Digital Photogrammetric System

PHOTOMOD

Version 6.4

USER MANUAL

Processing of UAS data

RACURS

Table of Contents

1. About

1.1. Purpose of the document

This document contains detailed information about UAS data processing in the *PHOTOMOD UAS* program. The document contains recommendations of processing order, program properties to obtain the best results, and also contains description of additional possibilities when working with UAS data.

1.2. Purpose and main definitions

The *PHOTOMOD UAS* program is purposed to process data from unmanned aircraft system (UAS). There is a limit on using of the source data when working with program.

Only central projection images with size not more than 80 Mpix could be used a source data.

The following definitions for UAS projects processing are provided in the program:

- preliminary preparing of source images;
- images interior orientation;
- relative orientation of images;
- input and measurement of GCP coordinates;
- Images exterior orientation;
- vectorization;
- stereovectorization;
- building DEM;
- creating orthomosaic;
- creating digital map;
- creating 3d-models.

1.3. Technical Support

The Racurs company technical support provides the actual information about system functionality, characteristics, price and services.

For technical support use one of the following ways:

- e-mail: support@racurs.ru;
- phone: (495) 720-5127;
- fax: (495) 720-5128;
- mail: RACURS Co., Ul. Yaroslavskaya, 13-A, office 15, Moscow, Russia;

1.4. Distribution kit

The *PHOTOMOD UAS* program is a stand-alone software, which does not require the *PHOTOMOD* system installation. Also the program could be launched as a module of the *PHOTOMOD* system.

License software distribute in a branded box.

The company name is place on the front. On the reverse side are placed address, technical support service phone and e-mail, web-site of company.

The system distribution kit includes:

- CD-ROM containing the system setup files and the documentation files in PDF format;
- 'System installation Manual';
- Hardware lock key (see Section 2).

2. Sentinel hard lock key

The distribution kit includes the unique hard lock key from *Sentinel HL* (previous called *HASP*), to protect the system and data from software piracy and unauthorized dissemination.

The *Sentinel HL* hard lock key is produced by *SAFENET* company (www.safenet-inc.com).

If the *Sentinel HL* hard lock key not found, the error message of protection system displays. Contact the Racurs company technical support service (see *Section 1.3*) to for the consultation.

To check congruity of hard lock key perform the following:

1. Choose **License info** in the right-click menu of the *System Monitor module* (the  icon in the *Windows* system tray). Process of licences checking starts. After checking, the **PHOTOMOD Distribution info** windows opens.

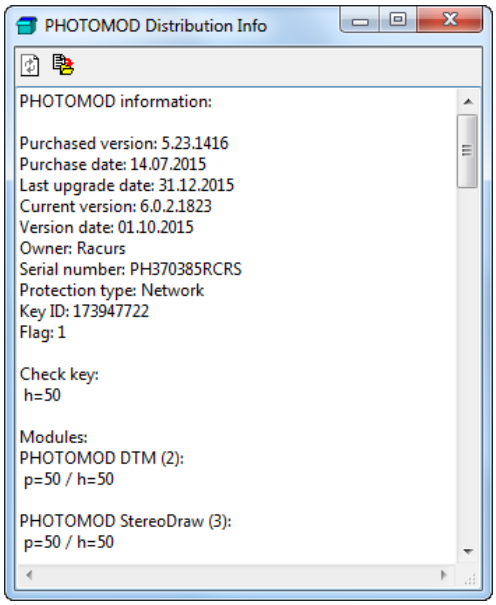


Fig. 1. Distribution Info

2. Compare the unique number of security key in the `Serial number` line with the number on hard lock key.

3. Compare quantity of license for modules in each line below the name of module. Quantity of licence in the hard lock key and in Certificate should be equal.

   'h' is quantity of licence in the hard lock key.

4. If number are not equal contact the RACURS company technical support service.

To use local system version, security key should be installed on a stand alone workstation. During the installation drivers of security key are installed automatically.

In case of problems with installation of security key drivers, install it manually. To do this open the *Hasp\Sentinel_HASP_Run-time_setup* folder from the installation CD and launch the `HASPUserSetup.exe` file. Install security key with default parameters.

It is recommended to install the security key on computer which is not used to project processing, recording CD/DVD, etc.

If there is not enough RAM or resource-intensive tasks are performed on workstation with the secure key, The protection system failure or loss of data are possible.

3. System installation

Prior to the system installation, the unique security key from *Sentinel HL* should be installed on the workstation.

The system required 2 GB of free hard disk space.

To start the system installation, launch the `setup.exe` file or input the installation software and launch the `autorun.exe` file.

Click **Install › PHOTOMOD UAS**. The **Installation PHOTOMOD 6 UAS** window opens.

The system initial installation process consists of a sequence of steps with instructions.

In case of cancel at any step, installed program files and data are not removed. To complete the system installation, restart the `autorun.exe` or `setup.exe` file and go through all steps again.

The system installation process consists of the following steps:

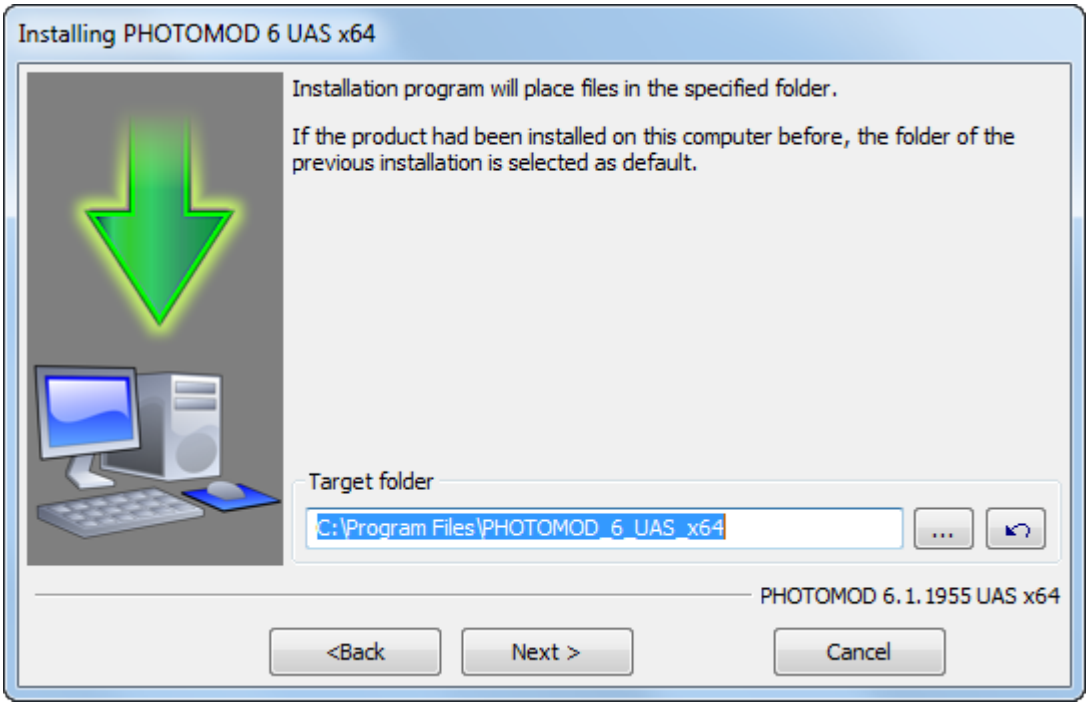
Preparation step

1. Read the welcome and warning messages. Click the **Next** button.

2. Read the license agreement. If you agree with it, set the **I accept the terms in the License Agreement** checkbox on and click the **Next** button.

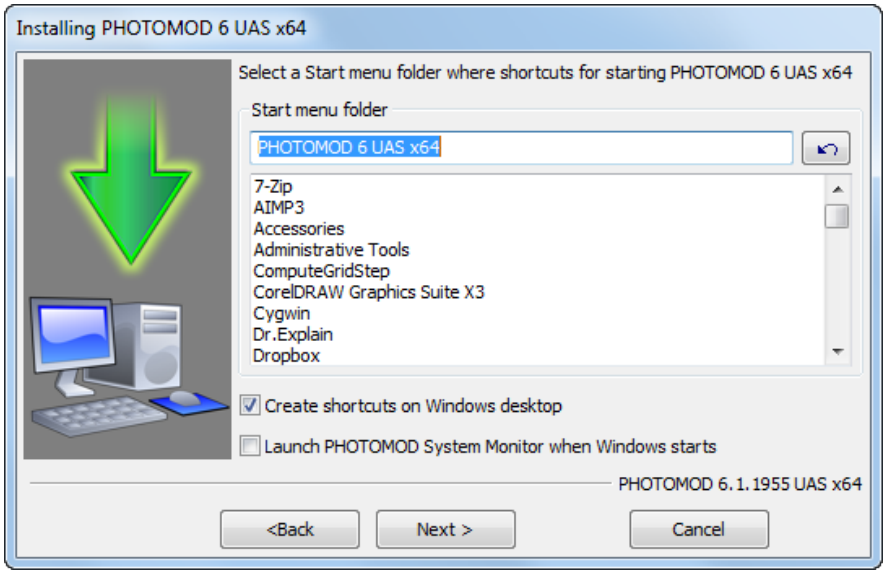
3. Define the folder to install the program files of the system. Click the **Next** button.

It is strongly not recommended to install the system in folder with name, which contains letters, different from Latin. By default for the program files the *C:\Program Files\ PHOTOMOD 6 UAS* is used for 64-bit operation system and *C:\Program Files (x86)\ PHOTOMOD 6 UAS* – for 32-bit OS.



4. Enter a folder name for the PHOTOMOD programs and modules in the Windows **Start** menu.

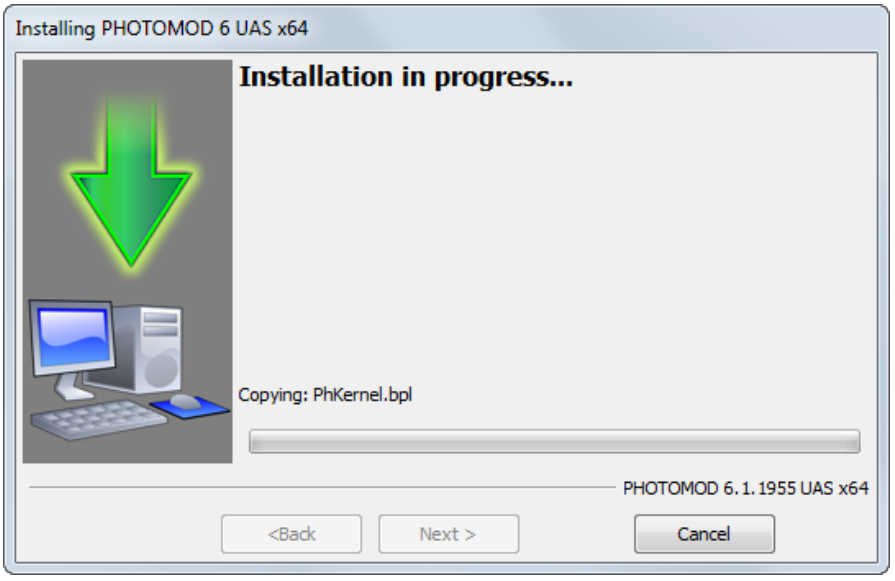
   The **Create shortcuts on Windows desktop launch automatically the System Monitor module at Windows start** checkboxes are set on by default.



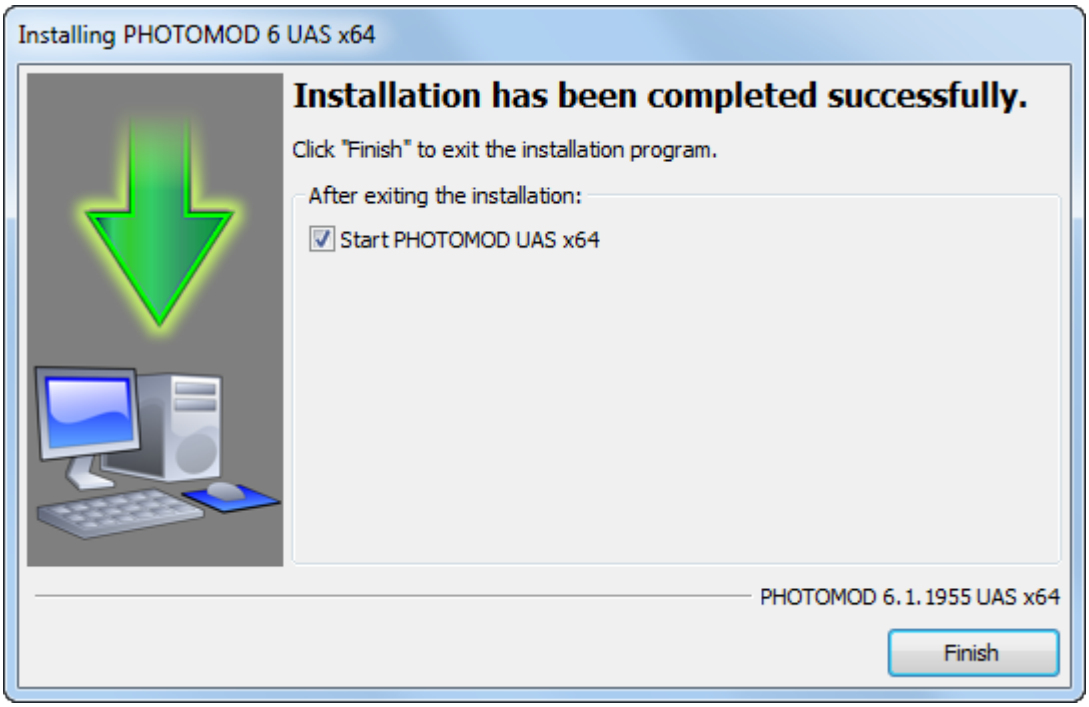
5. Click the **Next** button.

File copy stage

1. Click the **Next** button to start installation.



2. When installation complete, click the **Finish** button and proceed to the system configuration stage.



If the security key was not found, the error message displays. Install the security key and restart the system.

If the *Sentinel HL* hard lock key and filed `PhConsts50.dll` do not congruity, the error message from protection system displays. To obtain the licence file contact the Racurs company technical support service (see*Section 1.3*). After obtain the licence file copy it to the system folder (by default *C:\Program Files\ PHOTOMOD 6 UAS)* and launch the system.

System configuration stage

1. During the first launch of the system the PHOTOMOD UAS initial setup window is also opens.

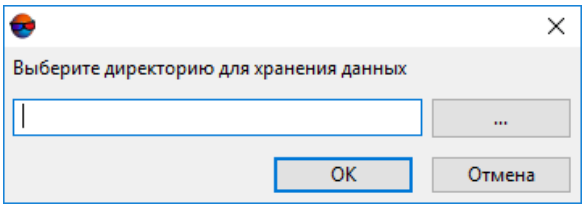


Fig. 2. Choosing a folder to store the projects

2. Click the ... button to select a physical folder on a local PC to store the PHOTOMOD UAS projects.

3. Click OK to finish system configuration and create the *local profile* automatically.

The *Control Panel* module is used to configure detailed system settings during the further work. More details about program resources, recommendations on organizing of local or network work, and about creating profiles and virtual folders connecting see in the “Prepare to processing” chapter of the “General information” User Manual.

System deinstallation

To remove the system from computer, close all modules of the system and choose **Start › Programs › PHOTOMOD 6 UAS › Uninstall PHOTOMOD UAS** or use standard tools in **Control panel** of *Windows file system*.

4. Start of work

Define the folder, in which are placed the sources data before the beginning work in the program. The program allows to place the files with the source data in the folders of *Windows* file system, as well as in the profile resources.

To start the program perform one of the following:

- in the context menu of *System Monitor module* (the  icon in the system tray) choose the **PHOTOMOD UAS**;
- choose the **Start › Programs › PHOTOMOD6 › PHOTOMOD UAS**.

5. Input data

During the project creation, aerial triangulation and block adjustment the following source data is used:

- [optional] The *list of GCP coordinates* is necessary for block adjustment. The system provides opportunity to measure GCP coordinates manually and also to perform import of GCP list from a text file.
- [optional] The *list of projection centers* coordinates to process central projection images. The program also provides the ability to import on-board data (coordinates) about projection centers from CSV files.

Block adjustment could be process only by projection centers without using ground control points. It is recommended to use GCP coordinates to increase adjustment accuracy.

- *Raster images*

  For working with images in program , it is recommended to use MS-TIFF internal raster format, which is the TIFF format with overview pyramid (set of subsampled images copies) for higher image display performance.

The *Raster Converter* module is used to preliminary raster image processing. It is possible to convert image into internal format both manually, before creating project, and on the stage of adding images into project with saving converted images into active profile resources. See the *Raster Converter module* description in the "General information" User Manual.

The following image formats are available to process central projection images:

- JPEG (JPEG);
- Tag Image File Format (TIFF) TIFF и GeoTiff format, included tags for saving of georeference information;
- Windows Bitmap File (BMP);
- Advanced Systems Format (ASF).

- *Information about coordinate system and map projection* – during project creation it is necessary to define coordinate system of GC points. By default there is an International coordinate system database and map projection (see the details in the "GeoCalculator" User Manual);
- also it is possible to use the following exterior data:
  - import of triangulation points from PAT-B and X-POINTS;
  - import of ground control points from text files `*.txt` and `*.csv` (see above *The list of GCP coordinates*);
  - import of interior and exterior orientation data from metadata;
  - import of external orientation data from PAT-B and CSV-files (see above *The list of projection centers*);
  - GPS data;
  - import additional data from different formats.

6. Output data

The program allows to process UAS data and acquire all types of value added photogrammetric products: DEM, 2D and 3D-vectors, orthomosaics.

There are the main output products:

- *Digital Terrain Model (DTM)* – digital cartographic presentation of terrain surface both as regular grid of elevations (DEM) and as triangulated irregular network (TIN). They are used for solving applied research problems.

- *3D vector objects* – used for creating a topographical base for cartographic production or as source data for a mathematical representation of a scene in three-dimensional digital terrain modeling;
- *orthophoto production* – single raster images in the form of a single frame or a set of sheets in a selected map projection with marginalia. In the resulting image, geometric and photometric distortions are corrected, creating seamless, color-balanced orthophotos with uniform brightness as an output;
- *3D models of terrain* – can be used to solve applied research problems, as well as for creation of multimedia presentations and commercials.

There is opportunity to export all photogrammetric products to various formats.

7. Interface and its elements

7.1. Work area interface

The GUI contains the following elements:

- the main menu, which contained the all program functionality (*A*);
- the main toolbar is used for quick access to main program functions and also contains **Aerial Triangulation**, **Compute DEM** and **Compute Orthophoto** tabs (*B*). The tabs layout and content displays the main steps of UAS data processing workflow;
- the optional toolbars is used for quick miscellaneous program functions access (*O*);

  Toolbars could be placed only one-lined, horizontal or vertical.

- the 2D-window, used for data displaying, contains the following elements:
  - the toolbar is used for the 2D-window modes managing (*C*);
  - the work area is used for viewing and processing with loaded data of mosaic project (F);
  - the navigation bar is used for fast moving on the specified block images area of mosaic project (D);

    By default on launch of the program layers are not shown in the navigation window. If necessary, click the **Navi** tab and choose layers to display.

  - the *Layer manager* is used for managing of project layers (E);

- the axes direction of project coordinate system (*M*);
- the status bar is used for viewing current real (ground) and pixel marker coordinates and brightness, contrast and gamma data adjustment in the work area (*G, K, L*).

When place marker is on the area out of image or on background, brightness is indicated as *NULL*.

