

Justin3

User Manual

Version 1.02

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1. Main Window

When Justin is starting the Main program window appears. This window contains Main menu, Tool and Status bars, a project and map panes as well.

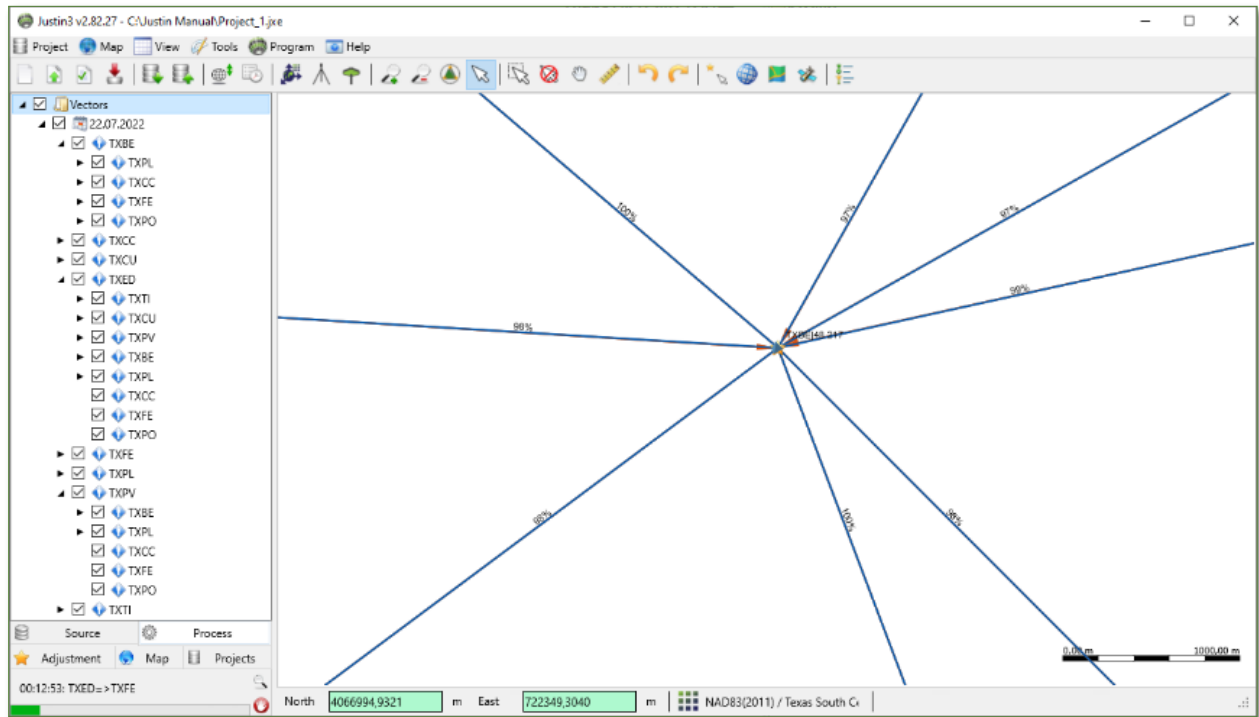


Figure 1: Main Window

Below are the terms used in this manual:

- Project – SQLite database.
- Dataset – Project table that contains data for unique receiver and antenna pair.
- Recordset – A query from Dataset.
- Vector – An object corresponds two overlapped in time Recordsets.
- Solution – A result of Vector post-processing.
- Edge – A result of a Solution adjustment.
- Site – An object created by import raw data file according to standalone, DGPS, RTK solutions, header of RINEX, tag in RTCM message.

1.1. Project

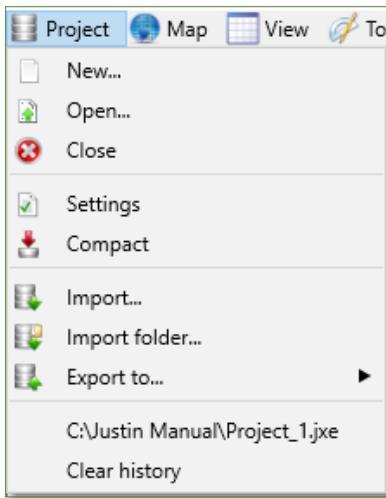


Figure 2: Project Menu

The Project menu contains the following items:

- New project creation.
- Open a project that already exists.
- Close a project and save it.
- Settings for opened project.
- Compact a project to remove empty records from database.
- Import – Import observations.
- Import folder – Import all raw data from a folder and subfolders.
- Export to – Export program layers to most popular GIS Formats (ESRI Shape, MapInfo TAB, MIF/MID, DXF, KMZ/KML, PNEZD, TXT).
- History list of five recently opened projects.

Note: Some of Project menu items are duplicated in the toolbar.

1.2. Map



Figure 3: Map Menu

The Map menu contains the following items:

- Zoom – Zoom In/Out to increase/decrease map scale.
- Select – Select map feature, select map feature by rectangle, unselect map feature.
- Pan (Alt) – Pan around map.
- Ruler – A tool for distance and azimuth measurements.
- View – View Options for map (Back, Forward, Scale, Snap disabled, Show Meridian and Parallel, Background Map, Background Satellites and Clear map cache).
- Legend – Enable/Disable map legend.

1.3. View

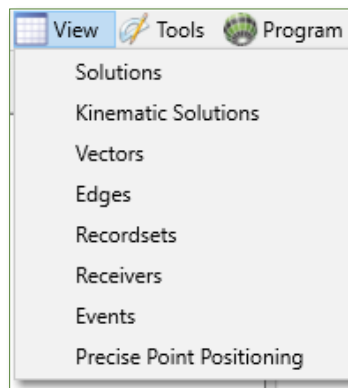


Figure 4: View Menu

The View menu contains the following items:

- Solutions – Open Solution table.
- Kinematic Solutions – Open Kinematic Solutions
- Vectors – Justin3 does not create vectors between data provided by receivers defined as rovers (rover to rover).
- Edges – Open the resultant table after adjustments.
- Recordsets – Open Recordsets.
- Receivers – Information and control.

Receiver type	Receiver number	Serial number	Firmware version	Rover
TRIMBLE NETR9	5504R50124		Nav 5.45 / Boot 5.45	<input type="checkbox"/>
TRIMBLE ALLOY	6042R40080		Nav 5.45 / Boot 5.45	<input type="checkbox"/>
TRIMBLE ALLOY	5949R40164		Nav 5.45 / Boot 6.05	<input type="checkbox"/>
TRIMBLE ALLOY	6042R40135		Nav 5.45 / Boot 6.05	<input type="checkbox"/>

Figure 5: Receivers Table

Events – Events information table.

Time	Event	Event Type	Latitude	Longitude	Height, m	DX X	DY Y	DZ Z	Azimuth	RMS
03.08.2018 11:18:55.2285436	XA00001	_XA	N 61° 33' 54,15557"	E 51° 31' 50,19117"	143,7338	0,906	1,730	1,656	27° 38' 43,29595"	0,5090
03.08.2018 11:33:30.3618836	XA00002	_XA	N 61° 33' 57,76697"	E 51° 31' 23,93769"	571,6587	-24,742	-23,186	-1,998	226° 51' 34,77492"	0,8023
03.08.2018 11:36:06.7042690	XA00003	_XA	N 61° 34' 21,04845"	E 51° 32' 10,02724"	618,3939	10,530	14,518	-3,042	35° 57' 10,28530"	1,2205
03.08.2018 11:39:11.0082268	XA00004	_XA	N 61° 35' 56,51167"	E 51° 34' 14,37808"	619,1027	10,122	16,600	-1,632	31° 22' 24,28599"	1,2864
03.08.2018 11:41:35.0695017	XA00005	_XA	N 61° 37' 14,06529"	E 51° 35' 55,00272"	616,0456	25,601	-2,698	-3,293	96° 00' 58,25419"	0,8782
03.08.2018 11:41:37.3894793	XA00006	_XA	N 61° 37' 13,86924"	E 51° 35' 59,13551"	616,4914	27,513	-2,591	1,122	95° 22' 49,52609"	1,0717
03.08.2018 11:41:39.5893848	XA00007	_XA	N 61° 37' 13,55291"	E 51° 36' 03,21179"	619,0711	28,235	-5,830	-1,061	101° 39' 56,26674"	0,9973
03.08.2018 11:41:41.7095243	XA00008	_XA	N 61° 37' 13,13813"	E 51° 36' 07,21895"	618,8808	27,648	-5,603	-2,580	101° 27' 21,53824"	0,8559

Figure 6: Events Table

Precise Point Positioning – Opens a table of results.

St.	Name	Begin time	End time	Time span	Processed	Latitude	Longitude	Height, m	RMS, m	Fix ra.	Num...	Num u...	discard...	Nu...	Num...	R...	A...	V...	Satellite	Epochs
	TXBE	7/22/2022	7/22/2022 11:59:00 PM	0 / 23:59:30	12/20/2022 4:38:07 PM	N 28° 25' 25.23367"	W 97° 44' 07.66124"	48.0060	0.0087	0	126700	126700	0	235	0		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	GPS(31),GLONASS(...)	2879
	TXCC	7/22/2022	7/22/2022 11:59:00 PM	0 / 23:59:30	12/20/2022 4:39:28 PM	N 27° 44' 26.86961"	W 97° 26' 30.04870"	-10.4807	0.0085	0	124398	124398	0	244	0		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	GPS(31),GLONASS(...)	2879
	TXPV	7/22/2022	7/22/2022 11:59:00 PM	0 / 23:59:30	12/20/2022 4:39:31 PM	N 28° 38' 17.43880"	W 96° 37' 06.69863"	-16.6448	0.0101	0	126458	126458	0	234	0		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	GPS(31),GLONASS(...)	2879
	TXPO	7/22/2022	7/22/2022 11:59:00 PM	0 / 23:59:30	12/20/2022 4:39:32 PM	N 27° 50' 22.05810"	W 97° 04' 11.68610"	-20.8488	0.0087	0	128270	128270	0	229	0		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	GPS(31),GLONASS(...)	2879
	TXCU	7/22/2022	7/22/2022 11:59:00 PM	0 / 23:59:30	12/20/2022 4:39:32 PM	N 29° 08' 01.90653"	W 97° 16' 34.76142"	52.6577	0.0101	0	128894	128894	0	241	0		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	GPS(31),GLONASS(...)	2879
	TXTI	7/22/2022	7/22/2022 11:59:00 PM	0 / 23:59:30	12/20/2022 4:39:57 PM	N 28° 28' 04.91020"	W 98° 33' 51.48809"	57.8446	0.0097	0	128908	128908	0	248	0		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	GPS(31),GLONASS(...)	2879

Figure 7: Precise Point Positioning Table

1.4. Tools

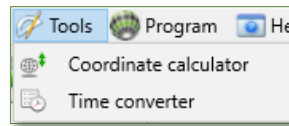


Figure 8: Tools Menu

The Tools Menu contains the following items:

- Coordinate calculator – Select a source and target coordinate system.
- Time converter – Opens the Time converter window.

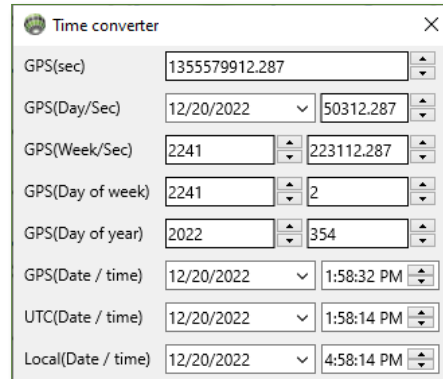


Figure 9: Time Converter

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 time differs from UTC by the number of hours of your time zone.

Modified Julian Date, MJD, is a modification of the Julian Date that is routinely used by astronomers, geodesists, scientists, financiers, and even some historians. This dating convention, designed to facilitate simplified chronological calculations, numbers all days in consecutive fashion, beginning at a date sufficiently far into the past so as precede the historical period. Day Number is an integer counter of the days starting at noon on January 1, 4713 B.C., which is Julian Day Number 0.

1.5. Program

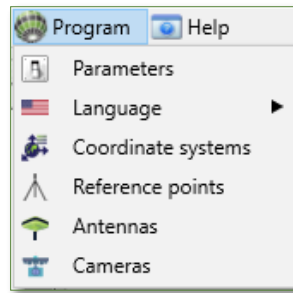


Figure 10: Program Menu

The Program Menu contains the following items:

- Parameters – Contains a list of Program Parameters, further detailed below.
- Language – Contains a list of available languages.
- Coordinate systems – Opens the Coordinate Systems Manager.
- Reference points – Opens the Reference Points Manager.
- Antennas – Opens the Antenna Window.

1.5.1. Parameters

Selecting Program -> Parameters opens the tabular Program Parameters Window.

1.5.2. Common Tab

The Common Tab allows for:

- Open last project – Open last used project.
- Use epoch in coordinate transformation – Apply time-dependent coordinate transformations.
- Request for downloading if geoid not exists – Asks for confirmation about downloading from JAVAD GNSS repository of Geo Data.

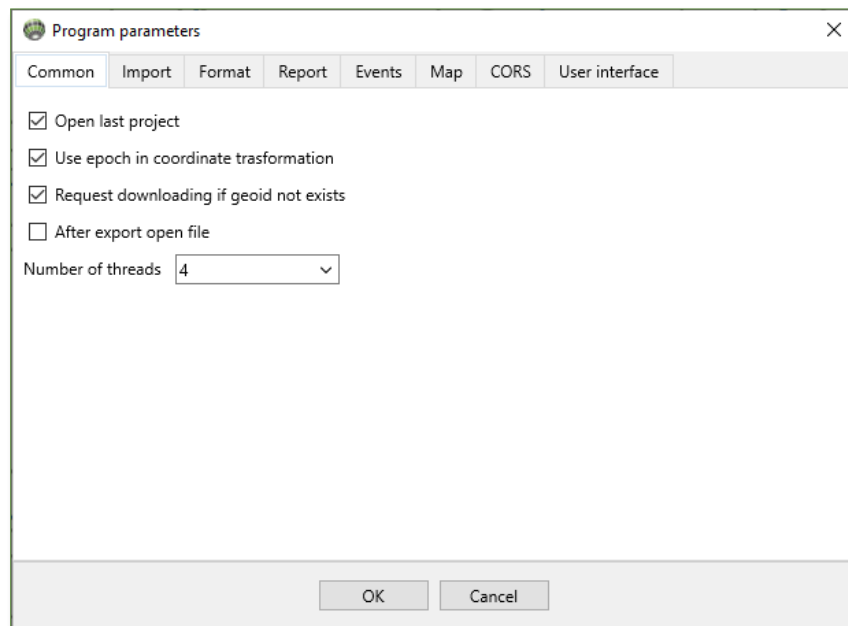


Figure 11: Program Parameters Window: Common Tab

1.5.3. Import Tab

The Import Tab allows for:

- Calculate coordinates – This will calculate coordinates for data import files.
- Don't import nested data – This will not import any nested data within import files.
- Don't load ephemeris from Internet – This will stop automatically loading ephemeris from the Internet.

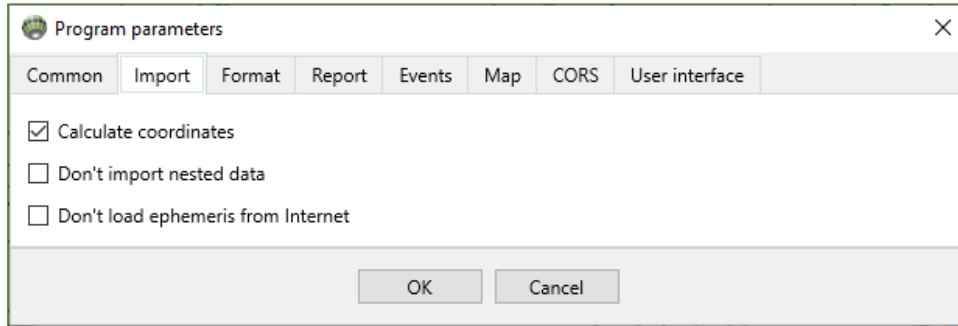


Figure 12: Program Parameters: Import Tab

1.5.4. Format Tab

The Format Tab allows for program measurement units (time, units and coordinates) to be selected.

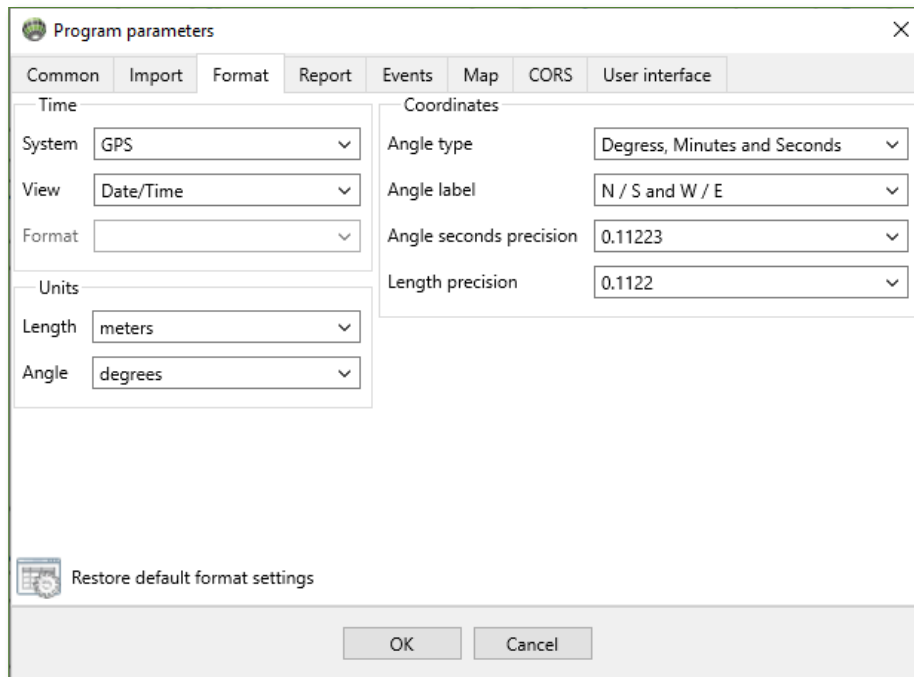


Figure 13: Program Parameters: Format Tab

1.5.5. Report Tab

The Report Tab shows a list of the supported report types. The supported report types are:

- Designer
- Render
- TXT
- Csv
- Html
- Pdf
- Word
- Excel
- OpenDocCalc
- OpenDoc
- Image

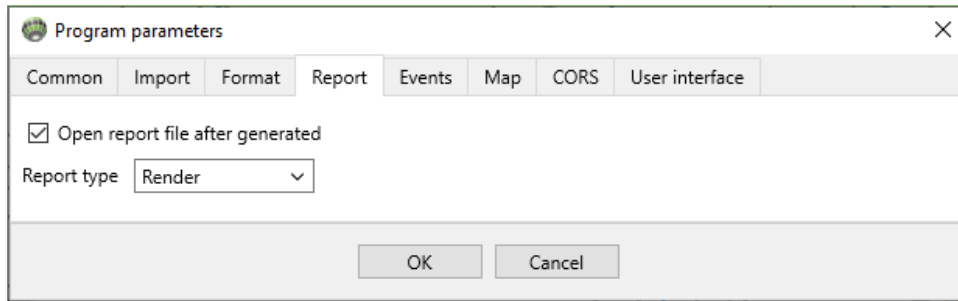


Figure 14: Program Parameters: Report Tab

1.5.6. Events Tab

The Events Tab allows for selection of type of epoch coordinates interpolation.

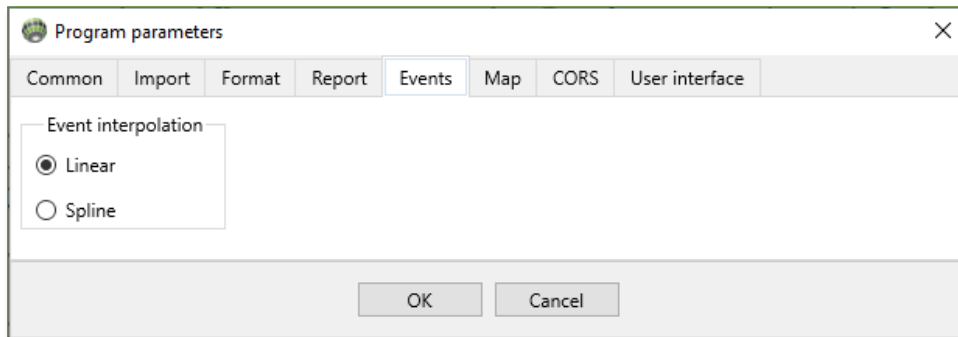


Figure 15: Program Parameters: Events Tab

1.5.7. Map Tab

The Map Tab contains the cartographic data source. Alternative allows Justin 3 to search for maps at the most popular Internet map repositories. Show grid add a grid on the map and Show coordinates panel adds coordinates on the map.

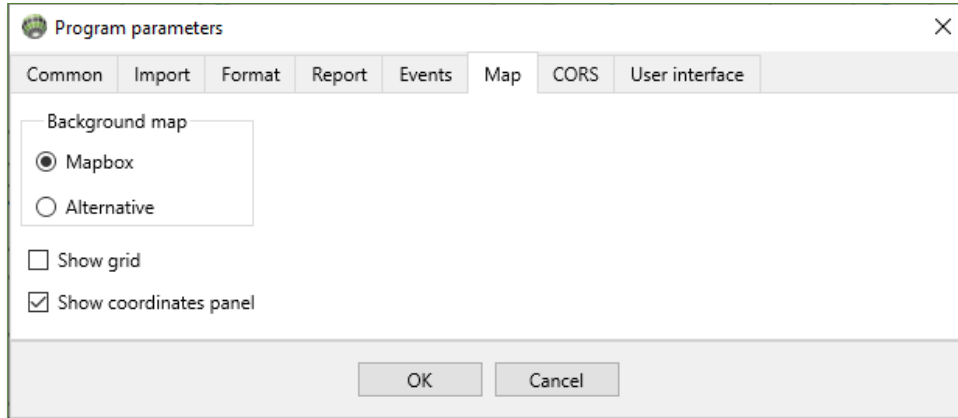


Figure 16: Program Parameters: Map Tab

1.5.8. CORS Tab

The CORS Tab allows for including/excluding the vectors created using CORS data.

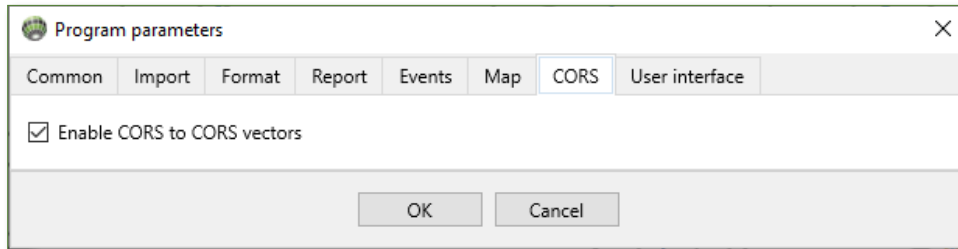


Figure 17: Program Parameters: CORS Tab

1.5.9. User interface Tab

The User Interface Tab allows for customization of the process tree and checkboxes.

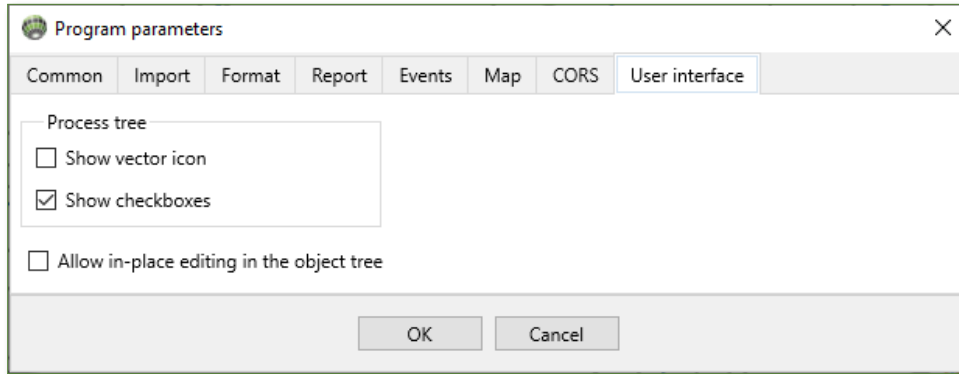


Figure 18: Program Parameters: User Interface Tab

1.6. Help

The Help Menu contains the following items:

- About – Illustrates the Program, Version, Support Email and creation date.
- User Manual – Loads this user manual from the Javad GNSS Repository.

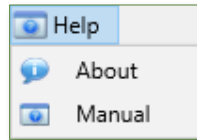



























Figure 19: Help

1.7. Tool Bar

The Tool Bar consists of icons across the top of the Main Window. Each Icon is further described in the table below.

Icon	Description
	Open New Project window
	Open Predefined File window
	Open Project Settings window
	Compact Project Database
	Import Observations File
	Export Project Data
	Open Coordinate Calculator window
	Open Time Converter window
	Open Coordinate Systems Manager Window
	Open Reference Point Manager window
	Open Antenna Manager window
	Increase Map Scale
	Decrease Map Scale
	Shows all program layers
	Cursor Select in Point Mode
	Cursor Select in Rectangle Mode
	Unselect
	Pan the Map
	Distance / Azimuth Measurement
	Previous Map position and scale
	Initial Map position and scale; used <i>after</i> 
	Ruler Snapping Mode
	Show / Hide Grid
	Show / Hide Raster Map
	Show / Hide Space Images
	Show / Hide Legend

1.8. Status Bar

The Status Bar is designed for progress information of a program routine. For example, it is active during a data import routine (shown below).



Figure 20: Active Status Bar (Data Import Routine)

The Status Bar is also active during data export, post-processing, skyplot, runtime and table view chart creation routines.

Click to stop the routine in progress.

Click to expand the Status Bar, as shown below.

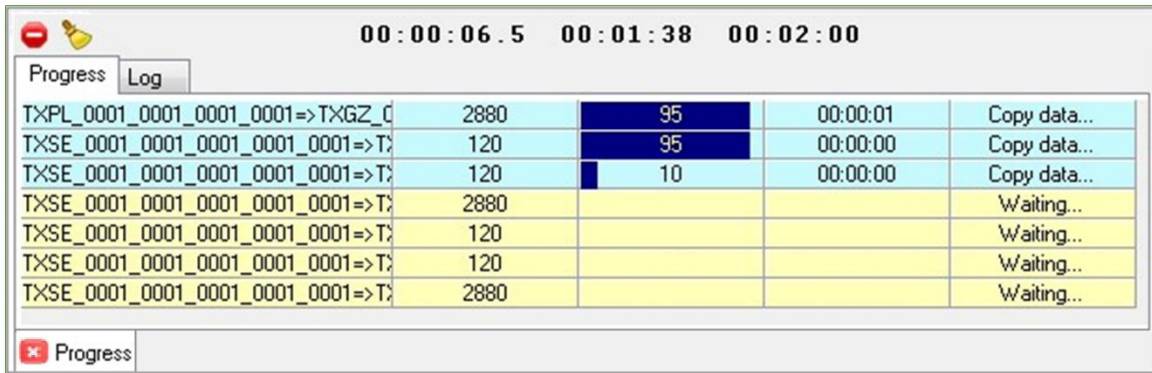


Figure 21: Expanded Status Bar: Progress Tab

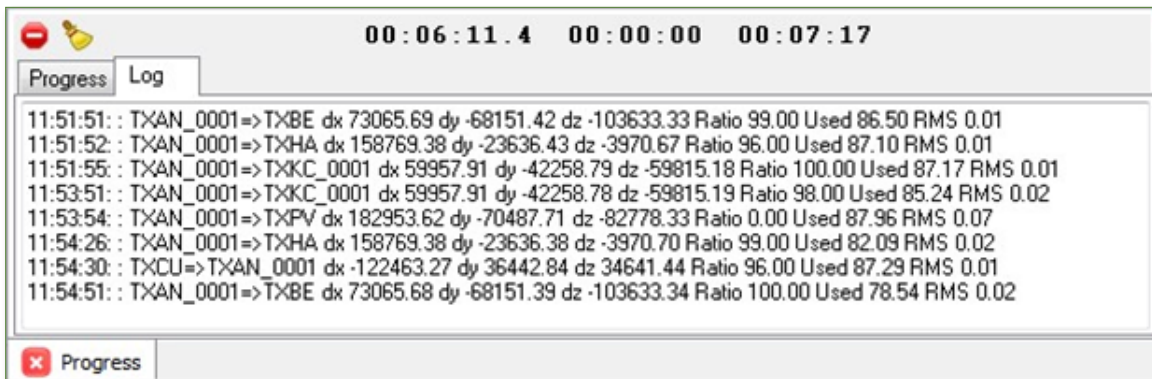


Figure 22: Expanded Status Bar: Log Tab

Click to minimize the expanded Status Bar.

Click to clear the window.

1.9. Project Pane

The Project Pane is designed to provide full access to program routines. There are four operational tabs:

- Source
- Process
- Adjustment
- Map

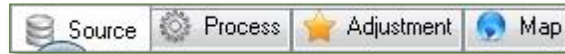


Figure 23: Project Pane Tabs

The available Source Tab menu options depend on Project and Sort options.

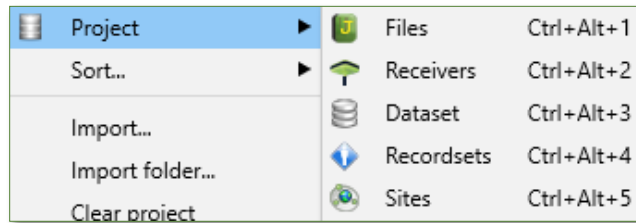


Figure 24: Project Pane: Source Tab

2. Map Tab

The Map Tab allows for Layers, Contours and CORS elements, each is further described below.

2.1. Layers

The Map Tab provides several predefined layers to control the view of principle objects. Click on the Map Tab to access the layer settings (shown below).

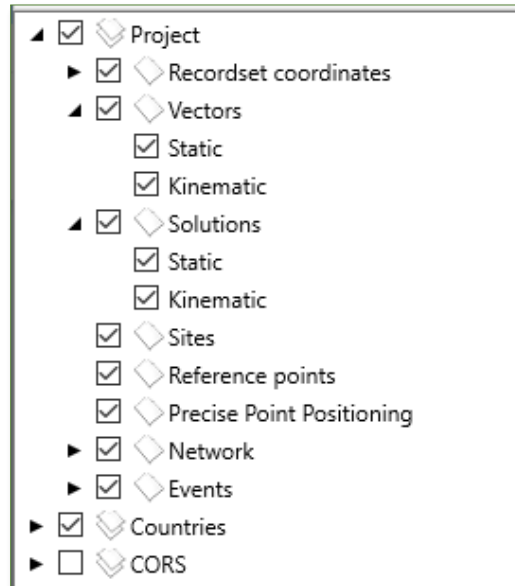


Figure 25: Map Tab: Layer Items

Below is a list of icons and descriptions shown in this section.

