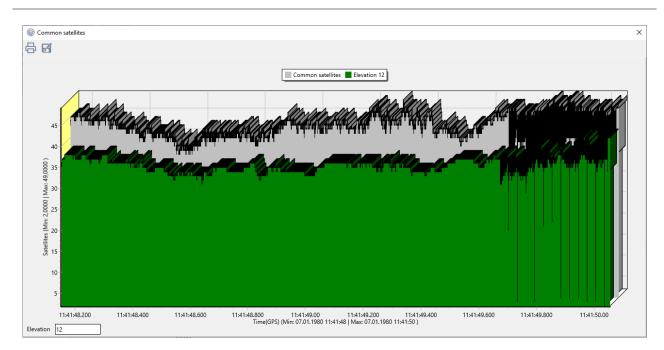


Figure 82 – Common satellites diagram

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

| | 4. Source | | | | | | | | |
|-----------------|---------------------|---------------------------------|---------------------------------------------------|---------------------------------------|--------------------------------|---------------------|---------------------|------------------------|----------------|
| Report - Viewer | pen 🔒 Save 🗸 🖂 🗸 | C. C. D. D. E | | | Close | | | | |
| ne | GPS | Angle type | e Degress, Minutes and S | econds v | | | | | |
| ne view | DateTime | Angle rou | nd 5 | | | | | | |
| ne format | 3/5/2024 5:26:51 PM | Length ro | und 4 | | | | | | |
| ordinate System | WGS84 | Project ep | och 0 | | | | | | |
| iit type | meters | ~ | | | | | | | |
| | | | Reset | Submit | | | | | |
| | | | | Navi | gation | Peport1 | | | |
| | | | | Navi | gation | Report1 | | 0 ⁰ | مى |
| | | | CoordinateSystem | | .gation | Report1 | Program | ProGeoOffice | <u>.</u> |
| | | | CoordinateSystem Height type | | <u></u> 0 | Report1 | Program Version | ProGesOffice 1.84.4 | <u></u> |
| | | | | WGS84 | Creator | Report1 | 975 y <u>7</u> 8888 | | e P |
| | | | Height type | WGS84 Ellipsoidal | Creator Agency | | 975 y <u>7</u> 8888 | | <u>, 8</u> |
| | | Recordset: | Height type Units | WGS94 Ellipsoidal meters GPS | Creator Agency | | Version | | <u>کی</u> ا |
| | | Recordset: Mode: Antonna: | Height type Units Time Extreme Static | WGS94 Ellipsoidal meters GPS | Creator Agency Processed | 05.03.2024 17:26:55 | Version | | |

| Time | Latitude | Longitude | Height, m | RMS , m | PDOP | TOffset | NumSat |
|-------------------------|---------------------|---------------------|-----------|---------|-------|------------|--------|
| 2020-09-25 19:19:15.000 | N 55° 39' 17,32770" | E 38° 06' 11,40770" | 143,5888 | 2,411 | 0,942 | 61 712,855 | 31 |
| 2020-09-25 19:19:16.000 | N 55° 39' 17,30580" | E 38" 06' 11,41144" | 143,3503 | 2,431 | 0,942 | 61 406,807 | 31 |
| 2020-09-25 19:19:17.000 | N 55° 39' 17,32601" | E 38" 06' 11,42268" | 142,9874 | 2,534 | 0,942 | 61 100,848 | 31 |
| 2020-09-25 19:19:18.000 | N 55° 39' 17,27671" | E 38° 06' 11,44356" | 142,0727 | 2,177 | 0,925 | 60 793,890 | 31 |
| 2020-09-25 19:19:19.000 | N 55° 39' 17,26426" | E 38° 06' 11,44554" | 144,3697 | 1,880 | 0,973 | 60 490,126 | 30 |
| 2020-09-25 19:19:20.000 | N 55° 39' 17,32034" | E 38° 06' 11,44570" | 142,3316 | 2,001 | 0,943 | 60 183,210 | 31 |
| 2020-09-25 19:19:21.000 | N 55° 39' 17,30204" | E 38° 06' 11,44510" | 141,8952 | 2,191 | 0,943 | 59 877,312 | 31 |
| | | | | | | | |

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:

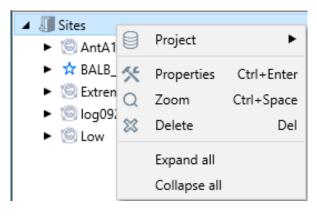


Figure 84 – Sites

Properties

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

| le AntA1 | | | × |
|-----------------|---------------|----------|---|
| Name AntA1 | | | |
| XYZ BLH Gr | id | XYZ NEU | |
| Coordinates | | Sigma | |
| Latitude N 55° | 50' 36,42049" | X 0,8557 | m |
| Longitude E 37° | 32' 14,58894" | Y 0,8436 | m |
| Height 204,4 | 758 m | Z 1,1348 | m |
| EPOCH 0,000 | 0 | | |
| 6 WGS84 | ~ | | |
| Comment | | · | |
| | OK | Cancel | |

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

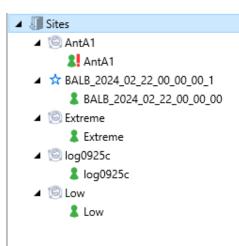


Figure 86 – Expand all

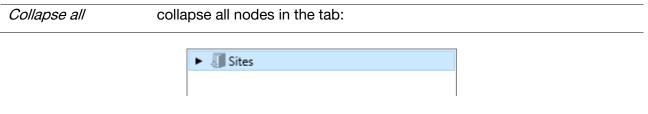


Figure 87 - Collapse all

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:

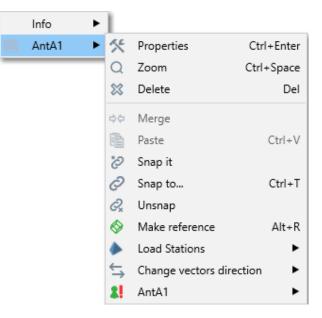


Figure 89 – Site operating

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

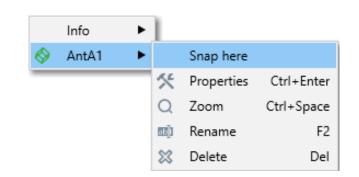


Figure 90 – Snap to selected reference site

| Snap to | snap site to the reference point selected in the list |
|---------|-------------------------------------------------------|
|---------|-------------------------------------------------------|

| LAVH_2023_11_23_12_00_00_1 | | – 🗆 × | |
|-----------------------------------------|-----------|---------------------|--|
| ▲ 💹 Reference points | XYZ BLH | H Grid | |
| ♦ LAVH(0.0057 m) ♦ DMDV(47678.8962 m) | Latitude | N 55° 51' 47.81243" | |
| NRFM(91350.7216 m) | Longitude | E 37° 28' 59.57865" | |
| NGNK(107433.0248 m) BALC(109516.2756 m) | Height | 209.4917 m | |
| Image: Solutions | EPOCH | 2000.2623 | |
| Image: Receiver | G WGS84 | 4 ~ | |
| Unsnap Snap to Cancel | | | |

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 |

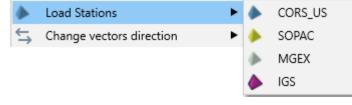


Figure 92 – CORS networks

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.

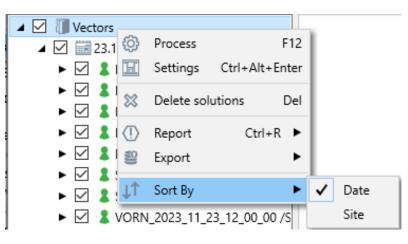


Figure 93 – Sorting vectors

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 |

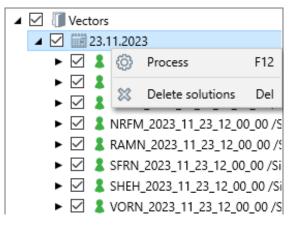


Figure 94 – Date node options

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.

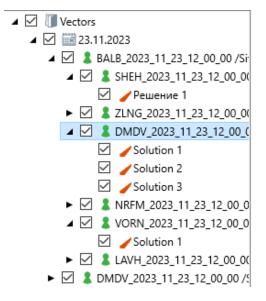


Figure 95 – Vectors tree

Both base site *BALB* and rover site *DMDV* are signed by ¹/₂ static recordset icon.

| ▲ 🗹 🚺 Vectors | |
|----------------------------------------------------------|--------------|
| ⊿ 🗹 🚟 23.11.2023 | |
| ▲ 🗹 🄱 BALB_2023_11_23_12_00_00_/Si | |
| ▲ 🗹 🄱 SHEH_2023_11 😳 Process | F12 |
| ✓ ✓ Решение 1 ► ✓ LNG_2023_11 | Del |
| ■ ■ 21NG_2023_11_ ■ ■ ■ DMDV 2023 11 ■ BALB_2023_11_2 | 3_12_00_00 ► |

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 postprocessing. Initially the rover node is empty. Processing adds a *Solution* to an item.

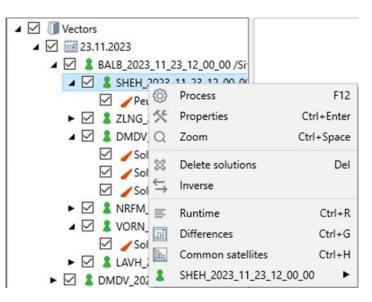


Figure 97 – Rover tree options

Rover node options:

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

| BALB_2023_11_23_12_00_00=>SHEH_2023_11_23_12 × | | | |
|------------------------------------------------|--------------------------|--|--|
| ☑ Visible or | n map | | |
| Base | BALB_2023_11_23_12_00_00 | | |
| Rover | SHEH_2023_11_23_12_00_00 | | |
| Begin time | 23.11.2023 ~ 12:00:00 | | |
| End time | 23.11.2023 ~ 12:59:59 + | | |
| Time span | 0 / 1:00:02 | | |
| Epochs | 3600 | | |
| Length | 51940,007 m | | |
| View base View rover | | | |
| | Close | | |

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 <i>Runtime</i> tab, which allows to process a single vector and obtain two or more solutions for it with different settings (described below in the section <i>Processing a Single Vector</i>) |
| Differences | chart of GNSS signal differences used in post-processing |

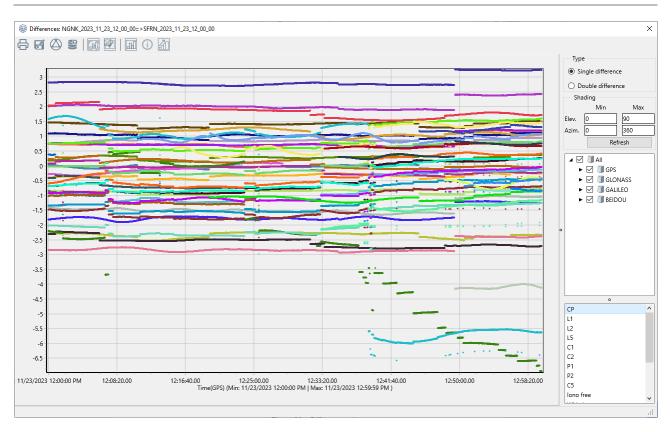
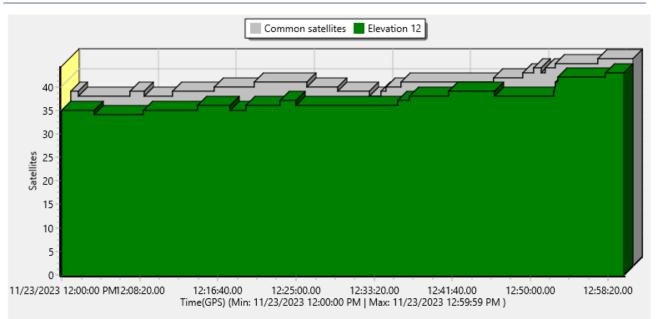


Figure 99 – Differences chart

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

Chapter 5. Post processing





5.1 Settings

| Proce | ess | | × |
|-----------|-------------|-----------------------------------|---|
| Static | Kinematic | | |
| Engine | Satellites | | |
| Engine ty | /pe Default | lt · · · · | ~ |
| Engine | mode | Troposphere Use precise ephemeris | |
| Auto | , | Model Auto ~ Interpolate base | |
| O Fixed | ł | Pressure 980 hPa | |
| ⊖ Float | t | Humidity 50 % | |
| O Code | 2 | ✓ Temperature 20 °C | |
| ○ L1 o | nly | | |
| () L2 or | nly | Cut off mask 12° | |
| ○ L5 or | nly | Max distance 500 km | |
| O L1 + | L2 + L5 | | |
| ⊖ Wide | e lane | Default | |
| | | | |
| OK Cancel | | | |

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.