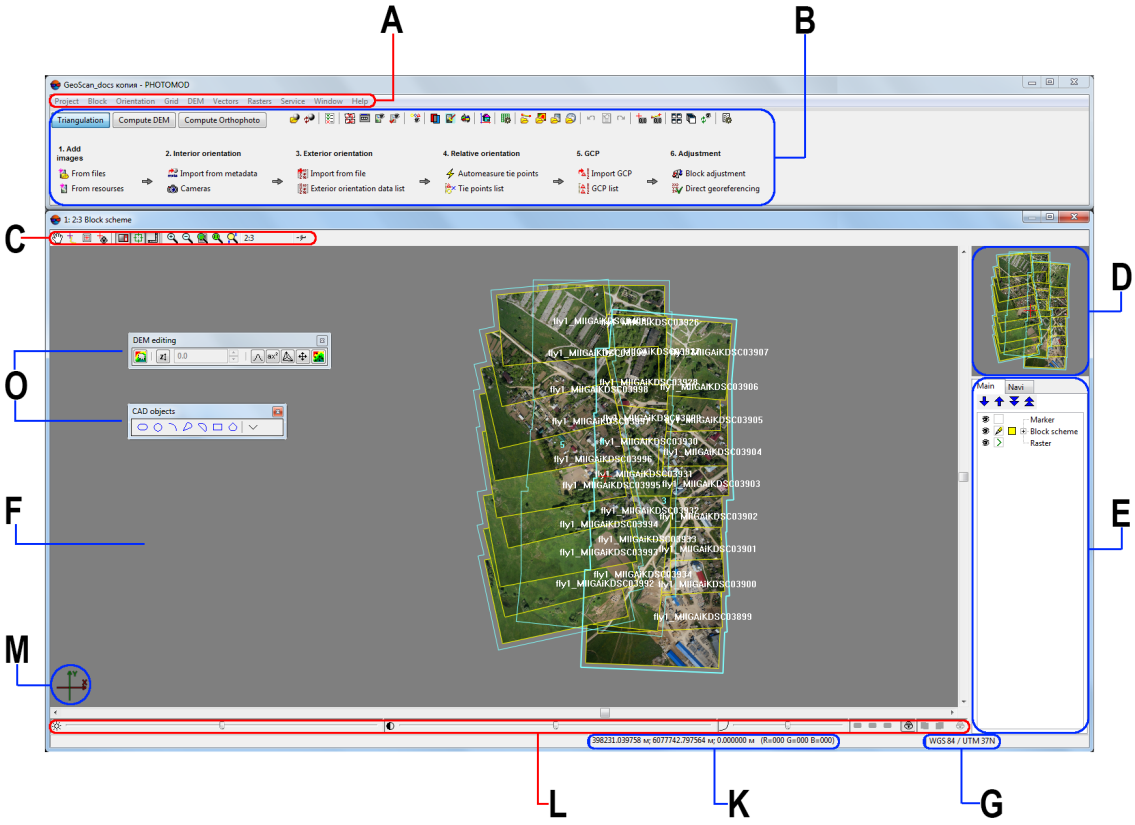


Fig. 3. The main program's window

7.2. Brief description of main menu

The program main menu contains the menu items for mosaic creation, vector data processing, additional applications starting and setting parameters.

Table 1. Main menu

Menu	Function
Project	contains menu items to create, open, save and convert project, and also to get an information about project

Menu	Function
Block	allows to form images block of mosaic project
Orientation	contains menu items to interior orientation, load and use ground control and triangulation points, exterior orientation parameters and also to import and export triangulation points for various formats
Grid	allows to create, open and save regular nodes grid (see the "Create DTM" User Manual)
Terrain	contains **Points**, **TIN**, **DEM**, **Contours** and **LAS** submenus
Vectors	purposed for creating, editing, import/export of vector data (see the "Vectorization" User Manual)
Rasters	allows to load and georeference raster images, and also to launch additional modules for editing and orthorectification images (see the "Orthophotomaps creation" User Manual)
Service	allows to launch applications, load additional data, set general parameters and edit coordinate systems (see the "General information about system" User Manual)
Window	allows to open additional toolbars and windows (new 2D-window, Marker and Measurements windows, window of Object Attributes)
Help	allows to start the *"Help"* system

7.3. The main toolbar

The main toolbar is used for quick access to main program functions and also contains **Aerial Triangulation**, **Compute DEM** and **Compute Orthophoto** tabs. The tabs layout and content displays the main steps of UAS data processing workflow;

Table 2. Brief description of main toolbar

Buttons	Function
	allows to open block editor window (see the 'Project creation' User Manual)
	allows to reload project to display the last saved version of project
	allows to perform import of exterior orientation from metadata
	allows to open block layout window (see the 'Aerial triangulation' User Manual)
	allows to open block editor window (see the 'Project creation' User Manual)
	allows to display all images, loaded to project, in the **Block scheme** window

Buttons	Function
	allows to display only selected on scheme images in the **Block scheme** window
	allows to load triangulation points
	allows to open 2D-window for selected stereopair (see the 'Vectorization' User Manual)
	allows to launch the *DustCorrect module* to edit MS-TIFF images (see the Project creation User Manual)
	allows to run the *GIS Panorama Mini*
	allows to launch the 3D-mod module
	allows to create, open and save regular nodes grid (see the 'Create DTM' User Manual)
	allows to load vector file into the project (see the 'Vectorization' User Manual)
	allows to load DEM file
	allows to load georeferenced raster image to project as a layer
	allows to load web-map
	allows to undo the last action (see the 'General system's parameters' User Manual)
	allows to display the list of last actions (see the 'General information about system' User Manual)
	allows to redo the last undone action (see the 'General system's parameters' User Manual)
	allows to open the **Marker** window (see the menu description in 'Vectorization' User Manual)
	allows to open the **Measurements** window (see the menu description in 'Vectorization' User Manual)
	allows to tile 2D-windows
	allows to stack 2D-windows
	allows to refresh all opened 2D-windows
	allows to open the general program parameters window (see the 'General system's parameters' User Manual)

Table 3. Brief description of the "Triangulation" tab of the main toolbar

Buttons	Function
 **From files**	is used for adding image files, locating in the resources out of active profile, to the selected strip
 **From resources**	is used for adding image files, locating in the resources of active profile, to the selected strip
 **Import from metadata**	allows to perform import of exterior orientation and interior orientation results
 **Cameras**	allows to input/edit parameters of project cameras, and also to assign cameras to project images

Buttons	Function
Import from file	allows to perform import of exterior orientation data from file of text format
Exterior orientation data list	allows to open exterior orientation data list
Automeasure tie points	allows to setup and start automatic tie points measurement using UAS data
Tie points list	allows to open **tie points list** (see the "Aerial triangulation" User Manual)
Import catalog	allows to perform import of ground control points from `*.txt` and `*.csv` files
GCP list	allows to open **GCP list** (see the "Aerial triangulation" User Manual)
Block adjustment	allows to open the **adjustment** toolbar
Direct georeferencing	allows to perform adjustment using imported exterior orientation parameters

Table 4. Brief description of the "Compute DEM" tab of the main toolbar

Buttons	Function
Compute points	allows to start automatic points calculation
Buildings and vegetation filter	allows to launch the buildings and vegetation filter for points
Build TIN	allows to build TIN by points and breaklines (**Ctrl+N, T**)
Build from TIN	allows to build DEM by loaded TIN (**Ctrl+N, D**)
Build contours	allows to create contour lines by DEM
Dense model	allows Создание to build dense DEM using SGM method
Buildings and vegetation filter	allows to launch the buildings and vegetation filter for DEM
Fill NULL cells	allows to Создание restore null cells of DEM using the smooth interpolation method

Table 5. Brief description of the "Compute Orthophoto" tab of the main toolbar

Buttons	Function
Orthorectification	allows to display the orthorectification toolbar (**Ctrl+Alt+M**) (see the Orthomosaic building User Manual)
Start GeoMosaic	allows to start *PHOTOMOD GeoMosaic* program (see the The Orthophotomaps creation User Manual)

7.4. The "Block" menu

The **Block** menu, buttons of **Block editor** window's toolbar and **Block forming** additional toolbar are used to work with images block in 2D-window.

It includes extended features for images block forming, as well as additional functions for block scheme creation and obtaining of auxiliary data.

Some menu items allow to manage operations with selected images in 2D-window. The **Tools** additional toolbar is used for group selection (highlighting) of images block in 2D-window (see the "Vectorization" User Manual).

Detailed information about **Block** menu items, buttons of **Block editor** window's toolbar and **Block forming** additional toolbar see in the "Project creation" User Manual.

Table 6. Brief description of the "Block" menu

Menu items	Function
Add images from files	allows to add image files, locating in the resources out of active profile, to the selected strip
Add images from resources	allows to add image files, locating in the resources of active profile, to the selected strip
Add images from resource folder	allows to automatically add images from specified folder of active profile resources to selected strip, with or without its subfolders
Split to strips	contains menu items used to split images block to strips automatically using images names or exterior orientation parameters
Block editor (**Ctrl+Alt+B**)	allows to open the **Block editor** window
Block layout (**Ctrl+Alt+L**)	allows to open the **Block layout** window to build block scheme in 2D-window considering source or acquired data (see the Aerial triangulation User Manual)
Create overlap map...	allows to create map of images and/or strips overlap in new vector layer (see Section 20.1)
Additional	contains the **Additional** menu

Table 7. Brief description of the "Block" menu (Additional)

Menu items	Function
Add strip	allows to add new strip
Delete strip	allows to delete selected strips of block in 2D-window
Strip properties	used to view and edit properties of selected strips – strip's name and type (regular or irregular)
Invert image order in strip	allows to invert strips order
Selected strips to block start	allows to move selected strips to the beginning
Selected strips to block end	allows to move selected strips to the end
Add strip	allows to add new strip
Delete strip	allows to delete selected strips of block in 2D-window

Menu items	Function
Strip properties	used to view and edit properties of selected strips – strip's name and type (regular or irregular)
Move selected strips up	allows to move selected strips one strip up
Move selected strips down	allows to move selected strips one strip down
Make selected strips irregular	allows to change regular strip to irregular
Make selected strips regular	allows to change irregular strip to regular
Delete images	allows to remove selected images from project
Delete images selectively...	allows to select images in accordance with specified criteria for deleting (see Section 20.2)
Image properties	is used to display and edit properties of selected image
Move images	opens a group of menu items used to images block editing; allows to invert images order in a strip, and to move selected image left/right/up/down
Image radiometric correction	allows to perform radiometric correction of selected image (see in the Project creation User Manual)
Show images	allows to show images of block in 2D-window if the limitation on images display is specified on the **Block scheme | Raster** tab in the **Settings** window (see "General information" User Manual)
Show selected images only	allows to turn on/of selected images display
Check images	allows to check images, for example, to find images, where radiometric correction is recommended
Mark all images as checked	allows to exclude project images validation - check their presence and compliance to images files during project opening at the next working session
Market to selected image	allows to move marker to center of the image, selected in the list of the **Block editor** window
Rotate selected images	allows to rotate selected images at any angle relatively to initial or current position of block images
Rotate images by block layout	allows to rotate all or selected images of block considering block layout data; images don't rotate if the **w\o layout** was used (see the "Aerial triangulation" User Manual)
Set GSD for selected images	allows to define/calculate GSD value in meters for all or selected images of block
Create vector layer from block layout	allows to create vector layers with common block outline, boundaries of all images or selected image of the block
Build pre-regions	allows to create pre-regions by images/stereopairs to provide joint work on a project
Export block layout to KML...	allows to export block scheme to KML format

7.5. The “Orientation” menu

To perform work on data collection for aerial triangulation serves the **Orientation** menu, and also buttons of the main toolbar and of the **AT** additional toolbar.

Table 8. Brief description of the “Orientation” menu

Menu items	Function
Manage projects cameras (**Ctrl+Alt+I**)	allows to input/edit parameters of project cameras, and also to assign cameras to project images
Import orientation from metadata...	allows to perform import of exterior orientation results
Import exterior orientation	allows to open the Exterior orientation data list
Automatic tie points measurements	contains menu items used to measure tie points coordinates in automatic mode
Tie points list (**Ctrl+Alt+T**)	allows to open catalogue of all *tie points* with their measurements (see “The “Triangulation points” window” chapter of the “Aerial triangulation” User Manual)
GCP list (**Ctrl+Alt+G**)	allows to open catalogue of *all ground control points*, including non-measured on block images (see the “GCP list” chapter of the “Aerial triangulation” User Manual)
Block adjustment (**Ctrl+Alt+S**)	allows to open the adjustment module, to view adjustment results and errors correction (see the “Block adjustment” User Manual)
Direct georeferecing	allows to perform adjustment using imported exterior orientation parameters
Processing report	allows to create the processing report
Delete adjustment results	allows to delete adjustment data (see the “Block adjustment” User Manual)
Additional	contains the **Additional** menu

Table 9. Brief description of the “Orientation” menu (Additional)

Menu items	Function
Report on interior orientation	allows to open a report about interior orientation results (see the Aerial triangulation User Manual)
Manual interior orientation	[only for film camera images] allows to measure manually coordinates of fiducial marks on images (see the Aerial triangulation User Manual)
Semiautomatic interior orientation	[only for film camera images] allows to perform semiautomatic interior orientation, which is to use image-standard with template of fiducial marks position used to search the same fiducial marks on other project images (see the Aerial triangulation User Manual)

Menu items	Function
Automatic interior orientation	[only for film camera images] is used to perform automatic interior orientation, which is the automatic recognition of fiducial marks by their type, peculiar to certain analog camera images (see the Aerial triangulation User Manual)
Calculate interior orientation	allows to re-calculate interior orientation parameters
Delete interior orientation data	allows to open the **Select images** window that is used to delete results of fiducial marks measurements on selected images
Quick Ties	contains menu items used to perform quick ties in order to use the data for block layout creation (see the "Aerial triangulation" User Manual)
Open selected images for measurements	allows to open the **Points measurement** module used to measure points coordinates in manual mode on images *selected*in 2D-window (see the "Aerial triangulation" User Manual)
Open images containing marker (**Ctrl+Alt+K**)	allows to open the **Points measurement** module used to measure points coordinates in manual mode on *images, that contain marker position in 2D-window*
Open in-strip stereopair	allows to open the **Points measurement** module used to measure points coordinates in manual mode on selected *in-strip stereopair* in 2D-window
Open inter-strip stereopair	allows to open the **Points measurement** module used to measure points coordinates in manual mode on selected in 2D-window *inter-strip stereopair*
Report on relative orientation (**Ctrl+Alt+R**)	allows to open the report with results of images relative orientation in order to perform analysis and removal of errors in tie points measurements
Delete point measurements	allows to choose types of triangulation points to be deleted and delete them
Clear point catalogue	allows to remove the whole list of triangulation points (GCP, check, tie) from triangulation points catalogue
Load triangulation points	allows to load measured coordinates of triangulation points to 2D-window with possibility to setup of display of certain type of points (see the Aerial triangulation User Manual)
Delete points outside useful areas	allows to delete points out of useful areas (with specified background color) (used mainly during automatic points measurements on spaceborne images)
Import	contains menu items used to import of triangulation points measurements from files of PAT-B, X-Points formats from PHOTOMOD 4.x (XPT) projects, as well as data import from flight path file (see the Aerial triangulation User Manual)
Export	contains menu items used to export of triangulation points measurements to files of PAT-B and X-Points

Menu items	Function
	formats, and for export of ties or GCP for further use them in *Geomosaic module (see the Aerial triangulation User Manual)*
List of exterior orientation parameters	allows to open the Exterior orientation data list
Export exterior orientation...	allows to perform export of list of source exterior orientation parameters and adjustment results to PAT-B and CSV formats
Load projection centres as vectors	allows to load projection centres data as vector point objects and to open them in 2D-window to perform analysis, at that an image name is saved to the `Name` point attribute
Create images georeferencing files	allows to perform export of georeference data after preliminary block exterior orientation and adjustment (to files of *ArcInfo World File*and *MapInfo TAB*formats)
Select subblock	allows to select part of block images to perform adjustment
Adjustment in batch mode	allows to specify adjustment parameters and to perform block adjustment without using the the **Adjustment** toolbar (see the "Block adjustment" User Manual)

7.6. The "DEM" menu

The **Terrain** menu contains **Points**, **TIN**, **DEM** and **Contours** submenus.

Table 10. Brief description of the "Terrain" menu

Menu items	Function
Points	The **Points** menu contains usual menu items used for automatic points measurement, filtering, import and export (see the "*Points*" chapter of the "Creating DTM" User Manual).
TIN	The **TIN** menu contains menu items used to load and save TIN layers, as well as to perform different operations on creation, editing and accuracy control of TIN building (see the "*Triangulation irregular network*" chapter of the "Creating DTM" User Manual).
DEM	The **DEM** menu contains standard menu items used to load and save DEM layers, as well as menu items used to perform various operations on DEM creation, accuracy control, filtering and editing.
Contours	The **Contours** menu contains usual menu items used for contours generating, editing, import and export.
LAS	The **LAS** menu contains usual menu items used for converting the LIDAR data to DEM which is saved

Menu items	Function
	into the file of active profile (see the “LIDAR Data processing” User Manual)

7.7. The “Windows” menu

Table 11. Brief description of the ’ Windows ’ menu

Menu items	Function
New 2D-window (block)	allows to open window with a block scheme
New 2D-window (stereopair) (**Ctrl+Alt+W**)	allows to open window with a stereopair
3D-window	allows to open the 3D-window (see the ’General information’ User Manual)
Marker window (**Ctrl+Alt+C**)	allows to open marker parameters window (see the ’Vectorization’ User Manual)
Measurements window (**Ctrl+Alt+D**)	allows to open window that allows to perform measurements by images (see the ’Vectorization’ User Manual)
Classifier	allows to open the **Classifier** window to show set of standard vector objects attributes (see the *Classifier* chapter in the ’Vectorization’ User Manual)
Objects attributes	allows to open the **Attributes** window to display attributes of selected vector objects (see the *Vector objects attributes* chapter in the ’Vectorization’ User Manual)
Toolbars	contains menu items allows to open additional toolbars
Additional	contains the **Additional** menu

See detailed description of the system’s windows in the “General information about the system” User Manual.

To get quick access to the *main* windows of the system, select **Windows › Toolbars › Windows**. The **Windows** toolbar is opened.

Table 12. Brief description of the ’ Windows ’ menu (Additional)

Menu items	Function
Show all toolbars	allows to show all toolbars
Find all toolbars	allows to show all opened toolbars in visible part of the screen
Temporarily hide toolbars (**TAB**)	allows to hide/show all opened toolbars
Image list...	allows to open the **Images list** window (see the ’Creating project’ User Manual)
New 2D-window (single image)	allows to open window with image selected on a block scheme
Open image under marker	allows to open all 2D-windows with marker place. Press and hold **Alt** key while clicking the menu item

Menu items	Function
	to open images with 1:1 zoom , otherwise, full images are displayed
Close all single image windows	allows to close all 2D-windows with images
Refresh all 2D-windows	allows to refresh information in all opened 2D-windows
Arrange	contains menu items allow to arrange opened 2D-windows in a work area with one of the following ways: • **Tile** (also on the main toolbar) – allows to tile 2D-windows; • **Row** – allows to row 2D-windows; • **Column** – allows to column 2D-windows; • **Stack** (also in the main toolbar) – allows to stack 2D-windows.
Stereopairs	contains menu items allows to move to other stereopairs (see the 'Vectorization' User Manual)
Triangulation points coordinates	allows to show table with triangulation points coordinates
Triangulation points view control	allows to choose triangulation points to display
Contours classifier table	allows to open contours classifier window to edit parameters of contours display (see the 'DTM generation' User Manual)
Objects list	allows to display list of active layer vector objects (see the 'Vectorization' User Manual)
Marker motion in pixel coordinates	allows to set on the mode allows to move marker in stereopair 2D-window in pixel coordinates
Zoom all in (**Shift+* NumPad**)	allows to zoom in all 2D-windows
Zoom all out (**Shift+/ NumPad**)	allows to zoom out all 2D-windows
Layer view mask	allows to use a view mask for active layer (see the 'General information' User Manual)
Windows list	allows to view list of opened 2D-windows

7.8. The "Block editor" window

The **Block editor** window is used to form a block of project images.

The **Block editor** window contains a table of created strips and images loaded to project and contains tools for images block editing.

The **Block editor** window is synchronized with 2D-window , so all changes in the images list of the **Block editor** (choosing, adding, deleting, moving of strips and images) are shown in the block scheme in 2D-window and vice versa.

Choose the **Block › Block editor** (**Ctrl+Alt+B**) to open the **Block editor** window.

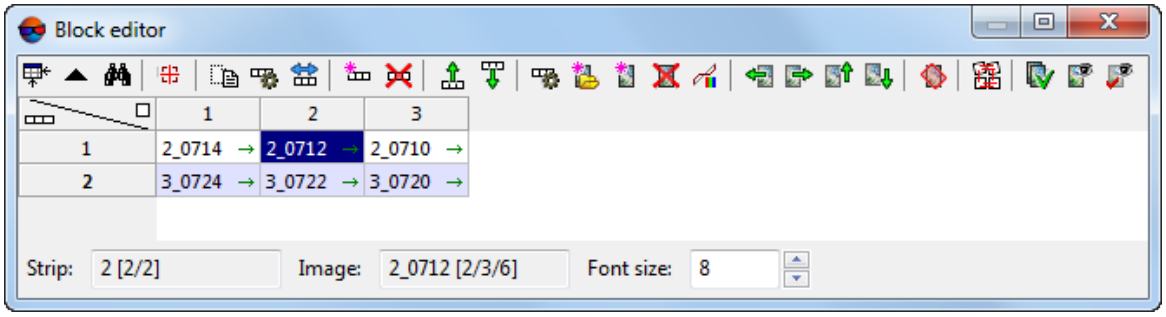


Fig. 4. The “Block editor” window

The **Block editor** window contains the following elements:

- toolbar to form and edit block images;
- the list of existed strips and loaded there images;
- the status bar with the following data:
  - **Strip** – the `Strip name [item No/total]` is displayed for strip selected in the table;
  - **Image** – the `Image name [item No/total in strip/total in block]` is displayed for image selected in the table;
  - **Font size** – allows to change the font size of table text.

To select (highlight) the image in the **Block editor** window click the image name in the list. To select strip click on the name of strip.