Icon	Description
	Recordset track – Collection of points
	Static vector – Grey line
	Kinematic vector – Track, collection of points
	Static Solution – Custom colored line
	Kinematic solution – track, collection of points
	Precise Point Positioning (PPP) solution
	Common edge – Blue line
	Blunder edge – Grey/Brown line
	Adjusted PPP solution
	Site on Standalone coordinates
	Site on Post-Processed coordinates
	Site on Adjusted coordinates
	Site snapped to Reference point
	Site on RTCM base coordinates
	Event – Oriented blue arrow
	Reference Point

2.2. Contours

Contours are displayed as boundary polylines allowing for several selections (shown below).

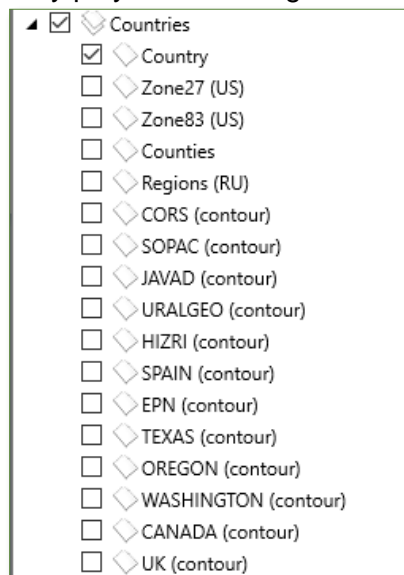


Figure 26: Map Tab: Contours

The checkbox next to the items enables / disables the layer. Some layers have style settings; click the right mouse button on the item to show available style settings.

2.2.1. Contour Style Options

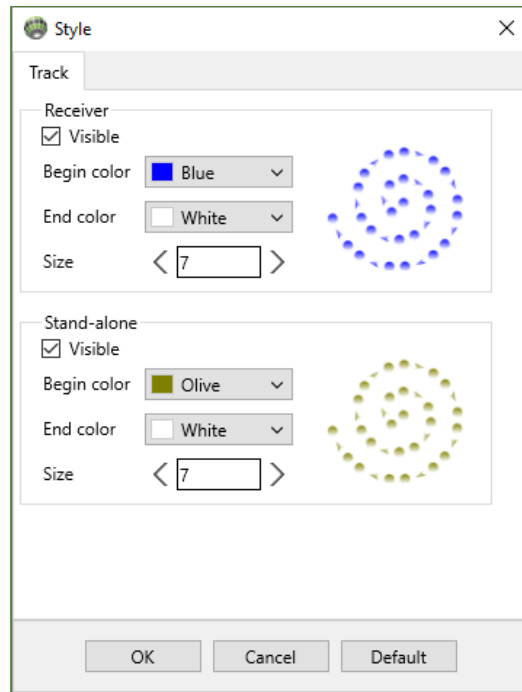


Figure 27: Contour Style Options

2.3. CORS

Continuously Operated Reference Station (CORS) options are shown below.

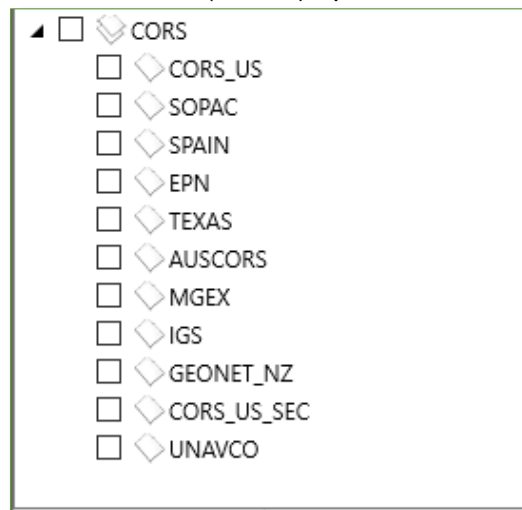


Figure 28: Map Tab: CORS

The checkbox next to the items enables / disables the layer. Some layers have style settings; click the right mouse button on the item to show available style settings.

2.3.1. CORS Style Options

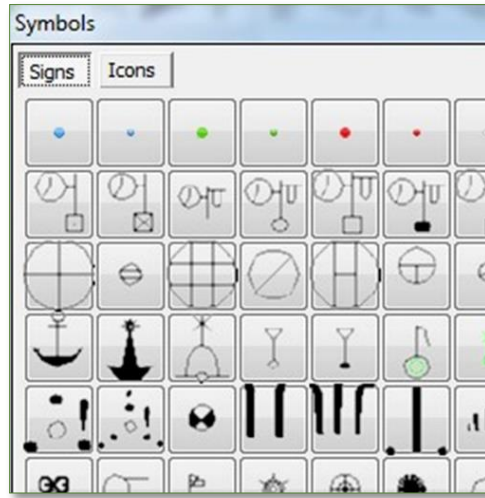


Figure 29: CORS Style Options?

3. Source

The Source Tab is for data management (Import / Export, View, Modify).

3.1. Project

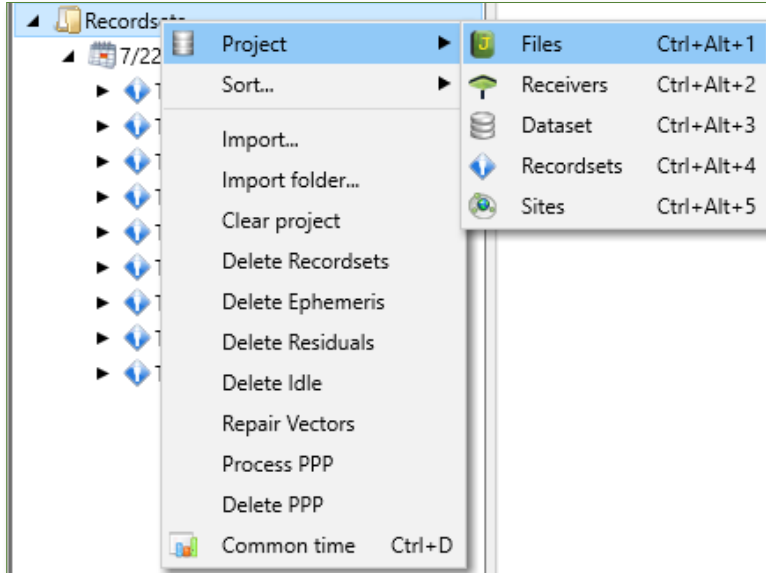


Figure 30: Source Tab: Project Menu

The root item may vary depending on project options. Clicking on Project allows the user to see the main project menu items (File, Receiver, Dataset, Recordset and Site). File shows items about imported files.

3.2. Sort

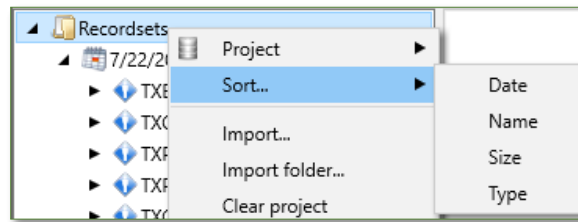


Figure 31: Source Tab: Sort Menu

Files sorted by Date contains common time options.

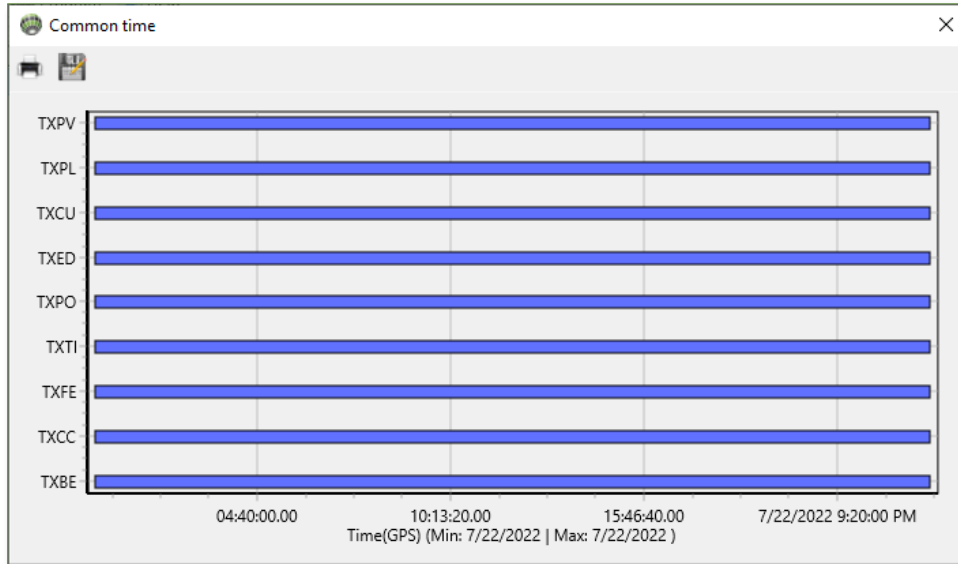


Figure 32: Common Time

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

Below is an example of sorting the Receiver item.

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 a dataset that is a corresponding receiver / antenna pair. The 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.

A Recordset is a query from Dataset. By default, every Dataset produces at least one Recordset linked to the parent object.

The user may modify Recordsets with no risk of corruption to the 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 case of Static / Dynamic event markers, epoch gaps, record interval changing inside raw data file and so on.

The Site is an object created by the import routine and being used as a point GIS feature. Coordinates of Site are the standalone solution or provided by the receiver. Justin separates Sites using tolerance.

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

3.3. Import

This option allows for importing different types of GNSS Data.

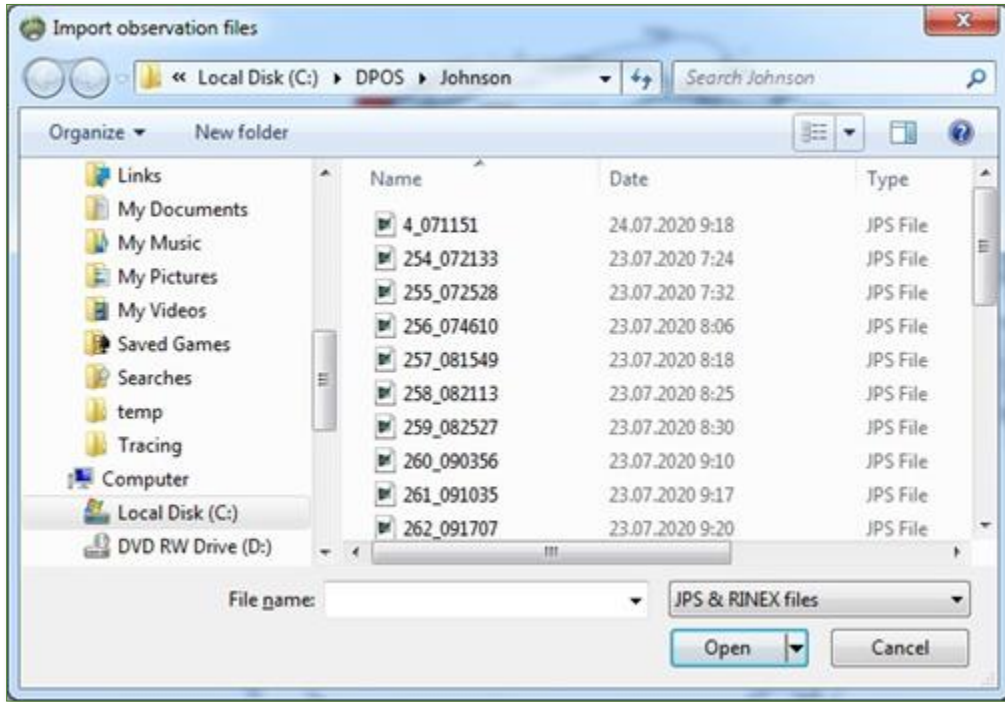


Figure 33: Import Observation Files

3.4. Import Folder

The Import folder option may be used for batch process of import all valid Justin GNSS data.

3.5. Clear Project

The Clear project option is used to remove all GNSS data from a project. A confirmation is needed.

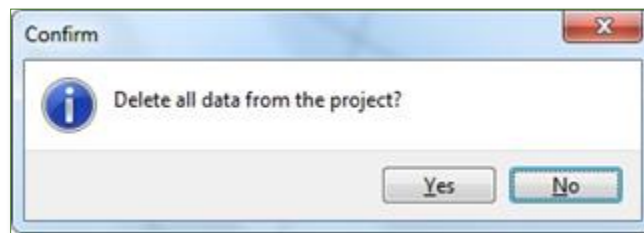


Figure 34: Delete Confirmation Screen

3.6. Delete Recordsets

The Delete Recordsets option drops all items.

3.7. Delete Ephemeris

The Delete Ephemeris option may be use in case of suspicious ephemeris in original raw data files. Just can download ephemeris data from the internet automatically.

3.8. Delete Residuals

The Delete Residuals option frees the project from a significant number of data generated by processes with residuals option.

3.9. Delete Idle

The Delete Idle option frees the project from GNSS data useless for Vector post-processing. This is the data that has no overlapping time.

3.10. Repair Vectors

The Repair Vectors option may be helpful in case the program crashes.

3.11. Files

The File menu is designed for managing file objects.

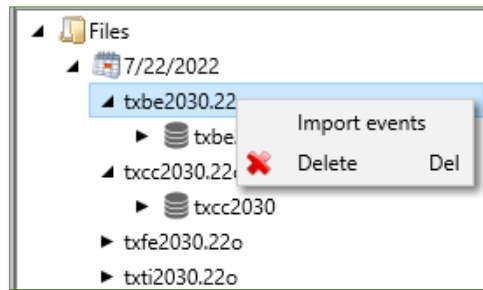



Figure 35: File Object Management

 B, J, R letters above the icons indicate file origin (Broadcasted ephemeris, Jps, Rinex). The File item contains related Datasets and Recordsets items.

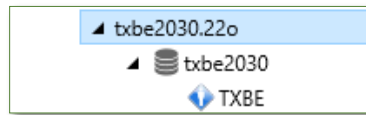


Figure 36: Datasets and Recordsets

Import external events file Ashtech (.dat), leica (.ev) formats and .csv. Event tags are File properties.

3.12. Receivers

If the user switches the project pane to Receiver mode, the upper item contains Datasets and Recordsets. A red exclamation mark indicates there is no antenna type specified.

3.13. Datasets

Select Datasets option to reconfigure project tree for Datasets. A Datasets tree is shown below.

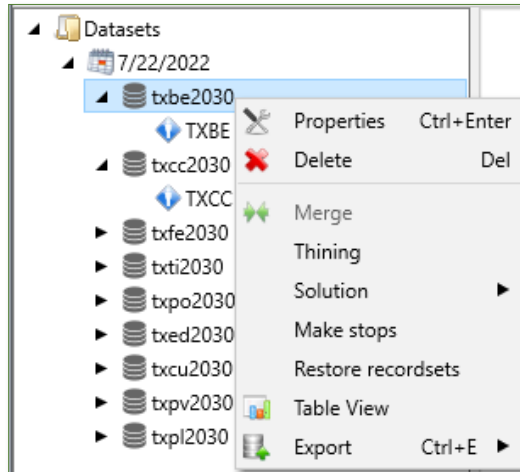


Figure 37: Datasets

3.13.1. Table View

The Table View shows raw data in detail.

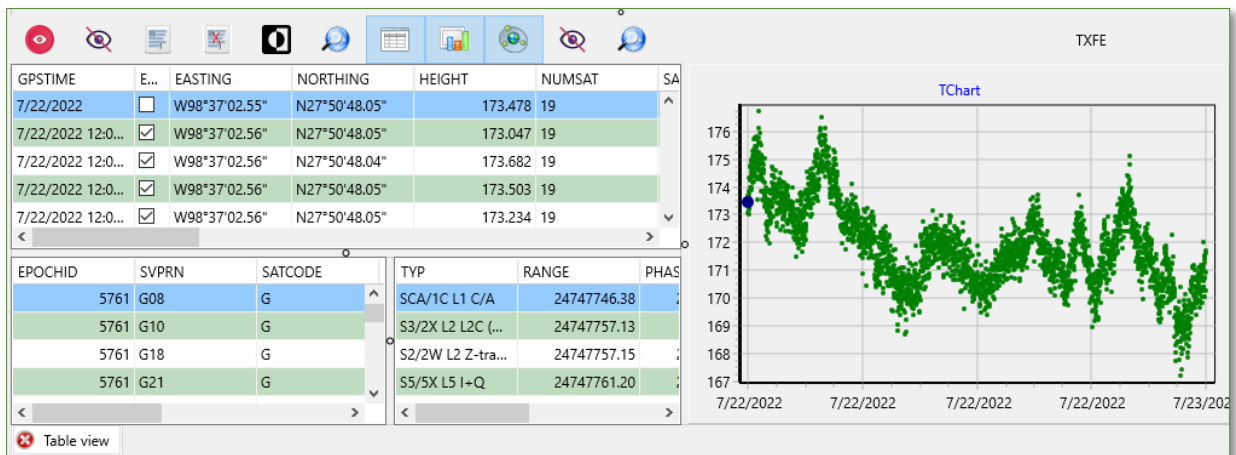


Figure 38: Table View

3.13.2. Thinning

The thinning option customizes data record interval. It may remove data from the project.

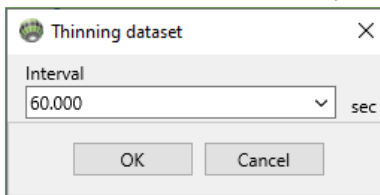


Figure 39: Thinning

3.13.3. Restore Recordsets

The Restore Recordsets option recreates objects by default program settings (e.g., during the import routine). Delete Dataset from the project. The appropriate file will also be deleted if that file corresponds only to one Dataset.

Multiple Datasets selection (Shift, Ctrl) allows to merge Datasets. Typically used to merge hourly raw data.

3.14. Recordsets

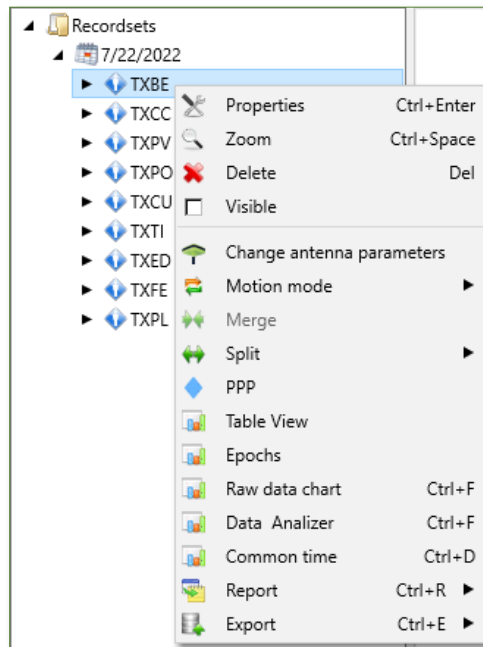


Figure 40: Recordsets

3.14.1. General Tab

The General Tab allows for changes to File name, Alias, Site, Comment, Observer, Agency, Begin time / date, End time / date, Interval and Epoch.

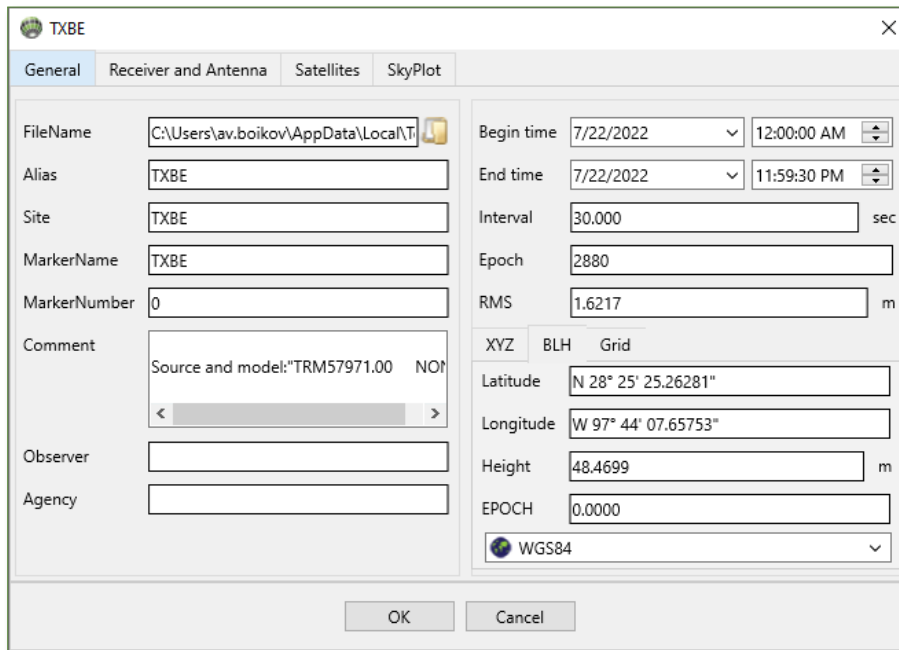


Figure 41: Properties: General Tab

3.14.2. Receiver and Antenna Tab

The Receiver and Antenna Tab allows viewing and editing of antenna parameters. Click the search icon next to Antenna Type for the antenna list. Slant(SHMP), shown next to Type means slant height measurement point.

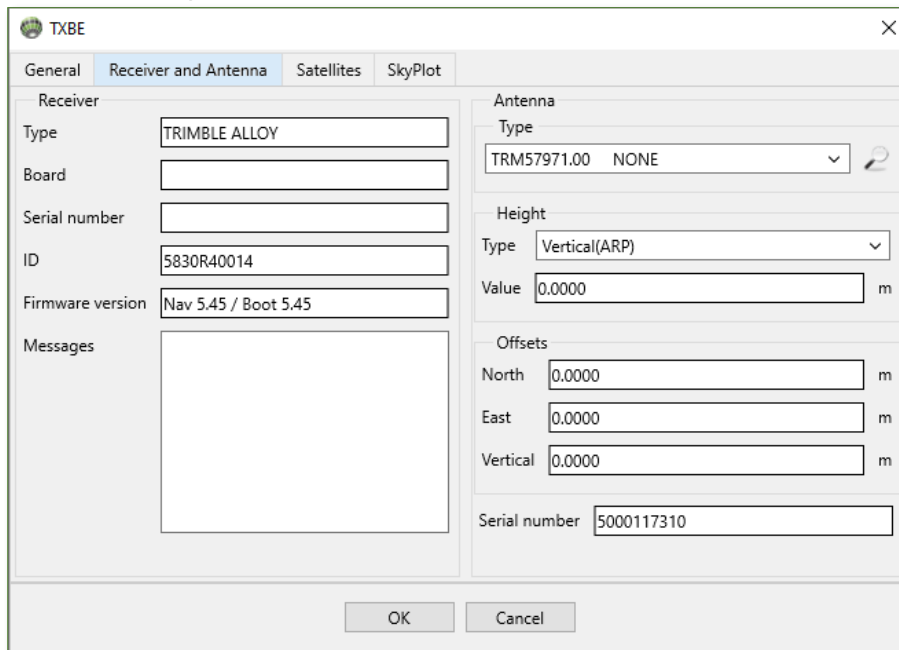



Figure 42: Properties: Receiver and Antenna Tab

3.14.3. Satellites Tab

The Satellites Tab shows GNSS Satellites and Signal information. Yellow circles mark unhealthy satellites whereas green circles mark healthy satellites. The icon  indicates the ratio of present/absent signals.

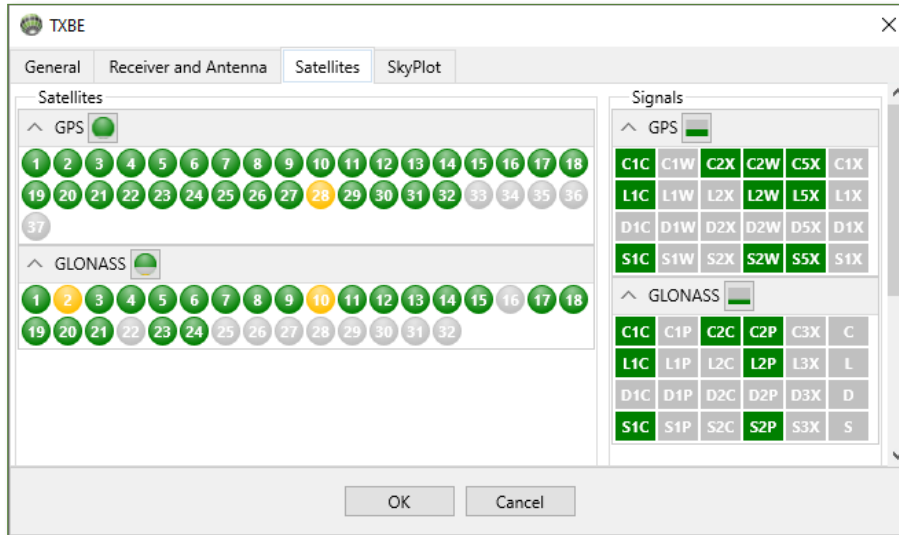


Figure 43: Properties: Satellites Tab

3.14.4. Skyplot Tab

The Skyplot Tab shows a current skyplot of along a timescale shown on the left. GPS is indicated by green, GLONASS is indicated by red, Galileo is indicated by blue, and Beidou is indicated by yellow. Use the timescale slide on the left to scroll between epochs.

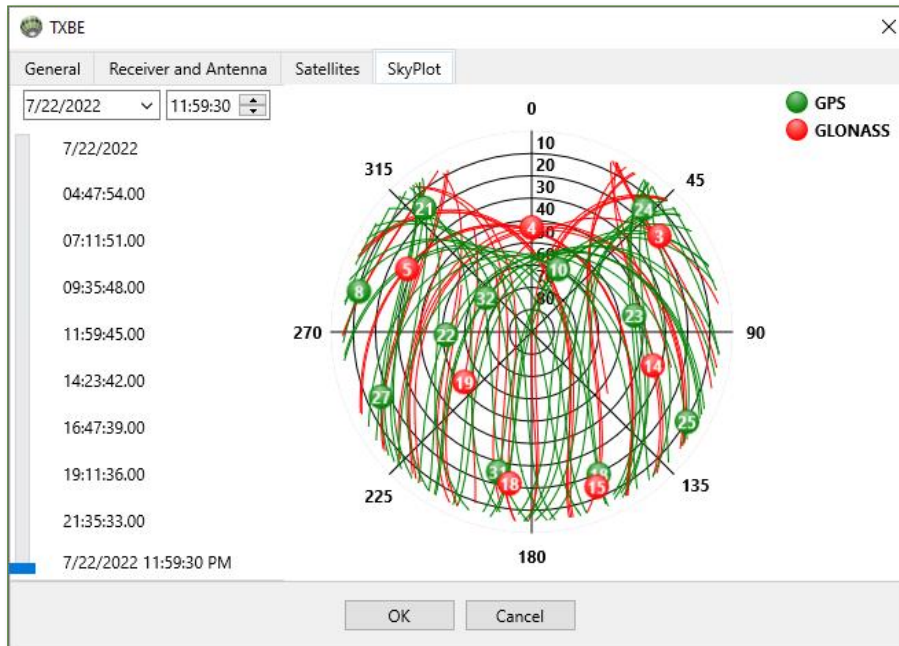


Figure 44: Properties: Skyplot Tab

3.14.5. Table View

The Table View shows raw data in detail.

3.14.6. Epochs

The Epoch option shows a table as follows:

Dataset	Solution type	Engine mode	Time	Status	Latitude	Longitude	Height, m	RMS, m	Satellite
txbe2030	Nav	4	7/22/2022	6	N 28° 25' 25.28508"	W 97° 44' 07.67048"	50.2375	0.7409	
txbe2030	Nav	4	7/22/2022 12:00:30 AM	6	N 28° 25' 25.27519"	W 97° 44' 07.65877"	50.6493	0.7187	
txbe2030	Nav	4	7/22/2022 12:01:00 AM	6	N 28° 25' 25.27802"	W 97° 44' 07.67166"	50.4008	0.7223	
txbe2030	Nav	4	7/22/2022 12:01:30 AM	6	N 28° 25' 25.26604"	W 97° 44' 07.66377"	50.3652	0.7011	
txbe2030	Nav	4	7/22/2022 12:02:00 AM	6	N 28° 25' 25.27653"	W 97° 44' 07.65241"	50.7029	0.7555	
txbe2030	Nav	4	7/22/2022 12:02:30 AM	6	N 28° 25' 25.27031"	W 97° 44' 07.66990"	50.8253	0.6565	
txbe2030	Nav	4	7/22/2022 12:03:00 AM	6	N 28° 25' 25.27631"	W 97° 44' 07.66553"	50.8474	0.8177	
txbe2030	Nav	4	7/22/2022 12:03:30 AM	6	N 28° 25' 25.26899"	W 97° 44' 07.66123"	51.0678	0.5462	
txbe2030	Nav	4	7/22/2022 12:04:00 AM	6	N 28° 25' 25.27295"	W 97° 44' 07.65440"	50.7886	0.7174	

Records count: 2880 | Selected: 1 | Epochs

Figure 45: Epoch Table

- Solution Type – navigational, float, fixed.
- Engine – Receiver or Justin calculated coordinates.
- Status – Depends on receiver or Justin solution.

3.14.7. Raw Data Chart

The Raw Data Chart option shows base to rover single differenced GNSS signal values. Interferometry shows satellite to satellite single differenced GNSS signal values. Statistics are shown on the status bar.