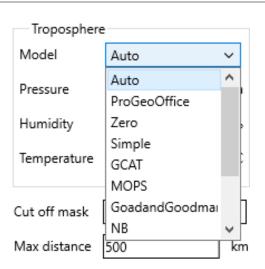
Engine mode options:

| 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



| Pressure, Humidity, Temperature | input of meteo parameters, <i>Humidity</i> 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 baseinterpolate base GNSS data if rover data sampling is differentSave residualsstore 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:

| 🛞 Style | × |
|--------------------|---|
| Lines | |
| Fixed Width < 2 | |
| Color V Arrow | |
| | |
| OK Cancel Default | |

Figure 103 – Object style

Satellites tab

Use this option to unable/disable satellites.

| 🛞 Pro | ocess | × |
|------------|--------------|----------------------|
| Static | Kinematic | |
| Engine | e Satellites | |
| | Enable / D | isable All |
| ~ GP | | |
| 12 | | |
| | | 3) 32 33 54 35 36 37 |
| ∨ GLO | DNASS 🔵 | |
| ∨ GA | LILEO 🔘 | |
| ∨ qz | ss 🔘 | |
| \vee bei | DOU 🔵 | |
| \sim irn | iss 🥘 | |
| | | |
| | | OK Cancel |

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

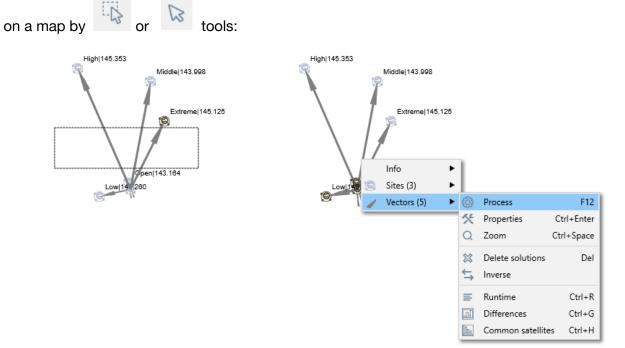


Figure 105 – Vectors selection for processing

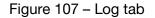
| fype | Time | Remaining | Name | Status | Progress | Finished | Speed |
|------|----------|-----------|-------------------|------------------|----------|----------|-------|
| | 00:00:09 | 00:00:01 | log0925c=>High | phase evaluation | | 72% | 72%/s |
| \$ | 00:00:09 | 00:00:01 | log0925c=>Middle | code processing | | 81% | 81%/s |
| ÷ | 00:00:09 | 00:00:01 | log0925c=>Extreme | base capturing | | 46% | 46%/s |
| ÷ | 00:00:09 | 00:00:01 | log0925c=>Open | base capturing | | 17% | 17%/s |
| 8 | 00:00:00 | 00:00:01 | log0925c=>Low | Waiting | | 0% | 0%/s |
| < | | | | | | | |

Figure 106 – Processing progress

۲

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

| 11:49:40 11:49:32: : Loading file:///D:/1/Osechenki 2020/2020-09-25/Extreme_191856.jps 11:49:39: : Unknown messages: 22335 10.44 11:49:39: : D:\1\Osechenki 2020\2020-09-25\Extreme_191856.jps finished; 3722 epochs total |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 11:49:41 11:49:32: : Loading file:///D:/1/Osechenki 2020/2020-09-25/Middle_171317.jps 11:49:39: : Unknown messages: 22323 10.46 11:49:39: : D:\1\Osechenki 2020\2020-09-25\Middle_171317.jps finished; 3720 epochs total |
| 11:49:42 11:49:32: : Loading file:///D:/1/Osechenki 2020/2020-09-25/Open_150728.jps 11:49:40: : Unknown messages: 22329 10.46 11:49:40: : D:\1\Osechenki 2020\2020-09-25\Open_150728.jps finished; 3721 epochs total |
| Records count: 5 Time: 00:03:17 Time left: 00:00:02 48% Finished / Total : 0/5 |



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:

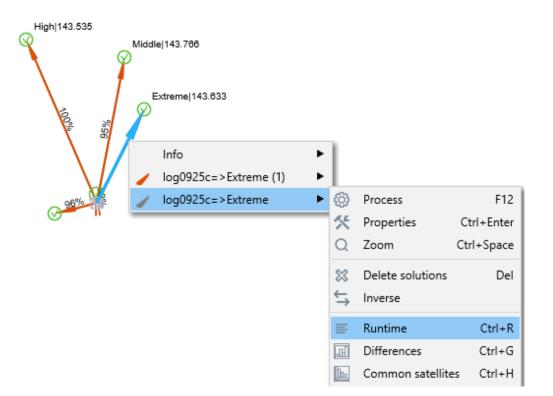
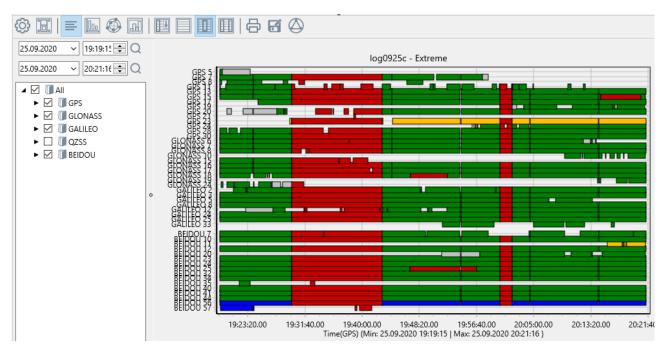
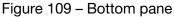


Figure 108 – Runtime

Bottom pane appears:





| ¢ | run post-processing |
|----|----------------------------------|
| | post-processing options |
| | diagram <i>Runtime</i> |
| | diagram <i>Common satellites</i> |
| | diagram <i>SkyPlot</i> |
| H. | Differences chart |
| | select all satellites |
| | clear chart |
| | disable satellites |
| | enable satellites |
| ₽ | print |

| Chapter 5. Post processing | | | | | |
|----------------------------|----------|--|--|--|--|
| đ | save as | | | | |
| \bigcirc | 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.

| - | gh 143 | 3.535 | | | | |
|---|--------|--------------------|---|--------------|------------|------------|
| Ø | | Middle 143.766 | | | | |
| | | Info | ۲ | 1 | | |
| | 1 | log0925c=>High (1) | ► | * | Properties | Ctrl+Enter |
| | 1 | log0925c=>High | ۲ | \otimes | Delete | Del |
| | _ | | | Q | Zoom | Ctrl+Space |
| | | co/ | | | Disable | Ctrl+D |
| | 0° | | | \checkmark | Enable | Ctrl+E |
| | | | | £H | Residuals | Ctrl+F |
| | | | | (!) | Report | Ctrl+R |
| | | | | 50 | Export | • |

Figure 110 – Solution menu item

| Properties |
|------------|
|------------|

| 🎯 log0925 | c - High / Solut | ion 1 | | | × |
|------------|------------------|-----------|------------|----------------|---|
| Coordinate | s Statistics | Antenna | Satellites | Settings | |
| XYZ BLH | l Grid | | | XYZ NEU | |
| Rover | | | | Increment | |
| Latitude | N 55° 39' 17,7 | 1051" | | X -14,9590 | m |
| Longitude | E 38° 06' 09,80 | 086" | | Y -32,8457 | m |
| Height | 143,5350 | | m | Z 21,6486 | m |
| EPOCH | 0,0000 | | | | |
| Base | | | | Sigma | |
| Latitude | N 55° 39' 16,4 | 6024" | | X 0,0072 | m |
| Longitude | E 38° 06' 10,75 | 5109" | | Y 0,0052 | m |
| Height | 143,7368 | | m | Z 0,0069 | m |
| EPOCH | 0,0000 | | | | |
| G WGS84 | 1 | | ~ | Length 42,0865 | m |
| | | Residuals | Dele | Close | |

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

| 🎯 log0925c - | High / Solut | tion 1 | | | × |
|-----------------|--------------|-----------|------------|-------------------|---------|
| Coordinates | Statistics | Antenna | Satellites | s Settings | |
| Begin time | | | | Measurement total | 461163 |
| 25.09.2020 | ~ | 18:16:17 | • | Measurement used | 321944 |
| End time | | | | | |
| 25.09.2020 | ~ | 19:18:18 | - | Ambiguity total | 639 |
| Process time | | | | Ambiguity fixed | 32 |
| 07.03.2024 | ~ | 12:55:27 | - | T . | |
| Туре | Fixed | | | Time span | 62 min |
| RMS residual | 0,0112 | | m | min/km | 1473,16 |
| Fix ratio | 100 | | % | | |
| Satellites used | 11 | | | | |
| Epochs | 3722 | | | | |
| | | | | | |
| | | | | | |
| | | Residuals | Dele | ete Close | |

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

| 🎯 log0925c - High / Solu | ition 1 | | × | | |
|--------------------------|-----------|------------|-------------------------|--|--|
| Coordinates Statistics | Antenna | Satellites | Settings | | |
| Base | | | Rover | | |
| Туре | | _ | Туре | | |
| Unknown V Q | | | JAVTRIUMPH_LSA NONE ~ Q | | |
| Height | | | Height | | |
| Type Vertical(ARP) | | ~ | Type Slant(SHMP) ~ | | |
| Value 0,0000 m | | | Value 0,0000 m | | |
| Offsets | | | Offsets | | |
| North 0,0000 | | m | North 0,0000 m | | |
| East 0,0000 m | | | East 0,0000 m | | |
| Vertical 0,0000 | | m | Vertical 0,0000 m | | |
| Serial number | | | Serial number | | |
| [| Residuals | Dele | Close | | |

Figure 113 – Antenna tab

| Туре | 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

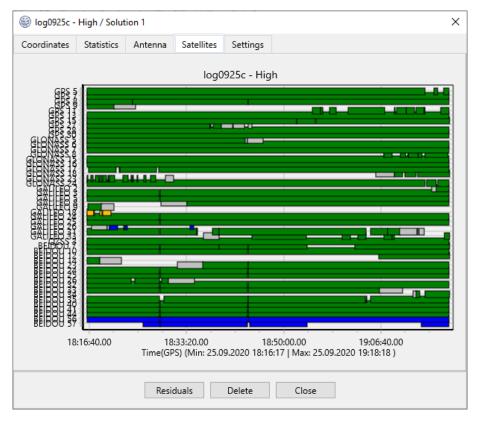


Figure 114 – Satellities tab

Snapshot of Timeline chart.

Settings tab

| | - High / Soluti | ion 1 | | | | | × |
|-------------|-----------------|-----------|------------|----------|--------|-----------------------|--------|
| Coordinates | Statistics | Antenna | Satellites | Settings | | | |
| Engine type | Default | | | | | | \sim |
| Engine mod | le | Tropo | sphere | | | Use precise ephemeris | |
| Auto | | Model | Auto | | \sim | Interpolate base | |
| ⊖ Fixed | / | Pressure | 980 | | hPa | Save residuals | |
| ⊖ Float | 1 | Humidit | y 50 | | % | | |
| 🔿 Code | 1 | Tempera | ture 20 | | °℃ | | |
| 🔿 L1 only | 1 | | | | | | |
| 🔿 L2 only | 1 | Cut off m | ask 12° | | | | |
| 🔿 L5 only | / | Max dista | nce 500 | | km | | |
| ○ L1 + L2 + | L5 🧹 | | | | | | |
| ⊖ Wide lane | - | | | | | | |
| | | Resid | luals | Delete | | Close | |

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:

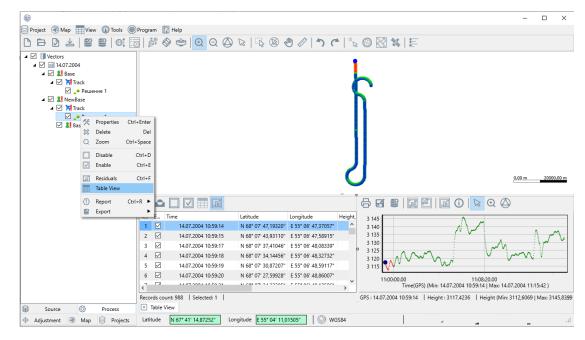


Figure 116 – Table view

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

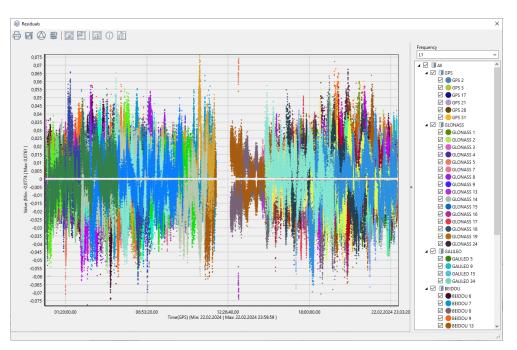


Figure 117 – Residuals

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:

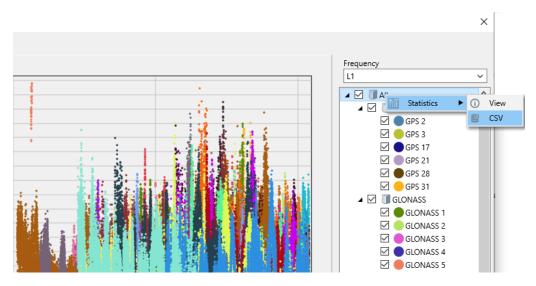


Figure 118 – Save residuals

or select View to display statistics on the screen.

| ۲ | | | | | | × | < |
|-------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|--------------------------------------|
| PRN: Samples: RMS : Minimum: Maximum: Peak to peak: Summa: Average: Variance: | GPS 2 11348 0,0113 -0,0398 0,0340 0,0738 -53,9471 -0,0048 1,7071 | GPS 3 11360 0,0100 -0,0338 0,0232 0,0570 -33,5470 -0,0030 1,2270 | GPS 17 10188 0,0113 -0,0257 0,0429 0,0686 100,2055 0,0098 2,2850 | GPS 21 9862 0,0105 -0,0428 0,0312 0,0740 -40,8381 -0,0041 1,2479 | GPS 28 11165 0,0125 -0,0307 0,0369 0,0676 8,6652 0,0008 1,7395 | GPS 31 8507 0,0129 -0,0450 0,0602 0,1052 19,5385 0,0023 1,4534 | G 1 0 - 0 8 0 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:

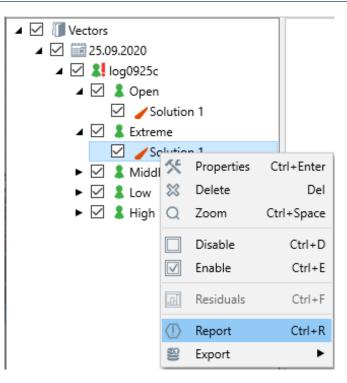


Figure 120 – Single solution repor

| Report - Viewer | en 📙 Save -> 🖾 -> 🕞 🖓 [| |] 🗈 🔳 🔎 🖃 🗄 🗸 🖽 🛛 Close |
|-------------------|---------------------------|---------------|--------------------------------|
| Time | GPS ~ | Angle type | Degress, Minutes and Seconds v |
| Time view | DateTime ~ | Angle round | 5 |
| Time format | 3/7/2024 5:19:35 PM ~ | Length round | 4 |
| Coordinate System | WGS84 ~ | Project epoch | 0 |
| Unit type | meters ~ |] | |
| | | | Reset Submit |

| | Single sol | ution re | port |
|---------------------|---------------------------------------|-------------------|----------------------------|
| Solution name | log0925c - Extreme | Solution type | Fixed |
| Process time | 07.03.2024 12:56:11 | Fix ratio | 95% |
| Begin time | 25.09.2020 19:19:15 | Time span,min | 62 |
| End time | 25.09.2020 20:21:16 | Interval, sec | 1,000 |
| Measurement used | 349957 of 474385 (26% discarded) | RMS | 0,013(m) |
| Satellites used | GPS(6)/GALILEO(6)/QZSS | (6) | |
| Used observations | C1 CP P1 L1 C2 CP2 P2 | L2 C5 L5 | |
| Ephemeris | Broadcast | Temperature,°C | 20 |
| Cut off angle,° | 12 | Pressure, hPa | 980 |
| Engine | Default | Humidity, % | 50 |
| Processing mode | Auto | 1. AS | V |
| Point name | log0925c | | Extreme |
| Session name | log0925c.; | jps | Extreme_191856.jps |
| Receiver | JAVAD TRIU | JMPH_1M | JAVAD TR_LS4 |
| Receiver number | 35003 | | 16 |
| Receiver ID | 055X908K4I | 06190QDSPVJA2QGHS | 1WUDUG4050JNN371LGYHOEA9DT |
| Antenna | 0 | - est | JAVTRIUMPH_LSA NONE |
| Serial number | | | |
| Antenna height, (m) | Vertical (A | ARP) 0,000 | Slant (SHMP) 0,000 |
| | 5155. °A. 's. 36353636363636363636363 | 888. 4 | ***** |

Figure 121 – Single solution report

CHAPTER 6. ADJUSTMENT

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

$$AX = L , (6.1)$$

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:

$$X_M - X_N = dX;$$

$$Y_M - Y_N = dY;$$

$$Z_M - Z_N = dZ$$
(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.

$$u_i = \frac{v_i}{\sqrt{q_{ii}}} , \qquad (6.4)$$

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.

$$Q_{\nu\nu} = Q_u - A Q_{xx} A^T, ag{6.5}$$

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

 $\tau\text{-}$ test treats solution as a blunder if a residual exceed τ - value.

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

a 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.

$$\chi_L^2 < \mu^2 = \frac{1}{n-k} \times V^T P V < \chi_H^2$$
 (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.

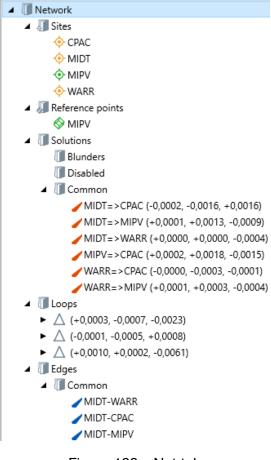
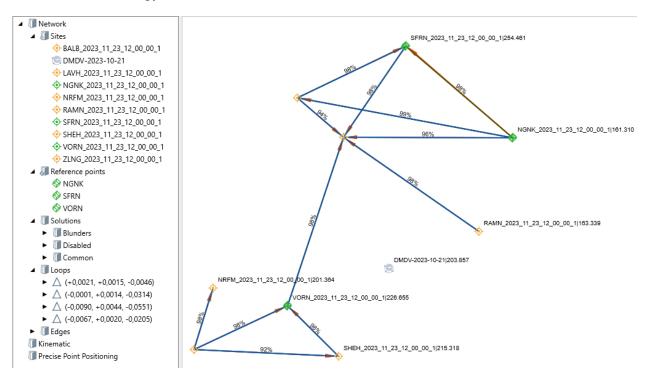


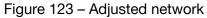
Figure 122 - Net tab

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 <i>Solutions</i> | | | | | | | |
| | 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 | site precise positions | | | | | | | |
| Positioning | | | | | | | | |

Introduce a terminology of other items:





| 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. |
| 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: |
| edge that shares with a network one site only |
| edge that connects loops. It does not form itself any loop |
| edge that has not passed τ -test. By default blunders are colored brown |
| others edges |
| 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:

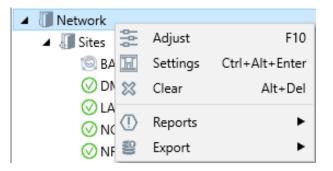


Figure 124 – Right-click menu items

| 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

| le Static | × |
|-------------------|-------------------|
| Static | |
| Blunder rejection | Blunder detection |
| Automatic | XYZ |
| ○ Interactive | ⊖ NEU |
| Constraints | Confitence Level |
| 🔿 Inner | ☑ Tau test 95% ✓ |
| Reference | Chi2 95% ~ |
| Loops | |
| E horz 0,0500 m | A horz 1,000 ppm |
| E vert 0,1000 m | A vert 2,000 ppm |
| ОК | Cancel |

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 |
| | • <i>Interactive</i> - 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 pass χ^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:

$$\Delta L = E \times \sqrt{N} + A \times L , \qquad (6.7)$$

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:

| RecNo | Status | Name | X, m | Y, m | Z, m | Tau, m 🛛 🞝 | / Reject |
|-------|--------|-----------------------------------|---------|---------|---------|------------|--------------------|
| 1 | / | RAMN_2023_11_23_12_00_00_1 - NRF | 0,1042 | -0,3017 | -0,0542 | 23,63 ^ | / Reject |
| 2 | 1 | NRFM_2023_11_23_12_00_00_1 - LAVH | 0,0398 | -0,0372 | -0,0244 | 4,24 | Restore |
| 3 | 1 | BALB_2023_11_23_12_00_00_1 - NRFM | -0,0378 | 0,0311 | 0,0138 | 4,15 | |
| 4 | 1 | RAMN_2023_11_23_12_00_00_1 - VOR | 0,0048 | 0,0426 | 0,0584 | 4,12 | Subnet Tau = 3,209 |
| 5 | 1 | ZLNG_2023_11_23_12_00_00_1 - NRFM | -0,0268 | 0,0503 | 0,0527 | 4,04 | |
| 6 | 1 | NRFM_2023_11_23_12_00_00_1 - VOR | 0,0321 | -0,0375 | -0,0274 | 4,00 | Chi high = 2,241 |
| 7 | 1 | SHEH_2023_11_23_12_00_00_1 - NRFM | -0,0337 | 0,0381 | 0,0248 | 3,81 | Chi2 test : No |
| 8 | 1 | RAMN_2023_11_23_12_00_00_1 - ZLN | -0,0130 | 0,0259 | 0,0219 | 3,80 | |
| 9 | 1 | DMDV_2023_11_23_12_00_00_1 - NRF | -0,0310 | 0,0413 | 0,0383 | 3,43 | Mu = 6,942 |
| 10 | 1 | RAMN_2023_11_23_12_00_00_1 - SHE | -0,0295 | 0,0103 | 0,0030 | 3,27 | Chi low = 0,031 |
| 11 | 1 | RAMN_2023_11_23_12_00_00_1 - LAVH | -0,0256 | 0,0213 | 0,0042 | 2,96 | CHI 10W = 0,051 |
| 12 | 1 | RAMN_2023_11_23_12_00_00_1 - NGN | -0,0101 | 0,0203 | 0,0240 | 2,48 | |
| 13 | 1 | RAMN_2023_11_23_12_00_00_1 - SFRN | -0,0173 | 0,0178 | 0,0123 | 2,16 🗸 | |

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.

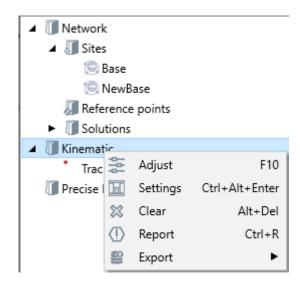


Figure 127 – Kinematic node

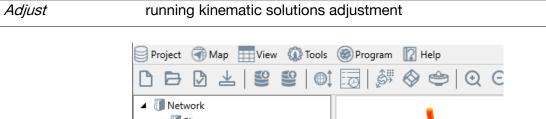




Figure 128 – Adjusted kinematic

| le Kinematic | × |
|-----------------------------|----|
| Kinematic | |
| Use fixed solution | |
| Fixed priority | |
| Use float solution | |
| Maximum length of base line | |
| Range 0 | km |
| OK Cancel | |