To select multiple images\strips use **Shift** and **Ctrl keys**

To highlight several images in 2D-window use additional toolbar of group selection (see the *Tool* section in the “Vectorization” User Manual).

The **Block** menu items, buttons of the **Forming block** toolbar and the toolbar of the **Block editor** window.

Table 13. The toolbox of “Block editor” window

Buttons	Function
	allows to change the **Block editor** window size so that window displays all list of strips/images
	allows to show/hide the list of strips/images and the status bar to comfort work with block images in 2D-window (in the **Block editor** window only toolbar displays)
	is used to search for an image by name (part of name)
	allows to select in the list initial images, which contain marker position

Buttons	Function
	allows to edit names of several strips of the block at the same time
	is used to display and edit properties of selected strip (name and type of strip)
	reverse images in the strip order
	allows to add new strip
	allows to remove selected strip
	allows to move selected strip up by one strip
	allows to move selected strip down by one strip
	is used to display and edit properties of selected image
	is used for adding image files, locating in the resources out of active profile, to the selected strip
	is used for adding image files, locating in the resources of active profile, to the selected strip
	allows to remove selected images from project
	is used to radiometric correction of selected image
	allows to move selected images left/right/up/down
	allows to rotate selected images to any angle in relation to source or current image's position in block scheme
	allows to open the **Block layout** window to build block scheme in 2D-window considering source or acquired data (see the Aerial triangulation User Manual)
	allows to open the *ImageWizard* window to setup images
	allows to show block images in 2D-window, if they were not displayed during project loading, due to limitation specified in the program's setting window (see the "General system's parameters" User Manual)
	allows to set on/off displaying only selected images mode

8. Workflow of UAS processing

Prior to UAS data processing it is necessary to perform the following actions:

- Creating and selecting active profile – creating local profile or creating/connecting network profile to place all project/project group files – resources, and selecting the profile as active.
- Creating UAS project.

Processing of data acquired by UAS implies performing the following steps: **Aerial Triangulation**, **Compute DEM**, and **Compute Orthophoto**.

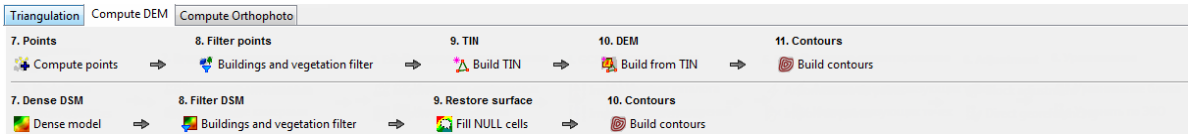


Fig. 5. Compute DEM tab of the main toolbar

The content and layout of the **Aerial Triangulation**, **Compute DEM** and **Compute Orthophoto** tabs of the main toolbar show main steps order of UAS data processing. The tables below contain grouped links to detailed description of functionality of each button of these tabs.

Table 14. UAS data processing steps (Triangulation)

1. Add images	**From files**	**From resources**
2. Interior orientation	**Import from metadata**	**Cameras**
3. Exterior orientation	**Import from file**	**Exterior orientation data**
4. Relative orientation	**Automeasure tie points**	**Tie points list**
5. GCP	**Import catalog**	**GCP list**
6. Adjustment	**Block adjustment**	**Direct georeferencing**

The **Tie points list** button allows to open **Tie points list** (see the "Aerial triangulation" User Manual).

The **GCP list** button allows to open **GCP list** (see the "Aerial triangulation" User Manual).

The **Direct georeferencing** button allows to perform adjustment using imported exterior orientation parameters.

Table 15. UAS data processing steps (DEM creation)

7.	**Compute points**	**7.**	**Dense model**
8.	**Buildings and vegetation filter**	**8.**	**Buildings and vegetation filter**
9.	**Build TIN**	**9.**	**Fill NULL cells**
10.	**Build from TIN**	**10.**	**Build contours**
11.	**Build contours**		

Table 16. UAS data processing steps (Orthomosaic creation)

1. Orthorectification	**Orthorectification**
2. Start GeoMosaic	**Start GeoMosaic**

Depending on tasks to be performed and requirements to output data, the order of UAS data processing may vary somewhat.

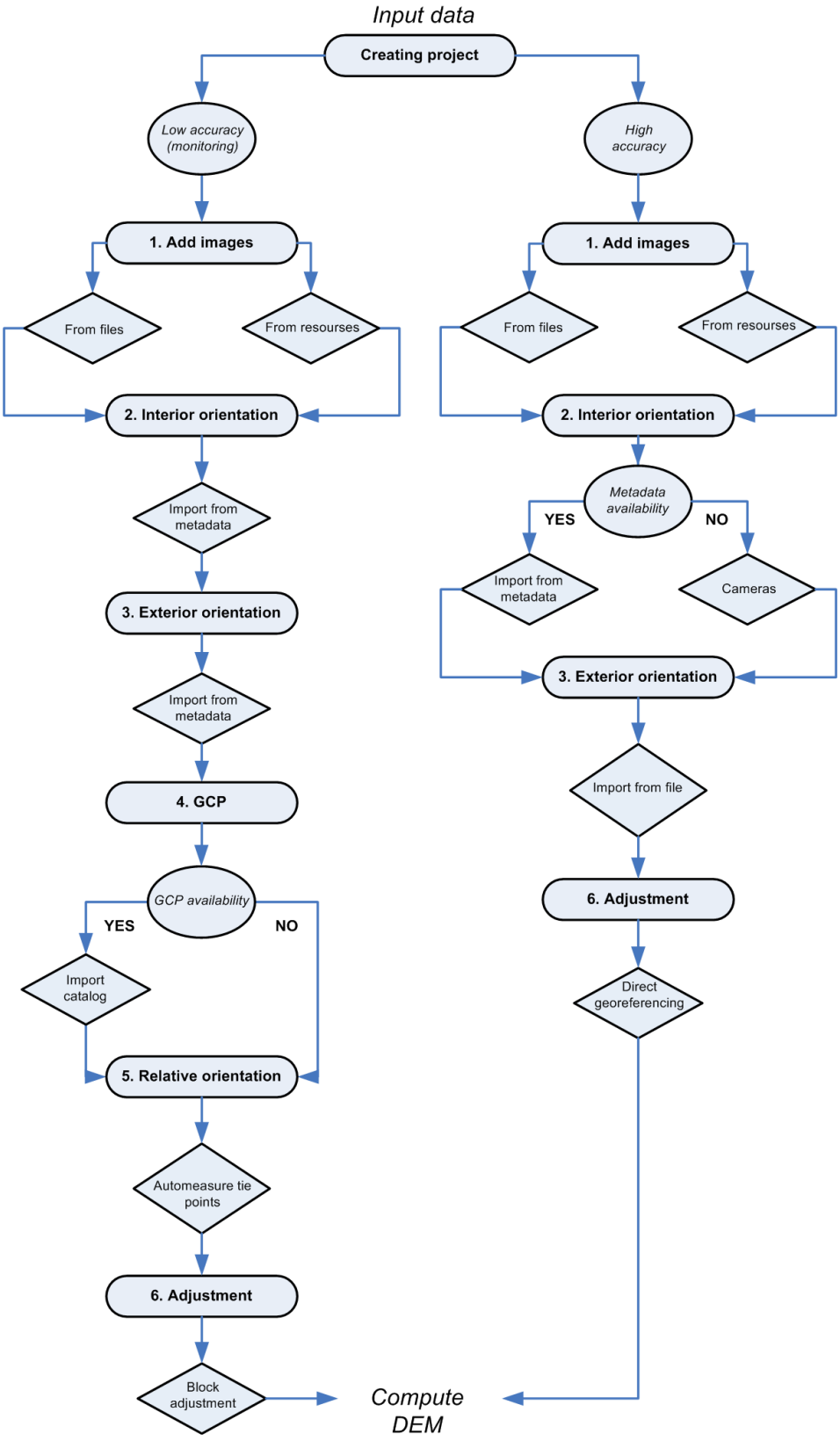


Fig. 6. Workflow of UAS processing

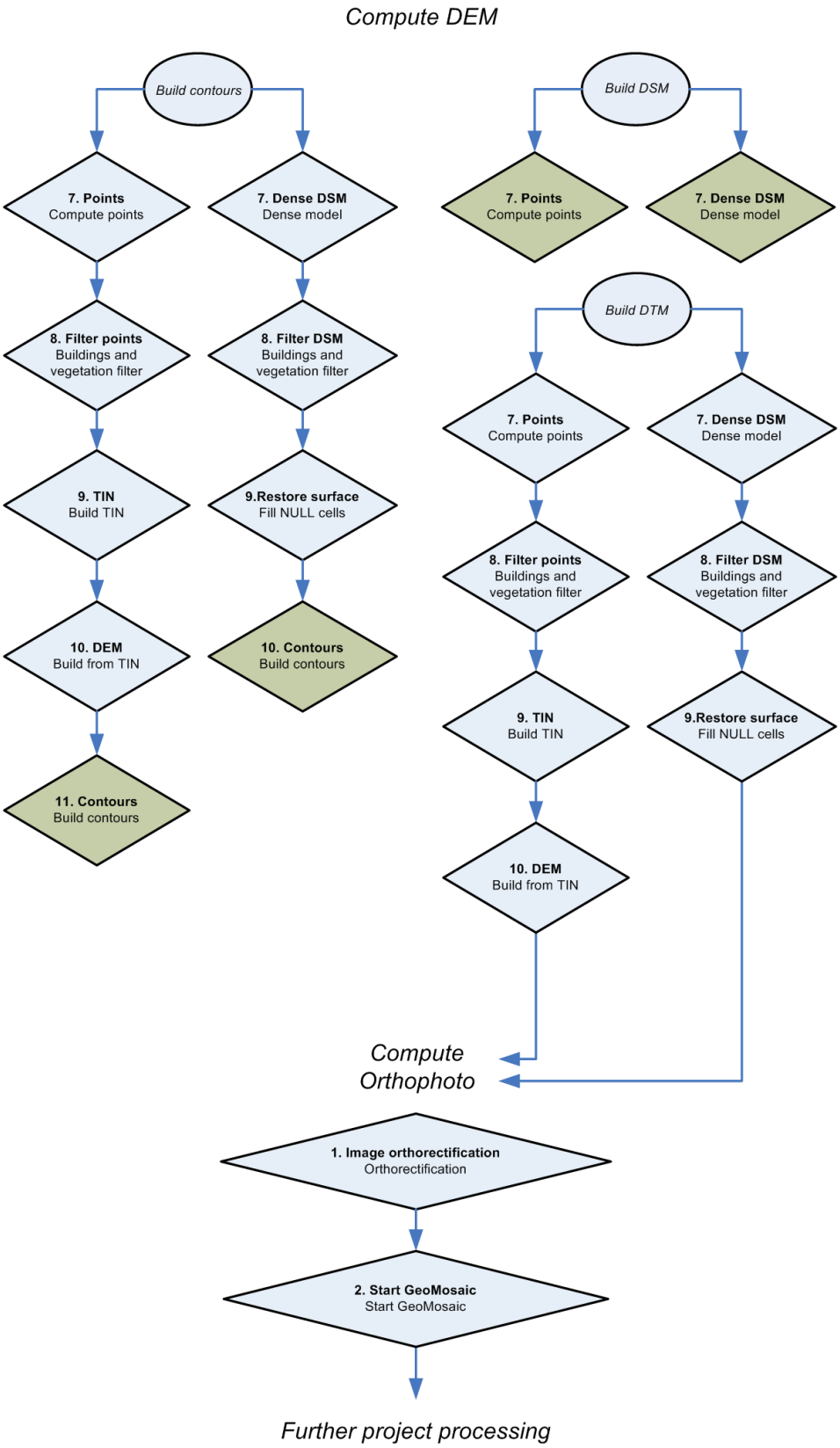


Fig. 7. Workflow of UAS processing

9. Creating and choosing active profile

Prior to work in the program you should create a profile for placing project resources such as project configuration files, images files, files processing projects/project group.

A profile represents a resources tree with the following structure:

- *Root* – profile virtual name.
- *Top level branches* – profile virtual folders – virtual names of physical local or network folders/disks.

  You can specify one physical folder/disk or folders/disks group as a virtual folder (storages group).

  Storage folders are a special type of virtual folder. Resources are automatically placed in storage folders by the program on the basis of free space analysis. Thus, storage folders allow optimization of multiple disk usage for storage resources, which is advantageous when network processing large projects.

- *Resources* – all data of a profile – all subfolders and files of each virtual folder in profile.

Thus, profile resources are placed on any servers, workstations or network disks.

Profiles can be *local* or *network* to organize individual or shared work with projects, respectively.

For profiles creation and organizing resources structure of each profile you can use the *Control Panel module*.

To view and edit active profile resources is used the *PHOTOMOD Explorer module*.

To launch these modules is used the **Start › Programms › PHOTOMOD UAS** menu and also the context menu of the *System Monitor module* (the  icon in the *Windows* system tray).

More details about program resources, recommendations on organizing of local or network work, and about creating profiles and virtual folders connecting see in the “General information” User Manual.

In one work session of the program could be used *only one* active profile.

Close all program modules an perform one of the following to choose *active* profile:

- choose active profile in the **Profile** list from the context menu of the *System Monitor module* (the  icon in the system tray);

- choose active profile with mouse double-click by profile name in the **Profile** list in the *Control Panel*.

Current active profile is marked in the profile list by the icon.

Restart program after chosen active profile.

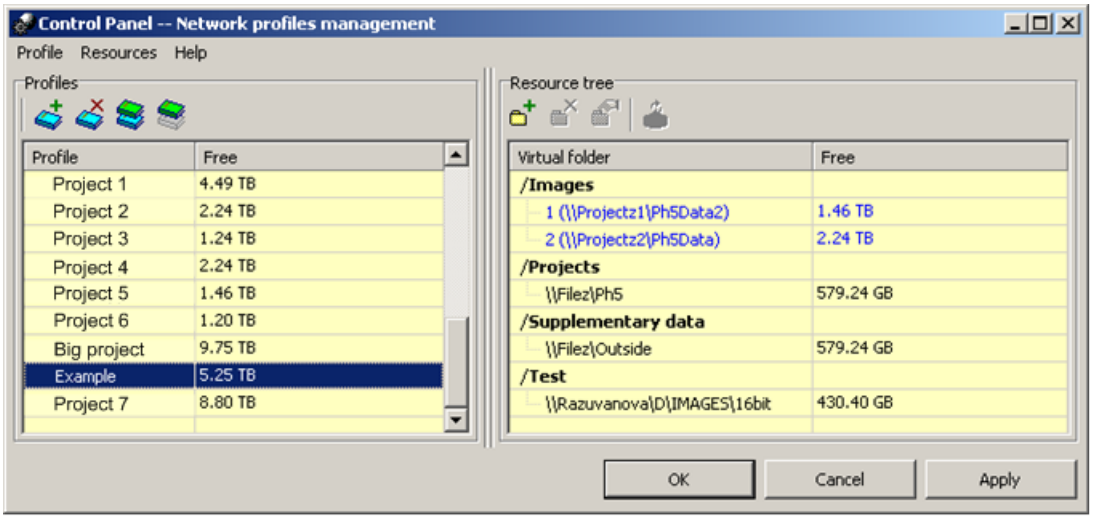


Fig. 8. Creating resources structure of network profile

The folder tree displays in the *PHOTOMOD Explorer* window after creating profile.

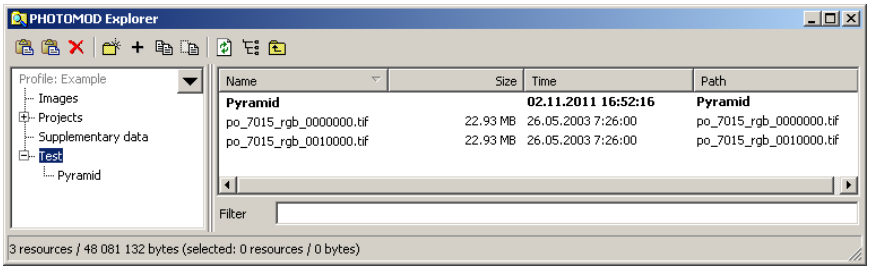


Fig. 9. Resources tree of network profile in the Explorer window *PHOTOMOD Explorer*

To avoid loss of data, it is not recommended to edit virtual folder for storage group.

10. Project creation

In order to create UAS project perform the following actions:

1. Choose active profile.
2. Start the PHOTOMOD UAS program.

3. Open the **New project** window using one of the following ways:

   - choose **Project › Open/Manage...** (**Ctrl+Alt+O**). The **Manage project** window opens. Click the **New** button;
   - choose **Project › New**.

   The **New project** window opens automatically if there is no existed projects in the active profile.

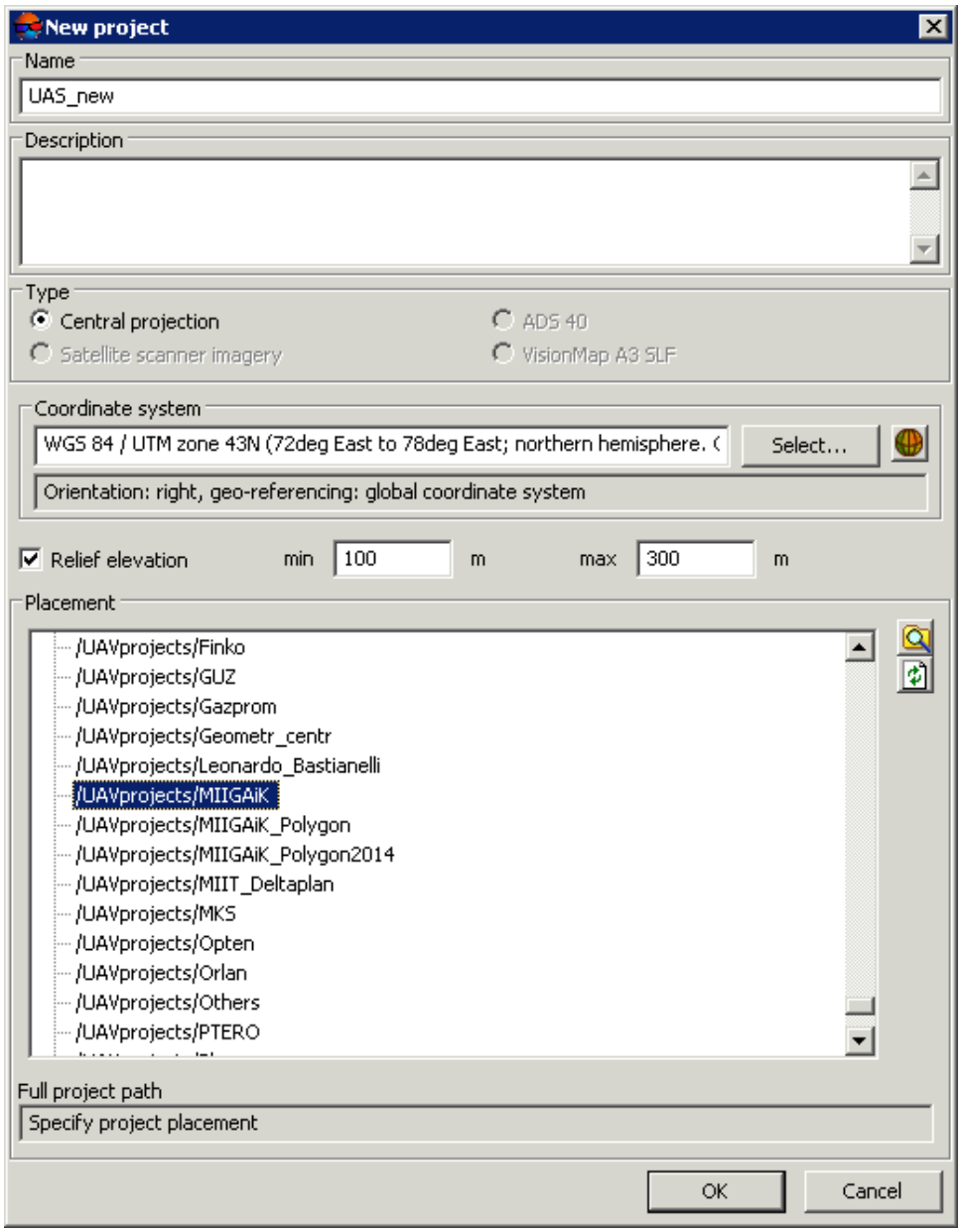


Fig. 10. Creating UAS project.

4. Define a **Name** of new project.

5. [optional] Input to the **Description** section a brief project description, its main features, notes etc.

6. Define a coordinate system using the **Select** button in the **Coordinate system** section.

7. Set on the **Relief elevation** checkbox and specify at least approximately difference of terrain heights on project images in the **min** and **max** input fields.

   If the relief elevation data is unavailable or inaccurate by the time of project creation, the program allows to define the value later in project properties. The relief elevation data is used to refine a block layout, it is considered during import of exterior orientation parameters and during calculation of ground sample distance (GSD).