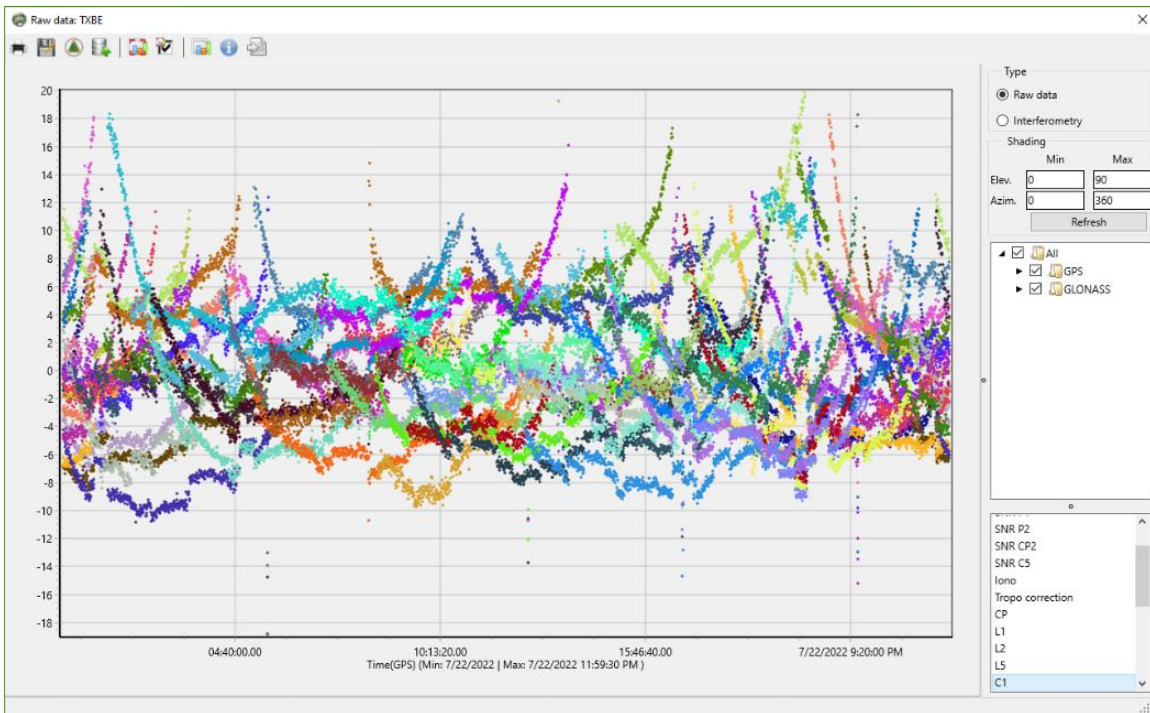


Figure 46: Raw Data Chart

3.14.8. Motion Mode

Justin automatically detects Recordsets type during import criterion for static in Project properties settings and Static / Dynamic tags / events inside the file. Default criterion equals 5 meters means that all epoch positions expected withing $3 \times 5 = 15$ meters for static. Here it is possible to change Recordsets type.

3.14.9. Split

The Split item contains two options: By time or by parts. The By time option generates new Recordsets with a selected fixed time interval.

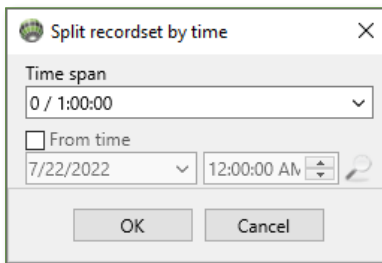


Figure 47: Split Recordset by Time

The By parts option generates new Recordset with the same time span.

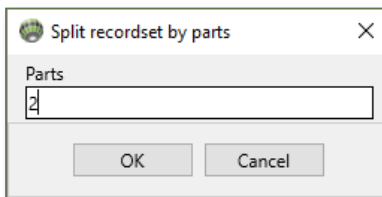


Figure 48: Split Recordset by Parts

3.14.10. Export

The export option allows for JPS or RINEX filetypes. The RINEX version (2.10, 2.11, 3.04) may be selected as well.

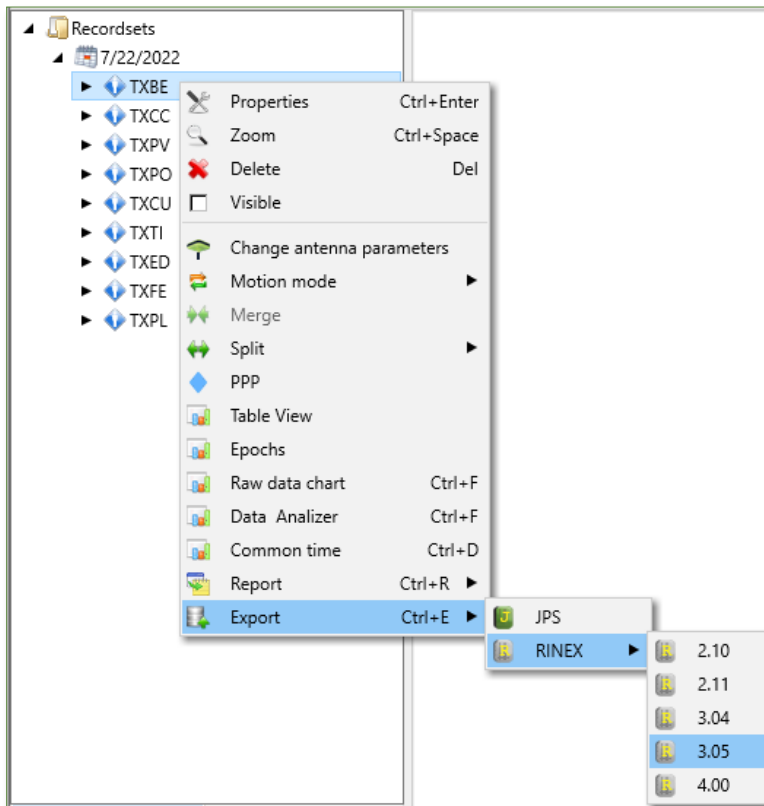


Figure 49: Export Options

When exporting RINEX, several settings are available and are shown below.

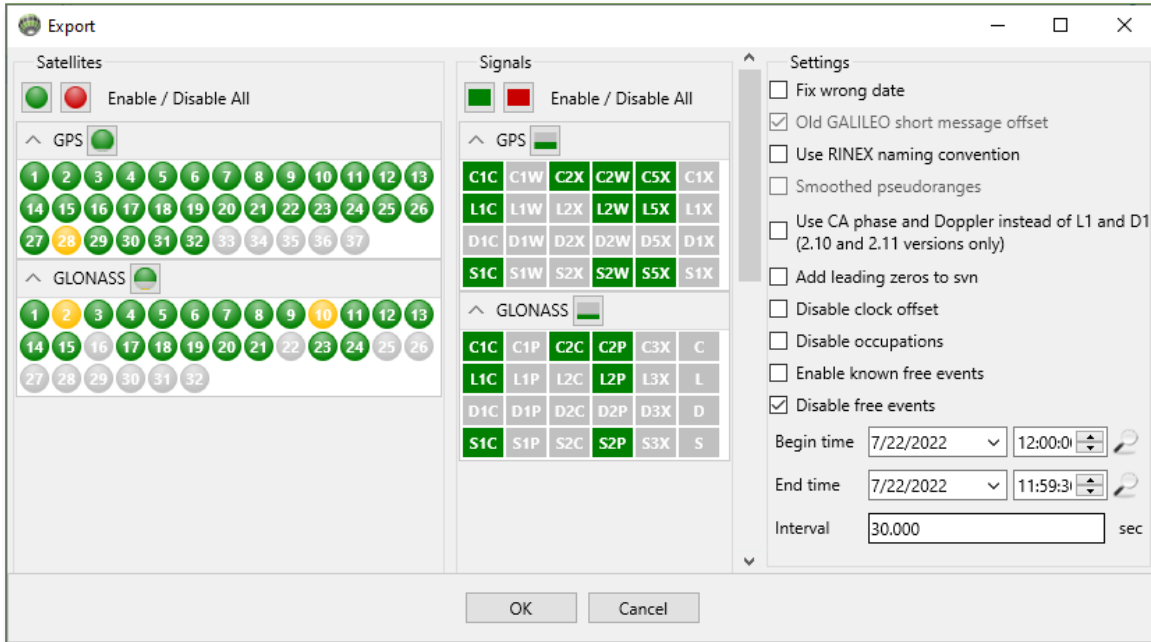


Figure 50: Export RINEX Options

3.14.11. Report

The Report option creates a report using a Table View structure.

3.14.12. Zoom

The Zoom option focuses on Site associated with Recordset.

3.14.13. Visible

The Visible checkbox shows / hides the track of epoch positions on a map.

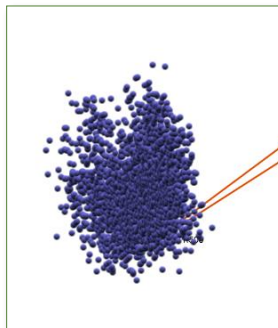


Figure 51: Visible Checkbox

3.14.14. Delete

This option will delete the Recordset. This will not delete the raw data.

3.14.15. PPP

The PPP option will run a computation of Precise Point Positioning. It is recommended to use daily data using a 30 second interval.

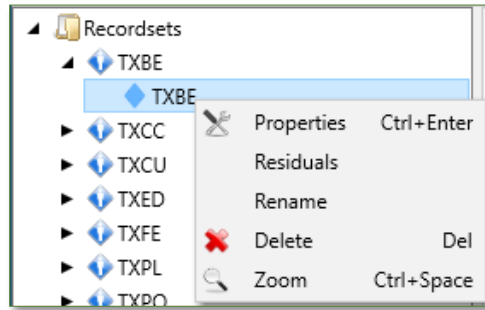


Figure 52: PPP

3.14.16. Sites

Sites are created by Justin using the Recordset. If Recordsets overlap in time, they create a vector that can be post-processed.

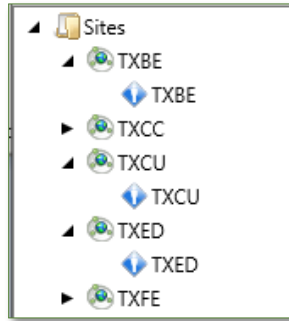


Figure 53: Sites

Icon	Description
	Reference Point Site
	Standalone Site
	RTCM Base Site
	Post-Processed Solution Site

4. 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 importing GNSS data relative to criterion for static in the project settings. Justin offers type editing though Recordset properties dialog. Active 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.

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.

4.1. Vectors

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 the solution vectors. We use band and rover indications for terminal points of a vector.

The static engine, as well as the kinematic one, use so-called single differences of GNSS Data.

4.1.1. Vector Node Options

Vector options include:

- Sort... - Initially vector's tree is structured by date of the start of timespan. Click Base or Solutions number option to look how they are working.
- Process – Run post-processing on all unprocessed Vectors.
- Settings – Open process settings window described below.
- Unhide – Shows all hidden Vectors.
- Delete Solutions – Delete all Solutions from a project.
- Delete Residuals – Delete all solution residuals. Be aware that residuals take more room in a project than a solution does.

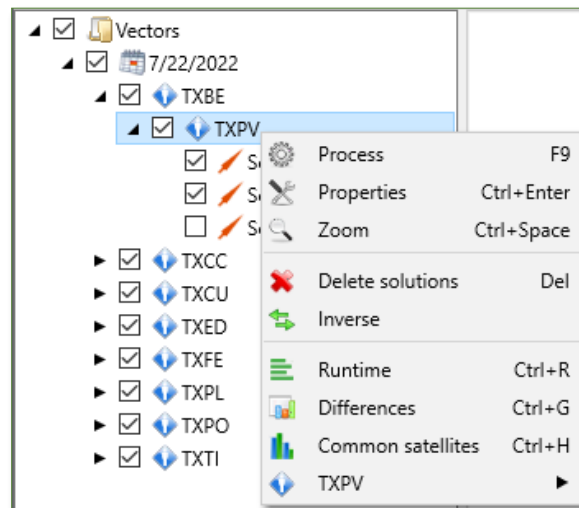


Figure 54: Vectors Node Options

4.1.2. Settings

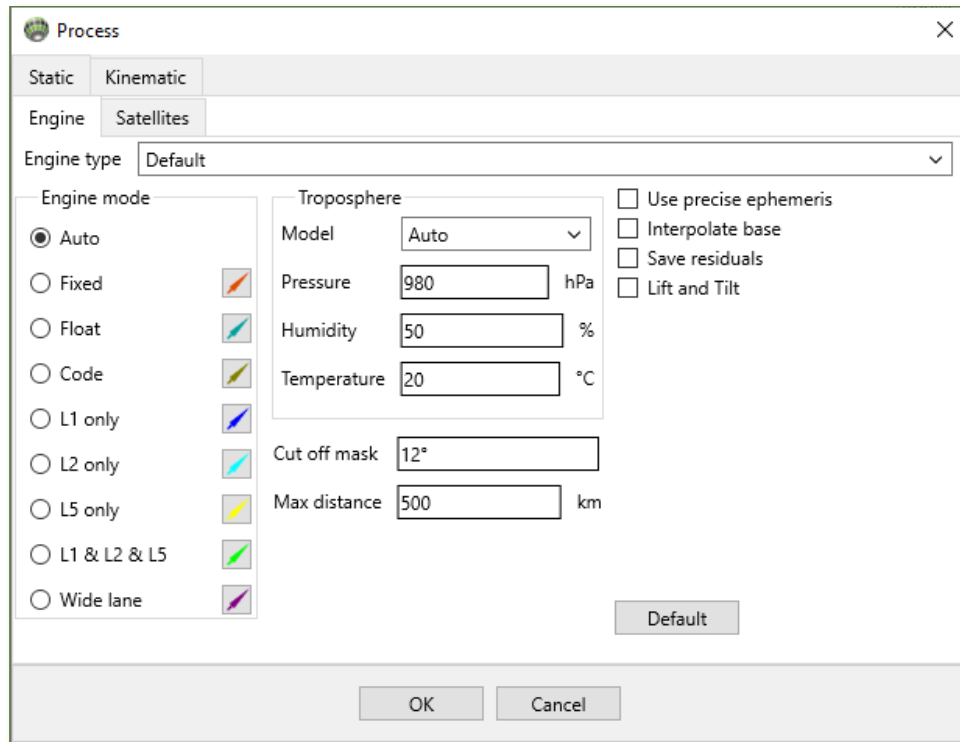


Figure 55: Vectors – Settings

4.1.2.1.1. Static Tab

Using the Static option, the default item is Engine. Regular Justin software is delivered with one default engine. By request, additional engines may be activated.

Engine mode options include:

- Auto – Auto detect best combination of base and rover overlapped data.
- L1 only – Process L1 data only.
- L2 only – Process L2 data only.
- L5 only – Process L5 data only.
- L1 & L2 & L5 – Process L1, L2, and L5 data together.
- Wide lane – Process L1 and L2 data in wide lane combination.
- Float – Not integer processing in Auto mode.
- Code – Code processing.


Troposphere options include:

- Model – A list of popular Troposphere models.
- Pressure, Humidity, Temperature – Input of parameters; humidity value affects altitude.

General options include:

- Cut off angle – Rejection of satellite data under entered value.
- Max distance – Maximum baseline length (in km). This value is a focus during batch processing, some vectors may be skipped.
- Use precise ephemeris – Process vectors using precise ephemeris if those are available on the date of processing. Just can automatically download ephemeris from the Internet.

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

Click on  to access the line style to be shown on map.

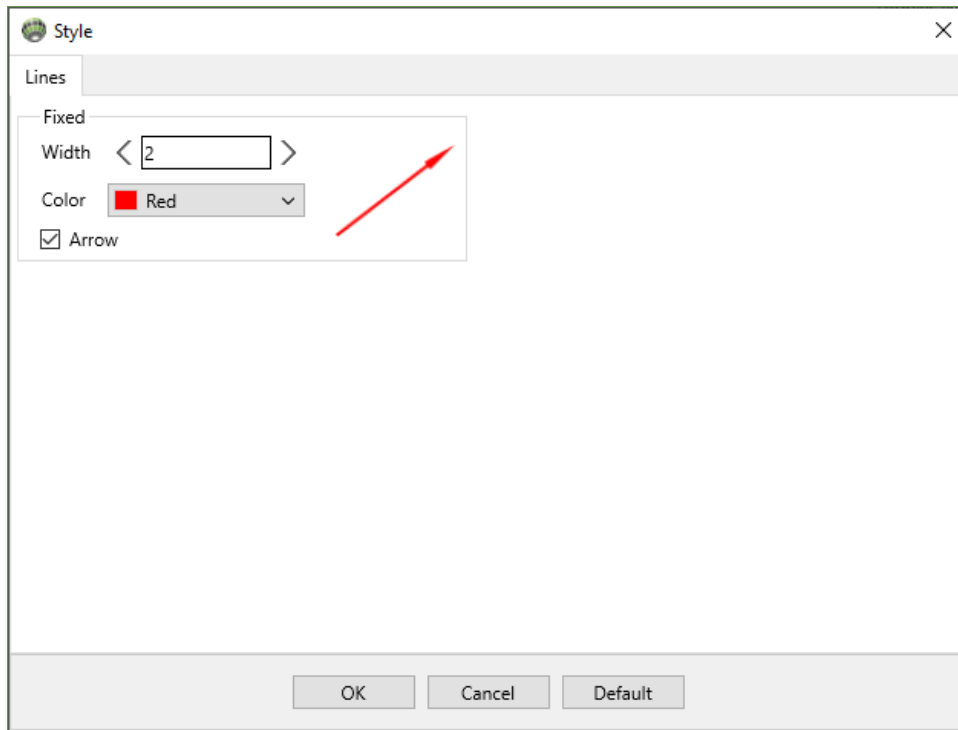


Figure 56: Line Style Options

The next option in the Static Window is Satellites. This option allows for the user to enable / disable satellites.

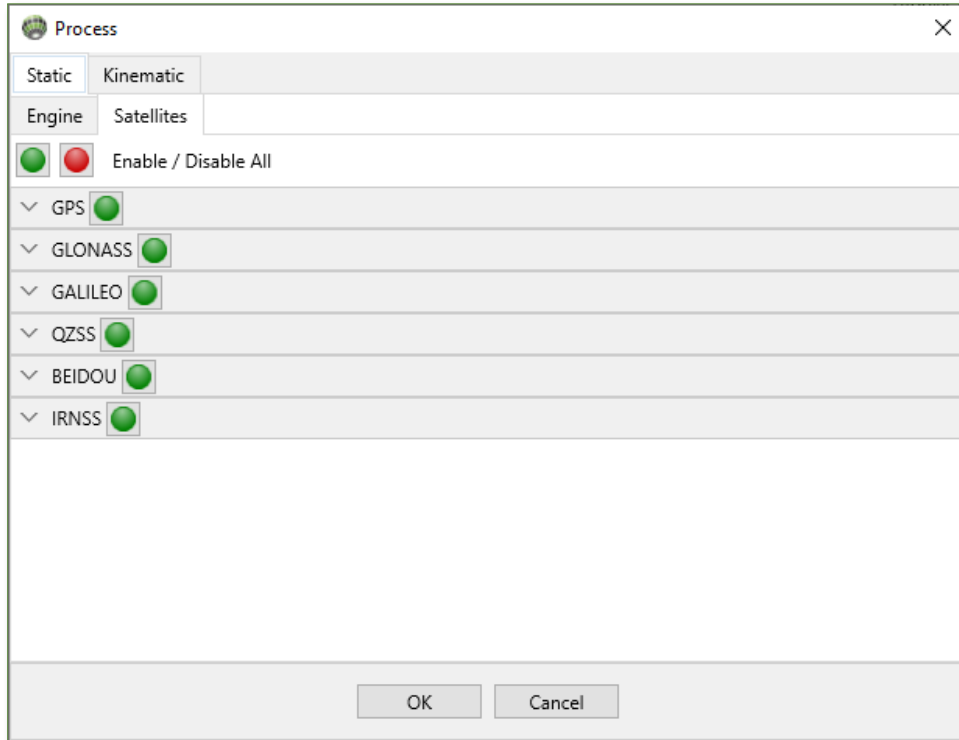


Figure 57: Satellites Options

4.1.2.1.1. Kinematic Tab

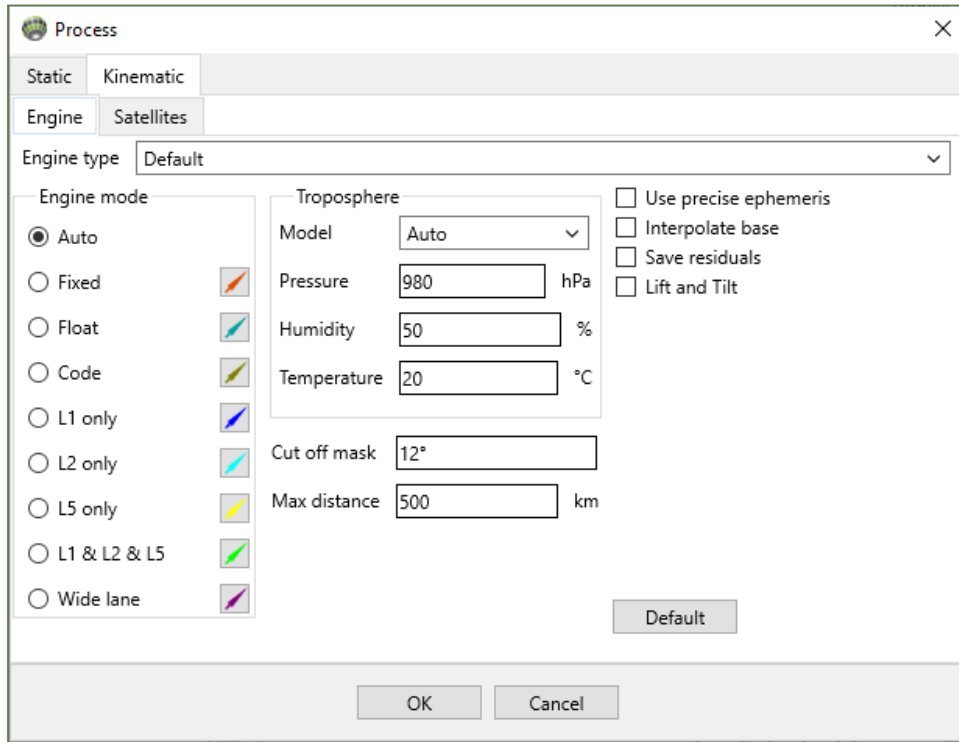


Figure 58: Process Settings - Kinematic Tab

The Kinematic tab allows the user to augment the Engine mode, data, RMS values, constellations and several general options.

Engine mode options include:

- Code Diff – Process code only data.
- Code Diff Smoothed – Process code data smoothed by phase.
- Code Carrier Float – Float processing.
- Carrier Fixed – a priori root mean square error of code measurements.

RMS Options are important for weighting of code and phase data for outlier rejection. The RMS Code and Carrier phase can be augmented to improve fixing in a difficult environment. RMS options include both Code (in meters) and Carrier phase.

Data options include:

- L1 – Process L1 data only.
- L2/L2 – Process L1 and L2 data.

General options include:

- Elevation mask – Rejection of satellite data under entered value.
- Memory factor – weight for passing epochs. It affects how fast engine forget old data. It is very import for high dynamic applications.
- SNR threshold – Cut off data by Signal to Noise Ratio (SNR).
- Iono factor – Combined factor of data random noise error.
- Fix level – Setup Contrast ration of integer procedure.
- GPS, GLONASS – Enable / Disable GPS and/or GLONASS data.

4.1.3. Data Item

The Data item options include:

- Process – run post-processing for all associated vectors.
- Hide – Make vectors invisible.
- UnHide – Make vectors visible.
- Delete Solutions – Delete all solutions.

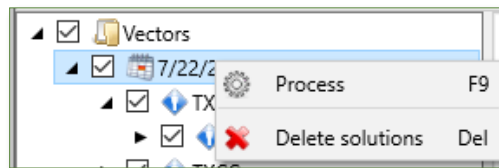



Figure 59: Vector Data Options

4.1.4. Base

The next level of the Vectors tree corresponds to the base object, shown below as base site 4 and is denote by , the static Recordset Icon.

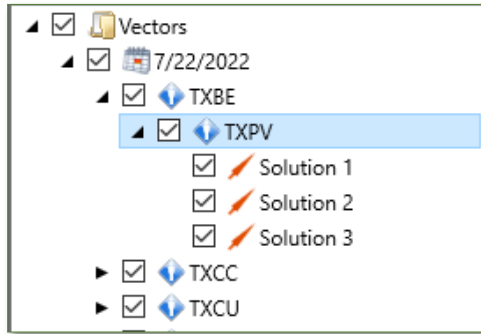


Figure 60: Vectors Tree

4.1.4.1. Base Node Options

Base node options include:

- Process – Run post-processing for all unprocessed vectors.
- Delete Solutions – Delete all solutions related to the base node.

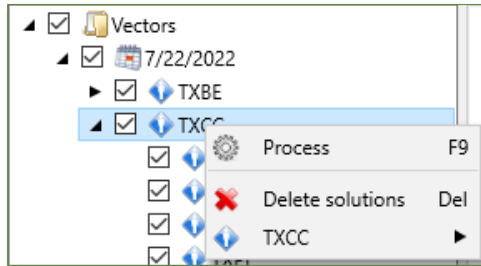



Figure 61: Base Node Options

4.1.5. Rover

The next level of the Vectors tree corresponds to the rover object, shown above as rover site 254 and is denoted by , the static Recordset Icon.

4.1.5.1. Rover Node Options

Rover node options include:

- Process – Run post-processing if no solution exists.
- Runtime – Used to get more than one solution.
- Delete Solutions – Delete all Solutions.
- Properties – Opens a vector properties window. View base and View rover opens relative Recordset properties windows.

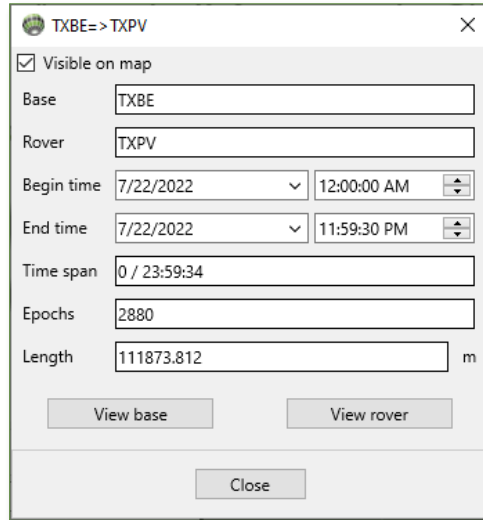


Figure 62: Rover Node – Properties

- Differences – Chart of GNSS signal differences.

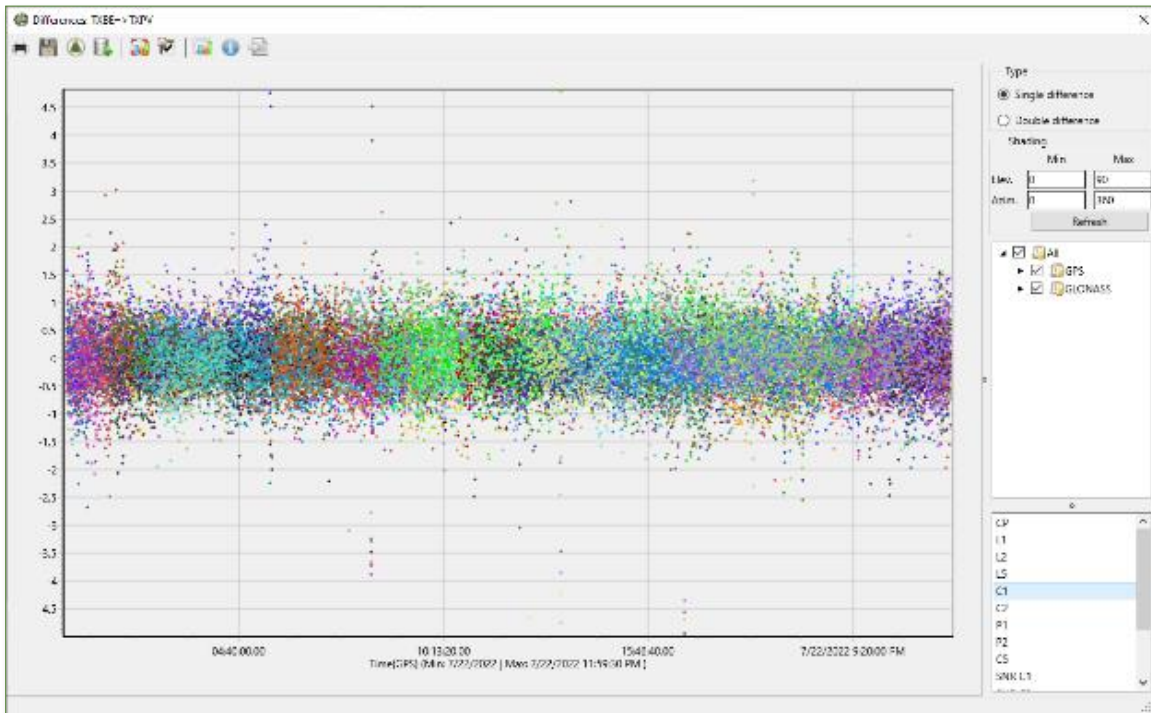


Figure 63: Rover Node – Signal Differences

- Common Satellites – Opens a chart.

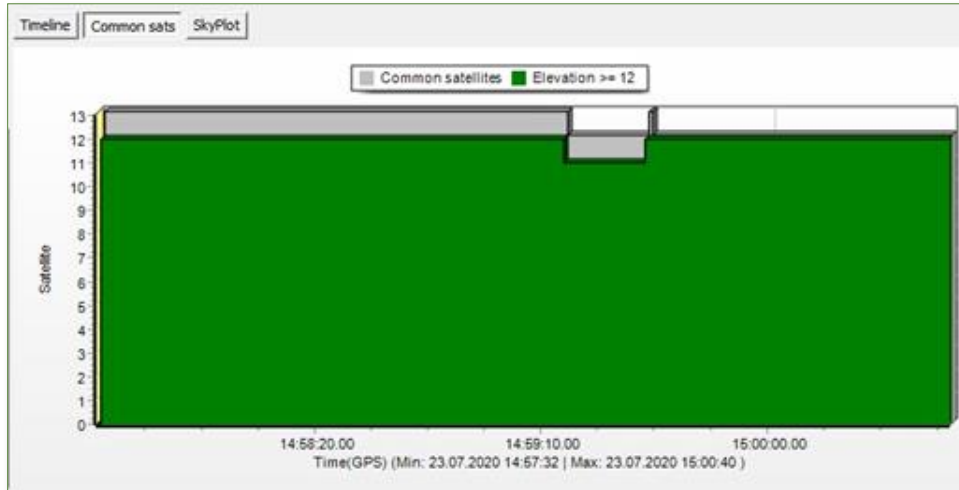


Figure 64: Rover Node - Common Satellites Chart

- Inverse – Redirect vector.
- Zoom – Focus on vector (on map).
- Visible – hide / unhide vector on map.

4.1.6. Solutions

The last level of the Vectors tree is for solutions. These appear under the rover node after post-processing. Initially, the rover node is empty. Processing adds a solution to an item.

4.2. Batch Processing

Multiple vectors can be post-processed by using the vectors tree item or by selecting them from the map using the or tools.