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 |
| | |

| ort - Viewer | | | | | | | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------------------------------------------|
| nt 🛅 Op | en 🔚 Save 🗸 🖂 🗸 | | 1 🗈 🔳 🔎 🖬 🗊 | ↔ · · · · · · · · · · · · · · · · · · · | Close | | |
| | GPS | Angle type | Degress, Minutes and Seconds | ~ | | | |
| w | DateTime | Angle round | 5 | | | | |
| mat | 3/14/2024 2:28:02 PM | Length round | 4 | | | | |
| | | | • | | | | |
| ate System | WGS84 | Project epoch | 0 | | | | |
| e | meters | ~ | | | | | |
| | | | Reset | Submit | | | |
| | | | Reset | Submit | | | |
| | Units | meters | Proces | eed 14 03 2024 | | | |
| Use fix | Time ed: Yes | GPS F | ixed priority: | Yes | 14:28:05 | | <u>¢</u> |
| Use fix Use flo | Time ed: Yes | GPS F | ixed priority: aximum range: | | 14:28:05 | | ¢ . |
| | ed: Yes at: No | GPS F | addalaidhachaí e Tiolaidhlichta | Yes | 14:28:05 | | <u>¢</u> |
| Use flo | ed: Yes at: No | GPS F M | addalaidhachaí e Tiolaidhlichta | Yes | 14:28:05 | RMS | Fix |
| Use flo Name | ed: Yes at: No | GPS F M rack (NewBase, Base) | aximum range: | Yes O | | RMS 0,396,m | |
| Use flo Name No 1 20 | Time ed: Yes at: No T Time | GPS F M rack (NewBase, Base) Latitude | Longitude | Yes O Height, m | Residuals | | Ye |
| Use flo Name No 1 20 2 20 | Time ed: Yes at: No T Time 04-07-14 11:00:00.000 | GPS F M rack (NewBase, Base) Latitude N 68* 05* 16, 35664* | Aximum range: Longitude E 55° 07' 01,10016" | Yes 0 Height, m 3114,7005 | Residuals 0,000,m | 0,396,m | Ye Ye |
| Use flo Name No 1 20 2 20 3 20 | Time ed: Yes at: No Time 0 04-07-14 11:00:00.000 04-07-14 11:00:01.000 | GPS F M rack (NewBase, Base) Latitude N 68° 05° 16,39684" N 68° 05° 13,11139" | Longitude E 55° 07' 01,10016" E 55° 07' 01,31155" | Yes 0 Height, m 3114,7005 3114,8254 | Residuals 0,000,m 0,000,m | 0,396,m 0,395,m | Ye Ye Ye |
| Use flo Name No 2 20 3 20 4 20 | Time ed: Yes at: No T T 04-07-14 11:00:00.000 00 04-07-14 11:00:01.000 00 04-07-14 11:00:01.000 00 | GPS P M Tack (NewBase, Base) Latitude 1 N 68° 05° 16,35684° N 68° 05° 13,11139° N 68° 05° 09,82611° | Longitude E 55° 07' 01,10016" E 55° 07' 01,31155" E 55° 07' 01,51525" | Yes 0 Height, m 3114,7005 3114,8254 3114,956 | Residuals 0,000,m 0,000,m 0,000,m | 0,396,m 0,395,m 0,395,m | Fix Ye Ye Ye Ye Ye |
| Use flo Name No 1 20 2 20 3 20 4 20 5 20 | Time ed: Yes at: No T T 04-07-14 11:00:00.000 04-07-14 11:00:00.000 04-07-14 11:00:02.000 04-07-14 11:00:03.000 | GPS P M Tack (NewBase, Base) Latitude N 68° 05° 16,39684" N 68° 05° 13,11139" N 68° 05° 09,82611" N 68° 05° 09,82611" | Longitude E 55° 07' 01,10016" E 55° 07' 01,31155" E 55° 07' 01,51525" E 55° 07' 01,70596" | Yes 0 Height, m 3114,7005 3114,8254 3114,956 3115,2451 | Residuals 0,000,m 0,000,m 0,000,m 0,000,m | 0,396,m 0,395,m 0,395,m 0,395,m | Уе Уе Уе Уе |
| Use flo No 1 1 20 2 20 3 20 4 20 5 20 6 20 | Time ed: Yes at: No Time T 04-07-14 11:00:00,000 04 04-07-14 11:00:01,000 04 04-07-14 11:00:03,000 04 04-07-14 11:00:03,000 04 | GPS P M P M P M P M P M P M P M P M | Longitude E 55° 07' 01,10016" E 55° 07' 01,31155" E 55° 07' 01,51525" E 55° 07' 01,70586" E 55° 07' 01,98494" | Yes 0 Height, m 3114,7005 3114,8254 3114,8254 3114,9568 3115,2451 3115,5402 | Residuals 0,000,m 0,000,m 0,000,m 0,000,m 0,000,m | 0,395,m 0,395,m 0,395,m 0,395,m 0,395,m | Ye Ye Ye Ye Ye Ye Ye Ye |

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:

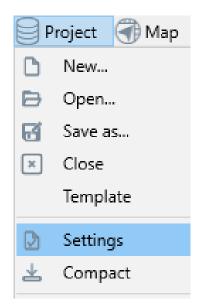


Figure 131 – Project menu item

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:

| Project | t settings | | | × |
|----------|---------------------------|-----|----------------------|----------------|
| Filename | D:\1.pgx | | Max epoch gap | 300 |
| Created | 14.03.2024 ~ 16:14:09 ÷ Q | | Min recordset size | 3 |
| Creator | | | Criterion for static | 5,00 m |
| Agency | | c | Tolerance for static | 3,00 m |
| Comment | | | Max vector length | 3000 km |
| | | | Epoch | 06.01.1980 ~ Q |
| | | | | |
| | ОК | Car | ncel Default | |

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 gapthe maximum number of skipped epochs between any two adjacentepochs 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:

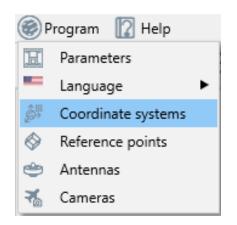


Figure 133 – Coordinate systems item



button on a toolbar:

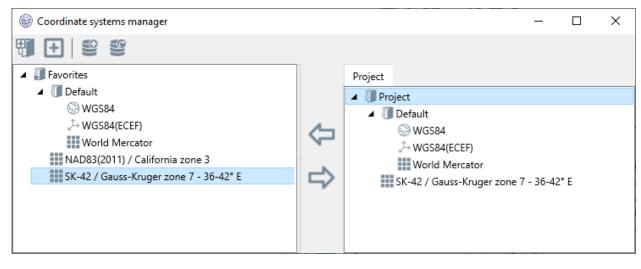


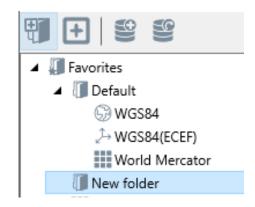
Figure 134 – Coordinate system manager

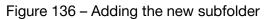
Default coordinate systems are:



Figure 135 – Default coordinate systems

Click button to add a subfolder Favorites root item:





To edit subfolder's name double click on it.



+

button to customize a list of preferable coordinate systems:

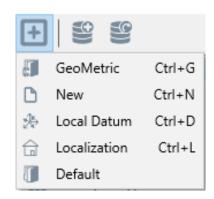


Figure 137 – Coordinate system creation way

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,

| leo Metric | _ | | × |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|-------|----|
| Search by Name | | Q | ୲ |
| ▲ (] Continents | | | |
| ► 🗍 Africa | | | |
| Image: Image: Antarctica Image: Image: Antarctica Image: Image: Image: Image: Antarctica Image: I | | | |
| 🕨 🚺 Asia | | | |
| ► 🕼 Europe | | | |
| II North America | | | |
| I Oceania | | | |
| I South America | | | |
| 🔺 🗍 Global | | | |
| ► 🗍 ITRF | | | |
| ► 🕼 PZ-90 | | | |
| ► [] WGS 72 | | | |
| WGS 72BE | | | |
| ► 🚺 WGS 84 | | | |
| Custom transformation | | | |
| Geoid Add | | Cance | 2l |

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:

| leo Geo Metric | _ | | × |
|---------------------------------------------|---|-------|-----------|
| Search by Name | | Q | \otimes |
| II Russian Federation | | | ^ |
| GSK-2011 6-degree Zones | | | |
| ► 🗍 SK-42 | | | |
| ► 🗍 SK-95 | | | |
| GS-63 St. Petersburg Region / Z2 | | | |
| GS-63 St. Petersburg Region / Z3 | | | |
| GS-63 St. Petersburg Region / Z3.5 | | | |
| GS-63 St. Petersburg Region / Z4 | | | |
| GS-64 / St. Petersburg | | | |
| MGGT-1 / Moscow Region | | | ~ |
| Custom transformation | | | |
| Geoid Next | | Cance | I |

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:

| leoMetric | _ | | × |
|---------------------------------------------------------------------|--------|-----|-----|
| Name SK-42 / MSK-02 zn. 2 Resp. Bashkortostan 10/3/2024 1:29:16 PM | | | |
| Q Show properties selected transformation | | | |
| A SK-42 to WGS 84 / Default / MSK-02 zn. 2 Resp. Bashkortostan | | | |
| 🕀 SK-42 to WGS 84 / GOST R 51794-2008 / MSK-02 zn. 2 Resp. Bashkort | tostan | | |
| | | | |
| | | | |
| Back Add |] | Can | cel |

Figure 140 – Transformation selection

Select a transformation and click parameters:

| Qs | Show | properties | selected | transformation |
|----|------|------------|----------|----------------|
|----|------|------------|----------|----------------|

to view transformation

| 🛞 SK-42 / MSK-02 zn. 2 Resp. Bashkortostan | - 🗆 X |
|-----------------------------------------------|-----------------------------------------|
| Helmert Transformation (7-param. linear) | Transverse Mercator |
| X-axis translation 23,570 m | Latitude of Origin N 0° 00' 00,00000" |
| Y-axis translation -140,950 m | Central Meridian E 58° 01' 60,00000" |
| Z-axis translation | Scale Factor |
| -79,800 m | 1,000000 |
| X-axis rotation 0° 00' 00,00000" | False Easting 2300000,000 m |
| Y-axis rotation -0° 00' 00,35000" | Flattening 298,300000000 |
| Z-axis rotation -0° 00' 00,79000" | Prime meridian E 0° 00' 00,00000" |
| Scale difference -0,220 ppm | False Northing -5409414,700 m |
| Semi-major axis (source) 6378245,000 m | Semi-major axis 6378245,000 m |
| Semi-major axis (target) 6378137,000 m | S III Forward |
| Flattening (source) 298,30000000 | |
| Flattening (target) 298,257223563 | |
| Prime meridian (source) E 0° 00' 00,00000" | |
| Prime meridian (target) | |
| E 0° 00' 00,00000" | |
| 🔊 🔶 🏷 Backward | |

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:

| GeoMetric | _ | | \times |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|-----|----------|
| ✓ Filter by coordinate system | | | |
| \$\Pi EGM2008 geoid g1 EGM2008 (Earth) \$\Pi EGM96 geoid g1 EGM96 (Earth) \$\Pi GAO2012 geoid g1 GAO2012 (Earth) \$\Pi Malin Head g1 OSGM15 Malin (Ireland) | | | |
| Back | | Add | |

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.

| t - S | |
|---------------|----------------------------------------------------------|
| 🔺 🚛 Favorites | |
| 🕨 🚺 Defau | lt |
| 🔺 🚺 New f | older |
| SK | -42 / Gauss-Kruger zone 7 - 36-42° E |
| SK | -42 / MSK-01 zn. 2 Resp. Adygeya / EGM2008 (Earth) |
| SK | -42 / MSK-02 zn. 2 Resp. Bashkortostan / EGM2008 (Earth) |
| 🕞 Amers | foort |
| 🕞 ED50 | |
| NAD8 | 3(2011) / California zone 3 |
| 🕞 WGS8 | 4(ITRF2014) |
| | |

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:

| Scoordinate systems | manager | | | | | |
|-----------------------|--------------|----------------|------|-------------|------|------|
| 9 🕂 😫 🧐 | | | | | | |
| Favorites Default | | | | | | Proj |
| New folder SK-42 | New folder | Shift+Ctrl+N | 008 | 'Farth) | 4 | |
| NAD83(2) 🗄 | Add coordina | ate system 🔹 🕨 | £. | GeoData | Ctrl | +G |
| SK-42 / G | Rename | F2 | D | New | Ctrl | ۴N |
| ~ | Cut | Ctrl+X | | Local Datur | | |
| Ø | Сору | Ctrl+C | IT . | Default | | |
| a | Paste | Ctrl+V | | | | |
| | Delete | Del | | | | |
| 8 | Import | Ctrl+I | | | | |
| | Export | Ctrl+E | | | | |

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:

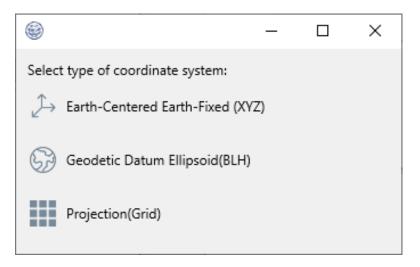


Figure 145 – Coordinate system type

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

Projection(Grid)

then select a datum from the list

or create a new one, if necessary:

To do this, select the option

| ۲ | _ | | Х |
|--------------|------------------|------|---|
| Create new o | or select datum: | | ~ |
| | Back | Next | t |

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:

| | _ | | × |
|-------------------------------|-----------|------------|---|
| Select ellipsoid or WGS 84 | r enter p | parameters | : |
| Semi-major axis | 63781 | 37,000 | m |
| InverseFlattening | 298,25 | 57223563 | m |
| Bac | :k | Next | : |

Figure 147 – Datum Selection/Creation

then type 7 Helmert transformation parameters:

| 8 | — | | × |
|---------------------|------------|-------------|------|
| WGS84 to target coo | ordinate s | ystem | |
| Helmert Transform | nation (7- | param. line | ear) |
| X-axis translation | | | |
| 0,000 | | | m |
| Y-axis translation | | | |
| 0,000 | | |] m |
| Z-axis translation | | | _ |
| 0,000 | | | m |
| X-axis rotation | | | |
| 0° 00' 00,00000" | | | |
| Y-axis rotation | | | |
| 0° 00' 00,00000" | | | |
| Z-axis rotation | | | |
| 0° 00' 00,00000" | | | |
| Scale difference | | | |
| 0,000 | | | opm |
| | | | |
| В | ack | Next | |
| | | | |

Figure 148 – 7 Helmert parameters

Then select the required geoid model or skip this step:

| 6 | — | | \times |
|---------------------------------------|----------|------|----------|
| Select a geoid or select a geoid file | or skip: | | |
| EGM2008 (Earth) | | | ~ |
| Base on WGS84 O Current | | | |
| File EGM2008 (Earth) | | | ₿ |
| Skip Ba | ck | Next | |