8. Choose a folder of active profile resources in the **Placement** list to place a project resources there. The **Full project path** input field shows a name and a path of a project.

9. Click OK to complete a project creation. Service folders and configuration files are created in specified project folder. The first strip create automatically.

See details about project creation in the “Project creation” User Manual.

11. Add images

Refer to the “Images block forming” chapter of “Project creation” User Manual for the detailed description of images load from *files* and *resources*, images setup and images block editing.

11.1. Image preparing

Prior to load UAS images to a project it is recommended to prepare them using the *Raster Converter module* as follows:

1. [if necessary] Perform the radiometric correction.

2. Convert the images to files of inner *MS-TIFF* format.

3. [optional] It is recommended to apply **JPEG compression** with **85 % quality** for output files to save place on hard disk.

4. Choose an individual folder of active profile resources in the **Placement** list to place a converted images.

See the *Raster Converter module* description in the “General information” User Manual.

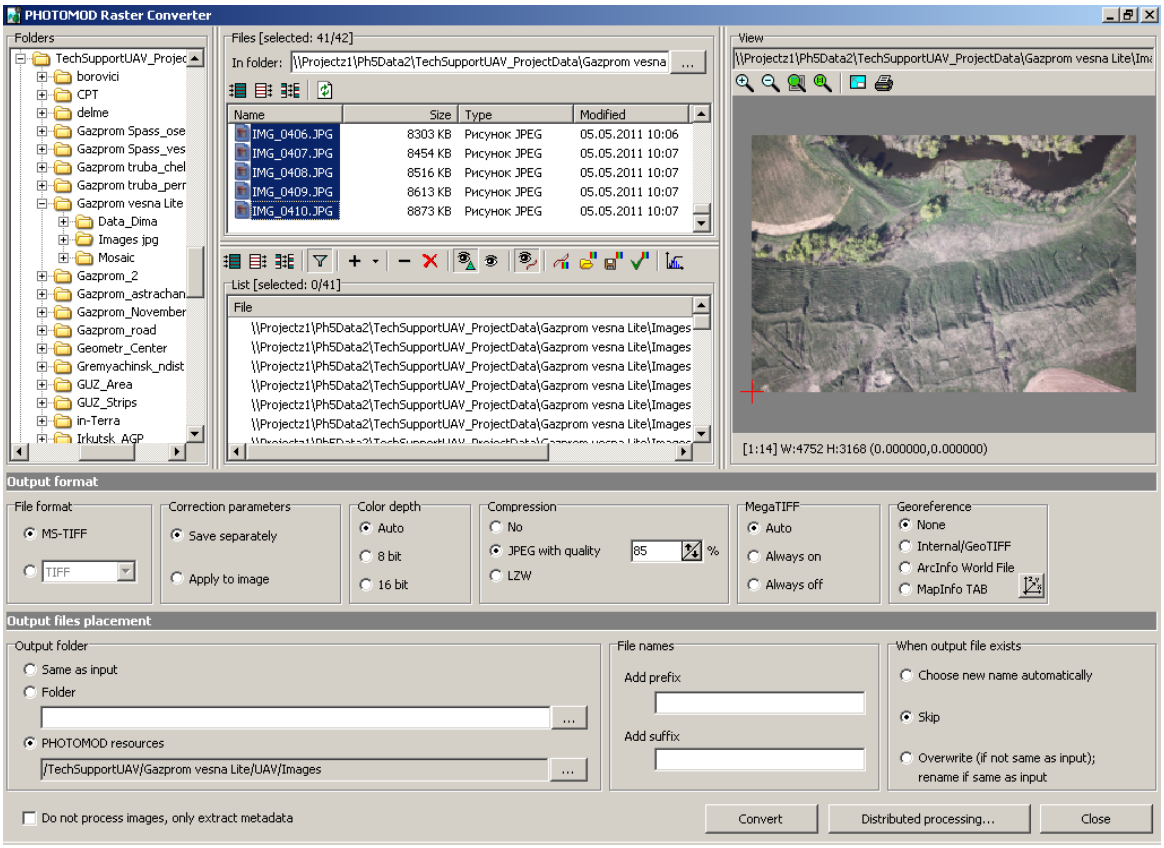


Fig. 11. Images conversion in the Raster Converter module

11.2. Adding images

Perform the following actions to load images to a project and to form a block:

1. Choose **Block › Add images from resources** or click the button in the **Block editor** window to start images adding.

2. Choose images files and click the **Open** button. After that all images are loaded to the first strip.

[optional] To filter showing files choose `Image in TIFF format` in the list rightward to the **Resources name** field.

Refer to the “Images block forming” chapter of “Project creation” User Manual for the detailed description of images load from *files* and *resources*, images setup and images block editing.

12. Interior orientation

Refer to the “Images interior orientation” chapter of “Aerial triangulation” User Manual for the detailed description of images interior orientation operation.

Interior orientation operation includes input or import of camera parameters, specifying of flight direction and angle of camera axes rotation for images of a project.

In order to perform interior orientation when metadata is available, perform the following actions:

1. Choose **Orientation › Import exterior orientation** or click the **Import from metadata** button on the **Aerial Triangulation** tab of the main toolbar to get camera data from EXIF-metadata in image files. The **Import orientation from metadata** window opens.

2. Make sure that the **Import interior orientation** checkbox is set on.

   The **Import preliminary exterior orientation** checkbox is also set by default, in order to import exterior orientation parameters.

3. [optional] Set **Replace existing data** checkboxes, if the information about internal and external orientation has always been imported into the system and data currently imported is more preferable.

4. Click OK.

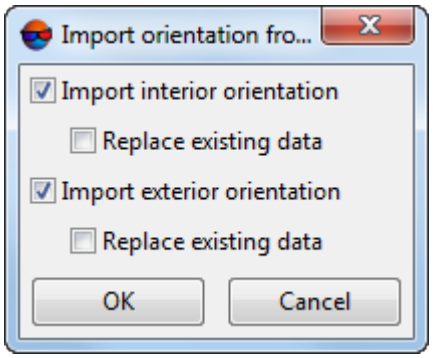


Fig. 12. Import orientation parameters from EXIF-metadata

[optional] To check the results of exterior orientation parameters import, perform the following actions:

1. Choose **Orientation › Manage cameras** or click the **Cameras** button on the **Aerial Triangulation** tab of the main toolbar to adjust camera parameters and define camera axes direction for project images. The **Manage project cameras** window opens.

2. Choose camera in the list and click the button. The **Camera** window opens to view and edit camera data.

In order to perform interior orientation when metadata is unavailable, perform the following actions:

1. Choose **Orientation › Manage cameras** or click the button of main toolbar to adjust camera parameters and define camera axes direction for project images. The **Manage project cameras** window opens.

2. Choose camera in the list and click the button. The **Camera** window opens to view and edit camera data.

3. [optional] Input camera additional data (if camera passport is available) and click OK.

4. Specify flight direction using window of images preview and define camera axes rotation for project images in the following way:

    1. Choose images in the table which do not require axes rotation.

    2. Set the **Set camera rotation for selected images** checkbox and specify a rotation angle so, that X axis coincides with flight direction.

    3. Click the **Execute** button. Interior orientation is performed automatically.

See detailed description of interior orientation step in the "Aerial triangulation" User Manual.

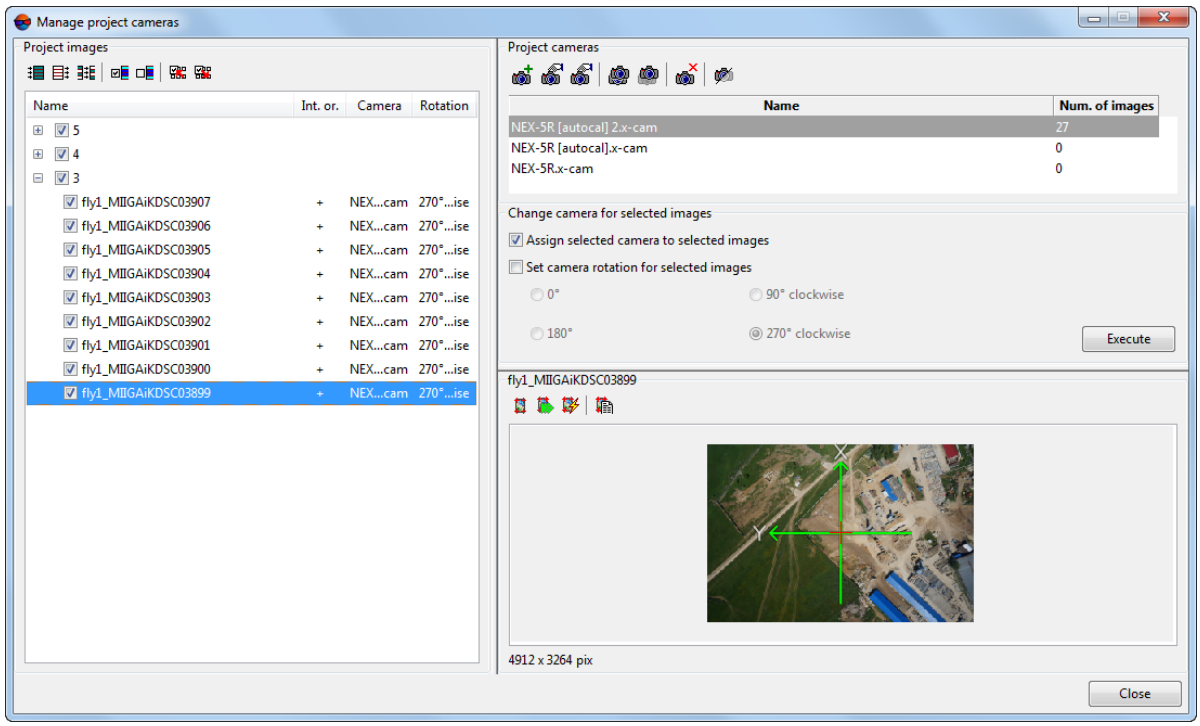


Fig. 13. Performing interior orientation

13. Exterior orientation

Refer to the “Images exterior orientation” chapter of “Aerial triangulation” User Manual for the detailed description of images exterior orientation operation.

Exterior orientation parameters are *coordinates of projection centres and 3 angles*, that allow to specify in whole real position of images in space.

Exterior orientation parameters may be *included to EXIF-metadata of images files* or *separately as a catalogue in a file of text format*. Additional information about import of preliminary exterior orientation data from EXIF-metadata is in Section 12.

If exterior orientation parameters are available for UAS project, you can import them to the project, together with Interior orientation parameters.

In order to perform import of exterior orientation data catalogue from a file of text format, do the following:

1. Choose **Orientation › Additional › Exterior orientation data list** or click the **Exterior orientation data list** button on the **Aerial Triangulation** tab of the main toolbar. The **Exterior orientation parameters** window opens.

2. Click the button to import exterior orientation parameters.

   The button is duplicated by the **Import from file** button on the **Aerial Triangulation** tab of the main toolbar and the **Orientation › Import exterior orientation...** menu item.

3. Choose a file with exterior orientation parameters and click OK. The **Exterior orientation import – Step 1 of 3: File** window opens. The **File name** input field displays selected file placement and name.

   To select another file which contains exterior orientation parameters, click the ... button.

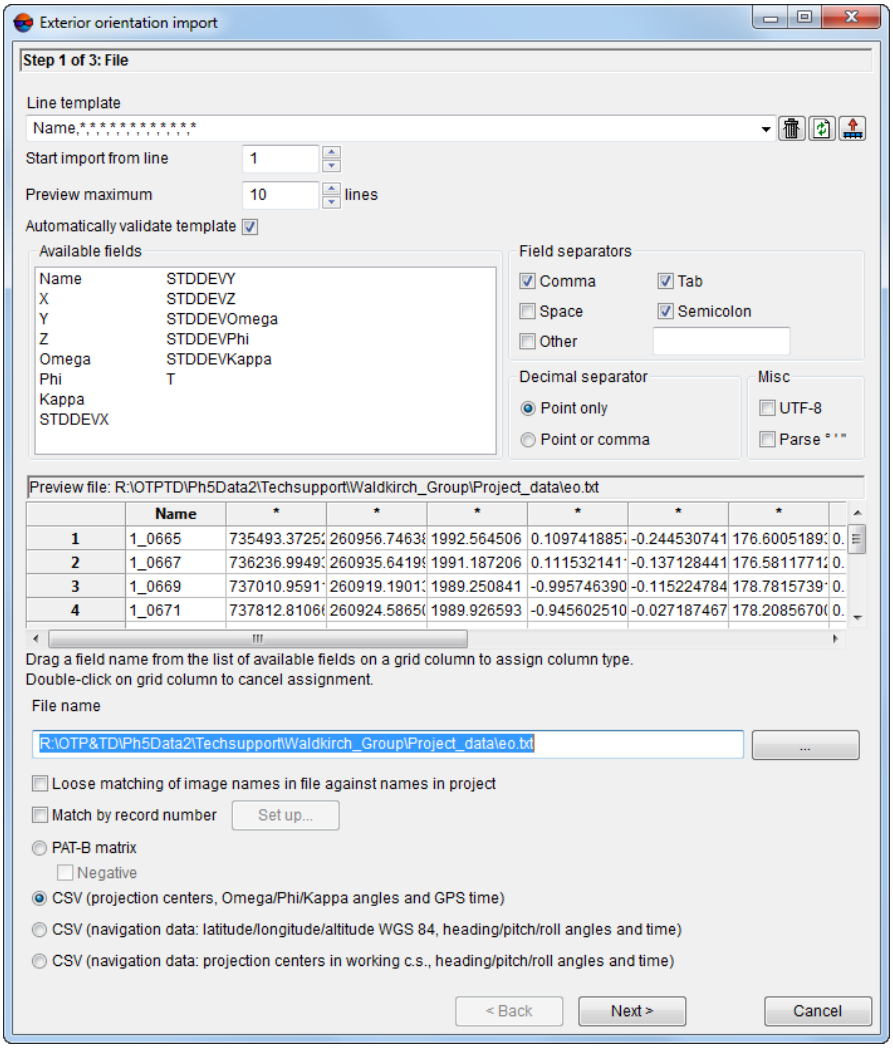


Fig. 14. Setup a file string template for import of exterior orientation parameters

4. [optional] If images names in file and in project are not the same, perform one of the following actions:

   - set on the **Loose matching of image names in file against names in project** checkbox. The program performs search for common substrings and matches images names. For example, it searches for common substring *018_02595* in image name *RGBI_018_02595* in file and image name *018_02595* in project.

     If the **Loose matching of image names in file against names in project** checkbox is set on the image name with file extension is also imported.

   - set on the **Match by record number** checkbox and click the **Setup...** button. The **Match images by numbers** window opens.

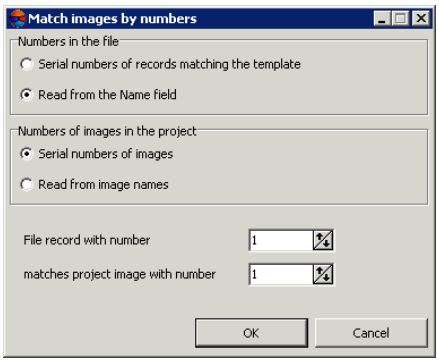


Fig. 15. Images matching by numbers

1. In the **Numbers in the file** section set the following parameters:

   - **Serial numbers of records matching the template** – is used to match a list of records numbers in a file by order;

   - **Read from the Name field** – is used to match a list of records numbers in a file by the last number from the filename.

2. In the **Numbers of images in the project** section set the following parameters:

   - **Serial numbers of images** – used to match a list of records numbers in a project by order;

   - **Read from images names** – used to match a list of records numbers in a project by the last number from the filename.

3. Input necessary parameters to the **File record with the number** and **matches project image with number** input fields.

   For convenient setup of necessary parameters it is recommended to place windows in that way that allows to display on screen a name of the first image in the table of the **Exterior orientation parameters** window, and also allows to display first rows in the **Preview file** table of the **Exterior orientation import** window. It is recommended to place the **Match images by numbers** window in such a way that allow to show both windows mentioned above.

5. Choose one of the following formats to specify a type of imported file:

   - **PAT-B matrix** – file containing coordinates of projection centers and rotation matrices.

   - **CSV (projection centers, Omega/Phi/Kappa angles and GPS-time)** – file containing coordinates of projection centers in any coordinate system, as well as exterior orientation parameters, and precise time from GPS-receiver.

CSV format is exchange text format with `*.csv` extension, which is supported by major applications in different industries. It is used as exchange format when special geospatial data formats are not applicable for some reason.

- **CSV (navigation data: latitude/longitude/altitude WGS-84, heading/pitch/roll angles and time)** – file containing navigation data (latitude/longitude set in degrees, altitude in meters, angles in degrees, radians or gons) and precise time from GPS-receiver.

  To perform import of exterior orientation parameters it is necessary that a project is in coordinate system consistent with WGS-84 coordinate system.

- **CSV (navigation data: projection centers in working c.s., heading/pitch/roll angles and time)** – file containing navigation data (coordinates of projection centers in project coordinate system, angles in degrees, radians or gons) and precise time from GPS-receiver.

6. The **Line template** field displays the list of fields, contained in each line of imported file:

   - **T** – precise time from GPS-receiver;
   - **Lat** – flight latitude;
   - **Lon** – flight longitude;
   - **Alt** – flight altitude;
   - **Heading** – flight heading;
   - **Roll** – roll;
   - **Pitch** – pitch.

   The * symbols marks columns with data which is not imported.

   In order to setup active template, perform one of the following actions:

   - drag by mouse field name from the **Available fields** list to the column of the **Preview file** table. After that the template in the **Line template** field is changes. In order to cancel field selection, double click the column of the **Preview file** table;
   - change the template manually in the **Line template** field. At that column types in the **Preview file** table are changed automatically.

The  button allows to use the default template `T Lat Lon Alt Heading Roll Pitch`.

The  button is used to compare the **Line template** field with data shown in the **Preview file** table.

The active template corresponds only to lines shown in the **Preview file** table.

The  button is used to replace specified field names by field values taken from the first line of the **Line template** table.

7. [optional] The **Automatically validate template** checkbox is set on by default that allows to select current template automatically. In order to configure the template for file containing lines with different columns number, set off the **Automatically validate template** checkbox and configure the template in the **Line template** field manually.

8. [optional] To specify a line from to start data import, define the value of the **Start import from line** parameter.

9. [optional] To display necessary number of lines in the **Preview file** table, set the **Preview maximum** parameter. Default number of lines is 10.

10. In the **Available fields** section select necessary field name and drag it to the table column. To cancel the field name double click the column header.

11. In the **Field separators** section set on one or multiple checkboxes to specify possible fields delimiter symbol: **Comma**, **Space**, **Tab**, **Semicolon** or **Other** delimiters. Default settings are comma and space.

12. In the **Decimal separator** section setup the following parameters:

    - **Point only** – to use point only as a decimal separator in coordinates;
    - **Point or comma** – to use both point and comma as a decimal separator in coordinates.

    If comma is used as **Field separator**, it is not recommended to use comma as **Decimal separator**, since it may cause import of incorrect data.

13. [optional] In the **Misc** section set the checkbox:

    - **UTF-8** – is used to recognize text in *Unicode* encoding;

    Unicode – symbols encoding format that allows to provide symbols of almost all written languages.

- **Parse ° ’ “** – is used to recognize records of projection centers or GCP.

When using this parameter it is highly recommended to check points coordinates recognition correctness after import. To do this select any point in 2D-window and check coordinates values in the **Marker** window (see the Vectorization User Manual).