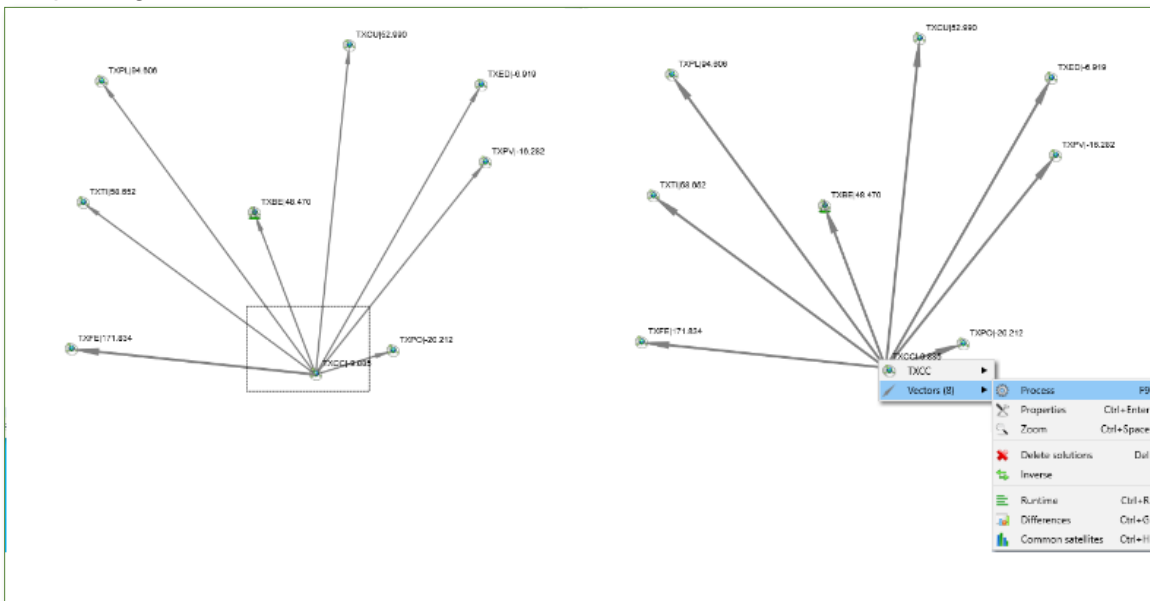


Figure 65: Multiple Vectors (Batch) Processing

The processing progress is shown on the bottom status bar (shown below).

Ty...	Time	Remaining	Name	Status	Progress	Complete	Speed	Log
	00:00:55	00:00:01	TXCC=>TXED	integer processing		1%	1%/s	...
	00:00:21	00:00:01	TXCC=>TXTI	phase evaluation		1%	1%/s	...
	00:00:07	00:00:01	TXCC=>TXPO	phase evaluation		2%	2%/s	...
	00:00:00	00:00:01	TXCC=>TXPL	Copy data...		96%	96%/s	...
	00:00:00	00:00:01	TXCC=>TXBE	Waiting		0%	0%/s	...
	00:00:33	00:00:01	TXCC=>TXFE	Done		100%	100%/s	...
	00:00:48	00:00:01	TXCC=>TXCU	Done		100%	100%/s	...
	00:00:54	00:00:01	TXCC=>TXPV	Done		100%	100%/s	...

Records count: 8 | Time: 00:00:55 |

Progress

Figure 66: Batch Processing Status Bar

6:21:22 PM	6:21:21 PM	:	TXCC=>TXFE	dx -113985.110	dy 21441.447	dz 10463.509	Ratio 97%	Used 82%	RMS 0.026
6:21:36 PM	6:21:36 PM	:	TXCC=>TXCU	dx 25473.668	dy 70782.576	dz 135787.093	Ratio 100%	Used 78%	RMS 0.020
6:21:43 PM	6:21:43 PM	:	TXCC=>TXPV	dx 85964.068	dy 36737.730	dz 87650.212	Ratio 99%	Used 78%	RMS 0.022
6:21:49 PM	6:21:49 PM	:	TXCC=>TXPO	dx 36989.753	dy 438.425	dz 9667.594	Ratio 98%	Used 88%	RMS 0.017
6:22:02 PM	6:22:02 PM	:	TXCC=>TXTI	dx -103961.545	dy 52892.632	dz 71122.173	Ratio 97%	Used 81%	RMS 0.023
6:22:09 PM	6:22:08 PM	:	TXCC=>TXED	dx 86493.083	dy 54411.737	dz 119710.894	Ratio 100%	Used 67%	RMS 0.016
6:22:11 PM	6:22:11 PM	:	TXCC=>TXBE	dx -23923.918	dy 39073.918	dz 66795.254	Ratio 99%	Used 91%	RMS 0.018

Figure 67: Batch Processing - Expanded Status Bar - Log Tab

4.3. Single Vector Processing

Single vector processing can be used to further refine solutions yielded from batch processing. Click the Vector item on the Vector tree or select from the map.

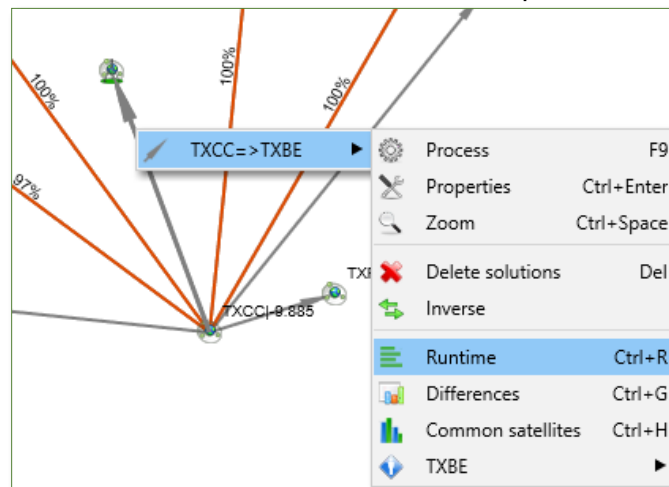


Figure 68: Vectors Selected - Runtime Option

Once the Runtime option is selected, the bottom pane appears (shown below).

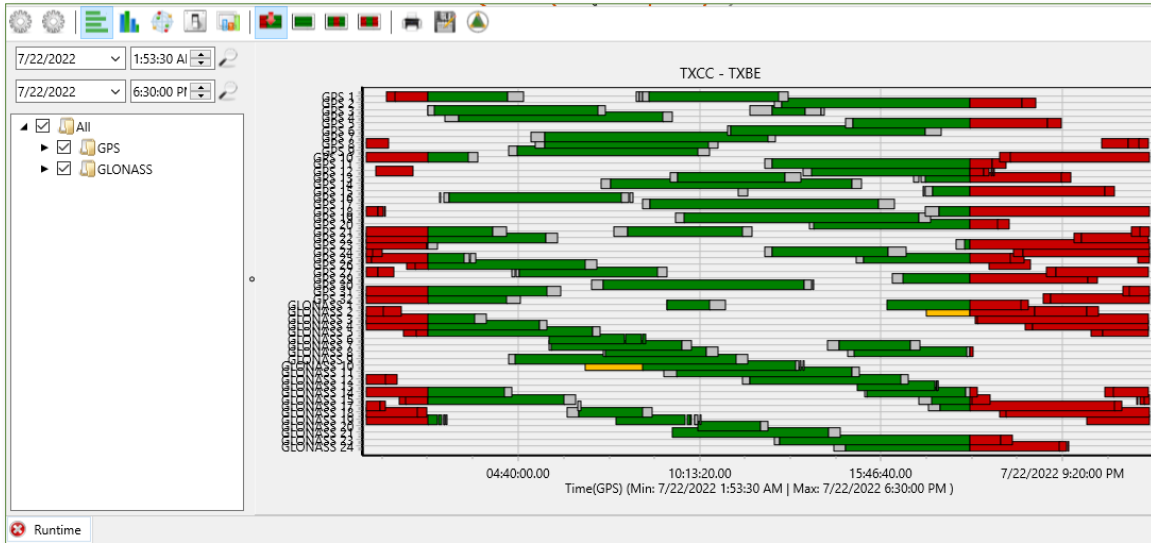


Figure 69: Runtime Option Selected - Bottom Pane

- Run post-processing
- Run post-processing by parts. Click on it to produce multiple solutions.

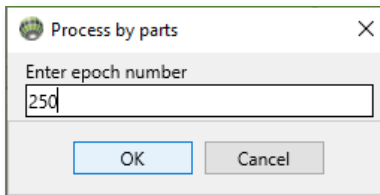


Figure 70: Process by Parts

- Multiple or single satellite strips selection mode.
- Erase all Selections.
- Erase red strip.
- Print a chart.
- Save chart as a raster file.
- Show entire timeline (after zooming).

The left pane is intended for enabling / disabling satellites and the start / end times may be edited. The settings button opens the settings tab of properties which is further described below. The Common sats and SkyPlot were previously described.

4.4. Solution

The solution is accessible through the map and from the project pane.

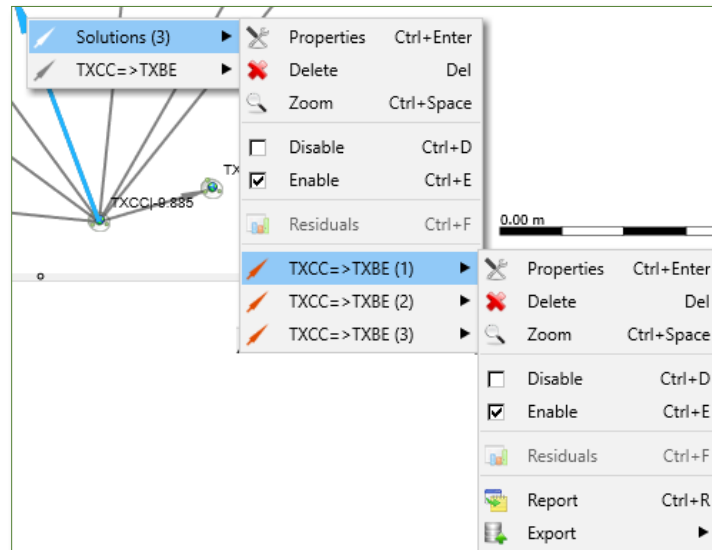


Figure 71: Solution Menu Options

4.4.1. Properties

Selection of Properties option opens the Solution Properties window. The first tab shown is the coordinates tab (shown below).

The coordinates tab shows:

- Base and Rover coordinates on epoch date of the project.
- Solution components in XYZ.
- Sigma's are diagonal elements of correlation matrix. Only coordinate systems declared within the project are available.

TXCC - TXBE / Solution 1

Coordinates Statistics Antenna Satellites Settings

XYZ BLH Grid XYZ NEU

Rover

Latitude N 28° 25' 25.26473"

Longitude W 97° 44' 07.65796"

Height 48.5778 m

EPOCH 0.0000

Base

Latitude N 27° 44' 26.90056"

Longitude W 97° 26' 30.04574"

Height -9.8853 m

EPOCH 0.0000

Increment

X -23923.9140 m

Y 39073.9437 m

Z 66795.2414 m

Sigma

X 0.0033 m

Y 0.0152 m

Z 0.0085 m

WGS84 Length 80998.3395 m

Residuals Delete Close

Figure 72: Solution Properties - Coordinates Tab

The Statistics tab shows:

- Total and left code and phase data in the solution.
- Number of total and left phase ambiguities.
- Time span equals epoch number multiplied by record interval.
- $\text{RMS residuals} = \sqrt{\frac{\sum(\text{sqr}(v))}{n}}$, v – residual, n – epoch number. • Fix ratio – Fisher statistics.
- Left Satellites used.
- $\text{Min/km} = \text{Time span} / \text{length}$.
- Begin, End time shows time tag of observation session.
- Process time is post-processing time and date.

Field	Value	Unit
Begin time	7/22/2022 5:31:30 AM	
End time	7/22/2022 11:59:30 PM	
Process time	12/20/2022 6:42:42 PM	
Type	Fixed	
RMS residual	0.0177	m
Fix ratio	99	%
Satellites used	33	
Epochs	2217	
Measurement total	126807	
Measurement used	105187	
Ambiguity total	161	
Ambiguity fixed	35	
Time span	1108	min
	13.68	min/km

Figure 73: Solution Properties - Statistics Tab

The Antenna tab shows:

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

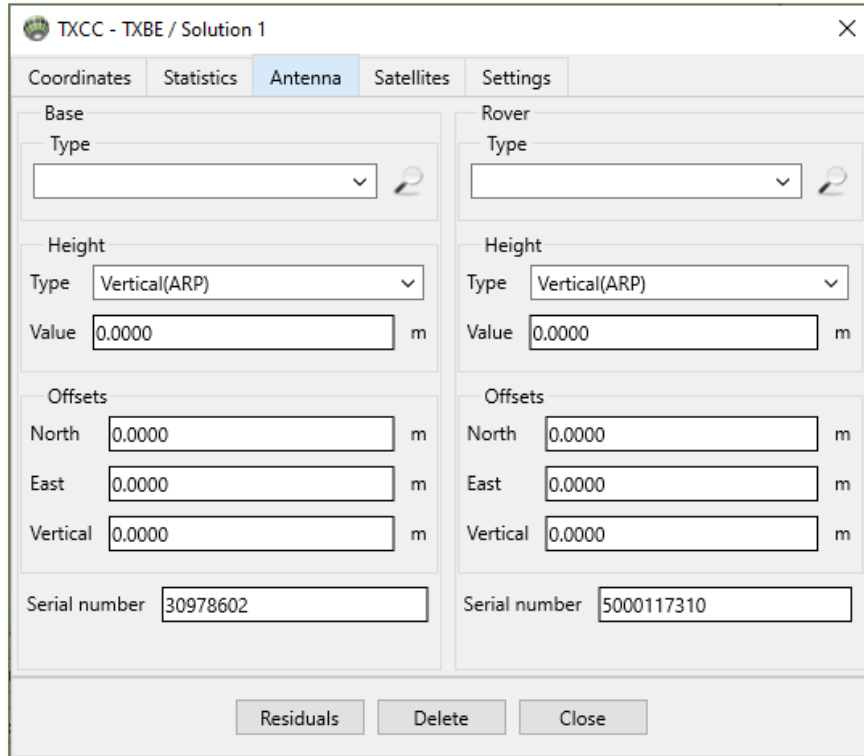


Figure 74: Solution Properties - Antenna Tab

The Satellites Tab shows a snapshot of the Timeline plot.

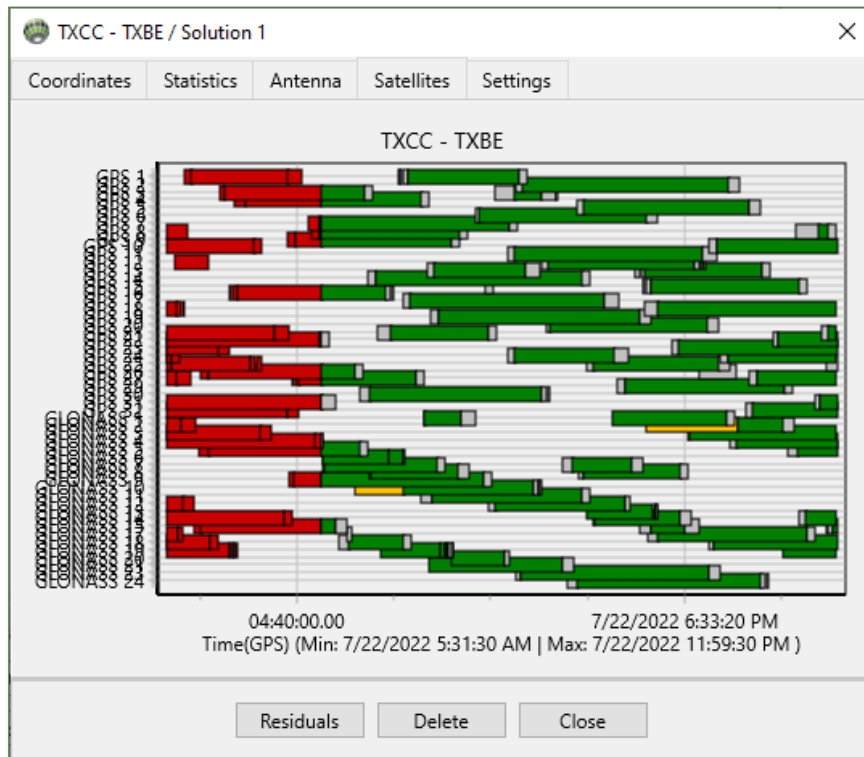


Figure 75: Solution Properties - Satellites Tab

The Settings Tab shows a snapshot of the post-processing settings window.

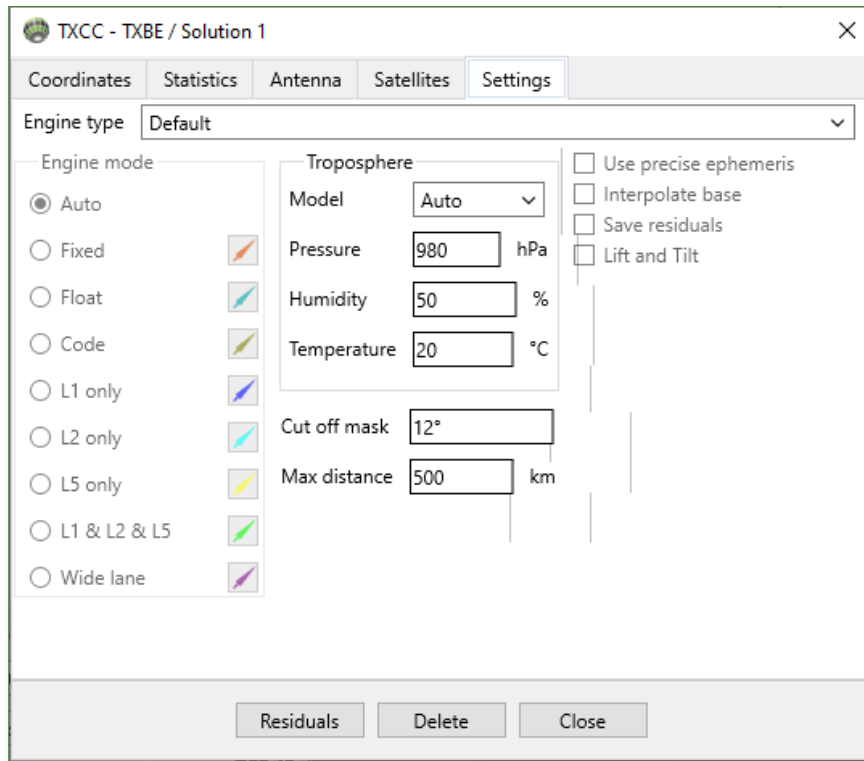


Figure 76: Solution Properties - Settings Window

4.4.2. Residuals

This option opens a plot displaying residual values contained in the recordset. Residual statistics are shown in the status bar on the bottom.

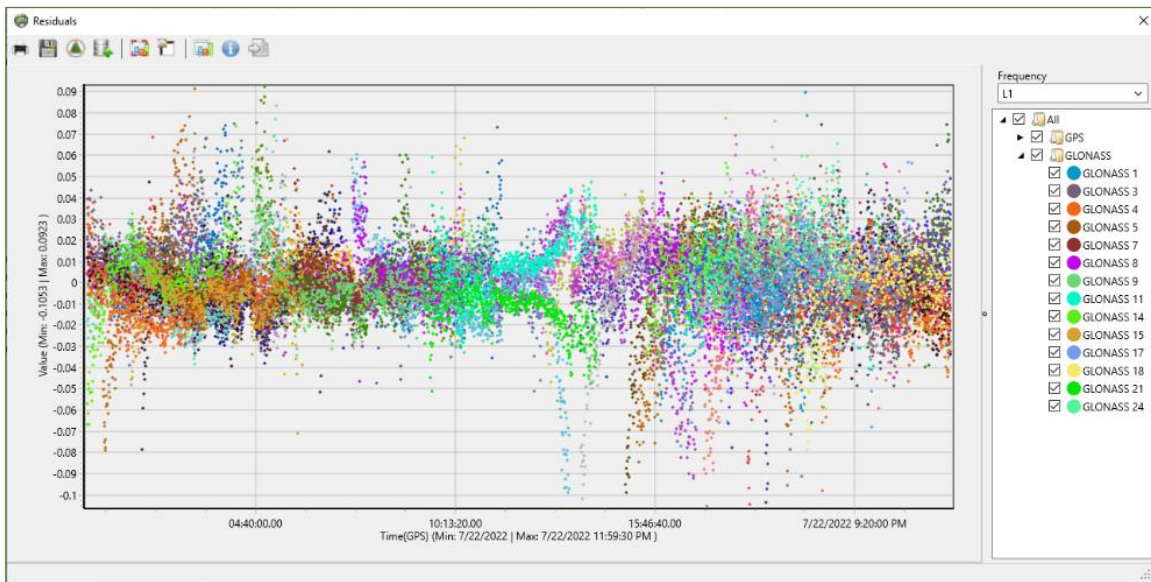


Figure 77: Residuals Plot

Statistics for a single satellite can be displayed or exported by right-clicking on the preferred satellite in the right pane. Select 'View' for a plot or 'CSV' to export (shown below).

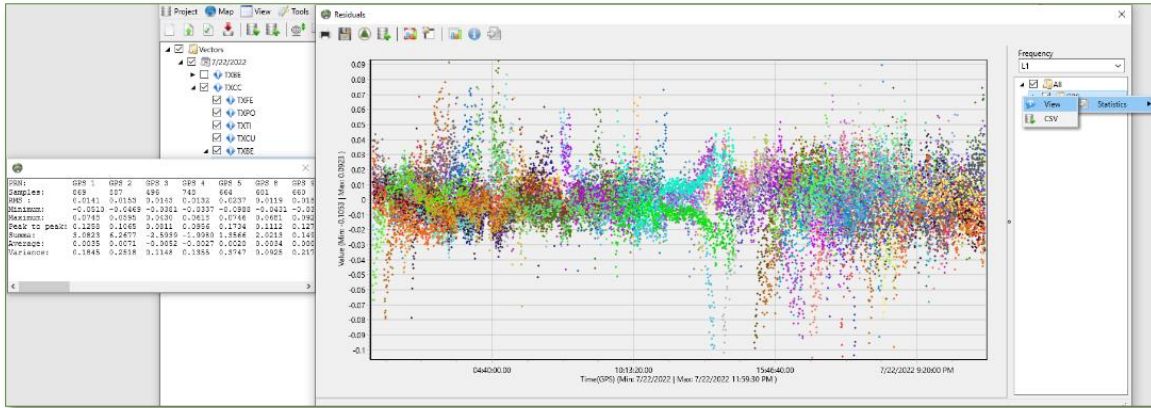


Figure 78: Display / Export Single Satellite Residual Data

4.4.3. Report

This option will open a solution report. Report options (time, time format, coordinate system, unit type, angle type, angle and length rounding) are available (shown below).

Single solution report			
Solution name	TXCC - TXBE	Solution type	Fixed
Process time	12/21/2022 11:17:41 AM	Fix ratio	100%
Begin time	7/22/2022 12:00:00 AM	Time span,min	1440
End time	7/22/2022 11:59:30 PM	Interval,sec	30.000
Measurement used	108009 of 164629 (34% discarded)	RMS	0.014 (m)
Satellites used	GPS (11)		
Used observations	C1 CP C2 P2 L2 C5 L5		
Ephemeris	Broadcast	Temperature, °C	20
Cut off angle, °	12	Pressure, hPa	980
Engine	Default	Humidity, %	50
Processing mode	Auto		
Point name	TXCC	TXBE	
Session name	txcc2030.22d.gz	txbe2030.22d.gz	
Receiver	TRIMBLE ALLOY	TRIMBLE ALLOY	
Receiver number	0	0	
Receiver ID	5826R40025	5830R40014	
Antenna	TRM57971.00 NONE	TRM57971.00 NONE	
Serial number	30978602	5000117310	
Antenna height, (m)	Vertical (ARP) 0.000	Vertical (ARP) 0.000	
Ant. delta, (m)	0.000/0.000/0.000	0.000/0.000/0.000	
Phase center variations:			
X, m	-731659.096	-755583.017	
Y, m	-5601556.947	-5562483.027	
Z, m	2951108.103	3017903.357	
Latitude	N 27° 44' 26.87068"	N 28° 25' 25.23503"	
Longitude	W 97° 26' 30.04339"	W 97° 44' 07.65574"	
Height, m	-10.399	48.080	

Figure 79: Report

5. Adjustments

Geodetic network adjustment uses a Weighted Least Squares method for solving over determined linear systems ($AX = L$). Depending on the dimensions (2D / 3D) of the adjustment, the design matrix A has $3n$ or $2n$ rows (where n is the number of solutions) and a structure comprising of $+1$ 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. L is an array of solution components dX, dY, dZ . In the case of adjustment in geocentric linear equations, the equation system is:

$$\begin{aligned} X_M - X_N &= dX, \\ Y_M - Y_N &= dY, \\ Z_M - Z_N &= dZ, \end{aligned} \text{ where } X, Y, Z \text{ are unknown coordinates of } M \text{ and } N \text{ network points.}$$

The redundancy of the network adjustment is the number of rows minus the number of columns. This is subject to a weight matrix W . The solution of $AX = L$ is then $A^T W A X = A^T W L$, where W is a block diagonal matrix formed using solution covariance matrices.

The network adjustment solves two main problems:

- 1.) Post-processing solution accuracy estimation and outlier / blunder detection.
- 2.) Calculation of final ground point coordinates tied to reference points and statistics.

Solution accuracy (1.) runs in inner-constrained mode. To overcome the singularity of the normal matrix $A^T W A$, we use a singular value decomposition (SVD) method. The research of networks adjusted in inner-constrained mode detects the impact of outliers / blunders in the post-processing solution accuracy estimation.

The detection of outliers / blunders is treated using Pope's τ - test. This method computes standardized residuals $u_i = \frac{v_i}{\sqrt{q_{ii}}}$ to detect outliers / blunders in iterations and remove suspicious data from the design matrix. Iterations continue until outliers / blunders have been minimized and the X^2 - test is passed depending on the significance level (68%, 95%, 98%) and the degrees of freedom. q_{ii} are diagonal elements of the cofactor matrix:

$Q_{vv} = Q_{ll} - A Q_{xx} A^T$, where Q_{ll} is a block diagonal matrix of 3x3 dimension solution and Q_{xx} is the invers of the $A^T W A$ matrix. The τ - test treats the solution as an outlier / blunder if a residual exceeds the τ - value. $\frac{\tau_{\alpha_0}}{2}, n - m$ is determined in τ - distribution, $\alpha_0 = 1 - (1 - \alpha)^{\frac{1}{n}}$, where α is a user-defined significance level. Level 99% corresponds to minimum restrictions whereas level 68% corresponds to maximum restrictions. Note that the τ - test uses standardized residuals for outlier / blunder detection instead of absolute values, so small residuals can be treated as outliers / blunders as well.

The Least Squares method deals optimal results in geodetic adjustments if GNSS data post-processing solution errors are normally distributed. The X^2 - test checks if the solution errors are normally distributed by comparing unit weight error μ and X^2 statistics.

$$X^2_{1-\alpha, \frac{1}{2}, n-m} < \mu^2 = \frac{1}{n-k} (V^T W V) < X^2_{\alpha, \frac{1}{2}, n-m}$$

The X^2 - test estimates the consistency of the solution covariance matrix, Q_{ll} , relative to a posteriori statistic. A failed X^2 - test indicates the GNSS data logging sessions were too short and loop closures are often big with μ out of limits.

The inner-constraints adjustment runs in relative coordinate systems. To show inner adjustment results in a cartographic window, we snap relative coordinated networks (Net) to the first listed reference point (if it exists) or to the first listed site.

For the calculation of final ground point coordinates (2.), the network (Net) must be snapped to the ground reference points and the final adjustment should be run under external constraints.

5.1. Net

To start the adjustment, switch to the adjustment tab in the project pane. Solutions that complete the process procedure are subject to adjustment. The first step of the adjustment procedure, using inner constraints (detailed above), is to evaluate loop closures. Justin software uses the edge category to show loops. The edge category will appear as a result of the solution adjustment. The solution is a result of vector post-processing and a special layer, edges, represented in the map pane.

Loop closures represent additional estimates of post-processing data accuracy. Loop closures are the sum of solution components. Loop detection is running during the network adjustment procedure.

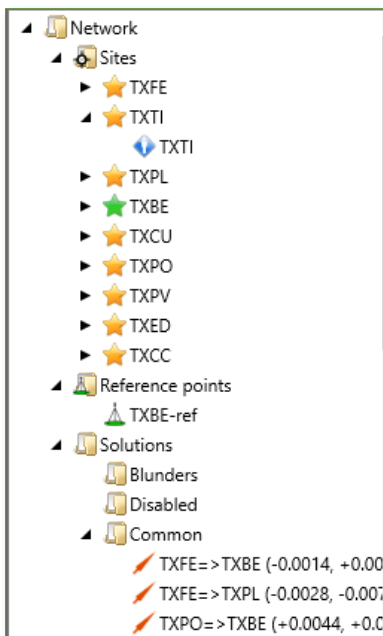


Figure 80: Adjustments - Net Tree

Upper items in the Adjustment tab are:

- Net – Main adjustment item.
- Sites – list of adjustment objects.
- Reference Points – List of control ground points with postulated coordinates using external-constraints.
- Solutions – Subjects of adjustments
 - Blunders – not passing the τ – test.
 - Disabled – Solutions excluded in interactive mode.
 - Common – Solutions passed all tests and included in the final results.
- Kinematic – Kinematic solutions (detailed below “Adjustment of Kinematic Solutions”).
- Precise Point Positioning – Site precise positions.