Figure 149 – Geoid model selection

Select projection type in the drop-down list:

| | | _ | | \times |
|---------------|-----------|---|-----|----------|
| Select projec | tion: | | | |
| Transverse N | /lercator | | | ~ |
| | Back | | Nex | ĸt |
| | | | | |

Figure 150 – Projection type selection

And type projection parameters:

| ۲ | | _ | | \times |
|------------|------------|----|-----|----------|
| Transver | se Mercato | or | | |
| Latitude o | of Origin | | | |
| N 0° 00' (| 00,00000" | | | |
| Central M | leridian | | | |
| E 0° 00' 0 | 0,00000" | | | |
| Scale Fact | tor | | | |
| 0,000000 |) | | | |
| False East | ting | | | |
| 0,000 | | | | m |
| False Nor | thing | | | |
| 0,000 | | | | m |
| Prime me | ridian | | | |
| E 0° 00' 0 | 0,00000" | | | |
| | | | | |
| | Back | | Nex | ct |
| | | | | |

Figure 151 – Projection parameters

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

| ۲ | | _ | | × |
|------|----------------------|------|-----|---|
| Name | New coordinate syste | em | | |
| | [| Back | Add | |

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:

| 4 📗 | Favorites |
|-----|------------------------------------------------------|
| ► | 🕼 Default |
| - | 🕼 New folder |
| | New coordinate system |
| | SK-42 / MSK-01 zn. 2 Resp. Adygeya / EGM2008 (Earth) |

Figure 153 – Created coordinate system

8.4 Select existing datum

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

| Click 🕒 , se | elect GeoMetric Ctrl+G , type datum nar | ne and cl | ick Ent | er: |
|--------------|----------------------------------------------------|-----------|---------|-----------|
| | le GeoMetric | _ | | × |
| | Search by Name ~ ED50 | | Q | \otimes |
| | I Continents I Global | | | |
| | Custom transformation | | | |
| | Geoid Add | | Cance | : |

Figure 154 – Datum name

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

| leoMetric | | | _ | | × |
|----------------------------------------|-------|-----|---|-------|-----------|
| Search by Name 🗸 ED50 | | | | Q | \otimes |
| ED50 / UTM zone 37N - 36-42° E | | | | | ^ |
| ED50 / UTM zone 38N - 42-48° E | | | | | |
| ED50(ED77) / UTM zone 38N - W of 4 | 48° E | | | | |
| ED50(ED77) / UTM zone 39N - 48-54 | l° E | | | | |
| ED50(ED77) / UTM zone 40N - 54-60° E | | | | | |
| ED50(ED77) / UTM zone 41N - E of 60° E | | | | | |
| 699 ED50 | | | | | |
| 6 ED50(ED77) | | | | | |
| 💮 ED50(Turkey) | | | | | |
| , ² → ED50 | | | | | |
| ^Ĵ → ED50(ED77) | | | | | ~ |
| Custom transformation | | | | | |
| | Geoid | Add | | Cance | 2 |

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:

| Select | E |
|-------------------|-----------|
| 🔺 🚛 Favorites | |
| 🔺 🚺 Default | |
| G WGS84 | |
| 🚺 New folder | |
| G Amersfoort | |
| 6 ED50 | |
| 3 WGS84(ITRF2014) | |
| | |
| | |
| | |
| | Ok Cancel |

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:

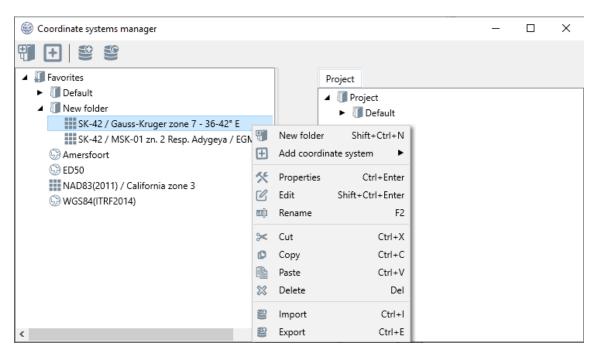


Figure 157 – Coordinate system options

Properties

To get full information about the coordinate system click Properties:

| Helmert Transformation (7-param. linear) | Transverse Mercator | GEOID_ADAPTER_COMMON |
|------------------------------------------|---------------------------------------|----------------------|
| (-axis translation | | Geoid model file |
| 33.570 | Latitude of Origin N 0° 00' 00,00000" | egm2008.db3 |
| /-axis translation | Central Meridian | |
| 140.050 | E 40° 58' 60,00000" | PAR_BASE_ON |
| | | WG304 |
| Z-axis translation | Scale Factor | |
| -79,800 m | 1,000000 | G Forward |
| (-axis rotation | False Easting | |
| 0° 00' 00,00000" | 2300000,000 m | |
| /-axis rotation | Flattening | |
| -0° 00' 00,35000" | 298,30000000 | |
| Z-axis rotation | Prime meridian | |
| -0° 00' 00,79000" | E 0° 00' 00,00000" | |
| cale difference | False Northing | |
| -0,220 ppm | -4511057,628 m | |
| emi-major axis (source) | Semi-major axis | |
| 5378245,000 m | 6378245,000 m | |
| emi-major axis (target) | | |
| 6378137,000 m | 🚱 📥 🏭 Forward | |
| lattening (source) | | |
| 298,30000000 | | |
| lattening (target) | | |
| 298,257223563 | | |
| Prime meridian (source) | | |
| E 0° 00' 00,00000" | | |
| Prime meridian (target) | | |
| E 0° 00' 00,00000" | | |
| | | |

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:

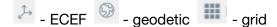
Figure 159 – Edit window

Status bar:

| ä | save transformation |
|---|------------------------------------|
| đ | 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:



Combined icon is 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:

| 2÷ | MDL_GEODETIC | |
|----|------------------------------------------|---|
| 67 | Helmert Transformation (7-param. linear) | |
| | Projections | ۲ |
| gţ | Geoid | • |
| G | Localizations | ۲ |

Figure 160 – Transformation types

Allowed projection list, geoid model types and localization types:

| | Transverse Mercator |
|-----|-------------------------------------------|
| | Transverse Mercator (South Orientated) |
| | Mercator (1SP) |
| | Oblique Mercator (Hotine Variant B) |
| | Oblique Mercator (Hotine Variant A) |
| | Oblique Mercator (2 points) |
| | Oblique Stereographic |
| | Polar Stereographic (Variant A) |
| === | Stereographic Double |
| | Cassini-Soldner |
| | Lambert Conformal Conic 1SP |
| | Lambert Conformal Conic 2SP |
| | Lambert Conformal Conic (West Orientated) |

Figure 161 – Projection list

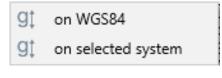


Figure 162 – Geoid model types

| ŵ | Grid plane and vertical localization |
|---|--------------------------------------|
| ŵ | Grid plane localization |
| G | Vertical Offset |
| | |

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:

| Select |
|---------------------------------------------------------------------------------------------------------------------------|
| Favorites Default World Mercator New folder New coordinate system |
| SK-42 / Gauss-Kruger zone 7 - 36-42° E |
| SK-42 / MSK-01 zn. 2 Resp. Adygeya / EGM2008 (Earth) NAD83(2011) / California zone 3 |
| Name New name Ok Cancel |

Figure 164 – New name

Rename

Click an option Rename for input and edit the name:

| 🔺 🚛 Favorites |
|-------------------------------------------------------|
| 🔺 🚺 Default |
| 59 WGS84 |
| 2 → WGS84(ECEF) |
| World Mercator |
| GS-63 St. Petersburg Region / Z4 10/3/2024 1:27:49 PM |
| MKEA |

Figure 165 – Rename

| Cut | an option for cut and paste | | |
|-------|-------------------------------------|--|--|
| Сору | 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 <i>PCS</i> |
| 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

(to create a backup file copy named Param_Year-Month-DayTHours_Minutes_SecondsZ.pcs icon in the folder C:\Users\UserName\Documents\ProGeoOffice\CoordinateSystems).

| Param_AutoGenBackUp | |
|------------------------------------|---|
| Param.pcs | |
| Delete | ۲ |
| Param_2024-03-27T17_54_37.360Z.pcs | |
| Param_2024-03-27T17_54_40.960Z.pcs | |

Figure 166 – List of backup files

Exchange of coordinates systems

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

| left Coordinate systems manager | | | _ | | Х |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|----|---|
| | | | | | |
| ▲ ↓ Favorites ▶ ↓ Default | | Project | | | |
| New folder New coordinate system SK-42 / Gauss-Kruger zone 7 - 36-42° E SK-42 / MSK-01 zn. 2 Resp. Adygeya / EGM2008 Amersfoort ED50 NAD83(2011) / California zone 3 WGS84(ITRF2014) | 小 | ✓ Toject ✓ Default ◇ WGS84 ◇ WGS84(ECEF) ✓ World Mercator ✓ NAD83(2011) / California zon ✓ SK-42 / Gauss-Kruger zone 7 | | ۴E | |
| < >> | | | | | |

Figure 167 – Coordinate systems exchange

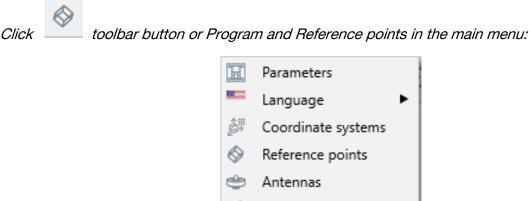
Use

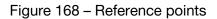


buttons to copy coordinate systems from program database to a project and vice versa. This makes it convenient to store frequently used coordinate systems and quickly and conveniently exchange coordinate systems between projects.

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.





Cameras

to open Reference points manager window:

| Reference points manager | | – 🗆 × |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1) 😵 😫 😫 | | |
| Favorites Final BALB DMDV LAVH NGNK NRFM RAMN SFRN SHEH VORN ZLNG | 小 | Edit Project Name BALB XYZ → Q J> WGS84(ECEF) ✓ Q Sigma Type Plane and vertical ✓ X 0,0000 m Z Q,0000 m Z 0,0000 m Z Q Q |
| ⊗ AntA1 | | Main Velocity Save Cancel |
| ОК | | Cancel |

Figure 169 – Reference points manager

Toolbar items:

| er V | create a new folder in the Favorites node |
|----------|-------------------------------------------|
| ₿ | create a new reference point |
| | create a backup file |
| <u>8</u> | restore backup file |

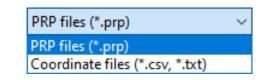
9.1 Left panel

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:

| 🔺 🚛 Favorites | | |
|---------------|-------------------|--------------|
| 🔺 🗍 Final | | |
| 🔗 в, 🖤 | New folder | Shift+Ctrl+N |
| 🗞 D 🛞 | New reference poi | nt Ctrl+N |
| 🛇 L/ 📷 | Rename | F2 |
| 🛇 N 🧮 | - tertainte | |
| 🗞 N 🔀 | Cut | Ctrl+X |
| 🛇 R. 👩 | Сору | Ctrl+C |
| SI 🗈 | Paste | Ctrl+V |
| SI 🔛 | Delete | Del |
| 🛇 VI 🔗 | Delete | Dei |
| 🛇 ZI 😫 | Import | Ctrl+I |
| 🛇 AntA' 😰 | Export | Ctrl+E |
| | | |

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 |
| Сору | 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

| Edit | Project | | | |
|--------|------------|------|--------------------|---|
| Name [| BALB | | | |
| XYZ | | | | |
| х | 2928242,52 | 80 | | m |
| Y | 2179312,92 | 64 | | m |
| z | 5213053,07 | '91 | | m |
| EPOCH | 0,0000 | | | |
| Ç→ WG | S84(ECEF) | | ~ + | Q |
| Sigma | | Туре | Plane and vertical | ~ |
| X 0,00 | 00 | m | | |
| Y 0,00 | 00 | m | | |
| Z 0,00 | 00 | m | | |
| Main | Velocity | | | |
| | , | | | |
| | | Save | Cancel | |

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:

| SK-42 / MSK-02 zn. 2 Resp. Bashkortostar 🗸 |
|----------------------------------------------|
| \downarrow WGS84(ECEF) |
| SK-42 / MSK-02 zn. 2 Resp. Bashkortostan / I |
| SK-42 / MSK-01 zn. 2 Resp. Adygeya / EGM2 |
| SK-42 / Gauss-Kruger zone 7 - 36-42° E |
| NAD83(2011) / California zone 3 |