14. Click the **Next** button. The **Exterior orientation import – Step 2 of 3: Import settings** window opens.

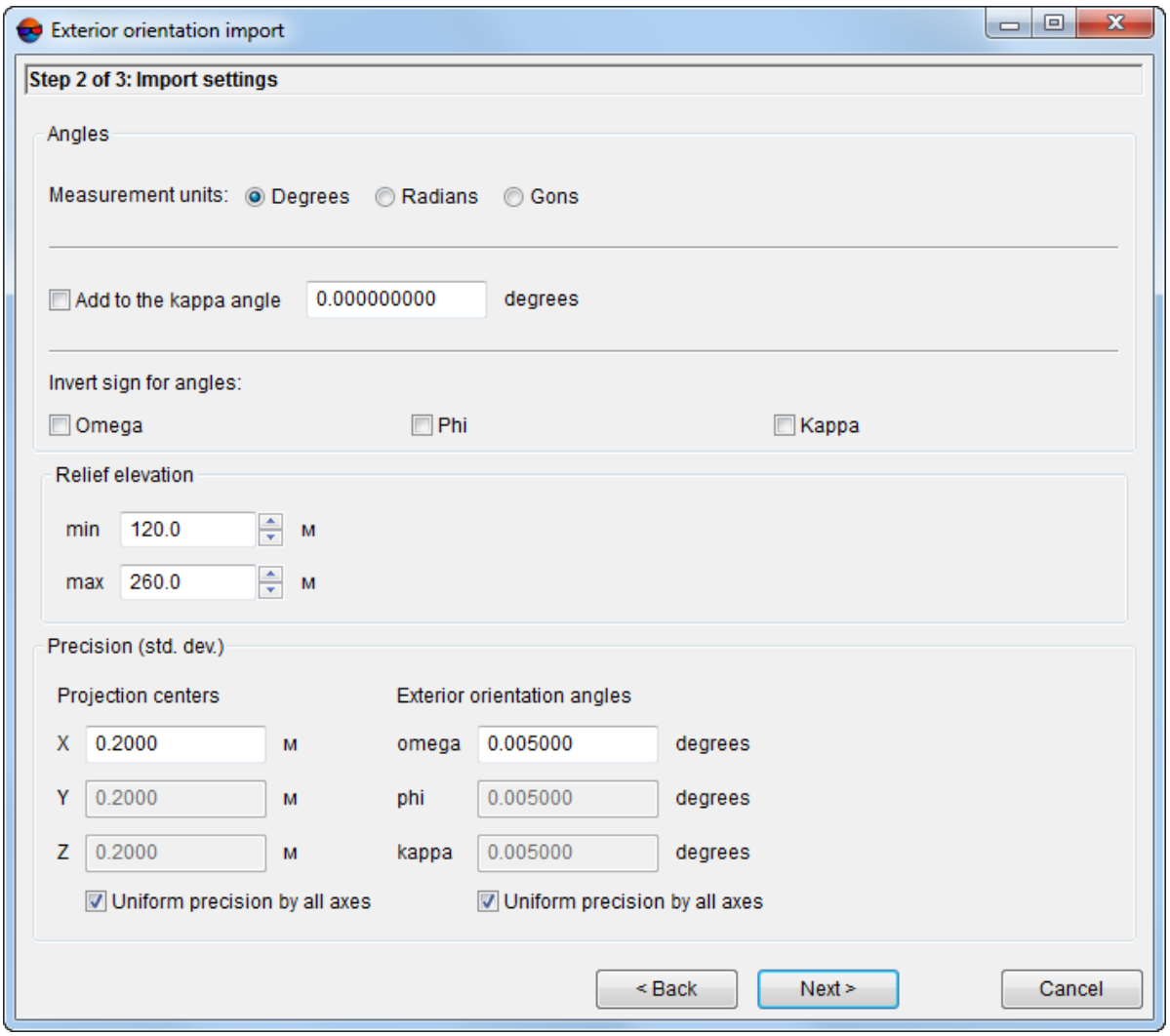


Fig. 16. Import options of exterior orientation parameters

Define the following parameters of datum:

1. In the **Angles** section specify measurement units for angles coordinates according to data of the file to be imported:

   - **radians**;

- **degrees**;
- **gons** – plane angle measurement unit that equals to 1/100 of flat right angle measurement unit, and full angle is 400 gons.

2. [optional] In order to make correction to kappa angle, set on the **Add to the kappa angle** checkbox and input correction value to the input field.
3. [optional] In order to **Invert sign** for angles **Omega**, **Phi** and/or **Kappa**, set on corresponding checkboxes.
4. [optional] **Relief elevation** is automatically set equal to values specified in the project settings (see the "Project creation" User Manual). To change values of relief elevation input then in **min** and **max** fields (in meters).

   If the **max** value bigger than projection centers coordinates elevations, the error message displays.

5. [optional] In the **Precision (std. dev.)** section change precision of a priori RMS of measurements of projection centers coordinates and exterior orientation angles.
6. [optional] In order to cancel automatic setting of the same precision by all axes, set off the **Uniform precision by all axes** checkbox.

15. If import of exterior orientation parameters is performed using the **Exterior orientation parameters** window, then click the **Execute** button. After that the exterior orientation parameters are imported to the **list of exterior orientation parameters**.

    If import of exterior orientation parameters is performed using the **Orientation › Exterior orientation import...** menu item or the button, then click the **Next** button. The **Exterior orientation import – Step 3 of 3: Additional actions** window opens.

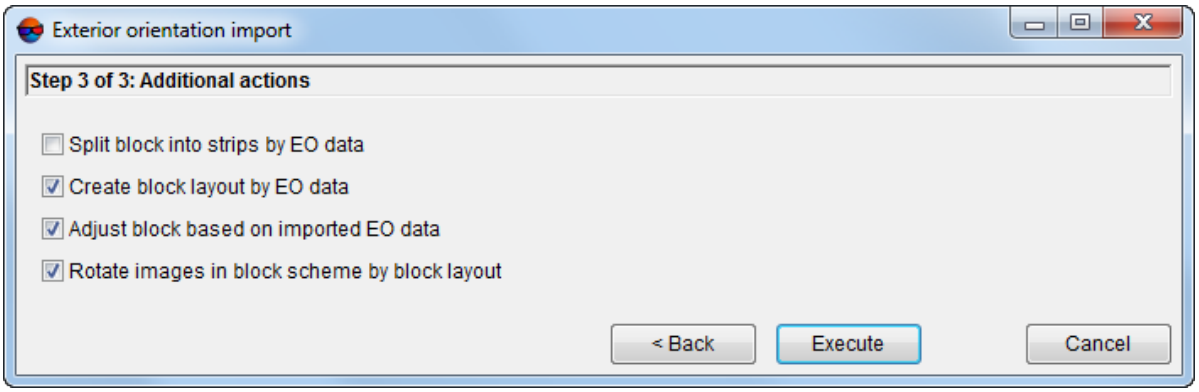


Fig. 17. Additional actions after exterior orientation import

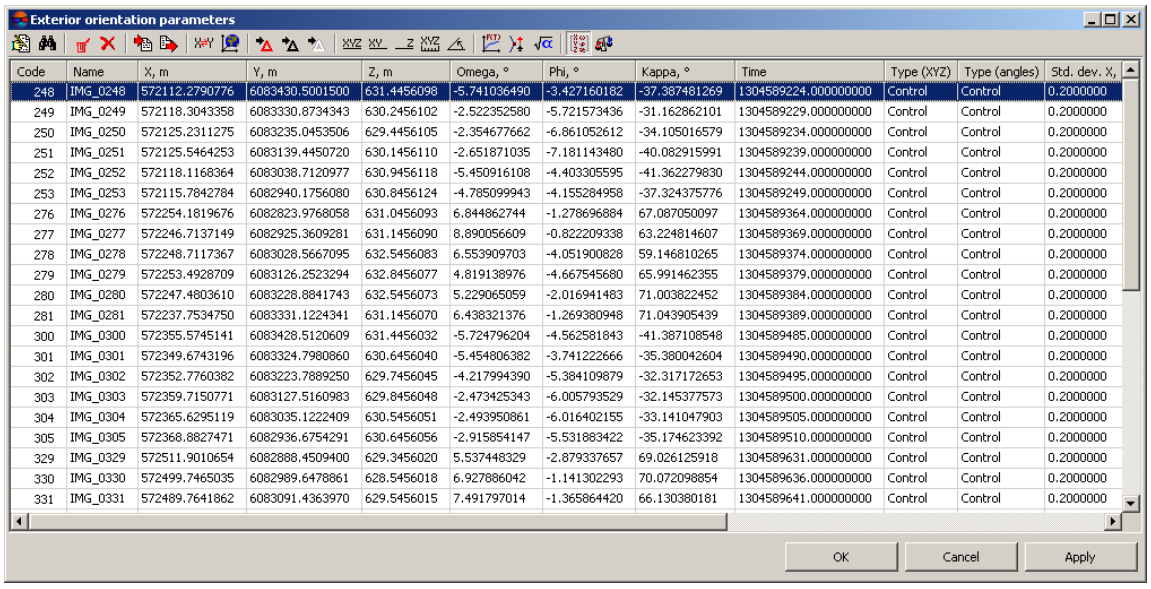
Select and set the following checkboxes to perform automatic execution of these actions just after import of exterior orientation parameters from file:

- **Split block into strips by EO data** – to split block images into strips using imported exterior orientation parameters (if all images were loaded to a single strip on a step of project creation);
- **Create block layout by EO data** – to create block layout considering imported exterior orientation parameters;
- **Adjust block based on imported EO data** – to perform block adjustment using imported exterior orientation parameters;
- **Rotate images in block scheme by block layout** – to re-create a block scheme in 2D-window using block layout по накидному монтажу (this checkbox is available if the **Create block layout by EO data** is set).

16. Click the **Execute** button. Exterior orientation parameters obtained after the import are displayed in the table of the **Exterior orientation parameters** window.

17. Click the **Apply** button in the **Exterior orientation parameters** window to save exterior orientation parameters folder in the project.

18. Click OK. The window closes block scheme by exterior orientation automatically (to build initial block layout).



Code	Name	X, m	Y, m	Z, m	Omega, °	Phi, °	Kappa, °	Time	Type (XYZ)	Type (angles)	Std. dev. X,
248	IMG_0248	572112.2790776	6083430.5001500	631.4456098	-5.741036490	-3.427160182	-37.387481269	1304589224.000000000	Control	Control	0.2000000
249	IMG_0249	572118.3043358	6083330.8734343	630.2456102	-2.522352580	-5.721573436	-31.162862101	1304589229.000000000	Control	Control	0.2000000
250	IMG_0250	572125.2311275	6083235.0453506	629.4456105	-2.354677662	-6.861052612	-34.105016579	1304589234.000000000	Control	Control	0.2000000
251	IMG_0251	572125.5464253	6083139.4450720	630.1456110	-2.651871035	-7.181143480	-40.082915991	1304589239.000000000	Control	Control	0.2000000
252	IMG_0252	572118.1168364	6083038.7120977	630.9456118	-5.450916108	-4.403305595	-41.362279830	1304589244.000000000	Control	Control	0.2000000
253	IMG_0253	572115.7842784	6082940.1756080	630.8456124	-4.785099943	-4.155284958	-37.324375776	1304589249.000000000	Control	Control	0.2000000
276	IMG_0276	572254.1819676	6082823.9768058	631.0456093	6.844862744	-1.278696884	67.087050097	1304589364.000000000	Control	Control	0.2000000
277	IMG_0277	572246.7137149	6082925.3609281	631.1456090	8.890056609	-0.822209338	63.224814607	1304589369.000000000	Control	Control	0.2000000
278	IMG_0278	572248.7117367	6083028.5667095	632.5456083	6.553909703	-4.051900828	59.146810265	1304589374.000000000	Control	Control	0.2000000
279	IMG_0279	572253.4928709	6083126.2523294	632.8456077	4.819138976	-4.667545680	65.991462355	1304589379.000000000	Control	Control	0.2000000
280	IMG_0280	572247.4803610	6083228.8841743	632.5456073	5.229065059	-2.016941483	71.003822452	1304589384.000000000	Control	Control	0.2000000
281	IMG_0281	572237.7534750	6083331.1224341	631.1456070	6.438321376	-1.269380948	71.043905439	1304589389.000000000	Control	Control	0.2000000
300	IMG_0300	572355.5745141	6083428.5120609	631.4456032	-5.724796204	-4.562581843	-41.387108548	1304589485.000000000	Control	Control	0.2000000
301	IMG_0301	572349.6743196	6083324.7980860	630.6456040	-5.454806382	-3.741222666	-35.380042604	1304589490.000000000	Control	Control	0.2000000
302	IMG_0302	572352.7760382	6083223.7889250	629.7456045	-4.217994390	-5.384109879	-32.317172653	1304589495.000000000	Control	Control	0.2000000
303	IMG_0303	572359.7150771	6083127.5160983	629.8456048	-2.473425343	-6.005793529	-32.145377573	1304589500.000000000	Control	Control	0.2000000
304	IMG_0304	572365.6295119	6083035.1222409	630.5456051	-2.493950861	-6.016402155	-33.141047903	1304589505.000000000	Control	Control	0.2000000
305	IMG_0305	572368.8827471	6082936.6754291	630.6456056	-2.915854147	-5.531883422	-35.174623392	1304589510.000000000	Control	Control	0.2000000
329	IMG_0329	572511.9010654	6082888.4509400	629.3456020	5.537448329	-2.879337657	69.026125918	1304589631.000000000	Control	Control	0.2000000
330	IMG_0330	572499.7465035	6082989.6478861	628.5456018	6.927886042	-1.141302293	70.072098854	1304589636.000000000	Control	Control	0.2000000
331	IMG_0331	572489.7641862	6083091.4363970	629.5456015	7.491797014	-1.365864420	66.130380181	1304589641.000000000	Control	Control	0.2000000

Fig. 18. List of exterior orientation parameters

The program provides possibility to create a block scheme by UAS images if angular exterior orientation parameters of block images are specified with low accuracy or are

unavailable. For this operation it is necessary to use the button of the **Exterior orientation parameters** window toolbox. For each highlighted image the program calculates the direction from previous to next center in a strip (for utmost images of a strip – from adjacent image to the current one) and kappa angle is setup from this direction.

If the survey time is available the correct images order is checked, otherwise images in strips should be located in chronological order only.

In order to eliminate blunders in block scheme building by exterior orientation parameters, perform the following actions:

1. Refine block layout parameters, by performing the following actions:

    1. Choose **Block › Block layout**. The **Block layout** window opens.

    2. Choose the **By ext. or.** mode and click the **Apply** button.

    See a description of block layout creation in the "Aerial triangulation" User Manual.

2. Import exterior orientation parameters from a file of text format once more and refine import parameters.

3. To split images into strips by imported exterior orientation parameters (if any), perform the following:

    1. Choose **Block › Split into strips › By exterior orientation data**. The **Split into strips by exterior orientation** window opens.

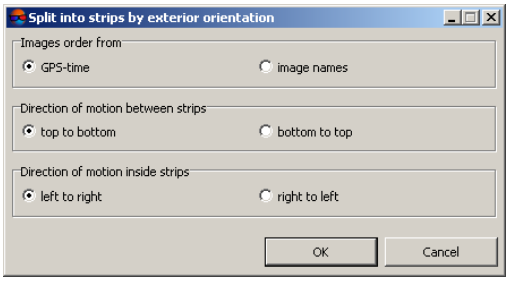


Fig. 19. Split images into strips by exterior orientation

    2. Specify the following parameters of splitting images into strips:

        - **Images order from** by GPS-time or image names;

        If the GPS-time is unavailable for part of images, they add to the separate strip automatically;

- **Direction of motion between strips** – up to down or bottom up;
- **Direction of motion inside strips** – left to right or right to left.

3. Click OK. Block scheme rebuilds by set parameters.

Block scheme, created using exterior orientation is an initial block layout and requires further refining by tie/GC points (see Section 14.1).

14. Relative orientation

Refer to the “Relative orientation of images” chapter of “Aerial triangulation” User Manual for the detailed description of relative orientation of images.

14.1. Automatic measurement of tie points coordinates

14.1.1. Workflow conditions and modes

The system provides possibility to measure tie points coordinates and perform relative orientation in automatic mode. When working in automatic mode correlation algorithm is used for search and measurement of tie points coordinates.

Data required for automatic tie points measurement

To perform automatic measurement of tie point coordinates the following data should be available:

- interior orientation parameters of images, which will be considered in automatic measurement of points coordinates;

  It is highly recommended to perform interior orientation prior to automatic search of tie points, since otherwise most of the filtering parameters are ignored, that considerably reduces relative orientation quality.

- block layout (see the “Aerial triangulation” User Manual)

  Sufficient condition for launch the operation of automatic measurement of tie points coordinates is availability of initial (“rough”) block layout, considering, for example, size of images overlap and/or quick ties data. However, the more data is used for the block layout creation, the more accurate is the block scheme and, hence, the better the results of measurement of tie points coordinates in automatic mode.

Modes of automatic measurement of tie points coordinates

The **Automatic tie points measurement** window have different configurations, provided to process various data types:

When working with airborne data the window allows to select manually optimal combination of basic and additional parameters of automatic ties search, measurement and filtering, and also to save sets of this parameters as files with `*.x-ini` extension for the further usage.

When working with UAS data the window allows to load parameters sets for automatic ties search, measurement and filtering (so called “presets”).

Preset – parameters set of automatic tie points measurement, preliminary created by user or setup in advance.

Order of automatic tie points measurement

To measure tie points using automatic mode (на примере airborne data) perform the following:

1. Create a block layout considering available data.

   Parameters of inter-strip stereopairs forming have a significant impact on automatic tie points measurement and on further adjustment.

   You can configure parameters of inter-strip stereopairs forming in the **Parameters** window (**Service › Settings**) on the **Block scheme** tab, **Forming interstrip stereopairs** section.

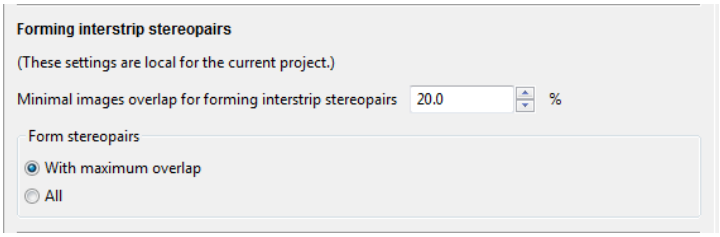


Fig. 20. The “Forming interstrip stereopairs” section of the “Block scheme” tab of the “Settings” window

   - When specifying the **Minimal images overlap for forming interstrip stereopairs** parameter, the user should correctly estimate the interstrip overlap value (in case of “bad” overlap high values of this parameter will lead to the fact that interstrip ties will not be measured);
   - The **Form stereopairs** parameters allows to choose, which stereopairs with specified overlap will be formed – **all** or **with maximum overlap**. If the **all** option is selected, it allows to considerably increase the number of measured interstrip points, with significantly increased time costs.

2. Setup parameters of tie points automatic measurement, transfer, filtering and start the operation of automatic measurement of tie points coordinates.

3. Perform accuracy estimation of relative orientation and detecting of tie points measurement errors.

4. Manually eliminate errors of tie points measurement in the **Points measurement** module or choose other filtering parameters (for example, specify more “strict” tolerances for measurement errors) and start the operation of automatic measurement of tie points coordinates once more.

5. Update block layout considering tie points. Change settings of automatic tie point measurement parameters if necessary and start once more operation of further collecting of tie points measurements. Repeat steps 3-4 until obtain satisfactory results.

14.1.2. Automatic tie points measurement on aerial survey data

Automatic measurement of tie points coordinates

To measure tie points coordinates in automatic mode perform the following actions:

1. Choose **Orientation › Automatic tie point measurement › Aerial survey**. **Automatic tie points measurement** window opens.

   For automatic measurements all images are selected by default. For tie points search just on selected images clear the checkbox **Select all images for automatic tie point measurement** on the **Orientation** tab of the **Parameters** window.

2. Use default setting of measurement parameters or set manually the main parameters for tie points search, measure and filter.

3. [optional] For more detailed tuning and refining of the main measurement parameters set the additional parameters.

4. [optional] In order to use distributed processing during measurement of tie points coordinates, perform the following actions:

   1. Click the **Distributed processing...** button. The **Distributed measurement of tie points** window opens.

      The **Maximum number of tasks for this project** value is displayed in the window. This parameter shows how many processing tasks is possible to divide the current project to.

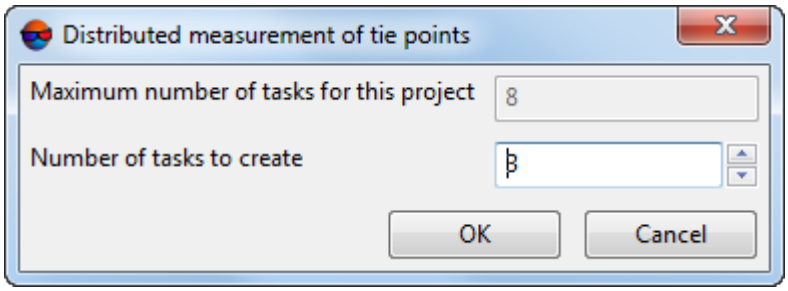


Fig. 21. Parameters of distributed measurement of tie points in automatic mode

2. Specify the **Number of tasks to create**, which will be processed on one computer. See the description of distributed processing setup in the General information User Manual.

3. Click OK to go back to previous window.

5. Click the **Start** button in the **Automatic tie points measurement** window to start operation of automatic measurement of points coordinates.

6. Open the relative orientation report to view results of relative orientation operation and to fix measurement errors.

Main parameters of tie points measurement

The **Automatic tie points measurement** window allows to use presets of tie points measurements, or manually choose optimal combination of basic and additional parameters for automatic search, measurement and filtering of tie points.

Choose **Orientation › Automatic tie point measurement › Aerial survey**. The **Automatic tie points measurement** window opens.