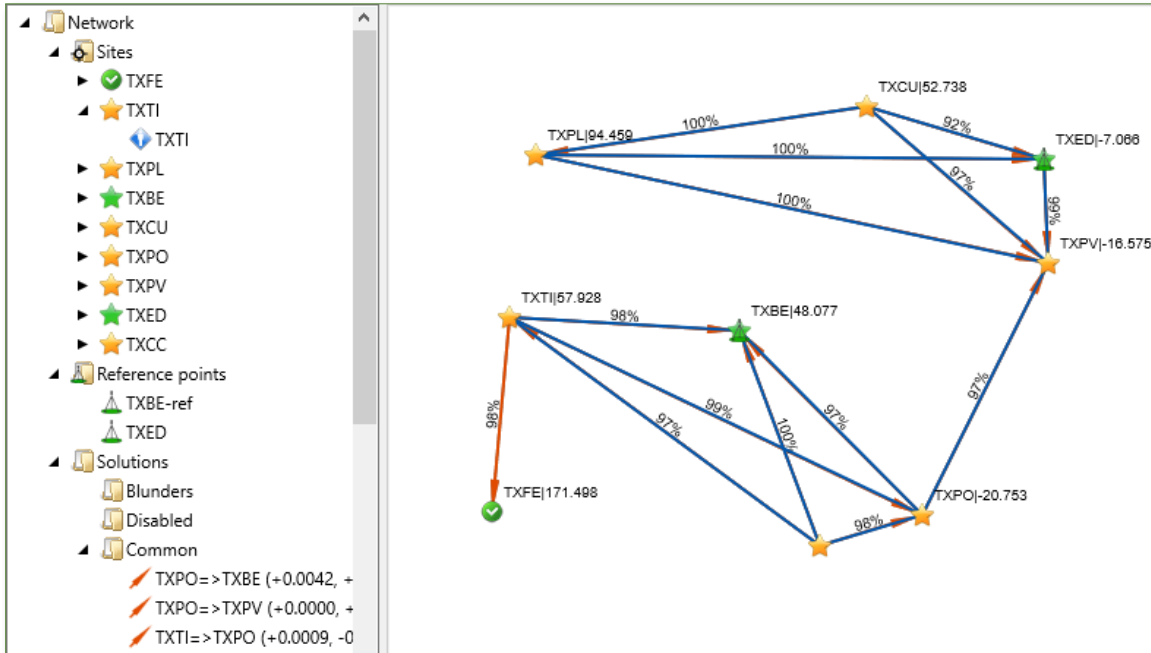


Figure 81: Adjustment – Network

Sites are point objects shown on the map with cartographic signs relative to the legend. Sites are generated from standalone raw data Recordsets solutions. The cartographic sign reflects its origin (receiver calculated, standalone, post-processed or adjusted). The snapped sites are green in color.

Shown above:

- TXAN is a standalone solution.
- TXTI is a post-processed solution.
- TXCU is snapped to a reference point.

Edges are linear objects created by adjustments. Edges connect to adjusted sites and from a network as shown above. Edges are shown on a special map layer. An edge table exists in the adjustment report to show residuals and relative error. There are several edge types:

Single-ended – Share only one site within the network (TXCU → TXHA).

Bridge – Connects Loops (TXPL → TXKC).

Blunder – Failed the τ – test, colored brown by default (TXPL → TXKC).

Common – Passed the τ – test, colored blue by default (TXKC → TXED).

Loops – A list of independent loops generated under the restriction of minimum edges quantity in a loop. Loop closure residuals are indicated depending on adjustment mode (XYZ / NEU).

5.1.1. Net Menu

Right-click on 'Net' to show Net menu items.

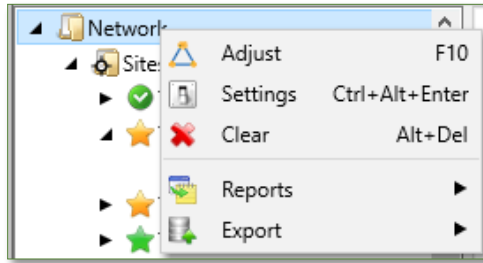


Figure 82: Adjustments - Net Menu

- Adjust – Run a network adjustment. The last adjustment will be dropped.
- Settings – Opens the adjustment settings window (detailed below).
- Clear – Drops the last adjustment.
- Reports – Generates a selectable popular format report.
- Exports – Exports files in selectable popular formats.

Adjustment settings allow for selections of blunder rejection, constraints, loops, blunder detection and confidence level.

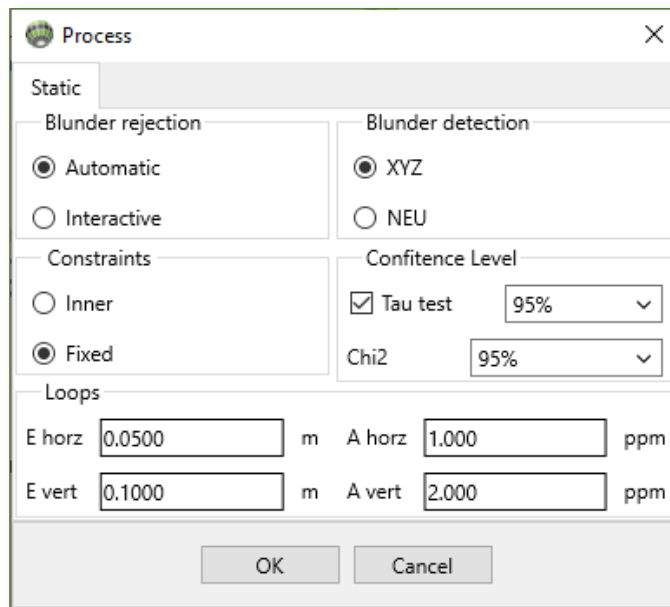


Figure 83: Adjustments - Network - Adjustment Settings

- Blunder Rejection – This is how blunders are processed.
 - Automatic Rejection – Runs adjustments in iterations where blunders are detected and excluded step-by-step until they are minimized (batch blunder processing).
 - Interactive Rejection – Runs adjustments in an interactive dialog window (shown below) step-by-step allowing the user to cancel a solution at each iteration (step-by-step blunder processing).
- Blunder Detection – Blunder qualification in inner-constraints adjustment.
 - XYZ – Residuals are calculated in a geocentric coordinate system.

- NEU - Residuals are calculated in the topocentric coordinate system. There is additional specifications of 2D / 3D to separate horizontal and vertical sources of error. If an edge is marked as a blunder in NEU 3D mode, it follows to readjust the network as 2D to excluded vertical error components due to data input error (e.g. antenna height).
- Confidence Level – Post-processed solutions based on GNSS data obtained in short sessions of observation may have low absolute accuracy and small standard deviation errors overvaluing its impact in the adjustment due to large values within the weight matrices. Edge residuals must not exceed sigma more than 2-5 times in the case of normal distribution or errors. Otherwise, the solution should be detected as a blunder. Confidence level settings allow for control of the blunder detection procedure. Unit weight error must correspond to solution accuracies. Regular μ – value varies from 0.4 to 1.6. $X^2_{1-\alpha_{\frac{1}{2},n-m}} < \mu^2 = \frac{1}{n-k} (V^T W V) < X^2_{\alpha_{\frac{1}{2},n-m}}$ computes more accurate limits using the degree of freedom and confidence interval values. 99% is the weakest limit. The blunder detection procedure will affect the X^2 – test. Control of confidence levels for both tests allow the X^2 – test to pass well.
- Constraints
 - Inner – Adjustment of a free network with no constraints. Residuals depend on network geometry and solution quality. It is a significant preliminary network adjustment which run automatically within a constrained network. It is recommended to run it in advance separately to minimize blunders / outliers. Inner-constraints adjustment computes site positions in a relative coordinate system. The results may be similar to a fixed constraints adjustment with one reference point.
 - Fixed – Adjustment which can be completed if network sites were snapped to at least one reference point. If not snapped to at least one reference point, Justin will provide a warning to the user. The statistic of the accuracy of reference points does not affect the residuals or computation but can be 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 $\Delta L = E(\sqrt{N}) + AL$; where N are the number of edges in a loop, L is the length of a loop. Loops with overpassed closure are colored red in the left project pane.

Shown below is the interactive dialog window which appears if blunder rejection is set to interactive.

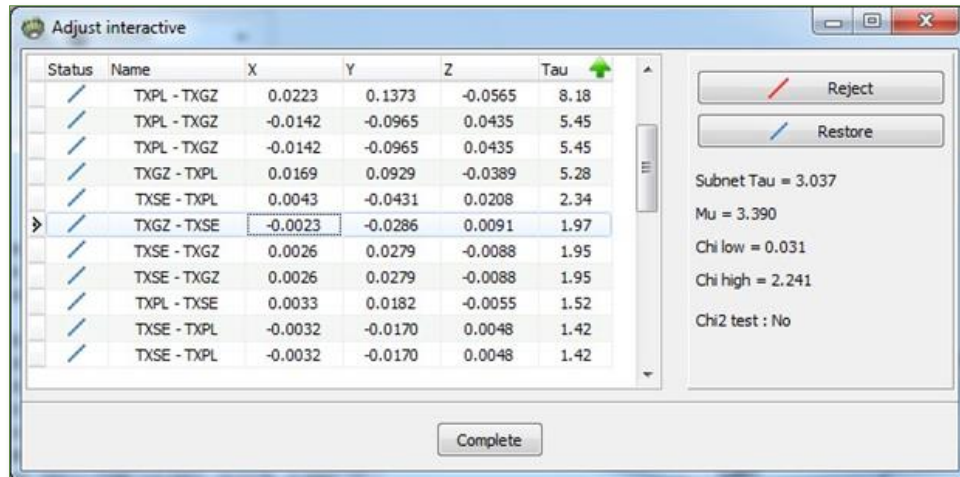


Figure 84: Adjustments - Network - Network Settings - Interactive Blunder Detection Dialog Window

The interactive dialog window shows a list of network edges and the X, Y, and Z components of edge residuals along with tau statistics in a table format. The tau column shows the maximum components of standardized residuals along the X,Y,Z / N,E,U axes. To the right of the table shows common network statistics:

- Common tau-value.
- Unit weight error (UWE).
- Low and High limits of the $X^2 - test$ for UWE.

To exclude an edge from the adjustment, select a row in the table and click 'Reject'. Press and hold the Ctrl or Shift button to exclude more edges at once. By clicking 'Reject', the 'Restore' button re-runs the adjustment. The dialog window will re-generate to continue. The 'Complete' button allows the user to end the iterative process.

The goal of interactive mode is to pass the $X^2 - test$. It is recommended to exclude edges with the highest values in the tau column. It is not possible to reject a bridge edge as it will split the network into two sub-networks. If attempted, Justin software will warn the user of this impossibility. In the case were a network needs to be divided into 2 or more sub-networks, the user should disable the edge solution prior to the adjustment process. A rejected edge is kept in the table, but the values are excluded from the adjustment and are shown in gray. A rejected edge may be restored by selecting it and clicking 'Restore'.

5.1.2. Kinematic Solutions

Processing data from multiple kinematic bases generates new trajectory objects in the Kinematic node with options:

- Adjust – This will run a kinematic solutions adjustment.
- Properties – This will show the properties of the new trajectory object within the Kinematic node.
- Zoom – This will show the entire trajectory.
- Delete – This will drop the last adjustment from the project and redraw the map.
- Report – This will generate a standard report.

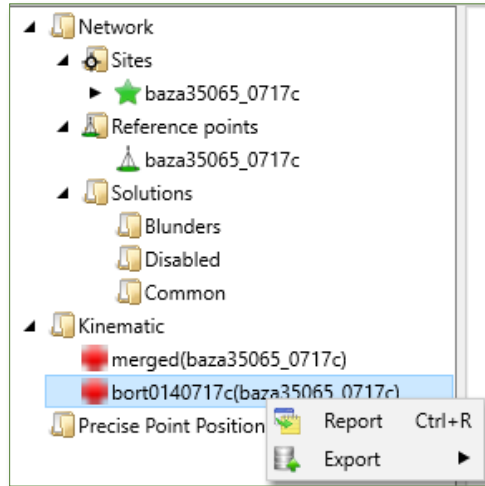


Figure 85: Adjustments - Network - Kinematic Solution - Trajectory Object Menu

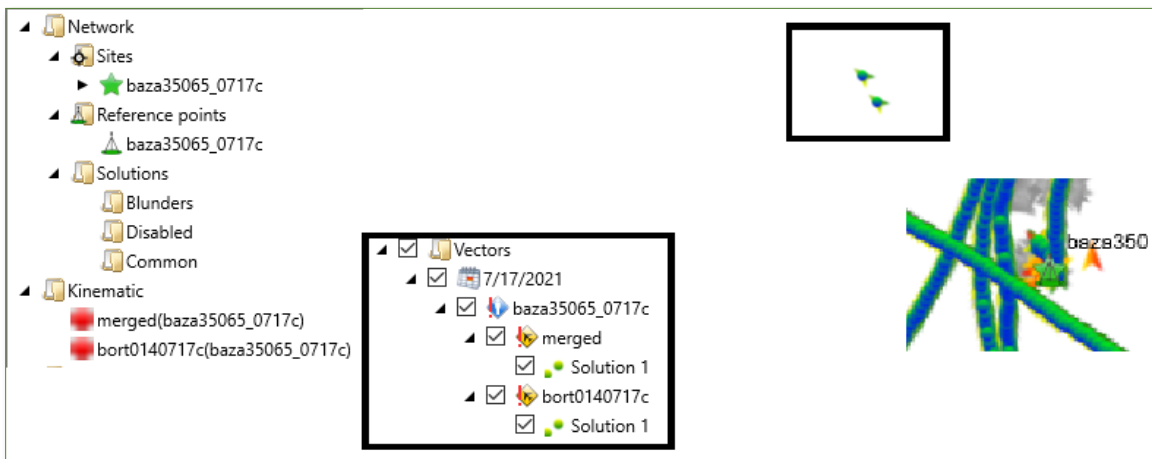


Figure 86: Adjustments - Network - Kinematic Solution - The Kinematic Adjustment

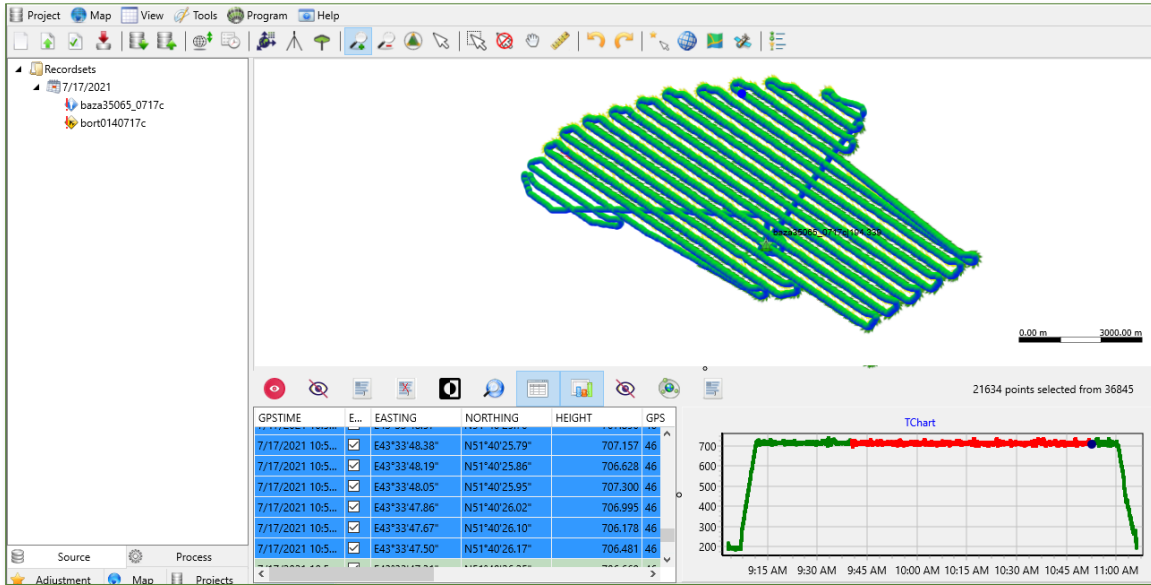


Figure 87: Adjustment - Network - Kinematic Solution – Trajectory

Selecting a row in the table pane generates the orange portion on the graph (shown above).

The kinematic adjustment could be running if multiple base solutions exist. In this case, only the Kinematic node is populated. A new trajectory object is intended to control the adjustment workflow.

5.1.2.1. Kinematic Settings

Kinematic settings are accessed by clicking on the kinematic item and selecting settings, this will open the Adjustment settings window (shown below).

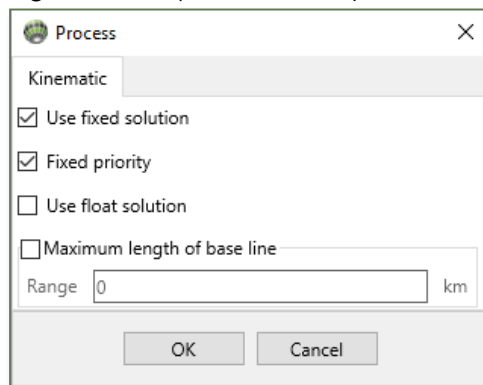


Figure 88: Adjustments - Network - Kinematic Solution - Kinematic Settings Window

Options in the Adjustment settings window include:

- Use Fixed Solution – Only fixed solutions are used in the adjustment.
- Fixed Priority – Ignore other solutions weaker than a fixed solution (float, ect.) if a fixed solution exists.
- Use Float Solution – Both float and fixed solutions will be used in the adjustment within the solution covariance matrices.
- Maximum Length of Base Line – Sets a maximum range parameter acceptable in the adjustment. This is the distance between the base and rover epoch positions.

5.1.2.1. Kinematic Report

This option will generate a standard report with kinematic settings used.

Use fixed:	True	Fixed priority:	True		
Use float:	False	Maximum range:	0		
Recordset name: bort224_0710a (log2_0710a, trm2_0710a)					
No	Time	Latitude	Longitude	Height, m	Residual
1	2017-07-10 04:22:08.000	N 71° 01' 53.22105"	E 180° 00' 00.00000"	-413582.497	0.000,m
2	2017-07-10 04:22:09.000	N 71° 01' 53.22107"	E 180° 00' 00.00000"	-413582.506	0.000,m
3	2017-07-10 04:22:10.000	N 71° 01' 53.22120"	E 180° 00' 00.00000"	-413582.522	0.000,m

Figure 89: Adjustments - Network - Kinematic Solution - Kinematic Report? No New Image

6. Project Settings

The Project Settings are located within the main program window. Click on Project – Settings to gain access to this option.

Figure 90: Project Settings - Project – Settings


The left side of the Project Settings window contains:

- Filename – Name of the current project file.
- Created – Date and Time of project file creation.
- Creator – Optional information of project file creator.
- Agency – Optional information of project file agency.
- Comment – Optional comment information.

The right side of the Project Setting window contains:

- Max epoch gap – The maximum number of skipped epochs between any two adjacent epochs within data.
- Min sample size – The minimum number of epochs to process the data.
- Criterion for static – The coefficient multiplied by the standard error of the epoch for the data. If the coordinates calculated for all epochs are inside a circle with a radius equal to the criterion, the data is determined by Justin as static. Otherwise, the sample is defined as kinematic.
- Tolerance for static – The maximum distance at which the recordsets refer to the same point.
- Max vector length – The maximum length of processed vectors.
- Epoch – The date of the project

7. Coordinate Systems Manager

The Coordinate Systems Manager is accessed using the main menu program item or by clicking the coordinate systems manager icon .

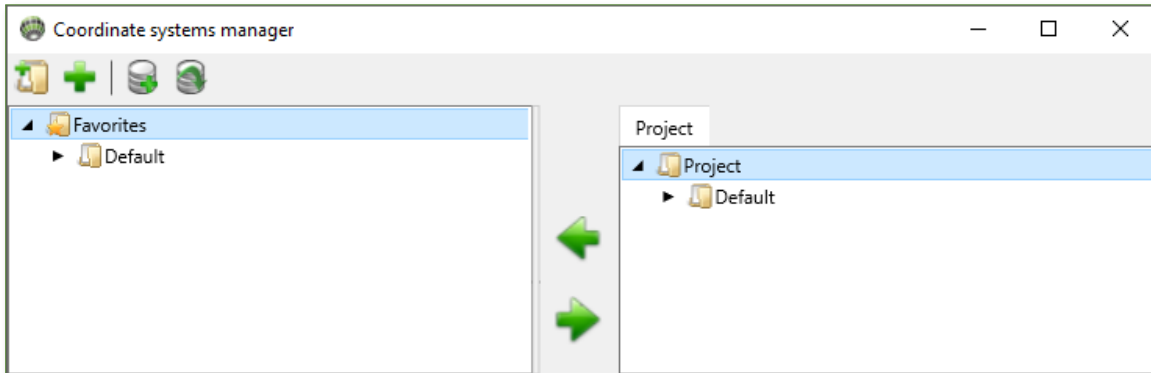


Figure 91: Coordinate Systems Manager

The default coordinate systems are WGS84, WGS84 (ECEF), and World Mercator.

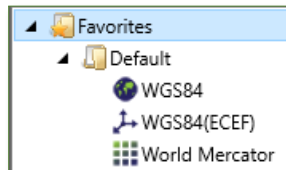



Figure 92: Default Coordinate Systems

Click the add subfolder  to add a subfolder to the Favorites root item subfolder's name.

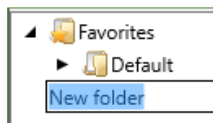


Figure 93: Subfolder Addition

Click on the customize the list of preferable coordinate systems  if needed.

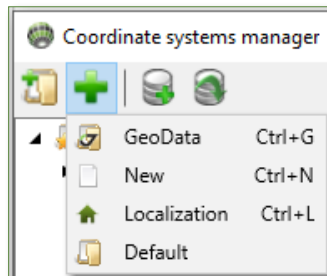


Figure 94: Customize Coordinate System List

7.1. GeoData Database

To search in the Javad geodata database, select the preferred geodata subset.

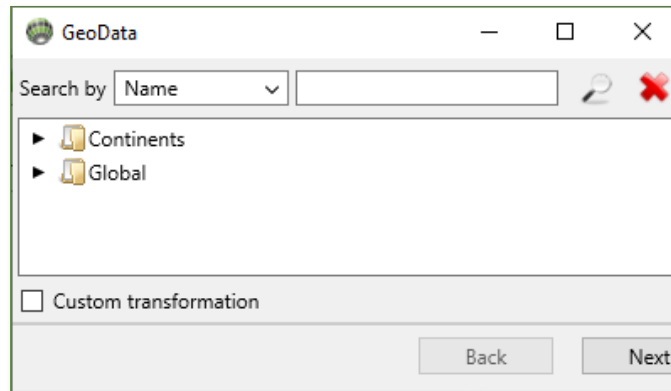


Figure 95: Geodata

Click on the subset to expand the item and continue to the desired folder:

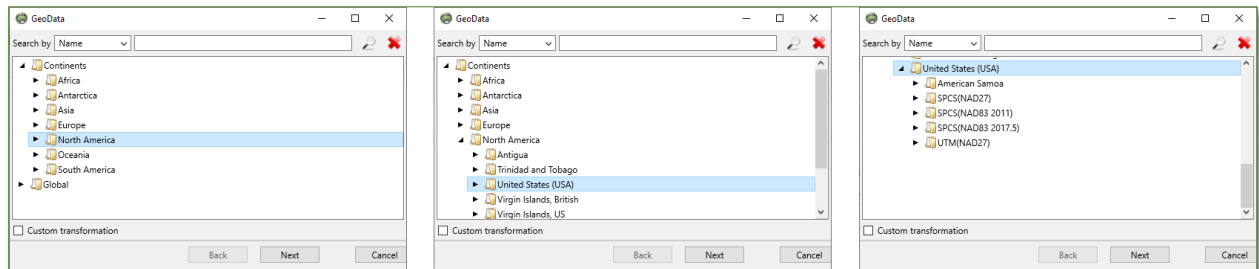


Figure 96: Item Expansion

Opening the desired folder brings up the specific list of preloaded coordinate system:

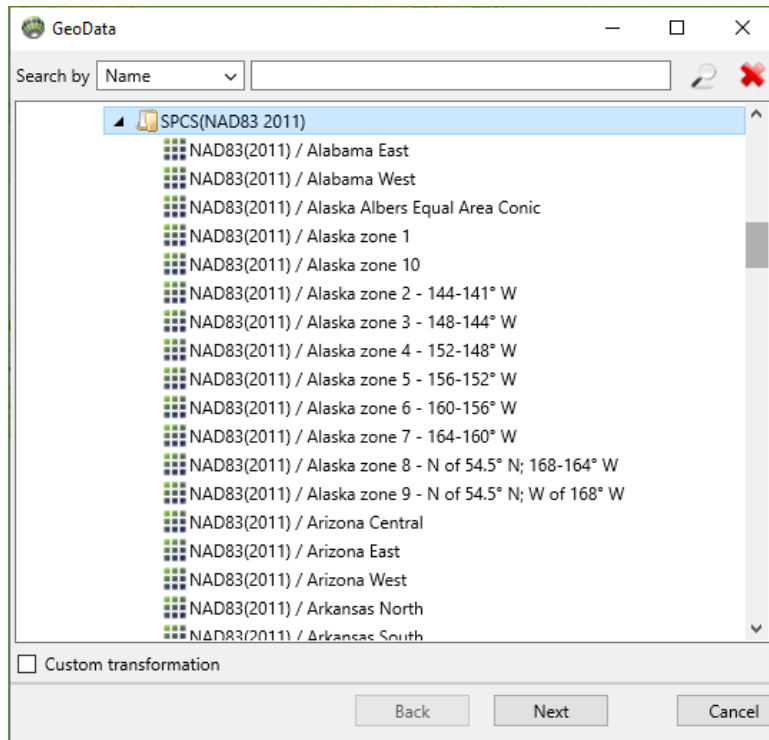


Figure 97: Selection of Coordinate System

If "Custom transformation" is checked, an additional window with a list of valid transformations appears after clicking "Next".

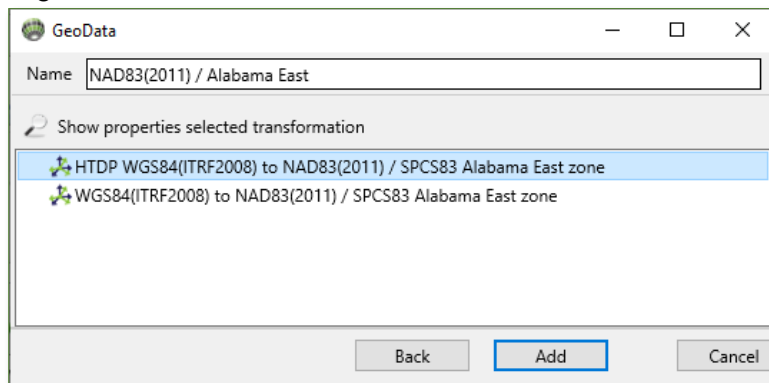




Figure 98: Custom Transformation

Click on the search button  to search, then to input stored in file transformation, then "Add" or "Back" to return.

7.2. Create a New Coordinate System

To create a new coordinate system, either click on the  button or right-click on the Favorites item, then select “New”:

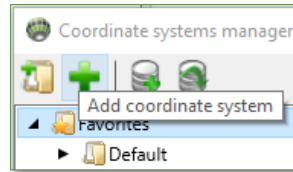


Figure 99: New Coordinate System

A new window with options of coordinate system types will appear:

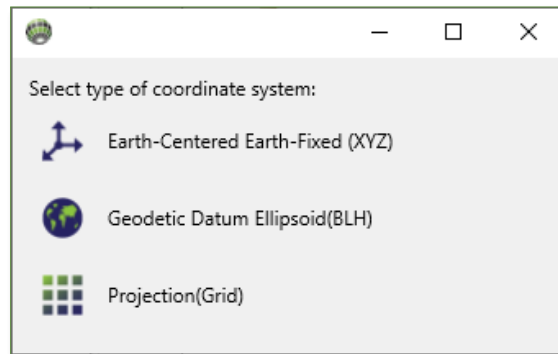


Figure 100: Coordinate System Type Selection

Select the Projection (Grid) option to specify the datum. It is possible to select on of the existing datums or create a new one. Datum parameters correspond to the transformation from ITRF2008(WGS84), which is the main system in Justin.

7.2.1. Specify a new Datum

Specify the ellipsoid from the drop-down menu or input new parameters:

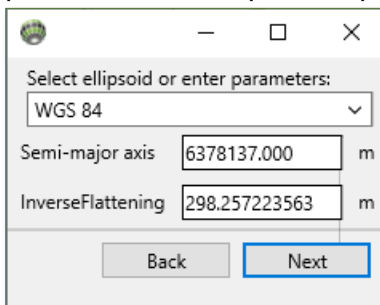


Figure 101: New Datum Specification

Clicking “Next” allows for input of the 7 parameters of the Helmert transformation:

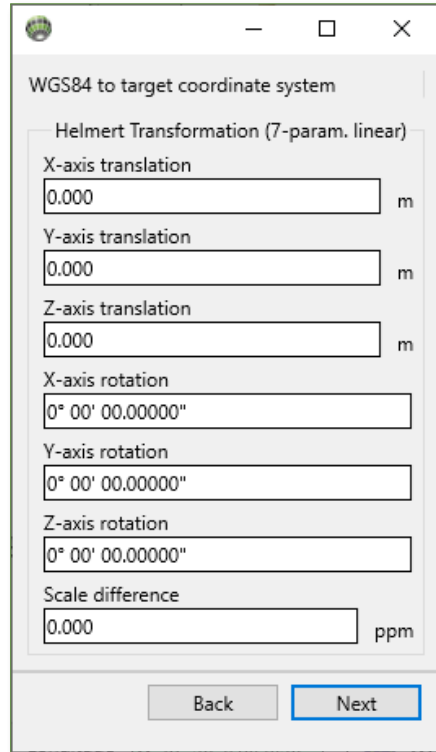


Figure 102: 7 Parameter Input

Clicking "Next" allows for projection selection:

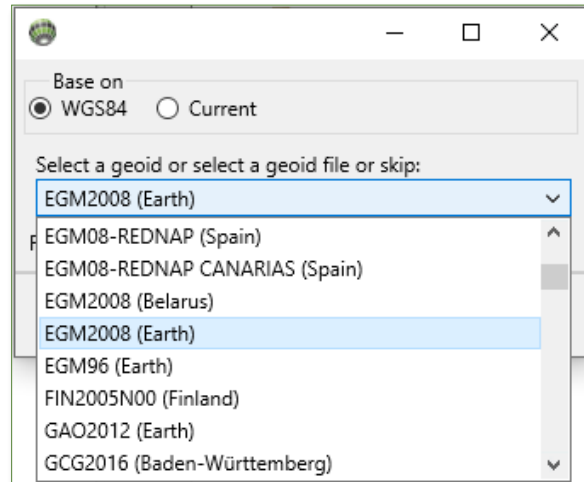


Figure 103: Geoid Selection

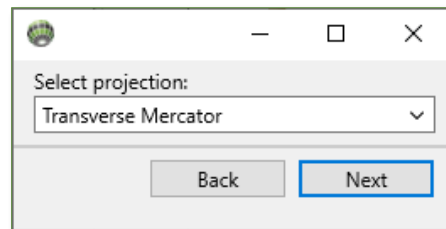


Figure 104: Projection Selection

Next, specify geoid or click “Skip”. Then select ellipsoid:

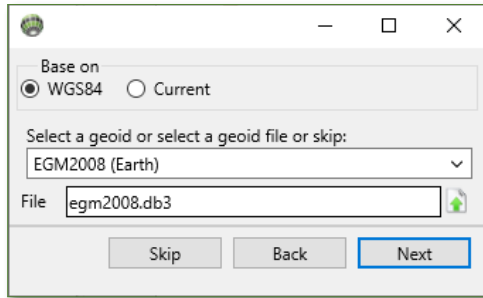


Figure 105: Select Geoid or enter own Geoid

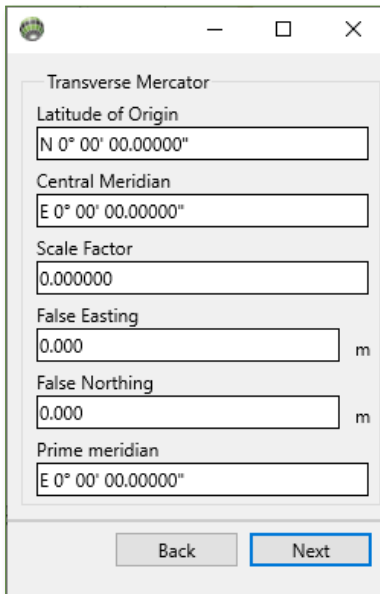


Figure 106: Projection Details

Clicking “Next” allows for entering the new coordinate system name:

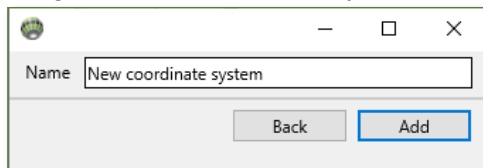


Figure 107: Coordinate System Name

Clicking “Add” finishes creating a new coordinate system.