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:

| 🎯 SK-42 / MSK-02 zn. 2 Resp. Bashkortostan / E | GM2008 (Earth) | – 🗆 X |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| SK-42 / MSK-02 zn. 2 Resp. Bashkortostan / E Helmert Transformation (7-param. linear) X-axis translation 23,570 m Y-axis translation -140,950 m Z-axis translation -79,800 m X-axis rotation 0° 00' 00,0000" Y-axis rotation -0° 00' 00,35000" Z-axis rotation | GM2008 (Earth) Transverse Mercator Latitude of Origin N 0° 00' 00,00000" Central Meridian E 58° 01' 60,00000" Scale Factor 1,000000 False Easting 230000,000 m Flattening 298,30000000 Prime meridian | - C × |
| Z-axis rotation [-0° 00' 00,79000" Scale difference [-0,220 ppm Semi-major axis (source) [6378245,000 m Semi-major axis (target) [6378137,000 m Flattening (source) [298,300000000 | Prime meridian E 0° 00' 00,000000" False Northing -5409414,700 m Semi-major axis 6378245,000 m | |
| Flattening (target) 298,257223563 Prime meridian (source) E 0° 00' 00,00000" Prime meridian (target) E 0° 00' 00,00000" Some meridian (target) E 0° 00' 00,00000" Backward | | |

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:

| EPOCH 0,0 | 000 | | | | | |
|--------------------------------------------------|--------|--|--|--|--|--|
| 📰 SK-42 / MSK-02 zn. 2 Resp. Bashkortostar 🗸 于 📿 | | | | | | |
| Velocity | | | | | | |
| N 0,0000 | m/year | | | | | |
| E 0,0000 | m/year | | | | | |
| U 0,0000 | m/year | | | | | |
| Main Ve | locity | | | | | |

Figure 174 – Epoch and velocities

9.3 Project

| Reference points manager Image: Im | | | | | - | | × |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------|---------------------------------------------------------------|--|---|--|---|
| Favorites Final BALB DMDV LAVH NGNK NRFM RAMN SFRN SHEH VORN ZLNG AntA1 | 4 小 小 | Edit | Project Project Project NGNK NRFM RAMN SFRN | | | | |
| OK Cancel | | | | | | | |

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 | \Diamond | and | ⇔ | are used to copy folders and items |
|----------------------------------------|------------|-----|---|-------------------------------------|
| program and project databases. Duttons | | anu | | 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):

$$\begin{bmatrix} X_T \\ Y_T \\ Z_T \end{bmatrix} = \begin{bmatrix} dX \\ dY \\ dZ \end{bmatrix} + M \times R \times \begin{bmatrix} X_S \\ Y_S \\ Z_S \end{bmatrix}$$
(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 ($1 \text{ ppm} = 1 \times 10^{-6}$).

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

$$R_{X} = \begin{bmatrix} \cos R_{1} & \sin R_{1} & 0 \\ -\sin R_{1} & \cos R_{1} & 0 \\ 0 & 0 & 1 \end{bmatrix}; R_{Y} = \begin{bmatrix} \cos R_{2} & 0 & -\sin R_{2} \\ 0 & 1 & 0 \\ \sin R_{2} & 0 & \cos R_{2} \end{bmatrix}; R_{Z} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos R_{3} & \sin R_{3} \\ 0 & -\sin R_{3} & \cos R_{3} \end{bmatrix}$$
(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:

$$\begin{bmatrix} X_S \\ Y_S \\ Z_S \end{bmatrix} = \frac{R^{-1}}{M} \begin{bmatrix} X_T \\ Y_T \\ Z_T \end{bmatrix} - \begin{bmatrix} dX \\ dY \\ dZ \end{bmatrix}$$
(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:

$$\tan L = \frac{Y}{X} \dots \ \tan B = \frac{Z}{\sqrt{X^2 + Y^2}} + \frac{e^2 \times N \times \sin B}{\sqrt{X^2 + Y^2}} \dots \dots H = \frac{\sqrt{X^2 + Y^2}}{\cos B} - N$$
(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:

$$X = (N + H) \times \cos B \times \cos L$$

$$L = (N + H) \times \cos B \times \sin L$$

$$Z = (N + H - e^{2} \times N) \times \sin B$$
(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:

$$Hgeod = H$$
ortho + ζ (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):

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

where

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

The formulas are:

$$N_T = dN + M \times (N_S \times \cos \alpha - E_S \times \sin \alpha)$$

$$E_T = dE + M \times (N_S \times \sin \alpha + E_S \times \cos \alpha)$$
(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;

a is the turning angle, counted clockwise;

M is the scale factor.

The formula for inverse transformation for coordinates on a plane:

$$\begin{bmatrix} N_S \\ E_S \end{bmatrix} = \frac{R^{-1}}{M} \begin{bmatrix} N_T \\ E_T \end{bmatrix} - \begin{bmatrix} dN \\ dE \end{bmatrix}$$
 (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,

 a_{N} , a_{E} are slope angles along the Northing, Easting axes.

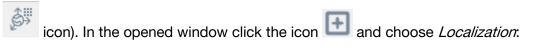
The determination of the transformation parameters of coordinate systems on the plane is performed by the ordinary least mean squares method (LMS) by comparing the resulting transformation chain 1 - 4 and the original (from the catalog) coordinates of the points.

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



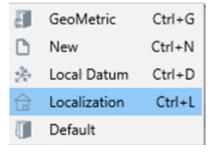


Figure 177 – Localization

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

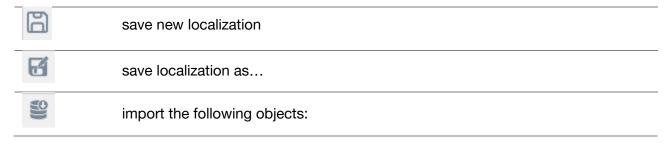
| Localization | n | | | | | | | | - | | Х |
|------------------|-----------------|--------------|---------|--------------------|------------------------|--------------|---------------|------|---------|-----|---|
| 861 | 9 9 × | σ @ | + | | | | | | | | |
| Network coord | inate system B | LH 🗸 🗋 | ± % | Transformation | type Plane | ✓ Confider | ice level 99% | ~ | | | |
| Select projectio | on: Oblique Ste | reographic ` | |] Adjust Central N | Meridian Interval 0° (| 0' 10,00000" | | | | | |
| | | | | | Network | | Reference | | Residua | als | |
| RecNo | Enable | Туре | Name | Latitude | Longitude | North, m | East, m | X, m | Y, m | EV | |
| 1 | \checkmark | \$ | Point | | | | | | | | |
| 2 | | \$ | Point 1 | | | | | | | | |
| 3 | \checkmark | \$ | Point 2 | | | | | | | | |
| 4 | \checkmark | \$ | Point 3 | | | | | | | | |
| 5 | | \$ | Point 4 | | | | | | | | |
| | | | | | | | | | | | |
| < | | | | | | | | | | | |

Figure 178 – Localization window

10.1 Icon bar

The bar of icons functionally corresponds to all localization commands:







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

| Coordinate files (*.csv, *.txt) | ~ |
|---------------------------------|---|
| Coordinate files (*.csv, *.txt) | |
| PL files (*.pl) | |

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

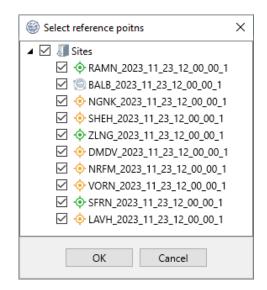


Figure 180 – Import site coordinates

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 |
| σ | 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 |
| | |

| lect import template | | | | | | × |
|----------------------|-----------------------------|--------|------------|------------|------------|---------|
| Template | Columns | Name | Latitude,° | Latitude,' | Latitude," | Longitu |
| 1 | Column Value | 1516 | 56 | 10 | 34.24673 | 40 |
| 3 | 0 Name | 2168 | 56 | 7 | 9.979511 | 40 |
| 5 | 1 Latitude,° | 2191 | 56 | 10 | 22.021424 | 40 |
| 4 | 2 Latitude,' | 2810 | 56 | 6 | 14.88016 | 40 |
| | 3 Latitude," | 9305 | 56 | 7 | 25.818161 | 40 |
| | 4 Longitude,° | 3274 | 56 | 7 | 2.600667 | 40 |
| | 5 Longitude,' 🗸 | 3913 | 56 | 10 | 26.505627 | 40 |
| | < > | 4316 | 56 | 11 | 1.692219 | 40 |
| 🗄 Add 🛛 🐹 Delete | 🗄 Add 🛛 🔄 Insert 🛛 🗱 Delete | 4741 | 56 | 10 | 31.675102 | 40 |
| | Tab Decimal Separator | | | | | |
| | | | | | | |
| Encoding UTF8 V | | < | | | | > |
| | ОК | Cancel | | | | |

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.

| Select | x |
|----------------|-----------|
| 🔺 🚛 Favorites | |
| 🕼 Default | |
| 🔺 🕕 New folder | |
| 🔓 Local-1 | |
| | |
| | |
| Name Local-1 | Ok Cancel |

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:

| Scalization | 1 | | | | | | | | _ | | < |
|----------------------------------------------------------------------------------------------|-----------------|-------------|------|--------------------------|-----------------------|-------------|-------------|---------|-----------|--------|---|
| Β.δ. ≌. ≌ 火 σ ⑫ ➡ 國 □ ※ | | | | | | | | | | | |
| Network coordinate system 🛛 BLH 🗸 🗋 🛃 🎌 Transformation type 🛛 Plane 🗸 Confidence level 99% 🗸 | | | | | | | | | | | |
| Select projectio | n: Oblique Ster | eographic 🗸 | |] Adjust Central Meridia | an Interval 0° 00' 10 | ,00000" | | | | | |
| | | | | Net | work | Ref | ference | | Residuals | | |
| RecNo | Enable | Туре | Name | Latitude | Longitude | North, m | East, m | X, m | Y, m | EV | |
| 1 | \checkmark | \$ | 1516 | N 56° 10' 34,24673" | E 40° 29' 56,45884" | 196784,7730 | 227246,9860 | -0,7629 | -1,4947 | 1,6782 | |
| | | | | | | | | | | | |

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. |
| Туре | sets the type of transformations in which a specific item can be used: |

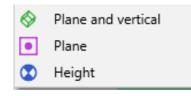


Figure 184 – Transformation types

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

| North, | East, | (Height | - if | from the Reference block - coordinates of points in the local |
|-------------------|---------|----------|----------|------------------------------------------------------------------------------------------------------|
| paramete | ers | for | height | coordinate system |
| transform | nation | are | also | |
| calculate | ed) | | | |
| X(м) Y(м block | ı) Z(м) | EV in Re | esiduals | 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:

| Localization | | | | | | | | | | | | _ | - 🗆 | > |
|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|-----------|------|---------------------|---------------------|-----------|-------------|-------------|-----------|-----------|---------|---------|--------|---|
| 861 | 8 X | σ ෯ | + | | | | | | | | | | | |
| Network coordin | Vetwork coordinate system 🛛 BLH 🗸 🗅 🛨 🛠 Transformation type Plane and vertical 🗸 Confidence level 99% 🗸 | | | | | | | | | | | | | |
| Select projection: Oblique Stereographic 🗸 📝 🗋 Adjust Central Meridian Interval 0° 00' 10,00000" | | | | | | | | | | | | | | |
| | | | | | Network | | Reference | | | Residuals | | | | T |
| RecNo | Enable | Туре | Name | Latitude | Longitude | Height, m | North, m | East, m | Height, m | X, m | Y, m | Z, m | EV | |
| 1 | \checkmark | \$ | 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 | \checkmark | ۲ | 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 | \checkmark | \$ | 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 | | 0 | 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 | | ۰ | 4316 | N 56° 11' 01,69222" | E 40° 26' 56,77807" | 185,3311 | 197567,3030 | 224129,5760 | | -1,0754 | 0,0447 | | 1,0763 | |
| 9 | | I | 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:

| | | | | | | | | | | | | _ | | |
|-----------------------------------------------------------------------------------------------------|--------------|-----------|------|---------------------|---------------------|-----------|-------------|-------------|-----------|---------|-----------|---------|--------|--|
| Localization | | | | | | | | | | | | - | | |
| 865 | * 😫 | σ 💮 | + | | | | | | | | | | | |
| Network coordinate system BLH 🗸 🗈 🕂 Transformation type Plane and vertical 🗸 Confidence level 99% 🗸 | | | | | | | | | | | | | | |
| Select projection: Oblique Stereographic V 🗹 🗋 Adjust Central Meridian Interval 0' 00' 10,00000" | | | | | | | | | | | | | | |
| | | | | | Network | | Reference | | | | Residuals | | | |
| RecNo | Enable | Туре | Name | Latitude | Longitude | Height, m | North, m | East, m | Height, m | X, m | Y, m | Z, m | EV | |
| 1 | \checkmark | S | 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 | \checkmark | • | 2168 | N 56° 07' 09,97951" | E 40° 21' 55,81245" | 183,8241 | 190295,4070 | 219080,6280 | | -0,9299 | -0,4103 | | 1,0164 | |
| 3 | \checkmark | \$ | 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 | \checkmark | \$ | 2810 | N 56° 06' 14,88016" | | 113,2061 | 188679,6640 | 223463,8840 | 3,3402 | | | | | |
| 5 | \checkmark | \$ | 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 | \checkmark | \$ | 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 | \checkmark | ٨ | 3913 | | E 40° 23' 20,76767" | 184,0758 | 196402,4400 | 220425,9350 | 74,2039 | | | | | |
| 8 | \checkmark | • | 4316 | N 56° 11' 01,69222" | E 40° 26' 56,77807" | 185,3311 | 197567,3030 | 224129,5760 | | -1,0244 | 0,2745 | | 1,0605 | |
| 9 | | 8 | 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:

| Localization | | | | | | | | | | | | _ | . 🗆 | |
|-----------------------------------------------------------------------------------------------------------|-----------------|-------------|------|--------------------------|-----------------------|-----------|-------------|-------------|-----------|-----------|---------|---------|--------|--|
| 8615 | ¥ ≌ | σ (බු | + | | | | | | | | | | | |
| Network coordinate system 🛛 BLH 👻 🎦 🗄 🎋 Transformation type 🛛 Plane and vertical 🔍 Confidence level 99% 🗸 | | | | | | | | | | | | | | |
| Select projection | : Oblique Stere | eographic 🚿 | |] Adjust Central Meridia | an Interval 0° 00' 10 | .00000" | | | | | | | | |
| | | | | | Network | | Reference | | | Residuals | | | | |
| RecNo | Enable | Туре | Name | Latitude | Longitude | Height, m | North, m | East, m | Height, m | X, m | Y, m | Z, m | EV | |
| 1 | \checkmark | \$ | 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 | \checkmark | ٠ | 2168 | N 56° 07' 09,97951" | E 40° 21' 55,81245" | 183,8241 | 190295,4070 | 219080,6280 | | -0,9102 | -1,0622 | | 1,3989 | |
| 3 | \checkmark | \$ | 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 | \checkmark | | 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 | | ا | 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 | | ٠ | 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:

| Localization | | | | | | | | | | | | | | ; |
|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|-----------|------|---------------------|---------------------|-----------|-------------|-------------|-----------|---------|---------|--------|--------|---|
| 8612 | 警 | ේ හි | | | | | | | | | | | | |
| | Vetwork coordinate system BLH 🗸 🗅 🗄 🋠 Transformation type Plane and vertical 🗸 Confidence level 99% 🗸 | | | | | | | | | | | | | |
| Select projection: Oblique Stereographic 💙 📝 🗋 Adjust Central Meridian Interval 0° 00' 10,00000" | | | | | | | | | | | | | | |
| | | | | | Network | | Reference | | | | | duals | | |
| 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:

| Grid plane and vertical localization |
|--------------------------------------|
| Northing offset |
| -3904159,771 m |
| Easting offset |
| -3819543,345 m |
| Rotation |
| 20° 57' 42,85963" |
| Scale difference |
| -288772,339 ppm |
| Vertical Offset |
| 136,181 m |
| North inclination |
| -0° 00' 08,66752" |
| East inclination |
| 0° 00' 04,17251" |
| |
| RMS 0,2044 |
| [V2] 0,0835 |

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:

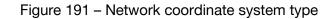
| Network coordinate system 🛛 BLH 🗸 🗅 🛨 🛠 | Transformation type | Plane and vertical $$ | Confidence level | 99% ~ |
|------------------------------------------------|--------------------------|------------------------|------------------|-------|
| Select projection: Oblique Stereographic 💙 🗹 🛛 |] Adjust Central Meridia | n Interval 0° 00' 10,0 | 0000" | |

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:

| Network coordinate system | BLH 🗸 |
|---------------------------|-------|
| | XYZ |
| | BLH |



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) 7parameter 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:

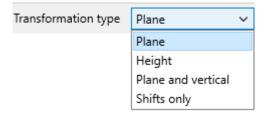


Figure 192 – Transformation type

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:

🗹 Adjust Central Meridian

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:

| | | x |
|----------------------|-----|---|
| — Oblique Stereograp | hic | |
| Latitude of Origin | | |
| N 0° 00' 00,00000" | | |
| Central Meridian | | |
| E 0° 00' 00,00000" | | |
| False Northing | | |
| 0,000 | m | |
| False Easting | - | |
| 0,000 | m | |
| Scale Factor | - | |
| 1,000000 | | |
| Prime meridian | | |
| E 0° 00' 00,00000" | | |
| - | | |

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:

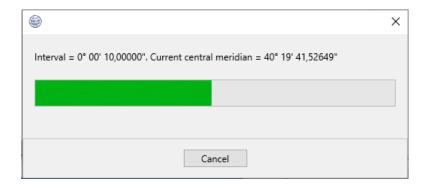


Figure 195 – Progress window

10.9 Progress window

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

| Confidence level | 99% ~ |
|------------------|-------|
| | 99% |
| | 95% |
| | 67% |

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 even on the icon bar of the Localization window.

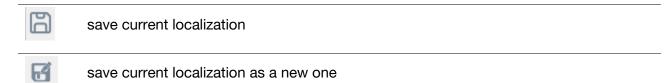
Import is carried out through a standard dialog from text files of arbitrary format with the extension csv, txt and files previously saved using a template with the extension PL.

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:



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



toolbar button or Program and Antennas in the main menu:

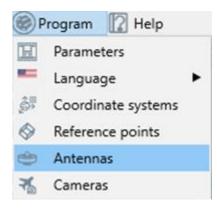


Figure 197 – Antennas item

to open Antennas window:

| Antennas | | | | | | | | | | | | | | | | _ | | × |
|------------------------------------------|-------------|----------------------|-------|------------|-------------|-------------|-------------|--------------|-------|-------|-------|--------|-------|-------|-------|-------|-------|-------|
| + □ 4 ≈ 2 2 0 0 | 🗄 🕂 d | 〕 膾 ☆ | | | | | | | | | | | | | | | | |
| Search by | Model | JAVTRIUMPH_1M NONE | | GPS GLO | DNASS | | | | | | | | | | | | | |
| Progress | Aliases | JAVTRIUMPH_1M NONE ~ | + ≈ | L1 (G01) | L2 (G0 | 2) | | | | | | | | | | | | |
| Others User | Manufacture | JAVAD GNSS | _ | Azimut\Z | 0°, 0,00 | 5°, 0.07 | 10° 0.24 | _ | | 25° | _ | | _ | | | 55° | | 65° 7 |
| GIAVTRIUMPH_1M _Clone | Description | | | 0° | 0,00 | 0,07 | | | | -0,24 | | | | | | | | |
| SERANTENNA 💬 USERANTENNA 1 | | | | 5° | 0,00 | 0,14 | 0,35 | 0,44 | | | | | | | | -2,07 | | |
| SERANTENNA_1 | | | 10° | 0,00 | 0,15 | 0,36 | 0,46 | | -0,18 | | | | | | | | | |
| ▲ 🗍 Last used | Radius | 88,75 | mm | 15° 20° | 0,00 | 0,15 | 0,37 | 0,47 0.49 | | -0,16 | | | | | | | | |
| SAVTRIUMPH_1M NONE | MPH | 54,40 | mm | 20 25° | 0,00 | 0,16 | 0,58 | | | -0,13 | | | | | | | | |
| | GPS GLON | IASS | ° 30° | 0,00 | 0,16 | 0,39 | | | -0,07 | | | | | | | | | |
| | Frequency | North, East, Up, mm | | 35° | 0,00 | 0,16 | 0,40 | 0,54 | 0,42 | -0,04 | -0,75 | -1,48 | -1,98 | -2,05 | -1,69 | -1,09 | -0,49 | -0,0€ |
| | L1 (G01) | 1,26 1,45 91,06 | | 40° | 0,00 | 0,16 | 0,40 | 0,55 | | -0,01 | | | | | | | | |
| | L2 (G02) | 2,64 -1,86 90,98 | | 45° 50° | 0,00 | 0,16 | 0,41 | 0,57 0.58 | 0,46 | 0,02 | | | | | | | | |
| | | | | 55° | 0,00 | 0,16 | | -1 | 0,51 | | | | | | | -1,22 | | |
| | | | | 60° | 0,00 | 0,16 | 0,41 | 0,59 | 0,52 | 0,11 | -0,58 | -1,36 | -1,97 | -2,19 | -1,95 | -1,41 | -0,82 | -0,44 |
| | | | | 65° | 0,00 | 0,16 | | | | 0,13 | | | | | | , | | |
| | | | | 70° | | 0,16 | | | | 0,15 | | | | | | | | -1,12 |
| | < | | 2 | | 0,00 | 0,15 | 0,40 | 0,50 | 0,00 | 0,13 | -0,34 | - 1,55 | -2,00 | -2,44 | -2,43 | -2,10 | -1,70 | > |

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

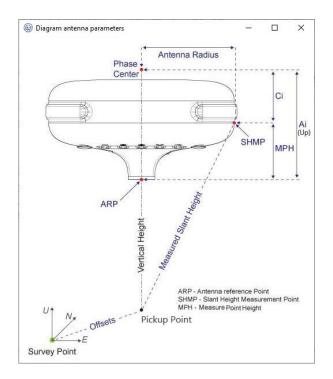
The central panel contains the name, description and parameters of the antenna selected in the lists and is used to edit the antenna parameters and the table of antenna phase center variations for antennas in the User list:

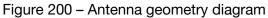
| le Antennas | | | | | | | | | | | | | | | | | - | | × |
|----------------------------------------|-----------|-------------|----------------------|-----|------------|--------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|---------|
| 🛨 💷 🖥 💥 😫 🕼 | () | ä 🛨 d |) 🖻 💥 | | | | | | | | | | | | | | | | |
| Search by | \approx | Model | JAVTRIUMPH_1M NONE | | GPS GL | ONASS | | | | | | | | | | | | | |
| JAVGRANT_G3TJ+G NONE | ^ | Aliases | JAVTRIUMPH_1M NONE ~ | F ⊠ | L1 (G01) | L2 (G0 | 2) | | | | | | | | | | | | |
| JAVGRANT_G5T NONE JAVGRANT G5T+GP JVGR | | Manufacture | | | Azimut\Z | | - | | 15° | | | | | | | | | | |
| JAVGRANT_G5T+GP JVGR | | Description | | | No azimut | -1 | 0,07 | 0,24 | 0,33 | | | | | -2,28 | | | | | |
| SAVGRANT_G5T+GP NONE | | Description | | | 5° | 0.00 | | 0,34 | | | | | | -2,23 | | | | | |
| JAVRINGANT_DM JVDM | | | | | 10° | | | | | | | | | -2,18 | | | | | |
| JAVRINGANT_DM NONE | | | | | | | | | | | | | | -2,14 | | | | | |
| JAVRINGANT_DM SCIS | | Radius | 88,75 | mm | 15° 20° | 0,00 | | | | | | | | -2,09 | | | | | |
| JAVRINGANT_DM SCIT | | MPH | 54,40 | mm | 20 25° | 0,00 | | | | | | | | -2,09 | | | | | |
| JAVRINGANT_GST_JAVC | | | | | ° 30° | 0,00 | | 0,38 | | | | | | -2,03 | | | | | |
| JAVRINGANT_G5T NONE | | GPS GLON | | | 35° | 0.00 | | 0,39 | | | | | | -1,98 | | | | | |
| JAVTRIANT NONE | | Frequency | North, East, Up, mm | | 40° | 0.00 | | 0,40 | | | | | | -1,96 | | | | | |
| ─JAVTRIANT_A NONE | | L1 (G01) | 1,26 1,45 91,06 | | 40 45° | -1 | | -1 | -1 | | | | | | | | | | |
| JAVTRIUMPH_1M NONE | | L2 (G02) | 2,64 -1,86 90,98 | | | 0,00 | | 0,41 | | | | | | -1,95 | | | | | |
| JAVTRIUMPH_1MR_NONE | | | | | 50° | 0,00 | | 0,41 | | | | | | -1,95 | | | | | |
| JAVTRIUMPH_2A NONE | | | | | 55° | 0,00 | 0,16 | 0,41 | 0,58 | 0,51 | 0,09 | -0,61 | -1,38 | -1,95 | -2,12 | -1,82 | -1,22 | -0,59 | -0,17 |
| JAVTRIUMPH_2A+G JVGR | | | | | 60° | 0,00 | 0,16 | 0,41 | 0,59 | 0,52 | 0,11 | -0,58 | -1,36 | -1,97 | -2,19 | -1,95 | -1,41 | -0,82 | -0,44 |
| JAVTRIUMPH_2A+P JVGR | | | | | 65° | 0,00 | 0,16 | 0,41 | 0,59 | 0,53 | 0,13 | -0,56 | -1,35 | -2,00 | -2,27 | -2,11 | -1,63 | -1,10 | -0,77 |
| JAVTRIUMPH_2A+P JVSD | | | | | 70° | 0,00 | 0,16 | 0,40 | 0,59 | 0,53 | 0,15 | -0,54 | -1,35 | -2,03 | -2,36 | -2,27 | -1,87 | -1,40 | -1,12 |
| JAVTRIUMPH_3A NONE | ~ | | | | 75° | 0,00 | 0,15 | 0,40 | 0,58 | 0,53 | 0,15 | -0,54 | -1,35 | -2,06 | -2,44 | -2,43 | -2,10 | -1,70 | -1,45 🗸 |
| | > | < | | > | < | | | | | | | | | | | | | | > |