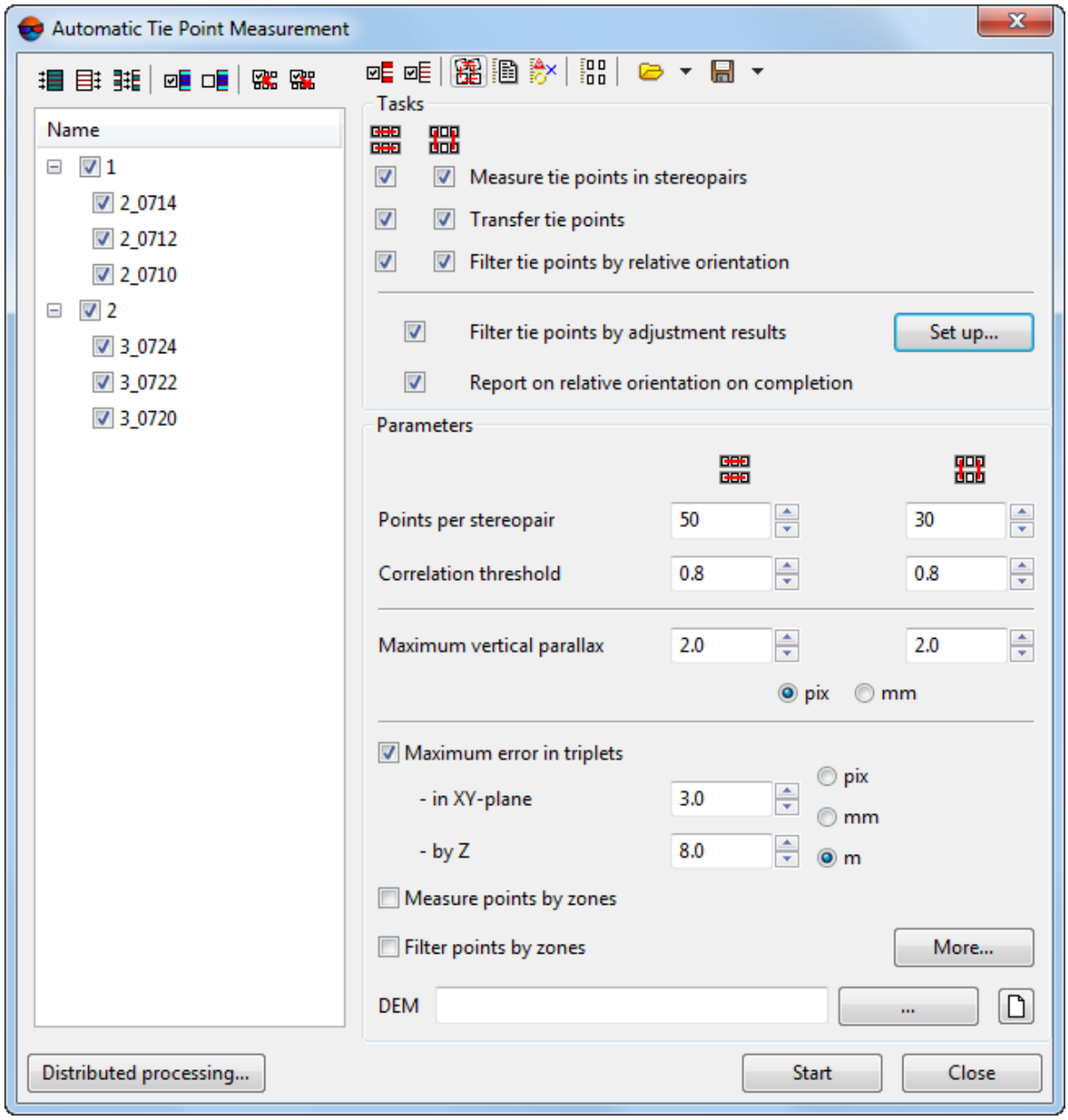


Fig. 22. The “Automatic tie points measurement” window

The **Automatic tie points measurement** window includes the following interface elements:

- the images selection toolbar used to open auxiliary windows, to save and load sets of parameters;
- a list of project images allows to select images, scheduled to perform automatic measuring of tie points coordinates;

- the **Tasks** section used to specify main actions (measurement, transfer, filtering, reporting) during operation of automatic measuring of tie points coordinates;
- the **Parameters** section used to specify main parameters of automatic measuring of tie points coordinates;
- the **More** button used to setup additional parameters of measuring of tie points coordinates;
- the **Start** button used to launch an operation of tie points measurement and to perform relative orientation in automatic mode;
- the **Distributed processing** button is used for automatic tie points measurement in distributed processing mode.

The system provides the following buttons in the toolbar to work with auxiliary windows:

- – allows to select triplets without tie points for repeated measures (these points are marked as “not performed”), and their adjacent images (it allows optimize the measurement time points);
- – allows to select stereopairs where there is no tie points coordinates measurements, and their adjacent images;
- – allows to open the **Block layout** window to create a block layout or update it;
- – allows to open the **Relative orientation report settings** window used to specify parameters and view a relative orientation report;
- – allows to open the **Triangulation points** window used to view a list of triangulation points;
- – allows to open the **Points measurement** module and open automatically open images selected in the list, if more than 6 images are chosen. Otherwise, an in-strip stereopair with image selected in the list will be opened.

To save and load sets of main and auxiliary parameters the system provides the following buttons:

- – is used to load a set of parameters from `*.x-ini` file saved previously in active profile resources or out of them.

  The arrow located next to the button allows to open a drop-down menu containing the following items:

  - **Load settings from file** allows to open the **Load settings** window used to load a set of parameters from `*.x-ini` file, located out of active profile resources;

- **Reset settings to defaults** allows to use default settings;

-  – used to save setting of main and additional parameters to a file with `*.x-ini` extension in active profile resources.

To save setting to a file with `*.x-ini` extension located out of active profile resources, open drop-down list by clicking the arrow next to the  button and choose **Save settings to file...**.

Setting saving is used to create files with settings directed to work with certain type of block, kind of images, or terrain, etc.

The **Tasks** section is used to specify the following actions during automatic tie points measurement:

- **Measure tie points in stereopairs** allows to perform search and measurement of tie points coordinates on in-strip and inter-strip stereopairs;

A stereopair is called in-strip, if it is formed by two adjacent images in a strip, and *inter-strip* is any other stereopair of a block.

- **Transfer tie points** allows to perform transfer of measured points to adjacent stereopairs (transfer of points located in triple overlap area to adjacent models), and transfer of tie points to adjacent strips;

- **Filter tie points by relative orientation** allows to perform points filtering that have measurements, exceeding specified values of errors thresholds;

Points check if to filter them or not, is performed sequentially by errors type – first check - whether the point falls within specified correlation threshold, then whether it does not exceed maximal vertical parallax value, and finally, search for triplet errors is performed, if the appropriate option is specified.

Check for exceeding correlation threshold is applied *only to new points* (if measured points are already available). In order to check *all* points whether they exceed correlation threshold, set the additional **Delete points with correlation below threshold** checkbox on the **Rejection** tab in the **Tie point measurement parameters** window of additional parameters.

It is possible to perform actions with tie points inside strips, between strips, or not perform at all.

- **Filter tie points by adjustment results** allows to perform automatic block adjustment using specified parameters and to filter measured tie points after that;

Points filtering using adjustment results is applied if there are blunders on images between strips. The filtering is performed using residuals tolerance specified in the **Adjustment parameters** window, see the “Block adjustment” User Manual.

- **Report on relative orientation on completion** allows to open the **Relative orientation report** window automatically to view and edit tie points measurements just after completing of automatic relative orientation.

The **Parameters** section allows to make the following settings of automatic measurement of tie points coordinates:

- **Points per stereopair** – allows to specify a number of points to be measured on in-strip and inter-strip stereopairs;

  Resulting amount of measured points may be either greater than a predetermined amount – because of points transfer from adjacent stereopairs, or less due to further filtering. Default amount of points is 30 per each images pair in forward overlap and 10 points in side overlap. The minimum number of points to perform control by the vertical parallax residual – 6 points.

  The **Points per stereopair** parameter depends on settings defined on the **Miscellaneous** tab in the Tie point measurement parameters window.

- **Correlation threshold** (%) – minimal acceptable value of correlation coefficient for tie points, that will be selected during automatic search;

  Recommended values lie in range from 90 to 95%. In contrast to all other filtering criteria, this parameter directly influences on operation of points measurement and transfer. Check for exceeding of correlation threshold is performed only for new points (if there are already measured points). To check all measured points for exceeding of correlation threshold (usually, at final stage of collecting measurements of tie points) set the additional **Delete points with correlation below threshold** checkbox on the **Rejection** tab in the additional parameters window.

- **Maximum vertical parallax** (in pixels or mm) – threshold value for rejection executed after points measuring/transfer. On each step of rejection process, the program searches for the point with maximal Y-parallax on the stereopair and rejects it. After that, it makes relative orientation once more and the iteration is executed until maximal Y-parallax exceeds the parameter specified here, or until 6 points or less remain on stereopair. Recommended value is a pixel size;

- **Maximum error in triplets in XY-plane and by Z** (in pixels, meters or mm) – threshold discrepancy of points measurements on adjacent stereopairs in triple overlapping zone of adjacent images in a strip. Use the following formula to calculate values of acceptable errors in triplets:

  $E_{max} \approx 2 \quad E_{mean}$, where E_{mean} – acceptable mean error.

  Mean triplet errors in XY plane is calculated using the following formula:

  $RMS \approx \sqrt{2} \quad E_{mean}$

Mean error by Z equals the mean error value in XY plane multiplied by the ratio of focal length (f) to survey basis (b):

$$E^{z}_{mean} = \frac{f}{b} \quad E^{xy}_{mean}.$$

- **Measure points by zones** – allows to apply a method of sequential measurement by zones of overlap area. If the checkbox is cleared, points search is performed over the whole area of images overlap. The system allows to select zones and define their size in the **Zones** section on the **Miscellaneous** tab of the additional parameters window;

- **Filter points by zones** – is used to filter points in stereopair zones sequentially;

  The operation provides filtering the worst (by parallax) points on stereopair, passing zone by zone one after another. So the worst point on stereopair is found and deleted first, then the worst one in the next zone and so on. Uniformity of point's distribution on stereopair is also verified in such a way.

- **DEM** – allows to choose a DEM (if any) to consider its data during automatic tie points measurement. For this it is necessary to have saved adjustment results available.

  This parameter allows to use DEM for calculation of the true position of the point. Thereby the required search area of points reduces.

  Click the button to clear a DEM.

Additional parameters of automatic measurement of tie points coordinates

For more detailed setup and adjustment and refinement of the basic parameters of tie points coordinates measurement the **Tie point measurement parameters** window of additional parameters is used. It is opened using the **More** button located in the main **Automatic tie point measurement** window.

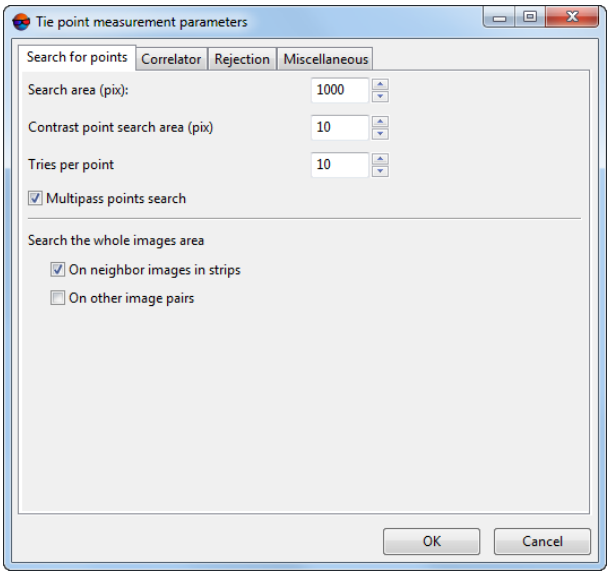


Fig. 23. Points search parameters

The **Tie point measurement parameters** window contains four tabs with parameters.

To reset to default parameters, delete the *ProjCorrMatchOptions.x-ini* file located in the project root folder.

The **Search for points** tab allows to setup the following parameters:

- **Search area** (pix) – allows to specify a “halfsize” of area of matching point search;
- **Contrast point search area** (pix) allows to search tie points in areas with maximal contrast (on images with clear objects outlines);

In some cases it is reasonable to measure points in areas with low contrast, for example, when forested areas have maximal contrast, and in these areas correlator’s errors are very probable. In this case the **Contrast point search area** value should be set to 0.

- **Tries per point** – number of tries of matching point search with correlation coefficient value that exceeds specified in the search area;
- **Multipass points search** allows to perform points search and filtering on stereopairs in multiple passes with help of different algorithms. It is applied in case of insufficient quality of the block layout, when real relative rotation of images relative to each other is sufficiently big;

For multipass points search it is recommended to set correlation threshold high enough, for example, 95%.

It is recommended to use multipass points search for UAS images.

- **Search the whole images area** allows to specify images pairs to search points: adjacent images in each strip and/or non-adjacent pairs of images in a strip and inter-strip pairs of images.

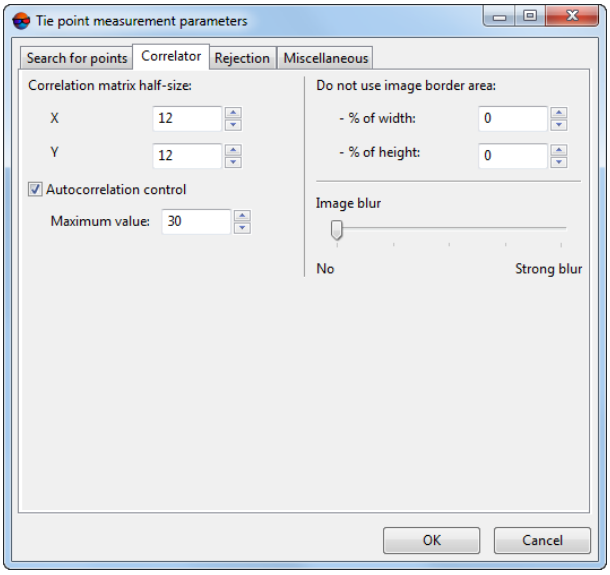


Fig. 24. Parameters of correlator

The **Correlator** tab is used to setup parameters of area correlator work and contains the following parameters:

- **Correlation matrix half size** (pix) allows to specify size of correlation matrix by X and Y axes;

- **Autocorrelation control** allows to specify level of auto-correlation – the **Maximum value** of sigma in Gaussoid that is the top limit of distribution of the mask correlation coefficient in a small area on the same image. The more the sigma value, the less probability of correct points measurement, which were measured using correlation with the given point as an initial one;

- **Do not use image border area** is used to specify a size of area near the image border, that is not used during correlation operation;

  Service area width (2% of image width and height by default) should not be less than on the image; otherwise a big amount of “bad” points would be measured in image service areas.

- the **Image blur** slider is used to consider image material quality, from **No** to **Strong blur**.

  For images without blur or with negligible blur it is *highly not recommended* to place the slider to position different from **No**.

In most cases the **Image blur** parameter is applied for processing of UAS images block.

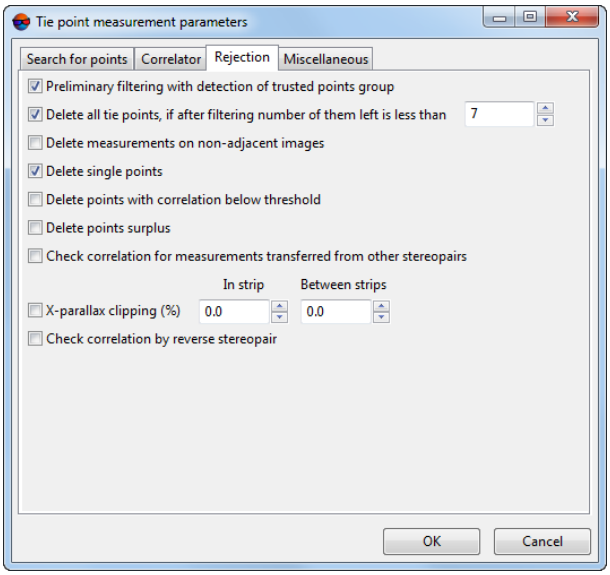


Fig. 25. Filtering parameters

The **Rejection** tab is used to setup filtering parameters of points found and contains the following options:

- **Preliminary filtering with detection of trusted points group** is used to preliminary filtering of blunders, that do not allow calculate correctly angular elements of relative orientation (see the parameters of trusted points group on the **Miscellaneous** tab);
- **Delete all tie points, if after filtering number of them left is less then** specified number – allows to delete *all tie points on a stereopair*, acquired during operation of automatic measurement of points coordinates, if after their filtering their number is not sufficient to perform correct relative orientation;
- **Delete measurements on non-adjacent images** allows to filter potentially erroneous points, measured on non-adjacent images inside a strip;

  To measure tie points for UAS images *in two steps* it is recommended to set the **Delete measurements on non-adjacent images** checkbox on the first step and to not to use this parameter on the second step.

- **Delete single points** allows to reject points measured on single images;
- **Delete points with correlation below threshold** allows to delete points previously measured using correlator, if their correlation coefficient in below threshold value specified in the **Correlation threshold** field of the **Automatic tie point measurement** window;

It is recommended to use the option for recurrent or final points filtration, since the filtering covers *all* measured points, not only new ones, added during just another start of automatic tie points measurement operation.

- **Delete points surplus** allows to delete points, if their number exceeds number specified in the **Points per stereopair** field of the **Automatic tie point measurement** window, sorted by the Y-parallax in descending order;

The parameter considers whether the **Filter points by zones** checkbox is marked, that allows to delete points evenly. It is recommended to use the option after the initial tie points measurement on UAS images.

The points are deleted regardless of type and number of measurements per point (the system may delete both GC point and the points in triple overlap).

- **Check correlation of measurements transferred from other stereopairs** is used to check on each stereopair correlation coefficient of measurements, collected during points transfer from other stereopairs, since the chain of such transfers may lead to errors accumulation and bring unacceptable result;
- **X-parallax clipping** (%) allows to specify number of points with minimal and maximal x-parallax (relatively to total amount of points) which will be deleted after filtering **in strip** and **between strips**.

It is recommended to apply this rejection method if erroneous points are dispersed clearly along stereopair basis (if, for example, a highway with bright marking goes in parallel to survey basis and correlator puts points on marking line elements, which do not correspond with each other.

- **Check by reverse stereopair** –allows to check the search results on reverse stereopair; if the results are not equal, point deletes;

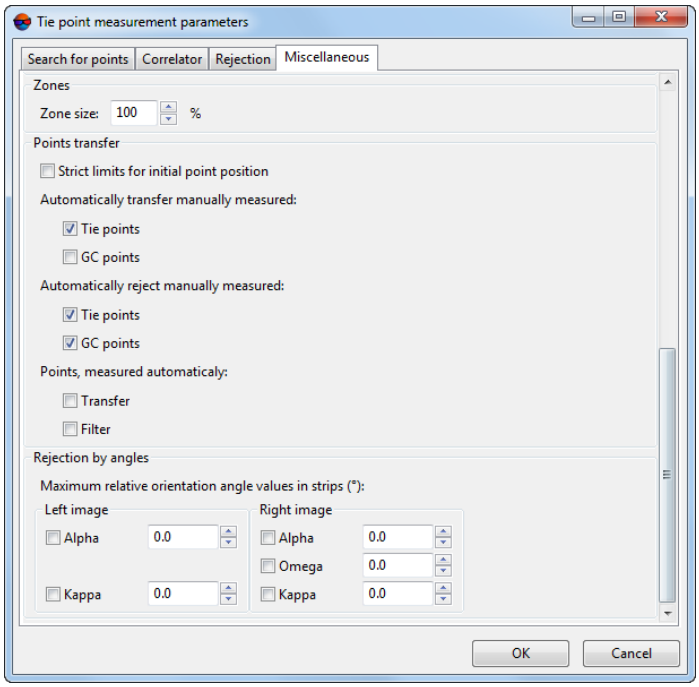


Fig. 26. Miscellaneous parameters

The **Miscellaneous** tab contains sections and options to setup the following additional parameters:

- **Number automatically measured points starting with** is used for automatic numbering of measured tie points starting with number, specified in the entry field, that allows to distinguish these points from the ones already measured on the project images;

  Regardless of the set value, the system does not generate points with duplicate numbers. If the point with some number already exists, then this number will be skipped when creating new points.

- **Minimum distance between points** (pix) allows to specify minimal distance in pixels between points measured on the image;

  It is recommended to increase the value of this parameter, when the problems with block adjustment occur. The parameter is considered only during measurement new points. Existing tie points are not rejected.

- **Minimal dispersion** allows to specify minimal dispersion of mask to protect from points search on the clouds and water bodies;

  The option is used to exclude points in monotonous areas, for example, for satellite scanner images, if there are black strips on images borders, and for overexposure due to cloudiness.