7.3. Coordinate System Options

Selecting a coordinate system from the Favorites menu allows for coordinate system options.

7.3.1. Properties

Selecting Properties opens the selected coordinate system properties window, shown below.

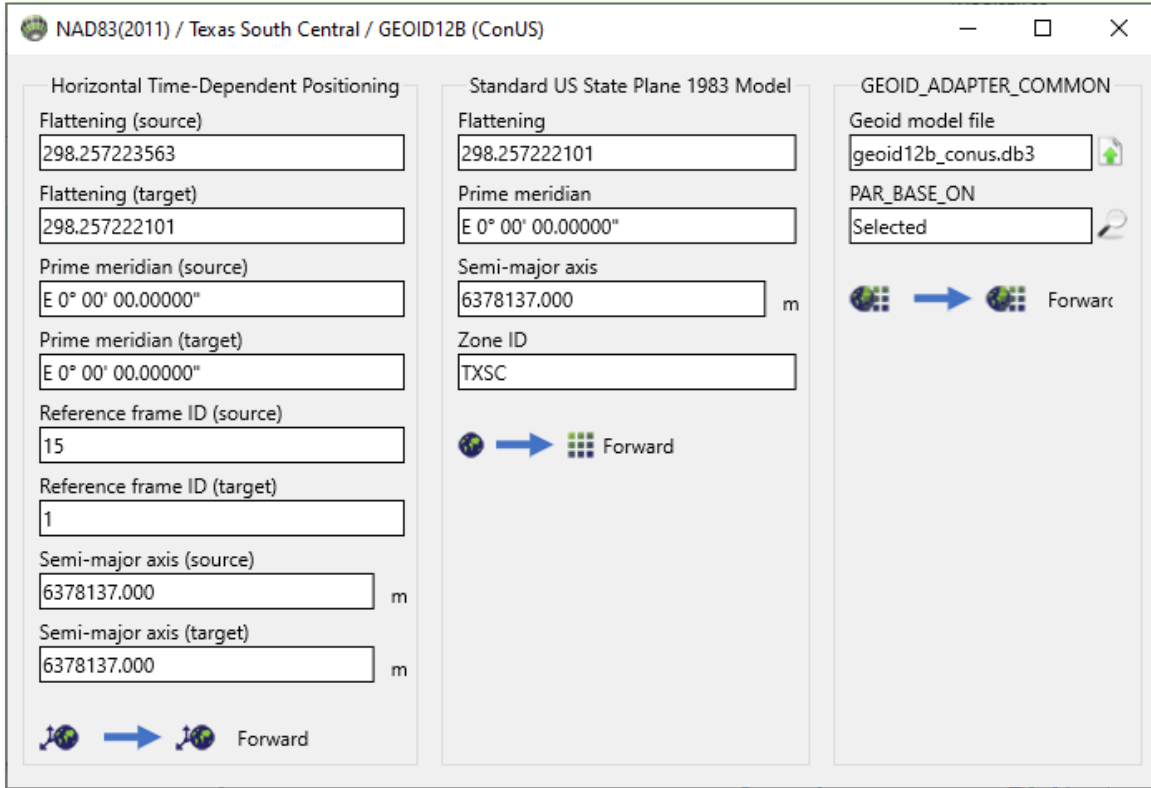


Figure 108: Coordinate System Properties

7.3.2. Edit

Click this option to edit the selected coordinate system. Every complete coordinate transformation from WGS84(ITRF2008) to a target coordinate system is a chain of consecutive transformation.

Icons on the top bar of the Edit window contain:

- - Save Transformation.
- - Save Transformation with new name.
- - Add Transformation.
- - Insert Transformation.
- - Delete Transformation.

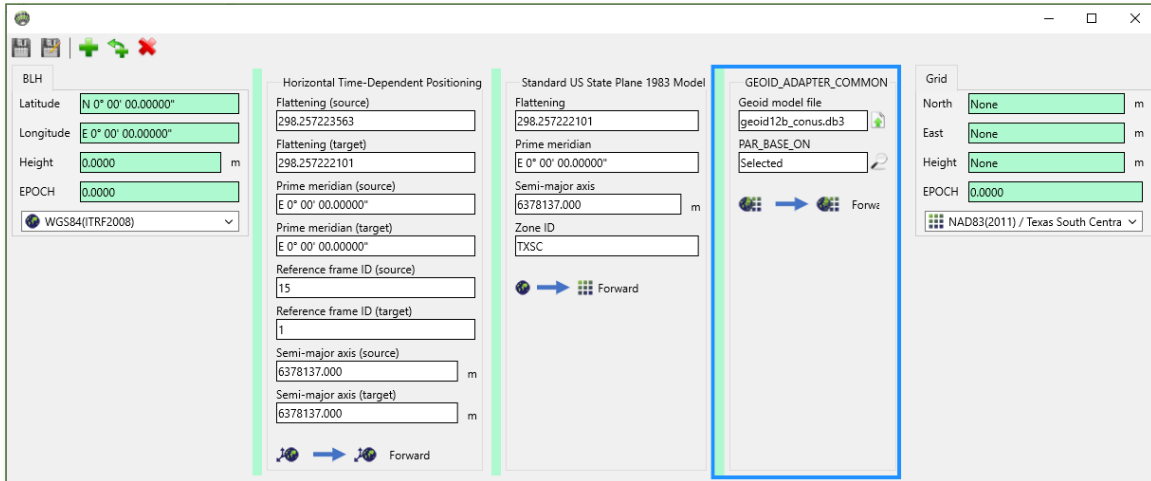


Figure 109: Coordinate System Edit Window

The far-left panel is designed for input / output coordinates in WGS84(ITRS2008). The far-right panel is designed for input / output coordinates in target coordinate system. Each panel in the middle represents consecutive transformations. These middle panels are highlighted by green / red to indicate correct / incorrect links between output data from the previous transformation and input data on the current transformation.

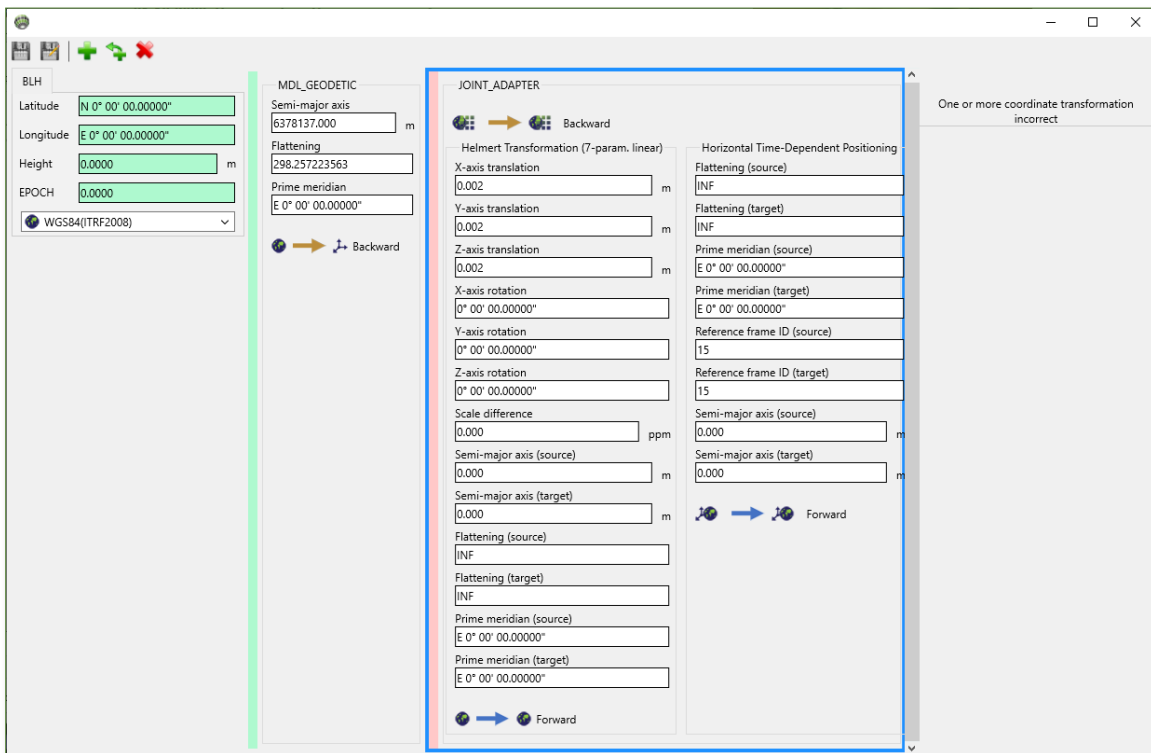


Figure 110: Coordinate System Edit Window

Validation between transformations is detected by coincidence type of input / output data. The type of transformation is shown on the bottom:

- - ECEF.
- - Geodetic.

- - Grid.
- - Combined (variant types of coordinates).

Transformations can be forward and backward, indicated by colored arrows:

- - Forward.
- - Backward.

Transformations can be added using the icon, inserted using the icon or removed using the icon.

The selected transformation is highlighted by the blue frame.

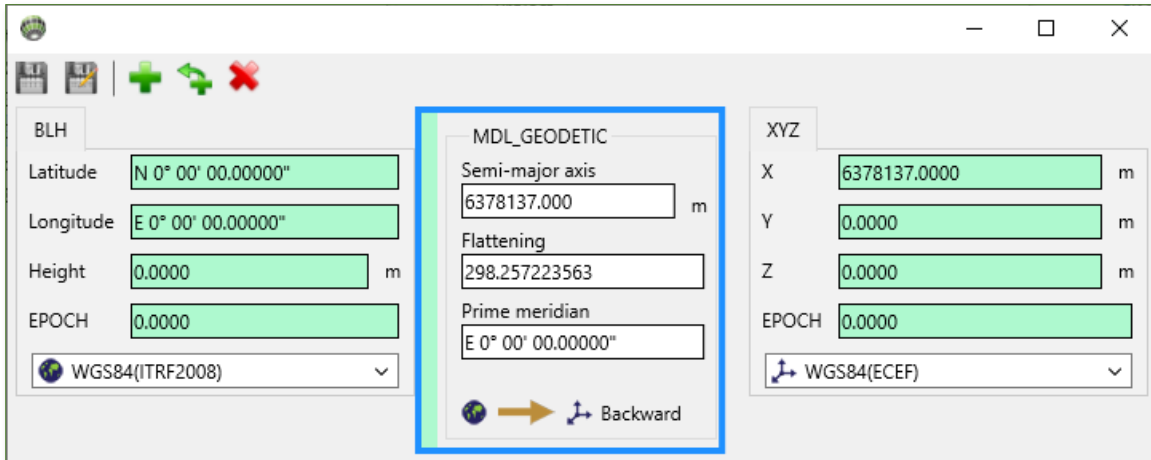


Figure 111: Edit Window - Selected Transformation

Transformation parameters can be added or inserted:

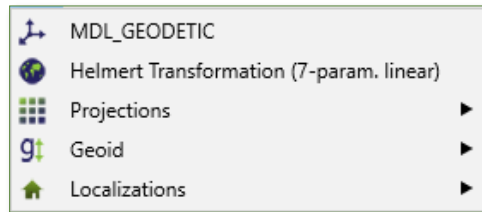


Figure 112: Add / Insert Parameters

Geoids can be added:

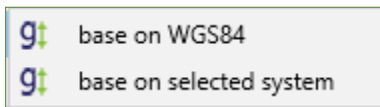


Figure 113: Geoid Options

A localization can be added:

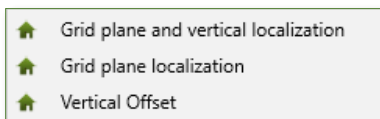


Figure 114: Localization Options

After selection options bases on the selected system, the user will need to select the panel where the data will be used to determine the geoid height. Click for information about the reference system. To change geoid files, click the icon. New geoid files will be copied to

Justin's program geoids folder. Valid transformations have all panels colored in green, only valid transformations may be saved; either by the save icon or by the save as icon. The name and type should be unique. To rewrite an existing coordinate system, select it in the window below.

7.3.3. Backup / Exchange

Creation of a backup file for the Favorites item is recommended as it assists in the case of new Justin version installation or running several instances of Justin on multiple PC's. Click on the create backup file icon with naming conventions: Parameter_Year-Month-DayTHours-Minutes-Seconds.jcs, where file is saved in C:\Users\Username\Documents\Justin\CoordinateSystems folder.

To restore a Favorites list from a list of backup files from the C:\Users\Username\Documents\Justin\CoordinateSystems folder. Click on the restore Favorites icon. A list of restore points will show in a window:

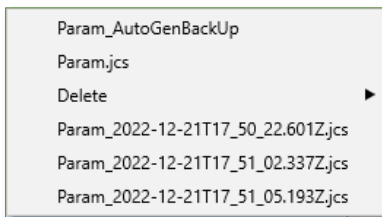


Figure 115: Restore Points

Coordinate systems can be exchanged using the right pane of the Coordinate systems manager window. Click on the Project tab to activate:

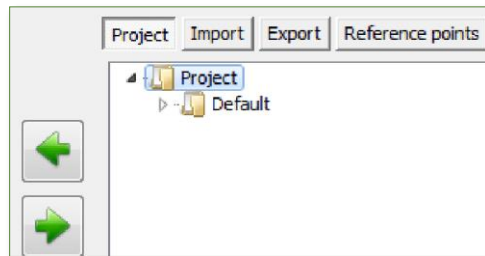


Figure 116: Active Project Tab? No new Image

Use the left and right buttons shown on the left to copy coordinate systems from the program database to a project. The Import tab allows the user to click on a selected coordinate system and click open. A copy can be made from the Import tab by selecting a coordinate system and clicking on the left button to copy that coordinate system to the program database.

The export tab allows for exporting a coordinate system by selecting the clicking on the right button. Coordinate systems can be saved by selecting that option from the drop-down menu. The Reference points tab allows for the user to copy coordinate systems to the Favorites program database using the left button.

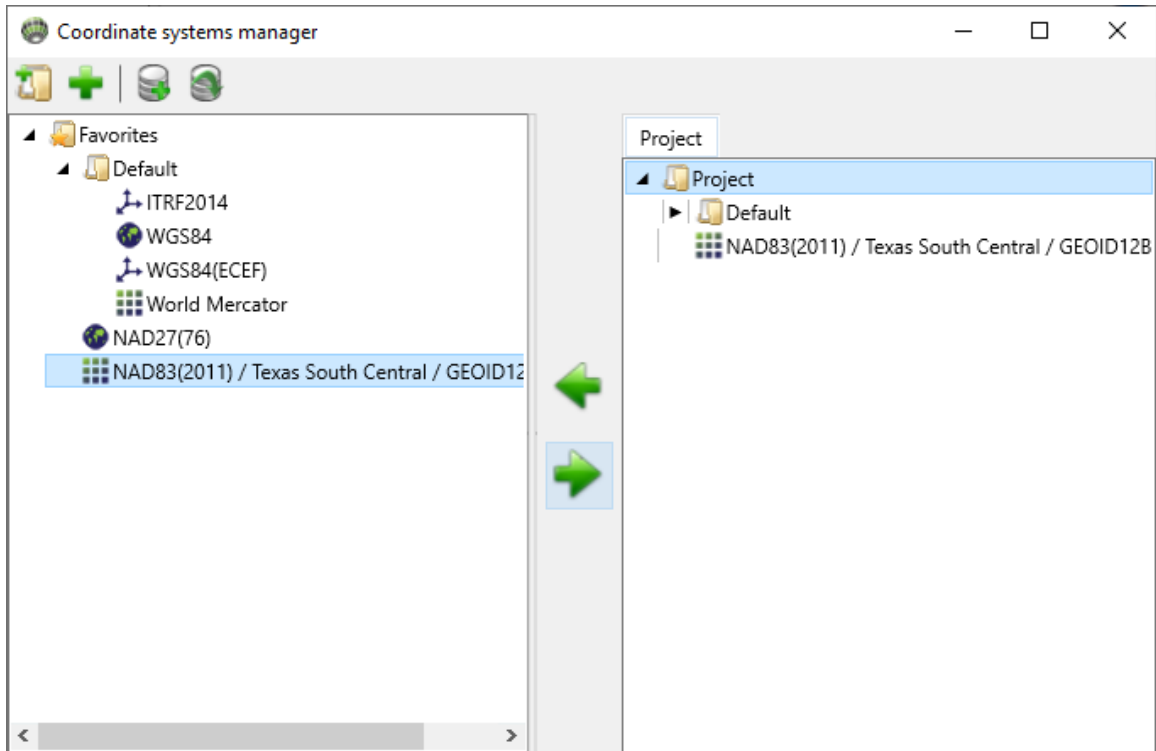


Figure 117: Coordinate System Manager Window


7.3.4. Other Options

- Rename – Click on the selected object to rename and edit the name.
- Cut – Use an option for cut and paste.
- Copy – Use an option for copy and paste.
- Paste – Use an option for pasting from buffer.
- Clone – Create an instant copy; will have suffix of ‘_Clone’.
- Delete – Deletes the item after confirmation.

8. Reference Points

Justin software treats reference points as points within a catalog of postulated coordinates. Raw data post-processing results in vector components in XYZ / NEU. Justin needs at least one reference point in the preferred coordinate system for post-processing components to be in this same preferred coordinate system. In practice, the user will collect data in the field over the preferred reference point and collect data in the field over the preferred rover point. Getting raw data from both locations, snap the beginning of processed vector to reference point and adjust.

8.1. Reference Point Manager

Click on the reference point manager  icon, located in the toolbar, to open the Reference point manager window.

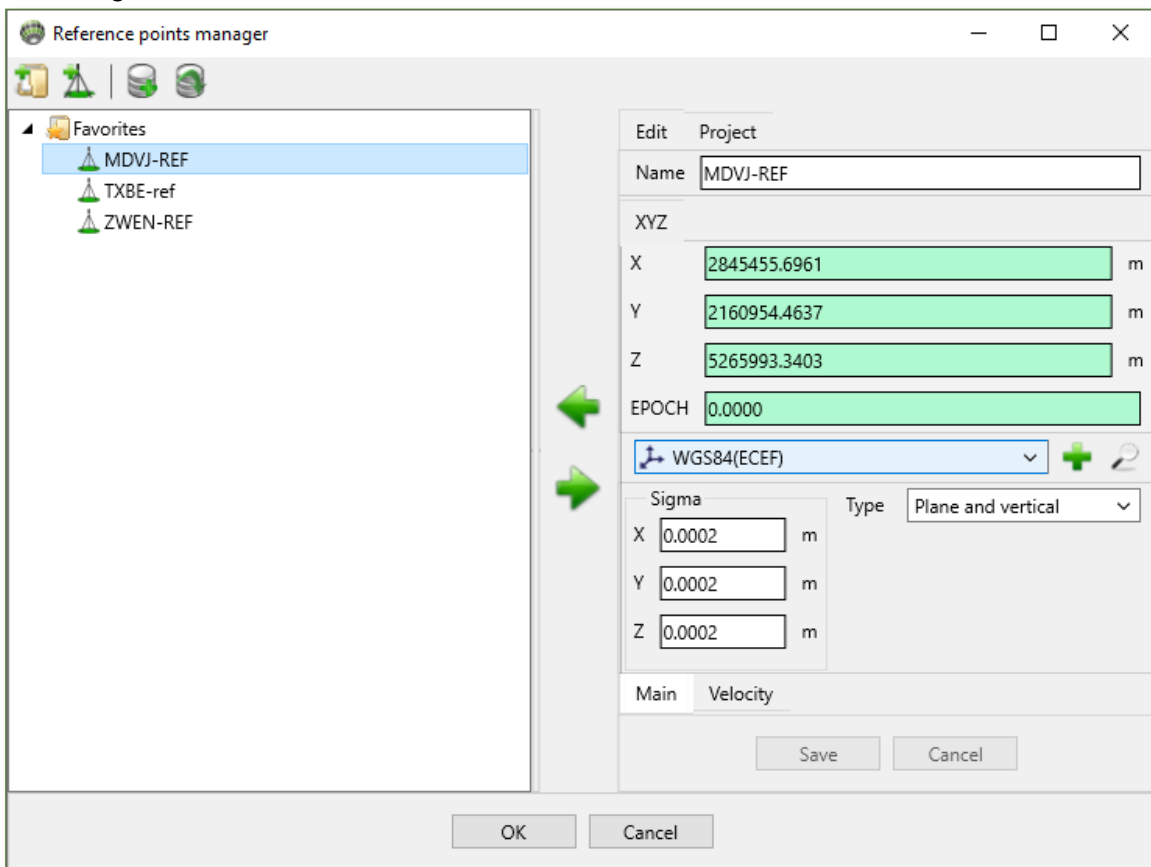








Figure 118: Reference Points - Reference Point Manager Window

The Reference point manager window toolbar contains:

-  - Creates a new folder.
-  - Creates a new reference point in a selected folder and enable the right panel for editing and saving.
-  - Import exchange files (.jst).
-  - Export reference points (.jst or .txt).
-  - Creates a backup file.
-  - Opens backup files.

The Reference point manager window's left panel has Reference points as the root item. It may contain some subfolders. Clicking on folder items invokes the menu, shown below.

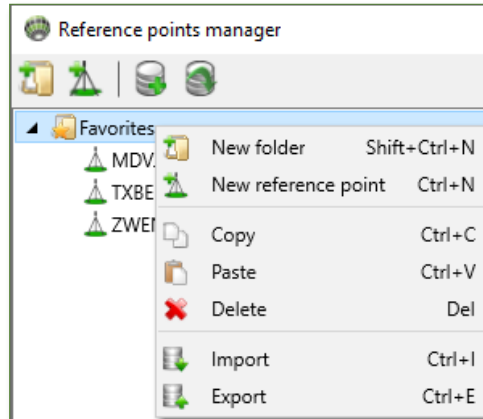


Figure 119: Reference Point Manager - Left Panel - Folder Menu

Items in the left panel folder menu contain:

- New folder – Creates a new subfolder.
- New reference point – Creates a new reference point in a folder.
- Copy – Copies item to buffer.
- Paste – Pastes from buffer into the selected folder.
- Clone – Clones a folder.
- Delete – Deletes a folder.
- Import – Opens dialog window to import file points (.jst) into the folder.
- Export – Exports a folder in selected file format (.jst or .txt).

The right panel of the reference point manager window offers four tabs (Edit, Project, Import and Export).

The Edit tab allows for editing of reference point properties, shown below.

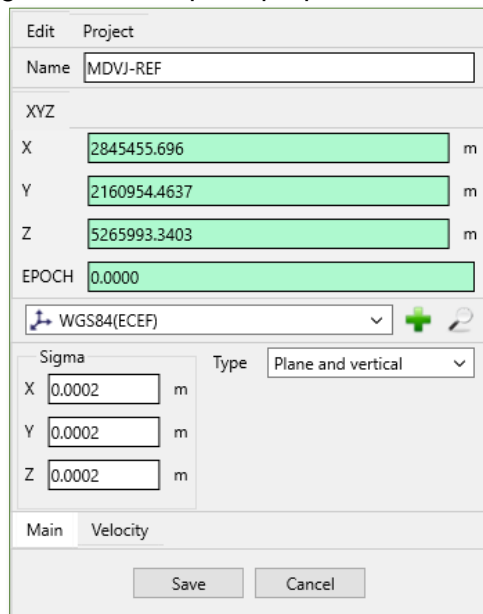


Figure 120: Reference Point Manager - Right Panel - Edit Tab

Depending on the item in focus, the right panel may be empty (TxDot folder selected) or contain reference point information (TXBE reference point selected). Click to start with a new point:

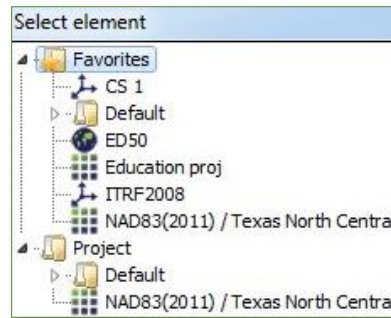


Figure 121: Select New Point

Click to open a list of accessible coordinate systems.

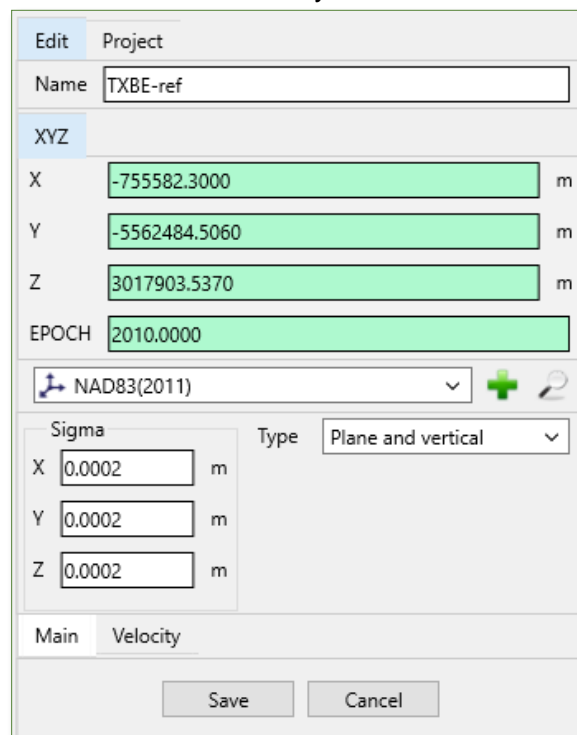


Figure 122: Select Coordinates

Select preferred coordinate system, then type coordinates, and click save to add a new point to the list in the left panel's selected folder.

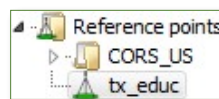


Figure 123: New Point Added to Left Panel's Selected Folder

Click on the Speeds/Epoch tab to view or type speeds if required. Time-dependent coordinate systems use predefined velocities (e.g., HTDP transformations), user-defined speeds have priority.

EPOCH 0.0000

WGS84(ECEF) + 🔍

Velocity

X 0.0000 m/year

Y 0.0000 m/year

Z 0.0000 m/year

Main Velocity

Save Cancel

Figure 124: Speeds/Epoch Tab

The Project tab opens the project repository and reference points exchange. Use the left and right buttons to copy folders and reference point items.

9. Localization

To convert the coordinates obtained by GNSS data processing from WGS84 to a local coordinate system, it is required to:

- 1.) Have reference coordinates in the local coordinate system.
- 2.) Have coordinate transformations which connect the local coordinate system to WGS84.

The order in which coordinates are calculated is shown below:

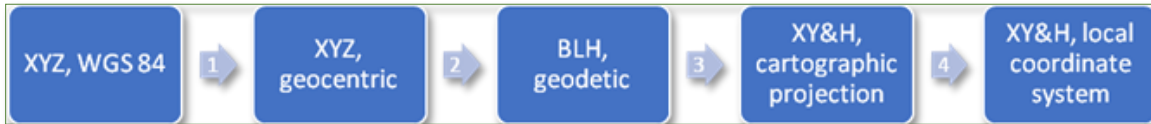


Figure 125: Coordinate Transformation Order

Transformation of geocentric coordinate systems is performed by the formula of 7 parametric Helmert transformations (*Amendment 2 of RTCM Standard 10403.1*):

$$\begin{matrix} X_T & dX & X_S \\ Y_T & dY & Y_S \\ Z_T & dZ & Z_S \end{matrix} \quad (9.1), \text{ where } X_S, Y_S, Z_S \text{ and } X_T, Y_T, Z_T \text{ are WGS84 geocentric coordinates}$$

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.

$M = (1 + dS * 10^{-6})$. The size of dS is indicated in the list of datum Justin parameters in ppm.

The rotation matrix $R = R_X * R_Y * R_Z R_X * R_Y * R_Z$, where:

$$R_X = \begin{matrix} \cos R_1 & \sin R_1 & 0 \\ -\sin R_1 & \cos R_1 & 0 \\ 0 & 0 & 1 \end{matrix}, R_Y = \begin{matrix} \cos R_2 & 0 & -\sin R_2 \\ 0 & 1 & 0 \\ \sin R_2 & 0 & \cos R_2 \end{matrix}, R_Z = \begin{matrix} 1 & 0 & 0 \\ 0 & \cos R_3 & \sin R_3 \\ 0 & -\sin R_3 & \cos R_3 \end{matrix} \quad (9.2)$$

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:

$$\begin{matrix} X_S \\ Y_S \\ Z_S \end{matrix} = \frac{R^{-1}}{M} \left[\begin{matrix} X_T \\ Y_T \\ Z_T \end{matrix} \right] - \begin{matrix} dX \\ dY \\ dZ \end{matrix} \quad (9.3)$$

The Helmert transformation is a similarity transform in which the scale factor is the same for each coordinate. The combination of the 7 parameters for transformation ($dX, dY, dZ, dS, R_1, R_2, R_3$) and the ellipsoid is called the datum. In the list of Justin datums, the signs of the parameters correspond to the transition from WGS84 to the reference system.

Example: $dX = +10 \text{ meters}$. $X_R = X(\text{WGS84}) + 10$.