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:





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 | GLC | NASS | | | | | | | | | | | | | | | | | | |
|---------|-----|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| G1 (R0 | 1) | G2 (R0 | 02) | | | | | | | | | | | | | | | | | |
| Азимут | \3 | 0°, | 5°, | 10° | 15° | 20° | 25° | 30° | 35° | 40° | 45° | 50° | 55° | 60° | 65° | 70° | 75° | 80° | 85° | 90° |
| Без ази | му | 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 |
| 4000 | | 0.00 | | 0.00 | 0.40 | A 14 | 0.04 | 0.07 | | 0.00 | 4 50 | 0.45 | 0.50 | - + F | 4 65 | 4 0.0 | 0.54 | 0.47 | A 10 | 4 0.0 |

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:

| 惽 | Clone | Shift+Ctrl+C |
|----|--------|--------------|
| 89 | Export | Ctrl+E |

| 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: |

| Export antenna | | | | | | Х |
|-----------------------|-------------------------------|-------------------------|------|--------------|--------|--------|
| ← → • ↑ | > This PC > New disk (D:) > 1 | | ٽ ~ | | | |
| Organize 🔻 Ne | w folder | | | | •== - | ? |
| 🖈 Quick access | ▲ Name | Date modified | Туре | Size | | |
| | * | No items match your sea | rch. | | | |
| 🕂 Downloads | * | | | | | |
| 🔮 Documents | * | | | | | |
| Pictures | * | | | | | |
| less oneDrive | | | | | | |
| Vander Nick | * | | | | | |
| File <u>n</u> ame: | | | | | | \sim |
| Save as <u>t</u> ype: | ANTEX files (*.atx, *.txt) | | | | | ~ |
| ∧ Hide Folders | | | | <u>S</u> ave | Cancel | |

Figure 203 – Export antenna window

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

| USERANTENNA | | | |
|-------------|-----|--------|--------------|
| 0 | Ð | Add | Ctrl+N |
| | ٥Ľ) | Rename | F2 |
| | 惽 | Clone | Shift+Ctrl+C |
| | ∺ | Delete | Del |
| | 22 | Import | Ctrl+I |
| | 89 | Export | Ctrl+E |

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:

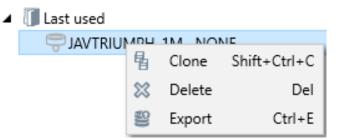


Figure 205 – Last used antennas menu

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 |
| ł | clone antenna |
| \otimes | 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

| ä | save changes in parameters |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| + | add a table of phase center variations for a specific navigation system and for a specific signal type |
| Ø | 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:

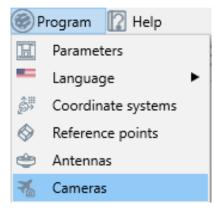


Figure 208 – Cameras

| Cameras and airplanes manager | - 0 | × |
|------------------------------------|-------------------|---|
| Ga 76 29 29 | | |
| Cameras | Edit Project | |
| i New Camera I New Camera 1 | Name | |
| 🙆 New Camera 2 | Offsets | |
| Airplanes | Forw/Back 0,0000 | m |
| ₩ New Airplane ₩ New Airplane 1 | Left/Right 0,0000 | m |
| X New Airplane 2 | Vertical 0,0000 | m |
| | Comment | |
| | Save Cancel | |
| ОК | Cancel | |

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:

| A | create an object New Camera |
|----------|-------------------------------|
| * | create an object New Airplane |
| ŶIJ | create BackUp File |
| S | 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:

| G | New Camera | Ctrl+N | * | New Airplan | e Ctrl+N |
|--------------|------------|------------|--------------|-------------|------------|
| * | Properties | Ctrl+Enter | * | Properties | Ctrl+Enter |
| <u>abj</u> i | Rename | F2 | <u>erj</u> i | Rename | F2 |
| × | Cut | Ctrl+X | ≻ | Cut | Ctrl+X |
| Ø | Сору | Ctrl+C | Ø | Сору | Ctrl+C |
| ħ | Paste | Ctrl+V | 齨 | Paste | Ctrl+V |
| ≈ | Delete | Del | ∺≋ | Delete | Del |
| 50 | Import | Ctrl+l | 89 | Import | Ctrl+I |
| 89 | Export | Ctrl+E | 8 | Export | Ctrl+E |

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: |

| 🙆 New Camera | 🛪 New Airplane → | | | |
|--------------------------|------------------|------------|--------------|---|
| Name New Camera | | Name | New Airplane | |
| Camera | | Offsets | | |
| Delay interval 0,000 | ms | Forw/Back | 0,0000 | m |
| Focal distance 0,000 m | nm | Left/Right | 0,0000 | m |
| Distance to film 0,000 m | nm | Vertical | 0,0000 | m |
| Gyro platform mounted | | Comment | | |
| Comment | | | | |
| L | | | | |

Figure 211 – Shifts and camera parameters

| Rename | rename an object |
|--------|------------------------------------------------------------------|
| Cut | cut out an object |
| Сору | 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 |

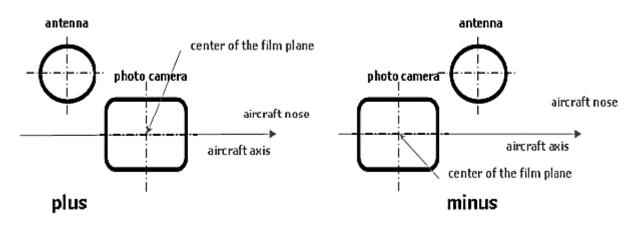
Parameters related to the aerial camera and the aircraft are automatically recognized when importing from *PAC* files.

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:





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:

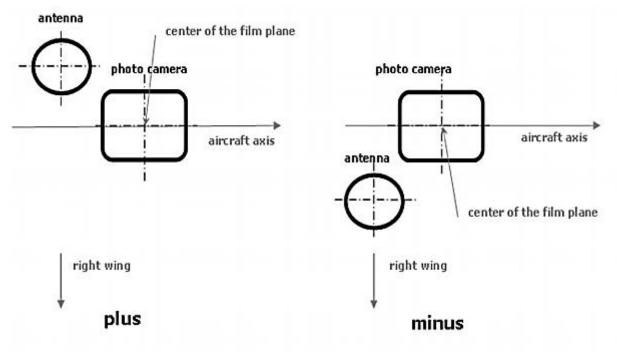


Figure 213 – Left/Right offset

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:

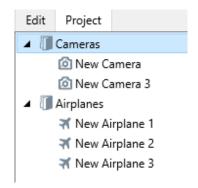


Figure 214– Project tab

To copy from program database to the project database or vice versa, select the element to be

copied and click the button \triangleleft or \triangleleft .

CHAPTER 13. COORDINATE CALCULATOR

The tool is available through main menu Tools item:

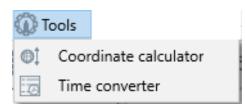


Figure 215 – Coordinate calculator item

| or by | clicking | button on a toolbar: | | | | | | |
|-------|------------|----------------------|--------------|--------------|----------------------------|---------|---|----------|
| | 🎯 Coordina | te calculator | | | | _ | | \times |
| | | Source | | | Target | | | |
| | BLH | | | Grid | | | | |
| | Latitude | N 0° 00' 00,00000" |] | North | 116,8692 | | | m |
| | Longitude | E 0° 00' 00,00000" | | East | 2775147,7970 | | |] m |
| | Height | 0,0000 n | " _~ | Height | -130,1648 | | | m |
| | EPOCH | 0,0000 | | EPOCH | 2010,0000 | | | |
| | 💮 WGS8 | 4 v 🕂 Q | | SK- | 42 / Gauss-Kruger zone 7 - | 36-4; ~ | + | Q |
| | | 4 | Convert coor | rdinate file | | | | |

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 🕒:

| Select | x |
|---------|---------------------------------------------------------------|
| 🔺 🚛 Far | vorites |
| ⊿ [] | Default |
| | G) WGS84 |
| | Ĵ→ WGS84(ECEF) |
| | World Mercator |
| | GS-63 St. Petersburg Region / Z4 10/3/2024 1:27:49 PM |
| | MKEA |
| | MNBD |
| | NCNA |
| | NEST |
| | P277 |
| | SCSR |
| | SK-42 / Gauss-Kruger zone 15 - 84-90° E 10/3/2024 1:26:39 PM |
| | SK-42 / Gauss-Kruger zone 7 - 36-42° E |
| | SK-42 / MSK-02 zn. 2 Resp. Bashkortostan 10/3/2024 1:29:16 PM |
| 1 | SK-42 / MSK-05 zn. 1 Resp. Dagestan |
| | TXVR |
| | WGS84(ITRF2014) |
| 🕨 🚺 Pro | oject |
| | Ok Cancel |
| | |

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:

| 67 | ED50 ~ |
|-----|---------------------------------|
| 67 | ED50 |
| | SK-42 / MSK-02 zn. 2 Resp. Basł |
| 67 | Adindan |
| | MSK-05 / Republic of Dagestan |
| 67 | WGS84 |
| Į÷, | WGS84(ECEF) |
| | SK-42 / Gauss-Kruger zone 7 - 🤅 |

Figure 218 – Choice of CS

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

| 🛞 SK-42 / Gauss-Kruger zone 7 - 36-42° E | – 🗆 X |
|------------------------------------------|-----------------------|
| Helmert Transformation (7-param. linear) | Transverse Mercator |
| X-axis translation | Latitude of Origin |
| 23,570 | n N 0° 00' 00,00000" |
| Y-axis translation | Central Meridian |
| 140.050 | m E 38° 59' 60,00000" |
| Z-axis translation | Scale Factor |
| -79,800 | n 1,000000 |
| X-axis rotation | False Easting |
| 0° 00' 00,00000" | 7500000,000 m |
| Y-axis rotation | Flattening |
| -0° 00' 00,35000" | 298,30000000 |
| Z-axis rotation | Prime meridian |
| -0° 00' 00,79000" | E 0° 00' 00,00000" |
| Scale difference | False Northing |
| -0,220 ppr | 0.000 |
| Semi-major axis (source) | Semi-major axis |
| 6370345.000 | m 6378245,000 m |
| Semi-major axis (target) | , |
| 6270127.000 | n 💮 — 🎹 Forward |
| Flattening (source) | |
| 298,30000000 | |
| Flattening (target) | |
| 298,257223563 | |
| Prime meridian (source) | |
| E 0° 00' 00,00000" | |
| Prime meridian (target) | |
| E 0° 00' 00,00000" | |
| | |
| 253 🔶 253 Backward | |
| | |

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 | Convert coo | | select the |
|--------------------------------------------------------------|---------------------|--------------|-------------|
| file containing the coordinates in the window | rce coordinate file | select the f | file. where |
| recalculated coordinates will be placed in the window and th | | | , |

Define templates

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

| Select import template X | | | | | | | |
|-----------------------------------------|---------|-----------------------|--------|--------------|--------------|-------------|--------|
| Template | Columns | | Empty | Northing | Easting | Height | |
| 1 | Column | Value | МНСВ | -2664063,74 | -4323171,986 | 3848361,519 | -26640 |
| 3 | 0 | Empty | P222 | -2689640,155 | -4290437,452 | 3865050,855 | -26896 |
| 4 | 1 | Northing | SLAC | -2703115,933 | -4291767,215 | 3854247,872 | -27031 |
| | 2 | Easting | ZOA1 | -2684436,493 | -4293337,322 | 3865351,523 | -26844 |
| | 3 | Height | S300 | -2645887,228 | -4307855,756 | 3876512,189 | -26458 |
| | | | P254 | -2645677,671 | -4322568,538 | 3861306,138 | -26456 |
| | | | P259 | -2619348,155 | -4342043,826 | 3855666,111 | -26193 |
| | | | P217 | -2672525,596 | -4335539,1 | 3826692,095 | -26725 |
| 🗄 Add 🛛 🐹 Delete | Œ | Add 🔄 Insert 🗱 Delete | P242 | -2663555,5 | -4352803,559 | 3813317,713 | -26635 |
| Separator Space Tab Decimal Separator . | | | | | | | |
| Combine lines 1 🗸 🗌 Igr | | | | | | | |
| Encoding UTF8 V | < | | | | > | | |
| | | OK | Cancel | | | | |

Figure 220 – Coordinate input template