- **Pyramid level for preliminary search** (only for central projection images) – allows to choose an image pyramid level used to preliminary search of points. If the checkbox is set on, preliminary search is performed by source image;

- **Fixed search sequence** – allows to obtain the same results of automatic measurement of tie points coordinates during multiple runs of the operation with the same initial parameters;

- **Use automatic block layout results** allows to use the block layout results, automatically created for UAS images;

  If the automatically generated block layout is available, then during automatic measurement of tie points coordinates information from current block scheme is not used, and the **Search the whole images area** parameter is also ignored. The default search parameters are used only (considering data of automatic block layout).

- **The "Points per stereopair"** parameter influences on the **Points per stereopair** parameters located in the **Automatic tie point measurement** window and allows to select the following number of points:

  ○ **Points to add per session** – values specified in the main window, that mean a number of *new* points, which will be added to already measured ones;

  ○ **Target number of points on a stereopair** – values specified in the main window, that define *total* points number;

  The resulting number of measured points may be both greater than a predetermined amount – due to points transfer from adjacent stereopairs, and less due to the subsequent rejection of points. Default value is 30 points on each in-strip images pair, and 10 points – in inter-strip overlap. The minimum number of points to control the vertical parallax residual is 6.

- parameters which allow to specify *trusted points group* to be used as a master sample for points rejection (see the **Preliminary filtering with detection of trusted points group** parameter on the **Rejection** tab). A group of points is considered as trusted if the following two conditions are met during the points search:

  1. The distance between the point on one image and the corresponding point on another image should not exceed the parameter specified in the **Maximum spread radius within trusted points group** input field.

  2. Number of points found, which satisfy to the first condition should not be less than the parameter specified in the **Minimum trusted points group size** input field.

  If a trusted group has been found, it supposedly means that angles of relative orientation have been computed correctly and the points rejection can be performed using these data. Otherwise, the rejection of points will not be executed, even if the **Prelim-**

inary filtering with detection of trusted points group checkbox is set on the **Rejection** tab.

The **Maximum points to use filtering by trusted group** parameter is used to specify the limitation on the number of points to reject.

It is recommended to set the **Maximum points to use filtering by trusted group** value from 40 to 60. It is not recommended to set more than 60 points.

The **Stereopairs** section contains the following parameters:

- **Create stereopairs based on exterior orientation data, from images, projection centers of which are within range of** – if this option is checked, the stereopairs will be composed from images, projection centers of which are located at the distance no more than a specified value (in meters), otherwise, the stereopairs are composed from nearest images in a strip.
- **From different strips only** – if this option is checked, the in-strip stereopairs will not be considered. Otherwise, all in-strip stereopairs will be considered, including the nonadjacent.

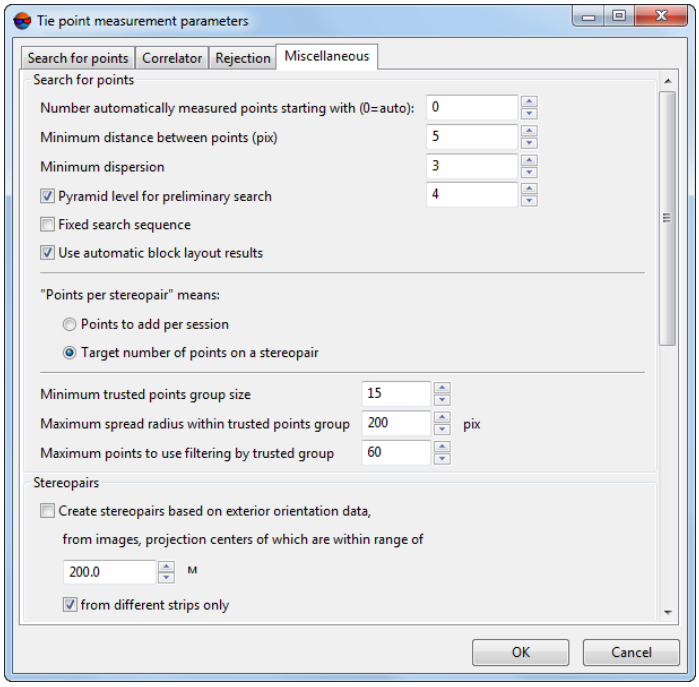


Fig. 27. Miscellaneous parameters

The **Zones** section allows to define a zone size on a stereopair, where the system performs automatic search and measurement of tie points coordinates. Refer to the "Aerial triangulation" User Manual for information about recommended zones.

The **Points transfer** section contains the following parameters:

- **Strict limits for initial point position** – if the checkbox is set, the system performs search for a point *only inside* of image, otherwise, the search is possible out of the image boundary, if the **Search area** parameter value on the **Search for points** tab exceeds the image size.
- **Automatically transfer manually measured** – allows to transfer tie and/or GCP, measured manually.
- **Automatically reject manually measured** – if the checkbox set on, tie and/or GC points manually measured are not transferred.
- **Points, measured automatically** – allows to **transfer** and **filter** GC points, measured automatically.

If checkboxes for filter are set on, but checkboxes for transfer are set off, filter does not perform, because there is no transfered points.

The **Rejection by angles** section allows to specify parameters of measured points filtering by single or multiple relative orientation parameters of the right or left image.

In some cases after automatic measurement of tie points coordinates due to erroneous points the images are rotated in a block and their relative orientation parameters are calculated incorrectly. To prevent images rotation the filtering of measured tie points by the values of the rotation angle is used. To do this it is necessary to change angles threshold value (in degrees) for each of stereopair elements. As a result, the points which cause exceeding of angles thresholds will be rejected after relative orientation recalculation.

It is not recommended to use this method of rejection for blocks, in which the images can actually be rotated in relation to each other, since in this case the likelihood of removing properly placed tie points increases.

14.1.3. Automatic tie points measurement on UAS data

Automatic measurement of tie points coordinates

To measure tie points coordinates in automatic mode perform the following actions:

1. Choose **Orientation › Automatic tie point measurement › UAS**. The **Automatic tie points measurement** window opens.

For automatic measurements all images are selected by default. For tie points search just on selected images clear the checkbox **Select all images for automatic tie point measurement** on the **Orientation** tab of the **Parameters** window.

2. Use default settings of measurement parameters (*presets*) or set manually the main parameters for tie points search, measure and filter.

3. [optional] Specify the adjustment parameters, if it is necessary to perform the adjustment on the current project step, otherwise – clear the **Make block adjustment** checkbox..

4. [optional] In order to use distributed processing during measurement of tie points coordinates, perform the following actions:

    1. Change settings and run the distributed processing server/client (see the "*Distributed processing*" chapter in the "General information about system" User Manual).

    2. Click the **Distributed processing...** button. The **Distributed processing settings** window opens.

        Specify the **Maximum number of parallel tasks** value is displayed in the window. This parameter shows how many processing tasks is possible to divide the current project to.

        In case the workstation processor supports the *hyperthreading technology*, it is recommended to reduce the **maximum number of parallel tasks** by half in order to ensure system's stability.

        Hyper-threading (hyper-threading technology) is simultaneous multithreading implementation used to improve parallelization of computations. With HTT, one physical core appears as two processors to the operating system, allowing concurrent scheduling of two processes per core.

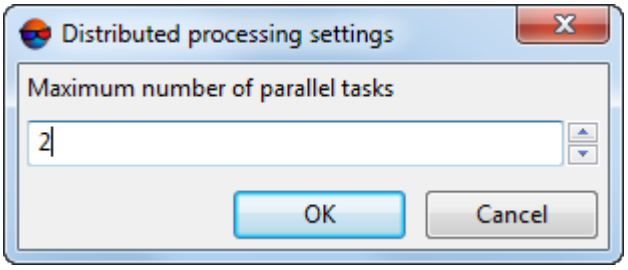
        

        Fig. 28. Parameters of distributed measurement of tie points in automatic mode

    3. Click OK to go back to previous window.

5. Click the **OK** button in the **Automatic tie points measurement** window to start operation of automatic measurement of points coordinates.

6. Open the relative orientation report to view results of relative orientation operation and to fix measurement errors.

Main parameters of automatic tie points measurement

The **Automatic tie point measurement** window allows to use parameters presets of tie points measurement, or to manually choose the optimal combination of basic and additional parameters for automatic tie points search, measurement and filtering.

Choose **Orientation › Automatic tie point measurement › UAS**. The **Automatic tie points measurement** window opens.

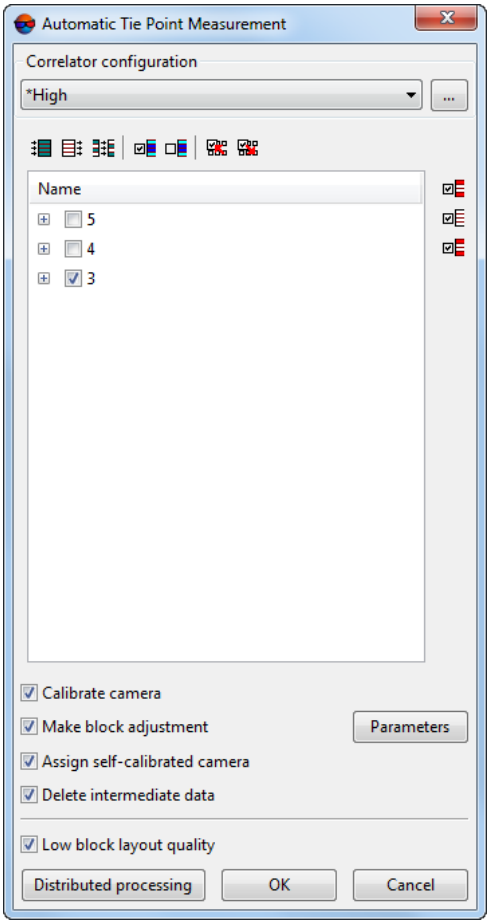


Fig. 29. The “Automatic tie points measurement” window

The **Automatic tie points measurement** window includes the following interface elements:

- the images selection toolbar used to open auxiliary windows, to save and load sets of parameters;
- a list of project images allows to select images, scheduled to perform automatic measuring of tie points coordinates;
- the **Correlator configuration** section is used to load, create and edit sets of parameters of automatic tie points measurement;

- the **Parameters** button is used to setup block adjustment parameters;

  During adjustment, at the stage of automatic tie point measurement, default adjustment **parameters** are to be changed:

  - **Point on image measurement precision (RMS)** (for **manual measurements** and **automatic measurements**, see the "Bundle adjustment method" chapter in the "Block adjustment" User Manual) is equal to the **Maximum vertical parallax** (in pixels) value set in the *preset* determining automatic tie point measurement parameters (see below).

    Values of **Maximum vertical parallax** (in pixels) for various presets:

    - **Low** correlator accuracy – 4;
    - **Medium** correlator accuracy – 2.50;
    - **High** correlator accuracy – 1.50;
    - **User preset** – set by user.

  - The **Perform direct georeferencing** checkbox is cleared (see the "Method of initial approximation by a block scheme" section in the "Block adjustment" User Manual);

- the **OK** button used to launch an operation of tie points measurement and to perform relative orientation in automatic mode;

- the **Distributed processing** button is used for automatic tie points measurement in distributed processing mode.

The system provides the following buttons in the toolbar to work with auxiliary windows:

- – allows to select stereopairs where there is no tie points coordinates measurements, and their adjacent images;

- – allows to select triplets without tie points for repeated measures (these points are marked as "not performed"), and their adjacent images (it allows optimize the measurement time points);

- – allows to select *interstrip* stereopairs where there is no tie points coordinates measurements, and their adjacent images;

To configure automatic tie points measurement and (optionally) for further adjustment procedure the following parameters are used:

- [optional] clear the **Calibrate camera** checkbox if camera calibration has already done and is not needed;

  It is recommended to clear the **Calibrate camera** checkbox only if there is reason to trust the camera calibration (see the chapter "Interior orientation" chapter of the current User Manual). It is necessary to consider, that if the calibration was not carried out in actual oper-

ating conditions, then significant discrepancies in the obtained calibration parameters may occur.

If *polyplets* (sets of several overlapped images located on different strips) are not found, one of camera calibration stages (calibration by polyplets) will be skipped (an appropriate warning message will appear). Other calibration stages will be carried out.

- [optional] clear the **Make block adjustment** checkbox if the adjustment operation is not necessary at this stage of the project;

The **adjustment parameters** are described in the "Block adjustment" chapter of the current User Manual.

- [optional] clear the **Assign self-calibrated camera** checkbox if needed (see the "Using self-calibration" chapter of current User Manual);
- [optional] clear the **Delete intermediate data** checkbox to not to delete processing data after computation is complete. It is recommended to leave the checkbox set if automatic re-measurement of tie points coordinates is not planned;

The intermediate processing data may occupy a significant.

Sufficient condition for launch the operation of automatic measurement of tie points coordinates is availability of initial ("rough") block layout. In this case it is not recommended to clear the **Low block layout quality** checkbox.

The **Correlator configuration** section is used to load, create and edit *sets of parameters of automatic tie points measurement*;

- the download button in the right part of the **Correlator configuration** section allows to open the **Correlator precision** window, which contains a list of available (both predefined and user-created) presets and the following buttons:

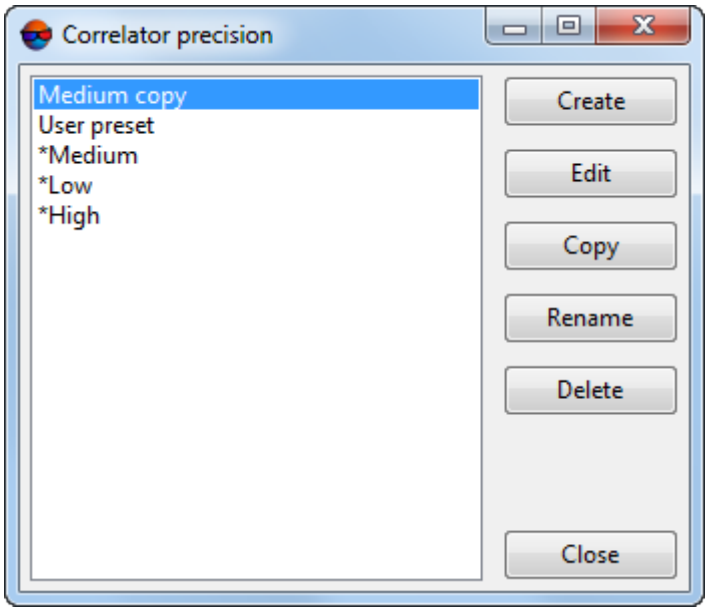


Fig. 30. The “Correlator precision” window

- **Create** – allows to create a custom preset – set of parameters of automatic tie points measurement. Click the **Create** button to open the **Enter entry** window, where user should enter a name for a preset to be created (default *user preset*).

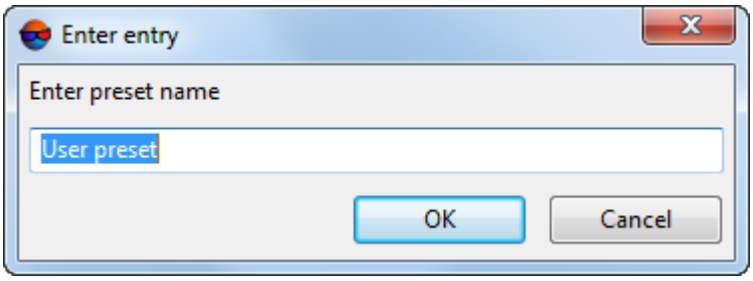


Fig. 31. The “Enter entry” window

It is not allowed to create presets with identical names. When you try to create presets with identical names, the system opens a window with a corresponding error message.

Clicking the OK button opens the **Edit parameters** window, where you should manually specify the following parameters:

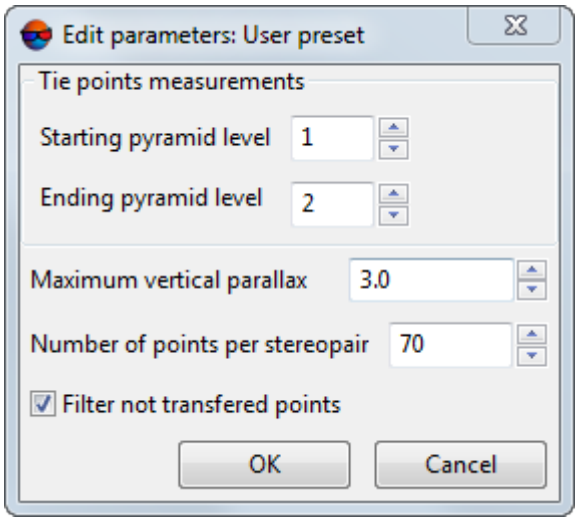


Fig. 32. The “Edit parameters” window

- **Starting pyramid level** – it is recommended to increase the value of starting pyramid level when system performance is insufficient, and when there is no high requirements to processing results accuracy. Recommended value of starting pyramid level is 1. The value of the starting pyramid level that equals to zero provides maximum accuracy of the results, but leads to increasing of data processing time;

- **Ending pyramid level** – it is recommended to increase the value of ending pyramid level when using data with different resolution (including cases of significant difference in spatial resolution within *one* image);

  For example, when using data which resolution varies 2 times, it is recommended to increase the default value of the ending level of the pyramid on the one.

- **Maximum vertical parallax** (in pixels or mm) – threshold value for rejection executed after points measuring/transfer. On each step of rejection process, the program searches for the point with maximal Y-parallax on the stereopair and rejects it. After that, it makes relative orientation once more and the iteration is executed until maximal Y-parallax exceeds the parameter specified here, or until 6 points or less remain on stereopair. Recommended value is a pixel size;

- **Points per stereopair** – allows to specify a number of points to be measured on in-strip and inter-strip stereopairs;

  The resulting number of measured points may be both greater than a predetermined amount – due to points transfer from adjacent stereopairs, and less due to the subsequent rejection of points. Default value is 30 points on each in-strip images pair, and 10 points – in inter-strip overlap. The minimum number of points to control the vertical parallax residual is 6.

- Set the **Filter non-transferred points** checkbox on to reject points located on inter-strip stereopairs. A point will be filtered, if the system recognizes it on a single image of some strip.

When you click OK, the system creates a new user preset – a set of parameters used for automatic tie points measurement.

- the **Edit** button allows to open the **Edit parameters** window to change settings of the selected preset.
- the **Copy** button allows to copy a preset.
- the **Rename** button allows to rename a preset.
- the **Delete** button allows to delete a preset.
- the **Close** button allows to close the **Correlator precision** window.

- The arrow to the right of the button which opens the **Correlator precision** window allows to open a drop-down list, used to select one of the following presets.

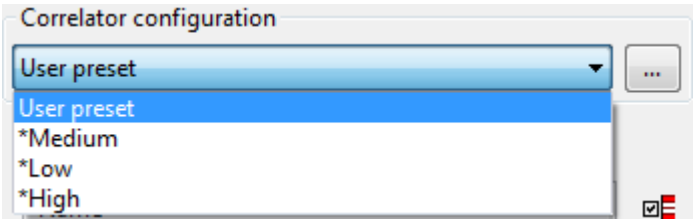


Fig. 33. Presets drop-down list

- The system provides a set of predefined presets, allowing to vary the accuracy settings of automatic tie point measurements. Predefined presets are marked by the asterisk symbol "*" – **Low**, **Medium** and **High** correlator accuracy.

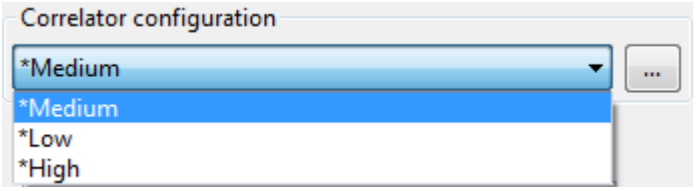


Fig. 34. Presets drop-down list

The system does not allow the user to edit the predefined presets. A copy of the predefined preset is available for editing, as well as a custom preset.

15. Ground control points

Refer to the “Aerial triangulation” User Manual for the detailed description of the **Points measurement** module and **Triangulation points** window.

15.1. Import of GCP catalogue

The system provides import of GC points coordinates list from file with `*.csv` or `*.txt` extension.

Refer to the “Import of triangulation points from X-points” chapter for the description of the GC points import from file with `*.x-points` extension.