The calculation of geodetic coordinates with the use of geocentric coordinates (item 2 of the transformation scheme) is performed by iterations using the formulas:

$$\begin{aligned} \tan L &= \frac{Y}{X}, \\ \tan B &= \frac{Z}{\sqrt{X^2 + Y^2}} + \frac{e^2 * N * \sin B}{\sqrt{X^2 + Y^2}}, \quad (9.4) \\ H &= \frac{\sqrt{X^2 + Y^2}}{\cos B} - N. \end{aligned}$$

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 B, L, H is described by the formulas:

$$\begin{aligned} X &= (N + H) * \cos B * \cos L, \\ Y &= (N + H) * \cos B * \sin L, \quad (9.5) \\ Z &= (N + H - e^2 * N) * \sin B. \end{aligned}$$

Where e is eccentricity and N is the radius of curvature of the first vertical.

To calculate geodetic coordinates, there is a 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_{geoid} geodetic (ellipsoidal) height, which is measured along the normal to the ellipsoid, to H_{ortho} orthometric height is performed by the formula:

$$H_{geoid} = H_{ortho} + \zeta, \quad (9.6)$$

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. The transformation performed between two rectangular coordinate systems is specified on the plane. Finding the parameters of the transformation is typically called localization or calibration. Planned transformation formulas are:

$$\begin{aligned} N_T &= dN + M * R * \frac{N_S}{E_S}, \quad (9.7) \\ E_T &= dE + M * R * \frac{E_S}{E_S}, \end{aligned}$$

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

$$N_T = dN + M * (N_S * \sin \alpha + E_S * \cos \alpha), \quad (9.8)$$

Where dN, dE are offsets along the coordinate axes.

N_S, E_S, N_T, E_T are Northing and Easting rectangular coordinates on a plane. α is the turning angle, counted clockwise. M is the scale factor. The formula for inverse transformation for coordinates on a plane is:

$$\begin{aligned} X_S &= \frac{R^{-1}}{M} \begin{bmatrix} X_T \\ Y_T \end{bmatrix} - \begin{bmatrix} dX \\ dY \end{bmatrix}, \quad (9.9) \\ Y_S &= \end{aligned}$$

The formula of altitude transformation is:

$$H_T = H_S + dH + \alpha_N * N_S + \alpha_E * E_S, \quad (9.10)$$



Where H_S is the height in the original coordinate system, dH is the height increment, α_N and α_E are slope angles along the Northing and 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. Typically, this is called a 4+3 datum. This highlights the difference between it and the datum with 7 parameters, which is used for calculation of geocentric coordinates transformations.

9.1. Localization Window

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 on the icon ). In the opened window, click  and select Localization.

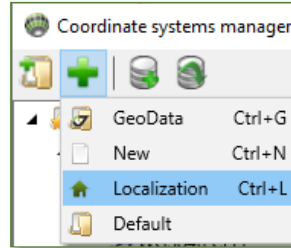


Figure 126: Program - Coordinate Systems – Localization

The Localization window has a bar of icons across the top, a settings panel and a coordinate entry table.

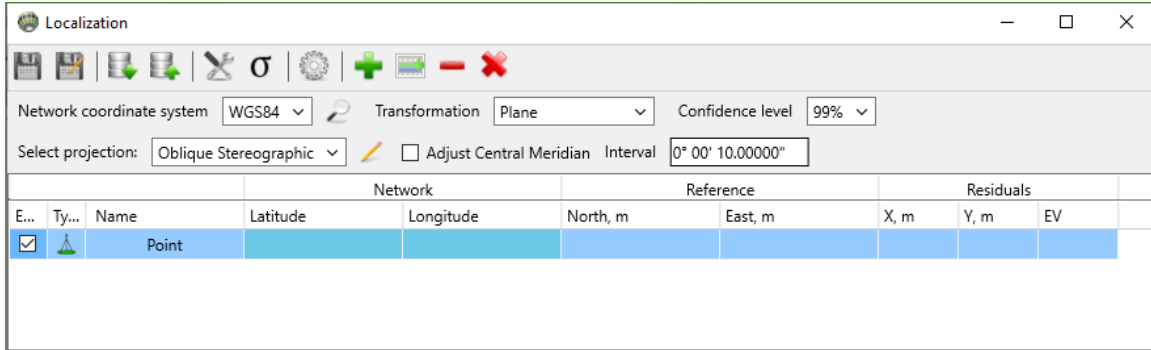















Figure 127: Localization Window

9.1.1. Icon Bar

The icon bar contains:

-  - Save a new localization.
-  - Save localization as...
-  - Import files (.jps, .txt).
-  - Export localization points.
-  - Calculate localization.
-  - Restore table default settings.
-  - Activate / Deactivate bookmark.
-  - Add columns to enter point coordinates accuracy estimates.
-  - Add row to end of table.
-  - Add previous row.
-  - Remove selected row.
-  - Delete all rows.
-  - Set column width to maximum cell length of current column.

By clicking on either of the save icons (save new or save as...) the localization will be saved to the program database.

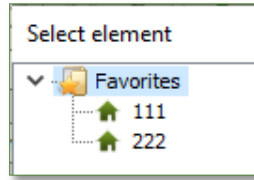


Figure 128: Saved Localization

Select a folder in the Favorites coordinates system. Not only transformation parameters are saved but all table data as well. It is possible to save unprocessed data.

9.1.2. Data Table

The main window is comprised of the 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.

Enable	Type	Name	Network			Reference			Residuals					
			Latitude	Longitude	Height, m	North, m	East, m	Height, m	North, m	East, m	Height, m	EV		
<input checked="" type="checkbox"/>		Point												

Figure 129: Titles of the Data Table

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

- Include – The selected checkbox means that the coordinates of the point will be used when calculating the parameters. Otherwise, the point is excluded from the calculation process. In this case, the corresponding row in the table is shaded, residuals are not calculated.
- Type – Sets the type of transformations in which a specific item can be used.

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

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

- North, East, (Height – if parameters for height transformation are also calculated) from the Reference block – coordinates of points in the local coordinate system.
- V (residuals block) – residuals of points of the coordinates by the corresponding component and residuals by radius vector.

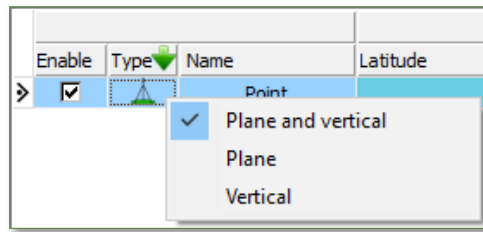


Figure 130: Item Type Selection

9.1.3. Working with Input Fields

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:

En...	Ty...	Name	Network			Reference			Residuals			
			Latitude	Longitude	Height, m	North, m	East, m	Height, m	North, m	East, m	Height, m	EV
<input checked="" type="checkbox"/>		1516	N 56.176179647222220°	E 40.499016344444442°	66.7820	196784.7730	227246.9860	46.7420	-0.0062	-0.0055	0.0287	0.0299
<input checked="" type="checkbox"/>		2168	N 56.119438752777775°	E 40.365503455555555°		190295.4070	219080.6280	73.9624	0.0119	0.0009		0.0119
<input checked="" type="checkbox"/>		2191	N 56.172783727777777°	E 40.412466941666665°	41.5936	196293.2460	221879.8550	21.5036	0.0044	-0.0077	-0.0835	0.0839
<input checked="" type="checkbox"/>		281	N 56.104133377777778°	E 40.435410919444443°	23.3102	188679.6640	223463.8840	3.3402	-0.0010	0.0045	0.0156	0.0163
<input checked="" type="checkbox"/>		93	N 56.123838377777780°	E 40.342110919444444°		190756.6690	217616.2070	41.4294	-0.0062	-0.0105		0.0121
<input checked="" type="checkbox"/>		Kusunovo	N 56.117389074999998°	E 40.507669730555556°	75.6604	190251.2770	227927.4280	55.6004	-0.0019	0.0119	-0.0168	0.0206
<input checked="" type="checkbox"/>		Polevaya	N 56.174029341666667°	E 40.389102130555557°	94.1339	196402.4400	220425.9350	74.2039	-0.0035	0.0037	0.0609	0.0611
<input checked="" type="checkbox"/>		Suzd_road	N 56.183803394444446°	E 40.449105019444446°	94.2970	197567.3030	224129.5760	74.2570	-0.0003	-0.0071	-0.0020	0.0074
<input checked="" type="checkbox"/>		Jur	N 56.175465305555555°	E 40.332062708333332°	97.0828	196492.4220	216880.3480	77.1284	0.0028	0.0098	-0.0031	0.0107

Figure 131: Data in the Height Column

When the coordinates are entered in the table in the columns of the Network block and there is no value of any planned 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 (site 1516). The result will be similar to deleting item information from the table or unchecking the check-box in the Enable column). The discrepancies of the row will be zero, and their fields in the table are highlighted in white:

En...	Ty...	Name	Network			Reference			Residuals			
			Latitude	Longitude	Height, m	North, m	East, m	Height, m	North, m	East, m	Height, m	EV
<input checked="" type="checkbox"/>		1516	N 56.176179647222220°	E 40.499016344444442°	66.7820	196784.7730	227246.9860	46.7420	-0.0057	-0.0064	0.0095	0.0128
<input checked="" type="checkbox"/>		2168	N 56.119438752777775°	E 40.365503455555555°	93.9124	190295.4070	219080.6280	73.9624	0.0117	0.0005	0.0223	0.0252
<input checked="" type="checkbox"/>		2191	N 56.172783727777777°	E 40.412466941666665°	41.5936	196293.2460	221879.8550	21.5036				
<input checked="" type="checkbox"/>		281	N 56.104133377777778°	E 40.435410919444443°	23.3102	188679.6640	223463.8840	3.3402	-0.0007	0.0042	0.0314	0.0317
<input checked="" type="checkbox"/>		93	N 56.123838377777780°	E 40.342110919444444°	61.4373	190756.6690	217616.2070	41.4294	-0.0064	-0.0108	-0.0457	0.0474
<input checked="" type="checkbox"/>		Kusunovo	N 56.117389074999998°	E 40.507669730555556°	75.6604	190251.2770	227927.4280	55.6004	-0.0013	0.0115	-0.0211	0.0241
<input checked="" type="checkbox"/>		Polevaya	N 56.174029341666667°	E 40.449105019444446°	94.1339	196402.4400	220425.9350	74.2039				
<input checked="" type="checkbox"/>		Suzd_road	N 56.183803394444446°	E 40.449105019444446°	94.2970	197567.3030	224129.5760	74.2570	0.0000	-0.0081	-0.0121	0.0145
<input checked="" type="checkbox"/>		Jur	N 56.175465305555555°	E 40.332062708333332°	97.0828	196492.4220	216880.3480	77.1284	0.0024	0.0090	0.0157	0.0182

Figure 132: Missing Data in the Field

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 1536 does not use plane coordinates.

En...	Ty...	Name	Network			Reference			Residuals			
			Latitude	Longitude	Height, m	North, m	East, m	Height, m	North, m	East, m	Height, m	EV
<input checked="" type="checkbox"/>		1516	N 56.176179647222220°	E 40.499016344444442°	66.7820	196784.7730	227246.9860	46.7420	-0.0083	-0.0062	0.0177	0.0204
<input checked="" type="checkbox"/>		2168	N 56.119438752777775°	E 40.365503455555555°	93.9124	190295.4070	219080.6280	73.9624	0.0108	0.0017	0.0318	0.0336
<input checked="" type="checkbox"/>		2191	N 56.172783727777777°	E 40.412466941666665°	41.5936	196293.2460	221879.8550	21.5036	0.0040	-0.0065	-0.0809	0.0812
<input checked="" type="checkbox"/>		281	N 56.104133377777778°	E 40.435410919444443°	23.3102	188679.6640	223463.8840	3.3402	-0.0009	0.0058		0.0058
<input checked="" type="checkbox"/>		93	N 56.123838377777780°	E 40.342110919444444°	61.4329	190756.6690	217616.2070	41.4294	-0.0072	-0.0100	-0.0352	0.0373
<input checked="" type="checkbox"/>		Kusunovo	N 56.117389074999998°	E 40.507669730555556°	75.6604	190251.2770	227927.4280	55.6004	-0.0012	0.0110	0.0015	0.0112
<input checked="" type="checkbox"/>		Polevaya	N 56.174029341666667°	E 40.389102130555557°	94.1339	196402.4400	220425.9350	74.2039			0.0661	0.0661
<input checked="" type="checkbox"/>		Suzd_road	N 56.183803394444446°	E 40.449105019444446°	94.2970	197567.3030	224129.5760	74.2570	-0.0012	-0.0060	-0.0101	0.0119
<input checked="" type="checkbox"/>		Jur	N 56.175465305555555°	E 40.332062708333332°	97.0828	196492.4220	216880.3480	77.1284	0.0039	0.0101	0.0092	0.0142

Figure 133: Item Type

Similar rules apply to coordinate columns of the Reference block. Fields in which coordinates are not entered (for all three columns) remain empty, and when importing a file with a coordinate value missing in the corresponding input template, a message is displayed indicating the line number in which it is absent or incorrect data is given:

En...	Ty...	Name	Network			Reference			North, m
			Latitude	Longitude	Height, m	North, m	East, m	Height, m	
<input checked="" type="checkbox"/>		1516	N 56.176179647222220°	E 40.499016344444442°	66.7820	196784.7730	227246.9860	46.7420	
<input checked="" type="checkbox"/>		2168	N 56.119438752777775°	E 40.365503455555555°	93.9124	190295.4070	219080.6280	73.9624	
<input checked="" type="checkbox"/>		2191	N 56.172783727777777°	E 40.412466941666665°	41.5936	196293.2460	221879.8550	21.5036	
<input checked="" type="checkbox"/>		281	N 56.004133377777777°	E 40.439808388888892°	188679.6640	223463.8840	3.3402		
<input checked="" type="checkbox"/>		93	N 56.123838377777780°	E 40.342110919444444°					
<input checked="" type="checkbox"/>		Kusunovo	N 56.117389074999998°	E 40.507669730555556°					
<input checked="" type="checkbox"/>		Polevaya	N 56.174029341666667°	E 40.389102130555557°					
<input checked="" type="checkbox"/>		Suzd_road	N 56.183803394444446°	E 40.449105019444446°					
<input checked="" type="checkbox"/>		Jur	N 56.175465305555555°	E 40.332062708333332°					

ImportTemplate.txt - SciTE

File Edit Search View Tools Options Language Buffers Help

```

1 Line 4 Latitude, : 5 -> Not correct
2

```

line 1, column 1 (INS) (CR+LF) - 0 chars selected

Figure 134: Input Error Message

Window with the message can be closed. This, it is possible to manually enter the known coordinate value leave the field blank.

9.1.4. Input 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) are displayed, three parameters of the vertical transformation (if calculated), 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.

Grid plane and vertical localization

Northing offset: 2431800.707 m

Easting offset: 638142.611 m

Rotation: 104° 08' 52.93113"

Scale difference: 6327894.538 ppm

Vertical Offset: -18.615 m

North inclination: 0° 00' 01.15830"

East inclination: -0° 00' 01.00596"

[V2]: 20349901336.0232

RMS: 50435.4802

Figure 135: Conversion Options Tab

9.1.5. Settings Panel

The settings panel is designed to select various settings and parameters when calculating conversion parameters. All settings are drop-down menu options.

Network coordinate system: WGS84

Transformation: PlaneAndHeight

Confidence level: 99%

Select projection: Oblique Stereographic

Adjust Central Meridian

Interval: 0° 00' 10.00000"

Figure 136: Settings Panel

- 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: WGS84

- WGS84
- Create new
- Select
- NAD83(2011) / Texas South Central / GEOID 12B (ConUS)

Figure 137: Selecting the Coordinate Type

These can be ellipsoidal (BLH) coordinates (set by default), or rectangular coordinates on a plane (GRID). Depending on the selected type of coordinate system, the table view is

configured, settings for the coordinate input template are selected (section Importing coordinates into a table).

Since the main purpose of the Localization module is to tie the coordinates of global satellite navigation systems – WGS-84, obtained as a result of processing / post-processing by the Justin 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 Justin 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 Justin menu.

The reference coordinate system is characterized by a map projection and a global (spatial) 7-parameter datum. The purpose of localization is to calculate the parameters of the local datum required for transformations of coordinates specified on the plane.

The local datum is used in the Justin 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.

- Transformation – The transformation drop-down list is used to define a set of calculated parameters:
 - Plane (default) – 4 parameters of the horizontal transformation are calculated.
 - Height – 3 parameters of the vertical transformation.
 - Plane + Height – 4 parameters of the horizontal and three parameters of the vertical transformation.
 - Shift – 2 parameters of the horizontal transformation (shifts along the North and East axes).

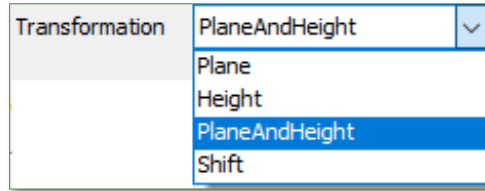


Figure 138: Transformation Selection

- Adjust Central Meridian – The checkbox is designed to select the central meridian when calculating transformation parameters.

If the checkbox 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 Select projection list of coordinate systems. If the checkbox 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 edit button.

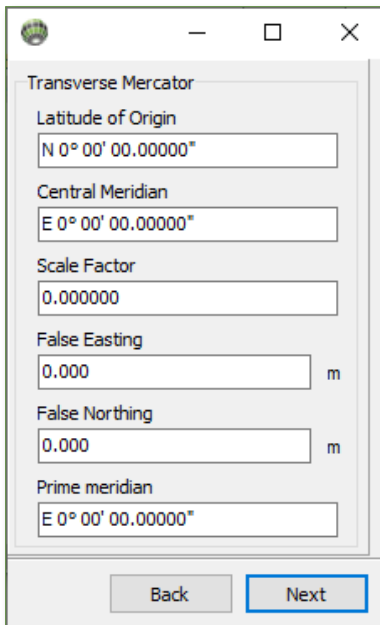


Figure 139: Plane System Parameters for Translation into the Reference Coordinate System

The values of these parameters are updated after each calculation of localization with the Auto-select CM checkbox checked or at any time can be changed manually in this window. If the Auto select CM checkbox is not selected, the values of these parameters are entered only manually and do not change during the calculation.

During 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 checkbox selected.

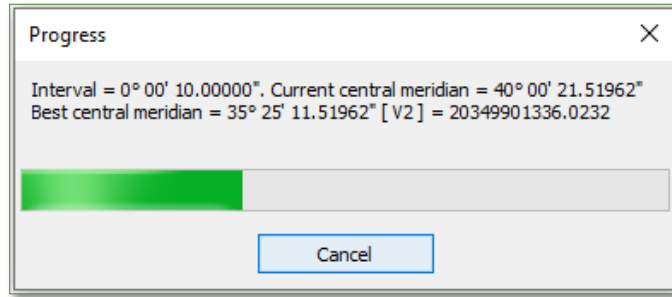


Figure 140: Progress Window

Confidence Interval – Confidence intervals are set to searching blunders in the τ – test. The 95% confidence interval corresponds to stringent criterion whereas the 99% confidence interval corresponds to a wider error interval.

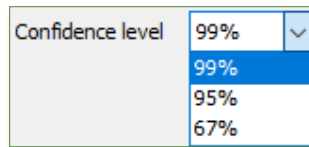


Figure 141: Confidence Interval Selection

9.1.6. Importing Coordinate Points into a Table

In the bar of icons of the localization window, click . In the dialog, it is possible to import text files of any format and text files of the saved template (*.jl). In the new window, select the file and click open. The Batch Coordinate Processing Templates window will appear, where the user may select or configure an import template.

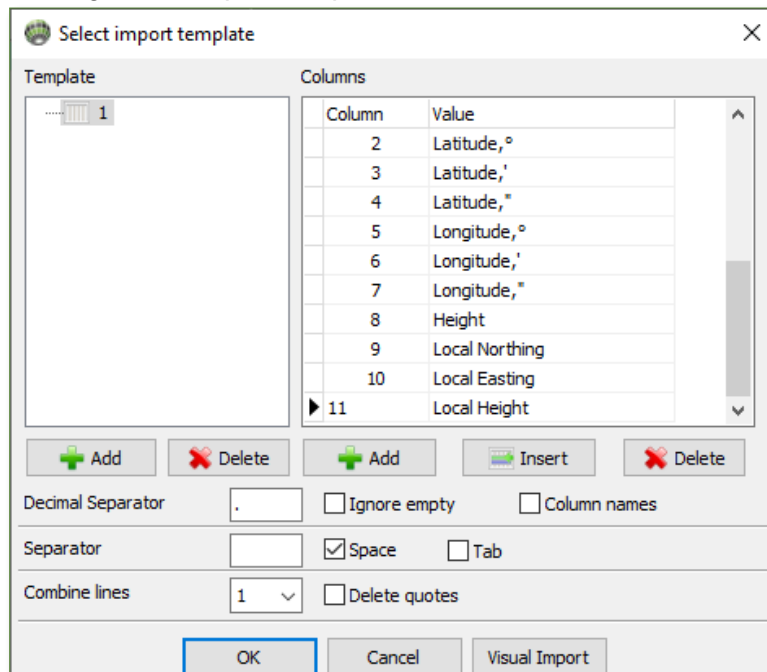




Figure 142: Batch Coordinate Templates Window

After creating a template and clicking OK, the coordinates will be imported into the table in accordance with the template. The type of template depends on the coordinate system (XYZ / BLH, Grid) from the network coordinate systems drop-down list.

The user may also import text files from a saved template by selecting the *.jl format. Specify the file in the dialog and click open. The coordinates will be imported into the table.

9.2. Save Localization

The user may save a localization by clicking on:

-  - Save Localization. Type name for a new one.
-  - Save As Localization.

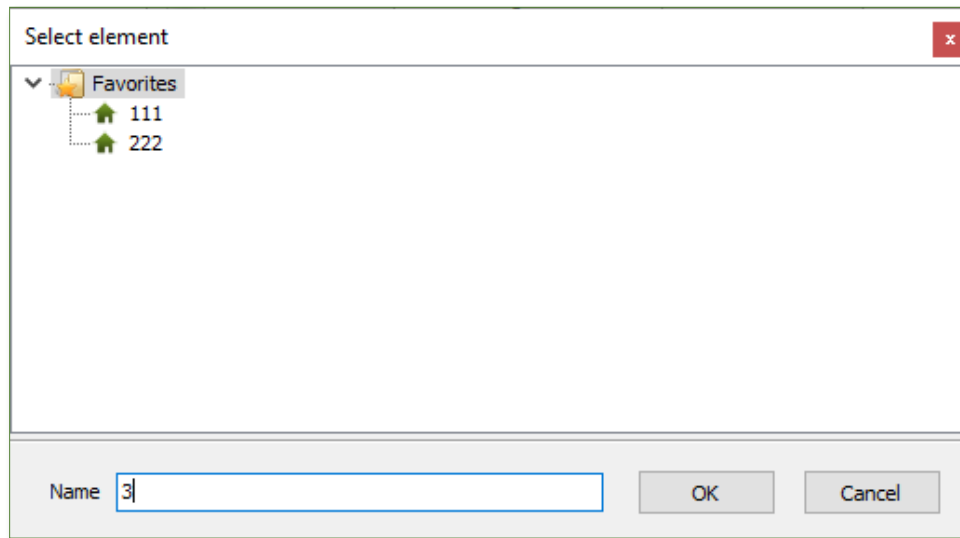


Figure 143: Save Localization

Saved Localizations store not only transformation parameters by also localization tables. It is possible to save a table independently. In this case all parameters equal zero. All localizations are stored in Favorites.

10. Antennas

The antennas panel can be activated through the Program option of the main menu and then the Antennas item or by clicking on the icon in the top ribbon.

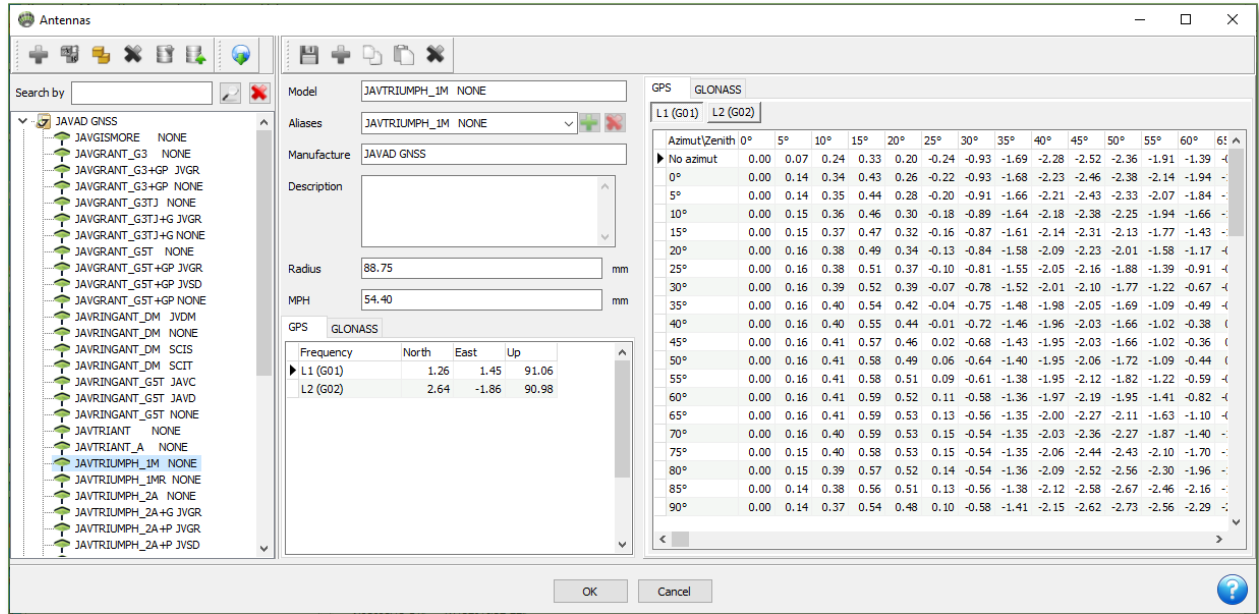


Figure 144: Antennas

The antennas panel is comprised of three panels (Left, Central and Right). The left panel has four items:

- JAVAD GNSS – Antennas manufactured by JAVAD GNSS.
- Other – Antennas manufactured by other companies, grouped by company name.
- User – Antennas added by the user.
- Last Used – Antennas used in the program.

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

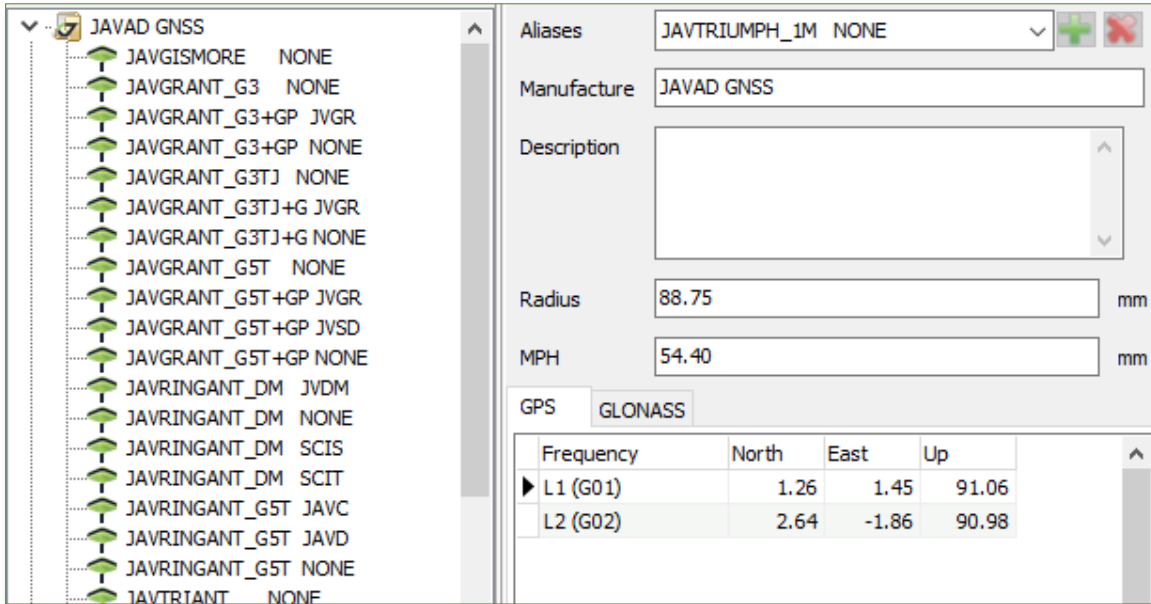


Figure 145: Selected Antenna Parameters

- Aliases – The NGS antenna descriptor.
- Manufacture – The manufacturer of the selected antenna.
- Description – Optional user description information.
- Radius – Antenna radius.
- MPS – 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.

Clicking on the icon (in the lower-right of the Antenna window) activates the Diagram antenna parameters panel. This shows a diagram of the main geometric parameters of the antenna.

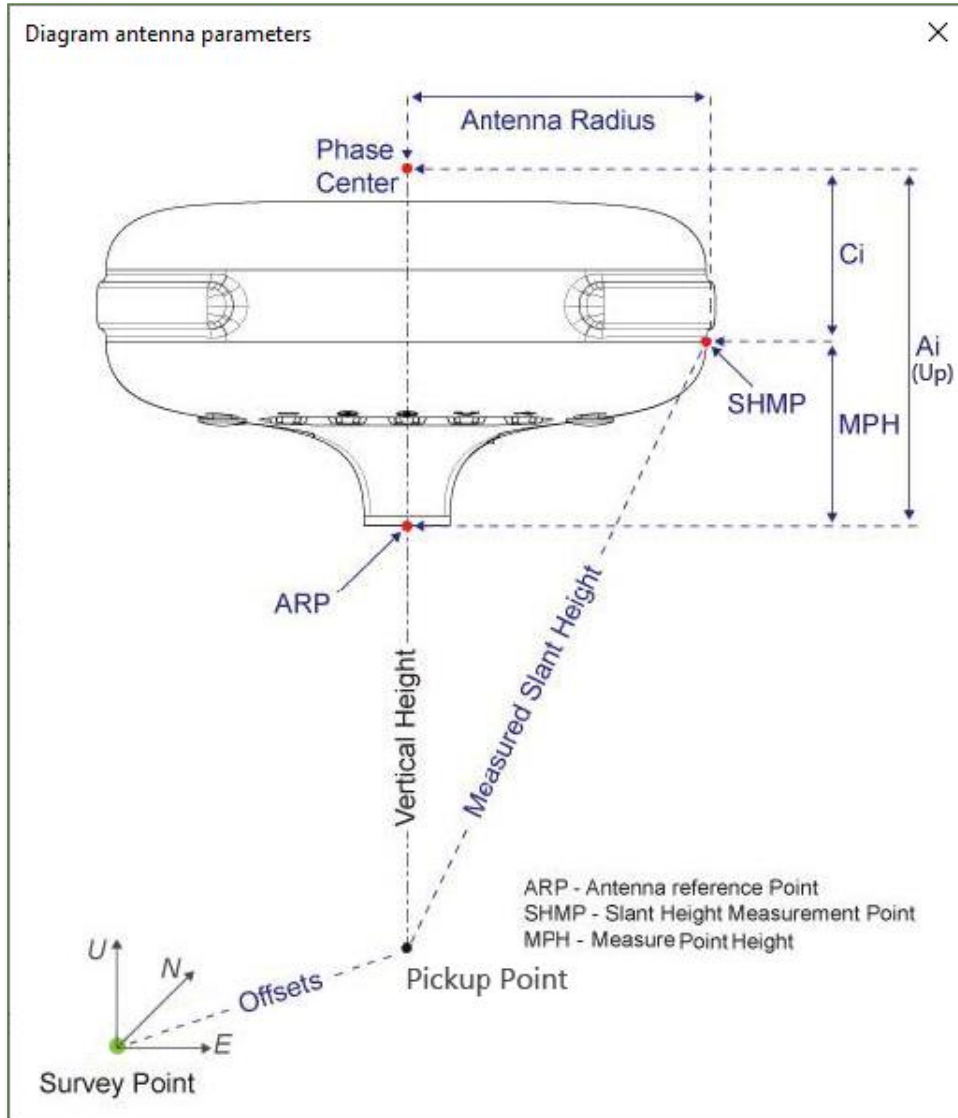


Figure 146: Antenna Geometry Diagram

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

GPS		GLONASS														
		L1 (G01)					L2 (G02)									
Azimuth\Zenith	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	
► No azimuth	0.00	0.07	0.24	0.33	0.20	-0.24	-0.93	-1.69	-2.28	-2.52	-2.36	-1.91	-1.39	-0.87	-0.35	
0°	0.00	0.14	0.34	0.43	0.26	-0.22	-0.93	-1.68	-2.23	-2.46	-2.38	-2.14	-1.94	-1.71	-1.48	
5°	0.00	0.14	0.35	0.44	0.28	-0.20	-0.91	-1.66	-2.21	-2.43	-2.33	-2.07	-1.84	-1.61	-1.38	
10°	0.00	0.15	0.36	0.46	0.30	-0.18	-0.89	-1.64	-2.18	-2.38	-2.25	-1.94	-1.66	-1.43	-1.20	
15°	0.00	0.15	0.37	0.47	0.32	-0.16	-0.87	-1.61	-2.14	-2.31	-2.13	-1.77	-1.43	-1.19	-0.95	
20°	0.00	0.16	0.38	0.49	0.34	-0.13	-0.84	-1.58	-2.09	-2.23	-2.01	-1.58	-1.17	-0.93	-0.69	
25°	0.00	0.16	0.38	0.51	0.37	-0.10	-0.81	-1.55	-2.05	-2.16	-1.88	-1.39	-0.91	-0.67	-0.43	
30°	0.00	0.16	0.39	0.52	0.39	-0.07	-0.78	-1.52	-2.01	-2.10	-1.77	-1.22	-0.67	-0.43	-0.19	
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	-0.25	-0.01	
40°	0.00	0.16	0.40	0.55	0.44	-0.01	-0.72	-1.46	-1.96	-2.03	-1.66	-1.02	-0.38	-0.14	0.10	
45°	0.00	0.16	0.41	0.57	0.46	0.02	-0.68	-1.43	-1.95	-2.03	-1.66	-1.02	-0.36	-0.12	0.12	
50°	0.00	0.16	0.41	0.58	0.49	0.06	-0.64	-1.40	-1.95	-2.06	-1.72	-1.09	-0.44	-0.20	0.14	
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	-0.37	0.16	
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	-0.60	0.18	
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	-0.88	0.20	
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	-1.18	0.22	
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	-1.48	0.24	
80°	0.00	0.15	0.39	0.57	0.52	0.14	-0.54	-1.36	-2.09	-2.52	-2.56	-2.30	-1.96	-1.74	0.26	
85°	0.00	0.14	0.38	0.56	0.51	0.13	-0.56	-1.38	-2.12	-2.58	-2.67	-2.46	-2.16	-1.94	0.28	
90°	0.00	0.14	0.37	0.54	0.48	0.10	-0.58	-1.41	-2.15	-2.62	-2.73	-2.56	-2.29	-2.07	0.30	

Figure 147: Phase Center Variation Table

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

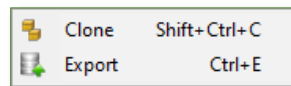


Figure 148: Clone / Export Options

A cloned antenna will have a “_Clone” suffix to the name and will be added to the user list. Exporting an antenna will allow for exporting the ANTEX file. For antennas created by the user, the following options are available:

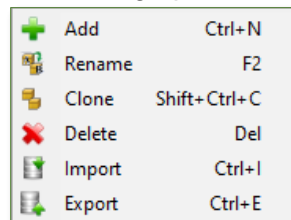


Figure 149: Custom Antennas Menu

- Add – Add an antenna named USERANTENNA to the User list with the addition to the name “_1”, if the name USERANTENNA is already used.
- Rename – Edit the name of the antenna.
- Clone – Clone the antenna name.

- Delete – Remove the antenna from the list.
- Import – Import parameters for the selected antenna from an ANTEX file.
- Export – Export parameters to ANTEX file.

For antennas in the last list used, an export option to an ANTEX file is available.

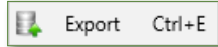


Figure 150: Export Option

The ribbon on the left panel contains the following options:



Figure 151: Left Panel Options

- Add – Adding an antenna named USERANTENNA to the user list.
- Rename – Rename the antenna name.
- Clone – Clone the antenna.
- Delete – Delete the antenna.
- Import – Import of antenna parameters into ANTEX file.
- Export – Export antenna parameters into ANTX File.
- Update Antenna Database – Update the antenna database.
- Show Diagram of Antenna Parameters – Display Antenna Diagram.

The central and right panels for the JAVAD GNSS, Other and Last Used are for informational purposes only. For antennas selected in the User list, the ribbon of icons on the central panel become active. The parameters and variations of the phase center of the selected antenna become available for editing.



Figure 152: Central Panel (Active) Options

- Save – Save changes in parameters.
- Add – Add a table of phase center variations for a specific navigation system and for a specific signal type.
- Copy – Copy the phase center variation table. The copied table is copied to an Excel or Notepad++ file, where the values can be edited. The edited data is copied to the program.
- Paste – Paste the phase center variation table copied into Excel or Notepad++.
- Delete – Delete the phase center variation table for a specific navigation system and for a specific signal type. Editing parameters can be initiated by a double-click.

11. Aerial Camera Editor

To calculate the coordinates of camera exposure moments (events), it is necessary to set the initial parameters.

The aerial cameras editor window can be activated by selecting the Program item of the main menu and then the Cameras item.

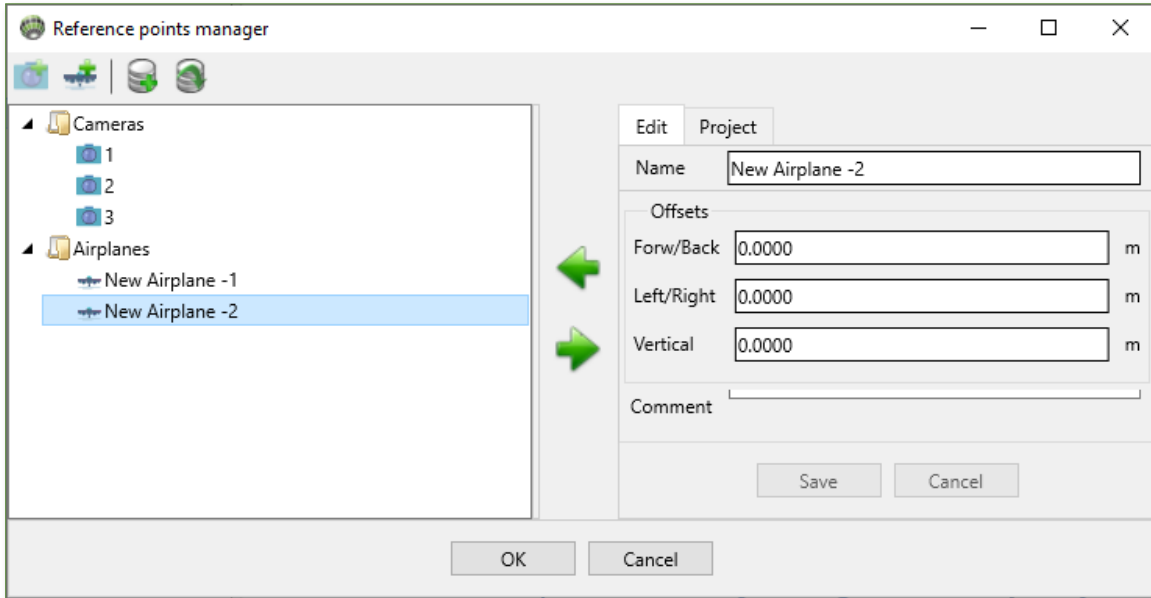


Figure 153: Aerial Camera Editor Window

The left panel has lists of cameras and airplanes defined within the program. The ribbon above the left panel contains:

- - Enter the parameters of a new camera.
- Create a set of shifts.
- - Create a backup file. Creation of a *.jac file, in which all information about shifts and cameras available is saved.
- - Restore a backup file. Restore information about shifts and cameras from a *.jac 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 that duplicates the ribbon, with the addition of the following items:

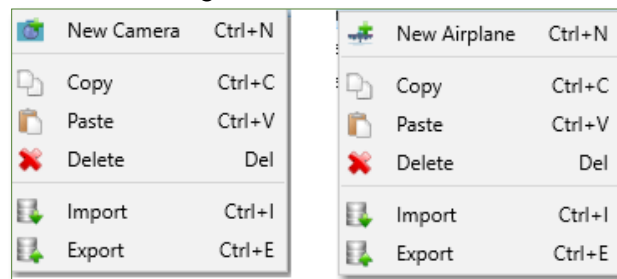


Figure 154: New Camera / New Airplane Menus

New Camera and New Airplane will bring up the parameters window for each:

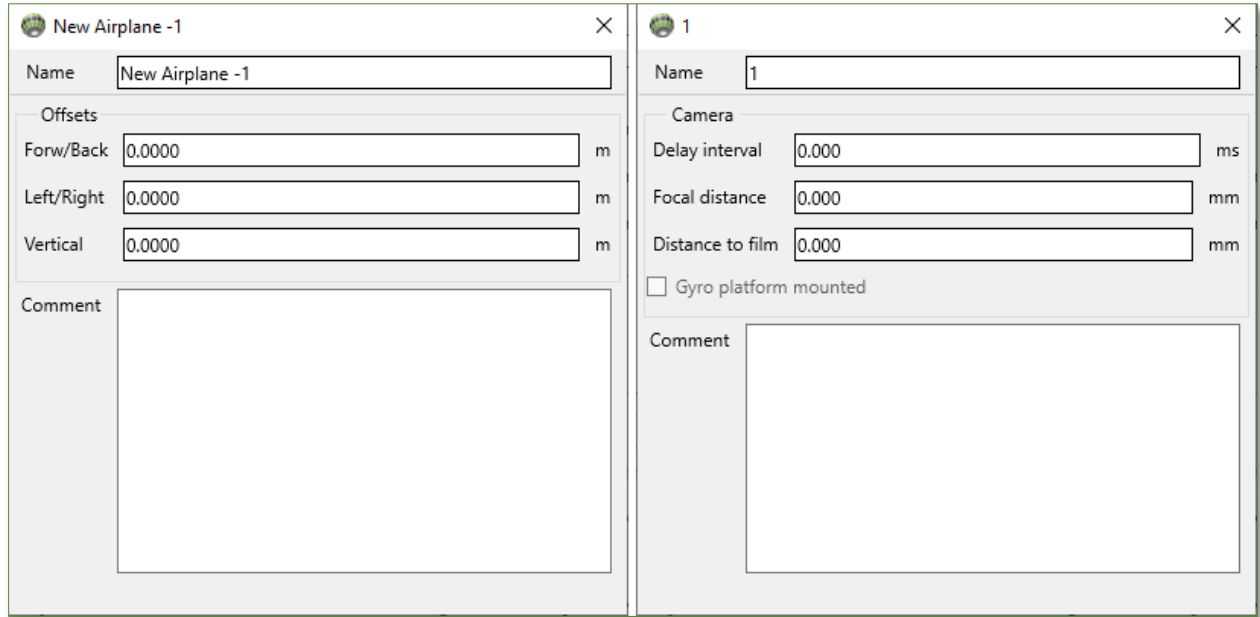


Figure 155: New Camera / New Airplane Parameters

The right panel of the aerial camera editor window contains information about shifts and camera parameters selected in the left panel. It is used to exchanged information between the project and the program. The main functions are implemented in the ribbon of icons or right-clicking on an object. The right panel has two tabs: Edit and Project. Further details on each is described below.

The edit tab is used to view and edit sets of shifts and camera parameters. 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 corresponding signs.

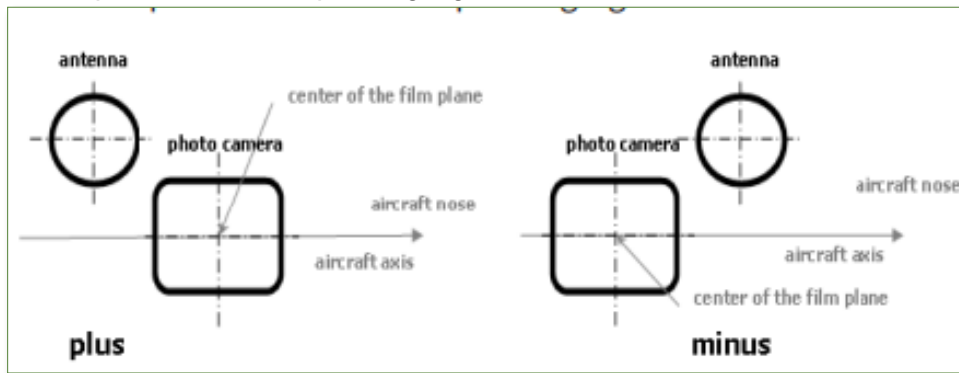


Figure 156: Forw / Back Offset

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 corresponding signs.

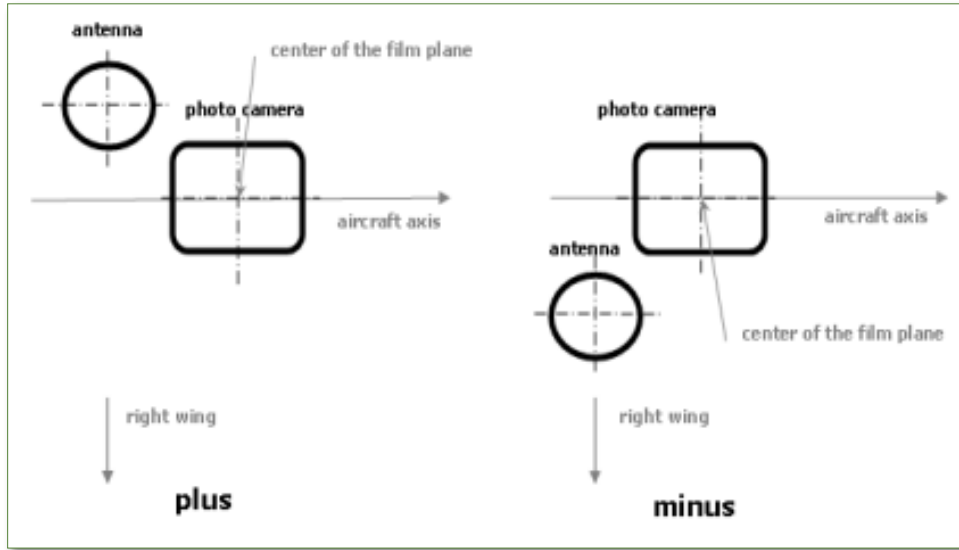


Figure 157: Left / Right Offset

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

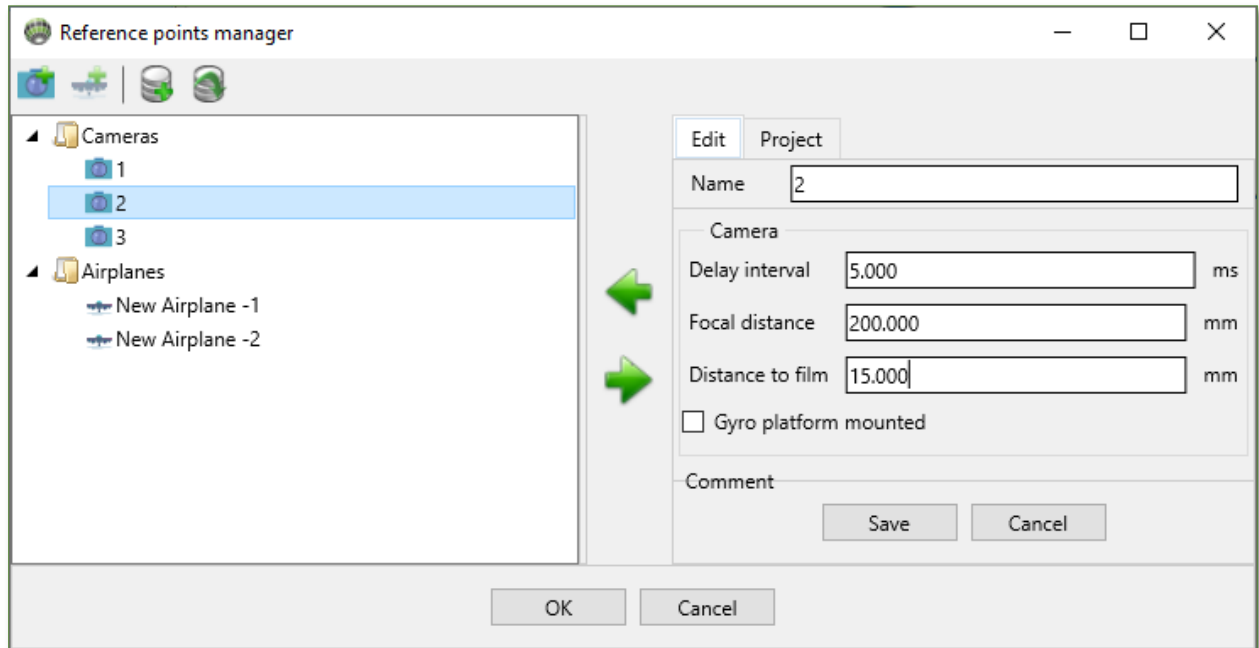


Figure 158: Edit Tab for Cameras

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 you to set the focal length of the camera.

Distance to the film (millimeters) allows you 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 mount 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 (Main menu>>View>>Events). The Project item shows lists of airplanes and cameras in the project database.

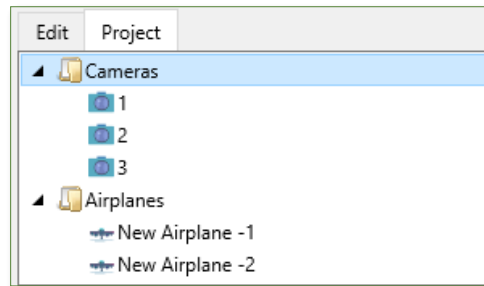


Figure 159: Project Tab

To copy from the program database to the project database, use the green arrow (left and right) buttons.

12. Coordinate Calculator

The coordinate calculator is launched by pressing the icon.

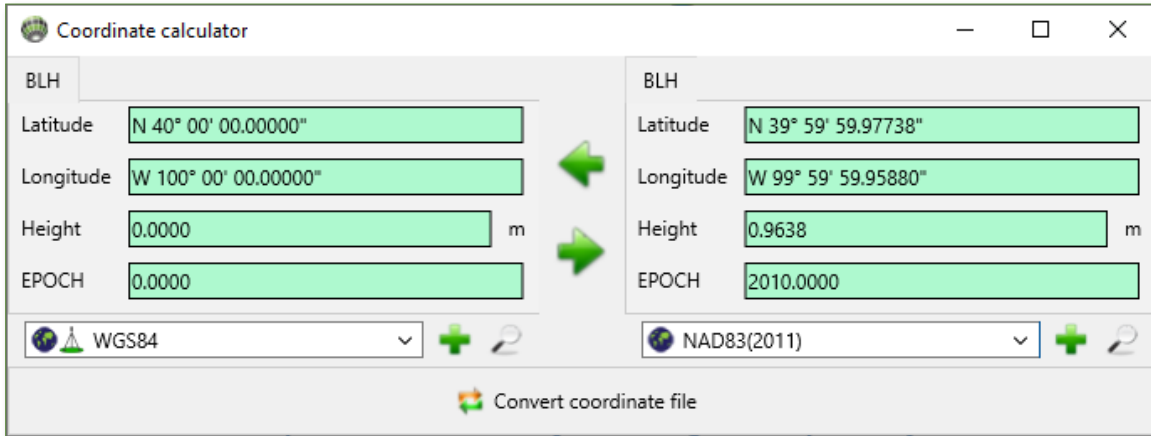


Figure 160: Coordinate Calculator

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. To expand the list copy CS from the Favorites folder or the Project database folder; it is possible to copy any number of CS from the program database to these folders. Establishing new CS in the program database and copying them to the appropriate folders is described in “Chapter 7. Coordinate systems manager” on page 61. Coordinates are recalculated by pressing the green (left and right) 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 CSs in both panels is carried out in the drop-down list of the CS of the calculator:

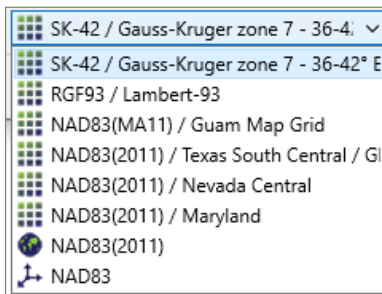


Figure 161: Project SC Drop-Down List

Clicking on the button opens a window with CS list in the favorites folder.

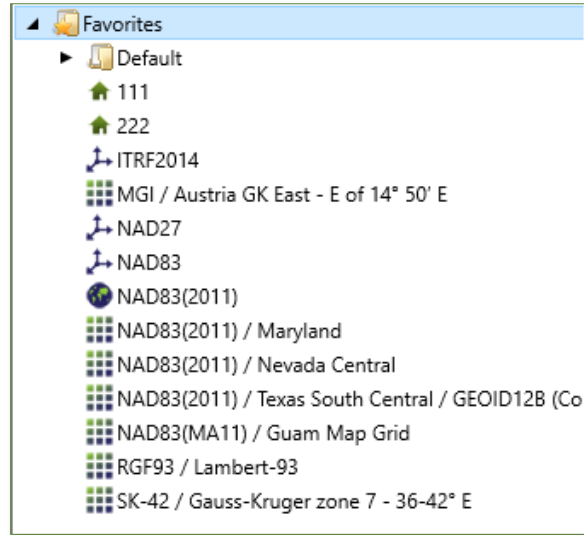


Figure 162: CS List in Favorites Folder

The CS selected in this window in any folder after clicking OK is entered automatically into the calculator's CS list.

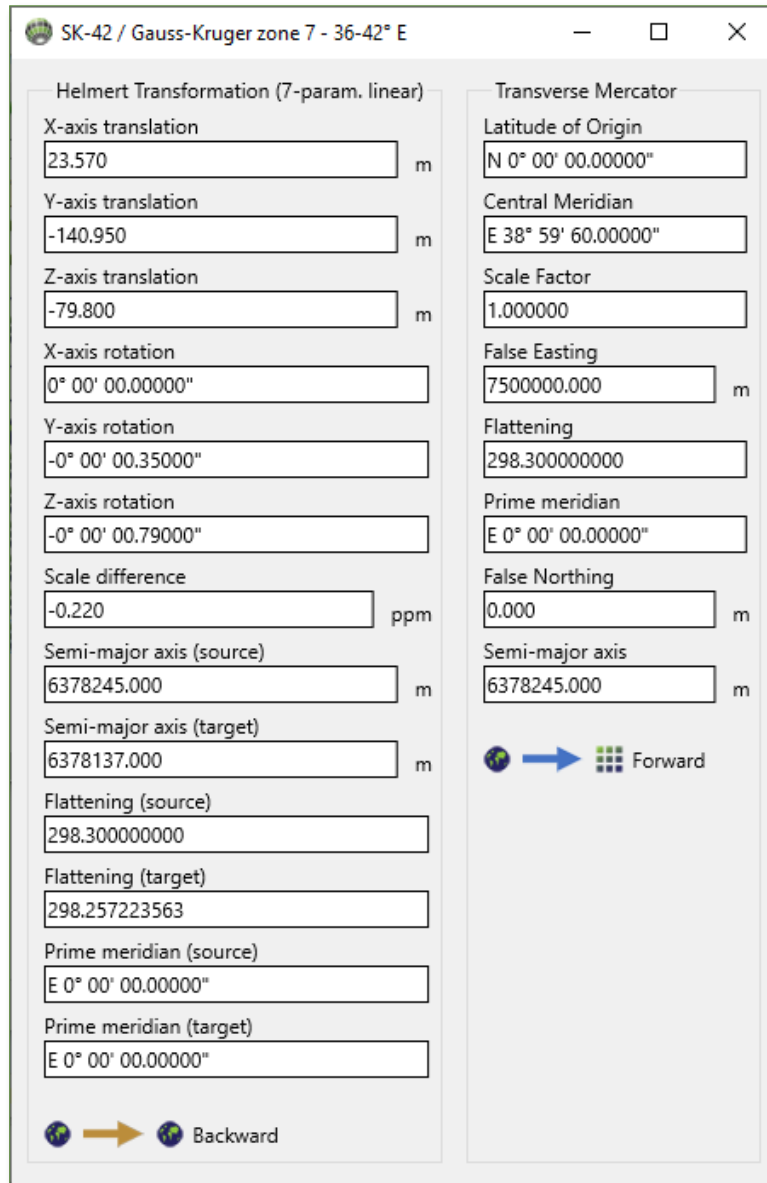


Figure 163: CS Parameters

By clicking the button activates the window with the parameters selected CS: The color of the arrow and the label show the direction of conversion, for which the parameters are given.

In the upper left corner of the panel, the type of CS selected in the panel is displayed: XYZ, BLH or Grid, respectively, the CS changes the type of input coordinates and labels to the input fields. Define the epoch for both the initial and final coordinates in the field.

For the batch recalculation of coordinates, click the button “Convert coordinate file”, select the file containing the coordinates in the window “Select source coordinate file” and click Open. In the window “Enter destination coordinate file,” enter the name of the file where recalculated coordinates will be placed and click save.

It is necessary to specify templates of formats for input and output of coordinates. After that coordinates can be recalculated correctly.

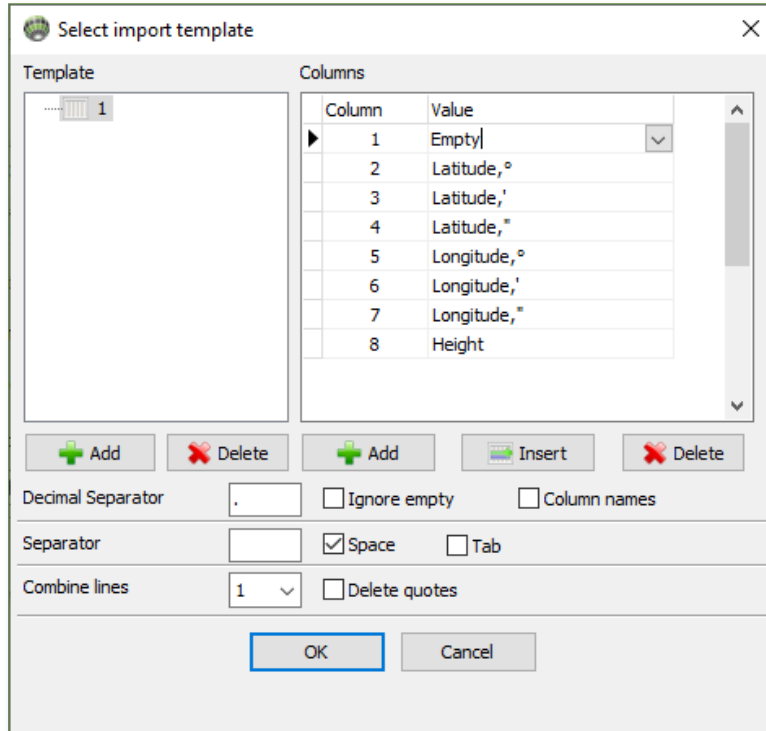


Figure 164: Coordinate Input Template

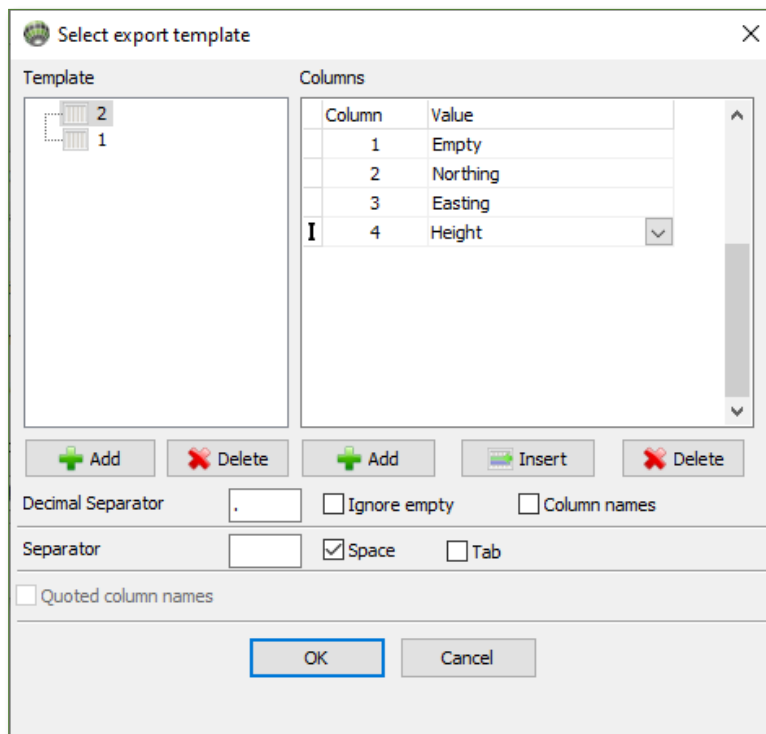


Figure 165: Coordinate Output Template