To perform import of GC points coordinates list from file perform the following actions:

1. Click the  **Import catalog** button on the **Aerial Triangulation** tab of the main toolbar.

2. Select a file containing GCP catalogue and click OK. The **Import GCP catalogue** window opens.

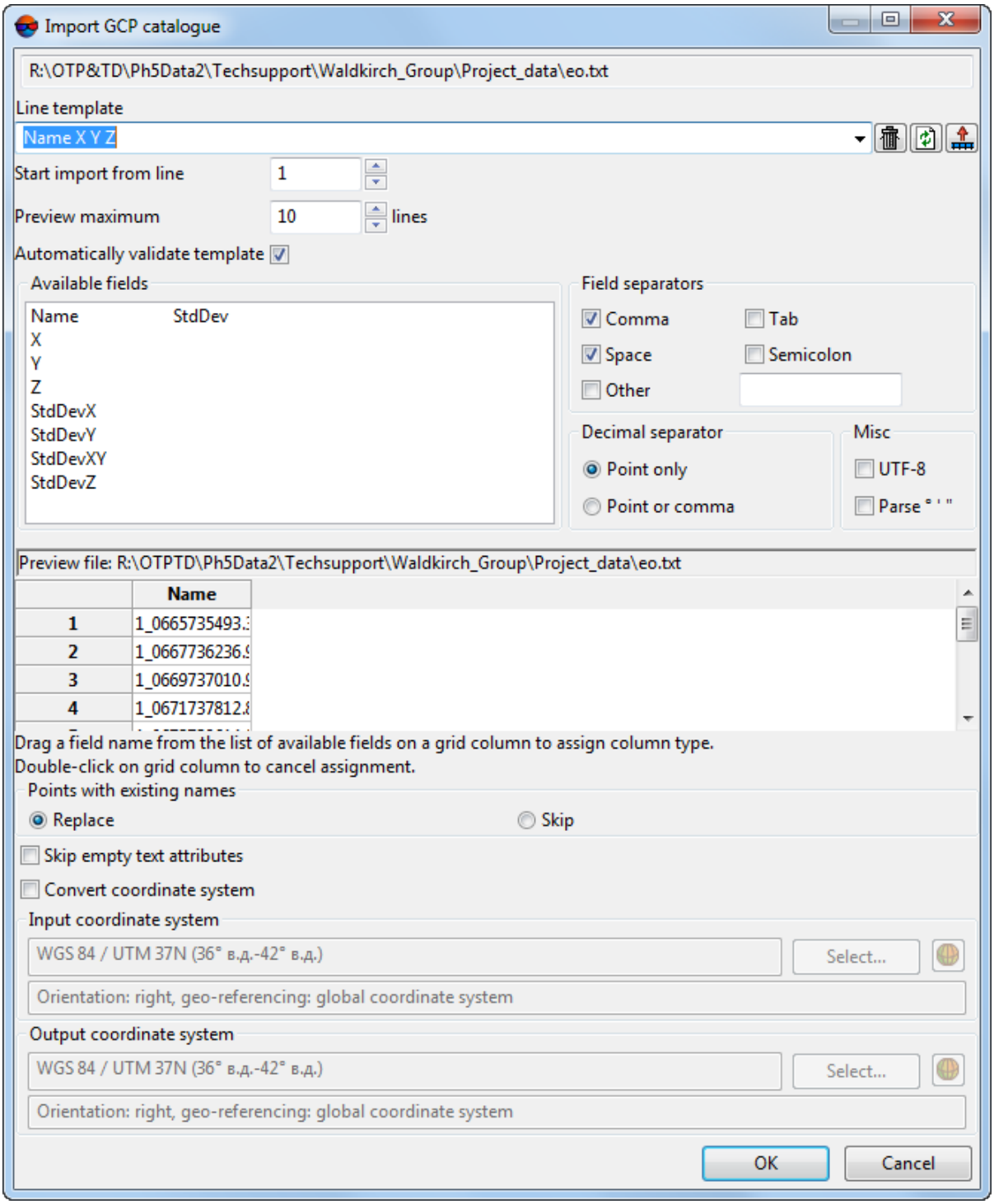


Fig. 35. Import of GCP catalogue

3. The **Line template** field displays a list of fields, contained in each line of the import file:

   - `Name` – object's name;

If imported file does not contain a column with GCP names (numbers), then after import operation the names like *Point0001* are assigned to the points automatically.

- `X Y Z` – values of GC point coordinates by X, Y, Z;
- `STDDEVX`, `STDDEVY`, `STDDEVZ` – accuracy of coordinates measurements by X, Y, Z axes (RMS);
- `*` – missed field during import.

All objects are saved using the same template. Each line of a file contains the same number of fields, that equals to number of fields in template. Lines which does not correspond to the template, are skipped. To all vertexes two (for 2D objects import) or three coordinates are specified.

In order to setup active template, perform one of the following actions:

- drag a field name from the **Available fields** list to the **Preview file** table column. After that the template in the **Line template** field is changed. To cancel a field selection, double click the **Preview file** table column;
- change a template manually in the **Line template** field. After that column types in the **Preview file** table will be changed automatically.

The  button is used to return to default template `Name X Y Z`.

The  button is used to compare the **Line template** field with data shown in the **Preview file** table.

Active template corresponds only lines shown in the **Preview file** table.

The  button is used to replace specified fields names with fields names from the first line of the **Preview file** table. It is possible to specify any names for vectors import.

For import of laser scanning data the field names from the list of available names are specified.

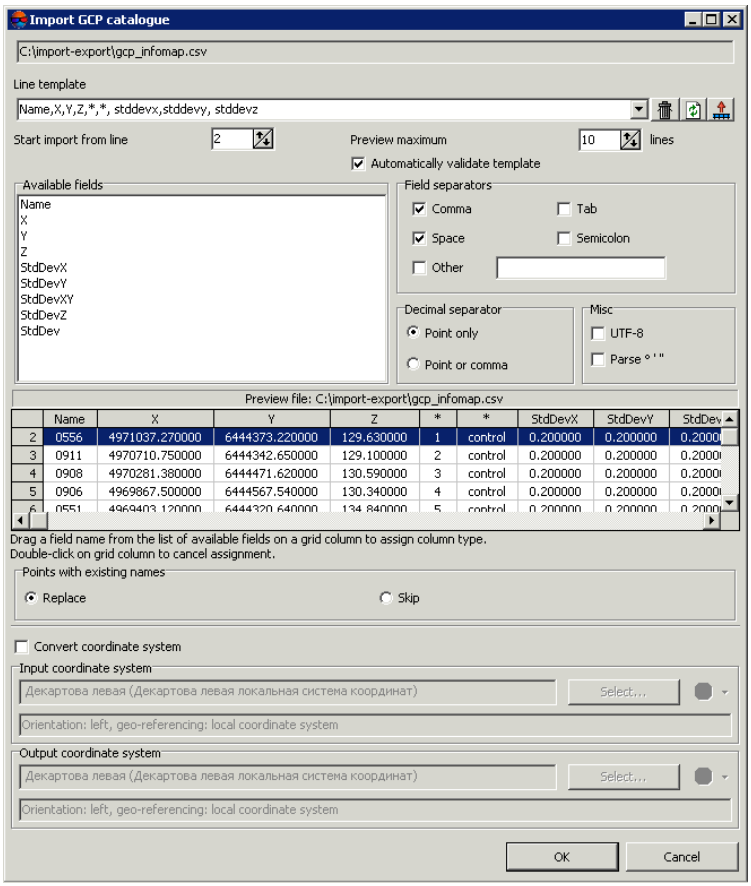


Fig. 36. Setup of a template sample

4. [optional] For automatic selection of current template the **Automatically validate template** checkbox is set by default. In order to setup a template for a file that contains lines with different number of columns, clear the **Automatically validate template** checkbox and setup the template manually in the **Line template** field.

5. [optional] In order to define a line from which to start data import, input the line number to the **Start import from line** field.

6. [optional] In order to display necessary number of lines in the **Preview file** table, set the **Preview maximum** parameter. 10 lines are displayed by default.

7. In the **Available fields** section select desired field name and drag it on a table column. To cancel the selection of the field name double click the column header.

8. In the **Field separators** section set single or multiple checkboxes to specify field separators in the file: **comma**, **space**, **tab**, **semicolon** or **other**. The comma and space are set by default.

9. In the **Decimal separator** section set the following parameters:

- **Point only** – to use only a point as a decimal separator in coordinates;
- **Point or comma** – to use both a point and a comma as a decimal separator in coordinates.

If the **Field separator** is selected as a comma, it is not recommended to specify the **Decimal separator** as a comma, since objects with incorrect coordinates will be created after import operation.

10. In the **Misc** section set the following checkboxes:
    - **UTF-8** – is used to recognize text in Unicode coding;
    - **Parse degrees minutes seconds** – is used to recognize records from the list of projection centers or GCP.

When using this parameter it is highly recommended to check recognizing correctness after import operation.

11. The **Preview file** table contains data of imported file. Fields type according to the template, located in the **Line template** field, are automatically assigned to the table columns.

The * symbols marks columns with data which is not imported.

12. In the **Points with existing names** section specify actions to perform when names of imported GC points coincide with points names already existing on the **GCP list** tab:
    - **Replace** – allows to replace a point with the same name in the list, i.e. the point data will be updated;
    - **Skip** – allows to cancel import of GCP with the same name.
13. [optional] To prevent creating text attributes without value during import, set the **Do not create empty text attributes** checkbox on.

When the **Do not create empty text attributes** checkbox is on, in some cases a data loss may occur.

14. [optional] To convert coordinate system set the **Convert coordinate system** checkbox and specify source and output coordinate systems.
15. Click OK. The **Import ground control points** window opens, which contains the GCP table to be added. Points which names are the same as names of existing

GCP in the **GCP list** of the **Triangulation points** window are shown by red color, new GCP – by black color.

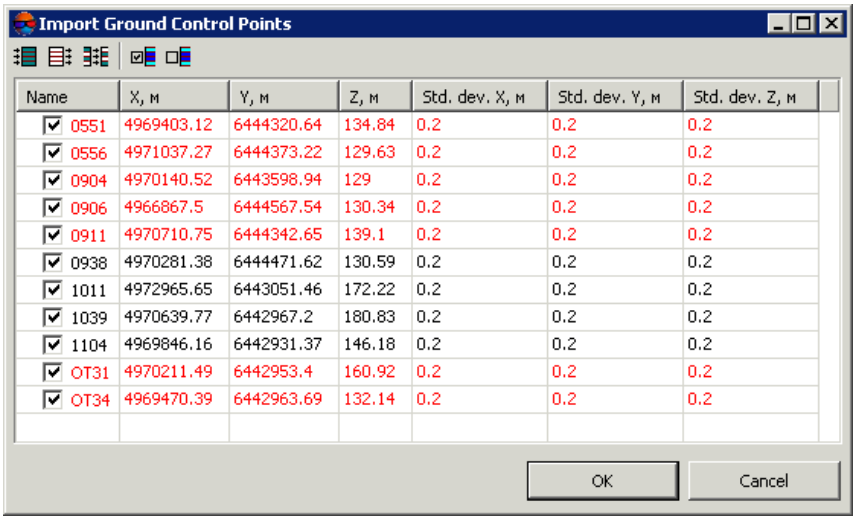


Fig. 37. Selecting GCP to be added to the list

16. Select points to be imported using checkboxes and/or standard selection tool. Click OK. After that coordinates of GC points with set checkboxes will be loaded in the end of the GCP list. The **Points measurement** module and **Triangulation points** window (on **GCP list** tab) are opened (see the "Aerial triangulation" User Manual).

If in the **Points with existing names** section the **Skip** parameter is selected, then only new GCP are selected for adding by default, if the **Replace** parameter is selected, all GCP checkboxes are selected to be added.

If RMS of X, Y, Z coordinates was not imported or is absent in GCP file, then default value of RMS for all coordinates is 0.2 meters.

16. Adjustment

Refer to the "Block adjustment" User Manual for the detailed description about block adjustment procedure.

16.1. Preliminary block adjustment

In order to adjust images block perform the following actions:

1. Click the button of **Block editor** window's toolbar to refresh initial block scheme (to refine block layout) using measured tie and GC points.

See a description of block layout creation in the "Aerial triangulation" User Manual.

2. Choose **Orientation › Block adjustment** or click the **Block adjustment** button on the **Aerial Triangulation** tab of the main toolbar. The **adjustment** toolbar opens.

   See detailed description of interior orientation step in the "Aerial triangulation" User Manual.

3. Click the button **Settings** on the **Adjustment** toolbar. The **Settings** window opens.

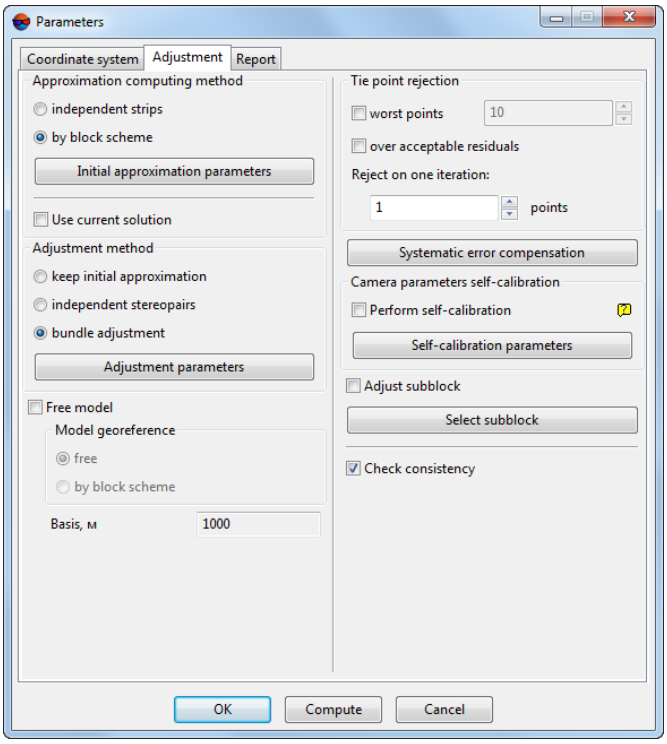


Fig. 38. Adjustment parameters for the first adjustment operation

4. On the **Adjustment** tab define the following parameters *for the first* start of the adjustment procedure:

   1. Choose the **by block scheme** option in the **Approximation computing method** section.

   2. Click the **Initial approximation parameters** button. The **Initial approximation parameters** window opens.

   3. Set the **Use ground control points coordinates** and **Use projection centers coordinates** checkboxes.

   4. Click OK.

5. Choose the **bundle adjustment** option in the **Adjustment method** section.

6. Click the **Adjustment parameters** button. The **Bundle adjustment parameters** window opens.

7. Set the **Use ground control points coordinates** and **Use projection centers coordinates** checkboxes.

8. Choose the **in 3D space** option in the **Minimize residuals** section.

9. Click OK to return for the **Parameters** window.

5. Click **Compute** to start the adjustment operation.

6. To analyse the adjustment results you can use visual control of residuals on block scheme and the **Residuals** window which contains brief residuals report.

7. Pick out adjustment parameters, analyse and eliminate residuals to obtain satisfying adjustment result.

After making any alterations to points measurements data it is necessary to re-start the adjustment procedure once again.

At subsequent start of the adjustment, the results of previous adjustment processes are used by default (the **Use current solution** checkbox on the **Adjustment** tab of the **Parameters** window).

The system allows to perform re-adjustment by changing any settings of bundle adjustment (in this case it is not recommended to clear the **Use current solution** checkbox, since that can lead to poor adjustment results).

8. It is recommended to use self-calibration of camera parameters during adjustment procedure, if camera without calibration was used.

16.2. Using self-calibration

[optional] If a complete set of camera parameters is unavailable, use self-calibration of camera parameters during adjustment procedure.

Self-calibration of camera parameters – is automatic calculation of camera parameters (corrections to principal point coordinates and focal length, distortion coefficients) during adjustment operation.

In *PHOTOMOD UAS* system self-calibration of camera parameters option is set on by default.

To use self-calibration of camera parameters during adjustment operation perform the following actions:

1. Make sure that the **Perform self-calibration** checkbox on the **Adjustment** tab of the **Parameters** window is set on and click the **Self-calibration parameters** button. The **Camera parameters self-calibration** window opens.

   See detailed description of self-calibration operation in the "Block adjustment" User Manual.

2. Choose camera to be calibrated in the **Cameras** table.

3. Select the **Calibration type**: **Physical** or **Mixed**.

   For self-calibration of a camera having a focal plane shutter, it is recommended to use **Mixed** self-calibration.

4. In the **Coefficients** table define initial values of camera parameters in the **Initial value** column and choose parameters for optimization in the **Optimize** column.

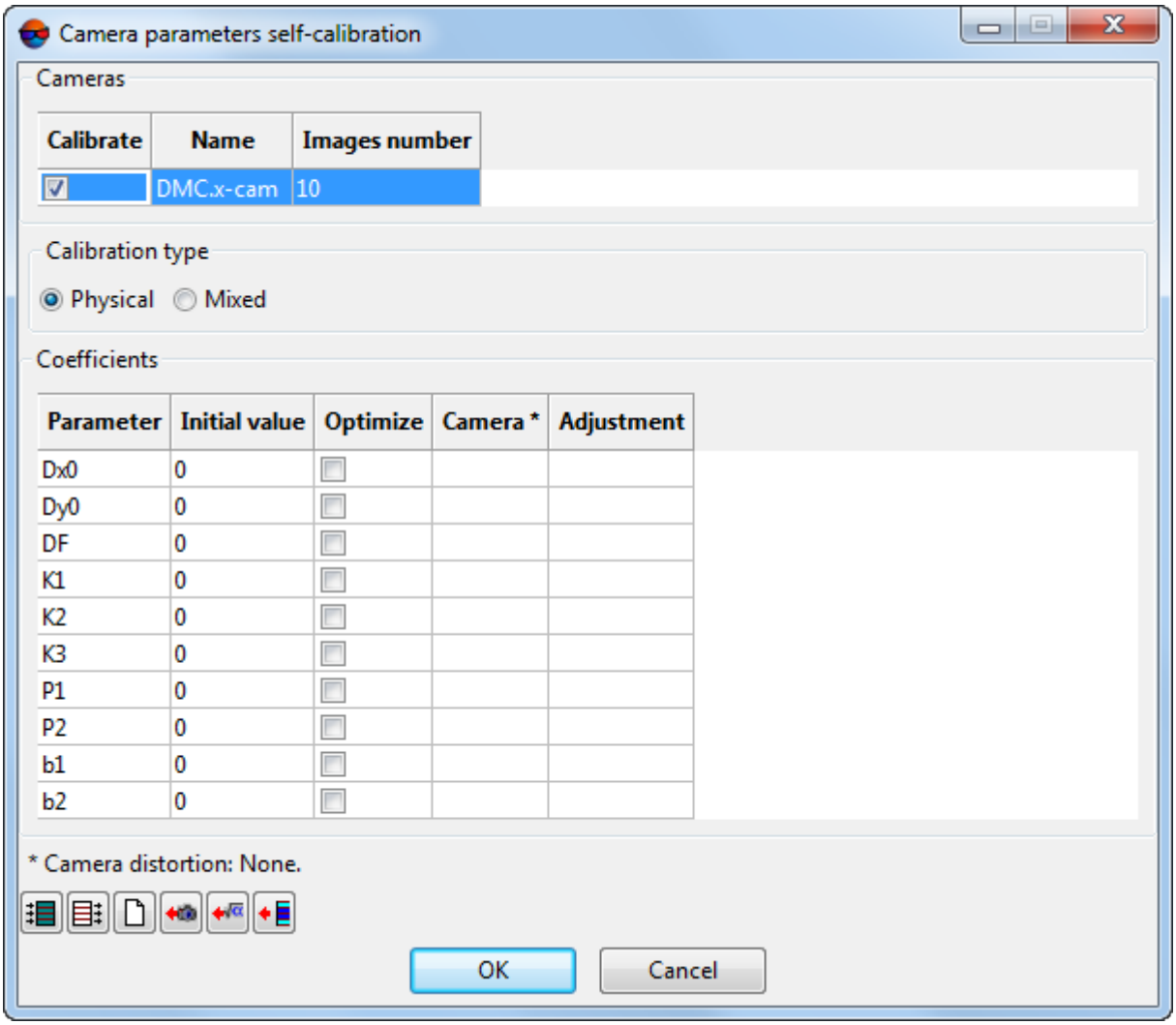


Fig. 39. Self-calibration of camera parameters

5. Click OK. Setup adjustment parameters in the **Parameters** window and click the **Compute** button to start the adjustment procedure.

6. When the adjustment procedure is completed estimate the adjustment accuracy and results of camera self-calibration shown in the **Adjustment** column of the **Camera parameters self-calibration** window. If you are satisfied with the results pass to step # 5, otherwise, change initial values of parameters and/or set of parameters for optimization and adjust the block once more.

7. Click the **Save** button to save the adjustment results.

8. Choose **Orientation › Manage cameras**. The **Manage project cameras** window opens.

9. In the **Project cameras** list select new calibrated camera (cameras) `[autocal].x-cam` and assign it (them) to project images. Click the **Execute** button. Click OK.

   See a description of the **Manage project cameras** window in the "Aerial triangulation" User Manual.

10. Choose **Orientation › Additional › Calculate interior orientation**.

11. Choose **Orientation › Block adjustment** or click the  **Block adjustment** button on the **Aerial Triangulation** tab of the main toolbar. Click the  button **Settings** on the **Adjustment** toolbar. Block will be adjusted considering new results of interior orientation.

16.3. Brief residuals report

The program allows to display brief residuals report, which contains RMS errors, mean absolute and maximal adjustment errors.

Brief residuals report is used for quick estimation of adjustment results without viewing detailed report.

In order to display brief residuals report, click the  button on the **Adjustment** toolbar. The **Residuals** window opens.

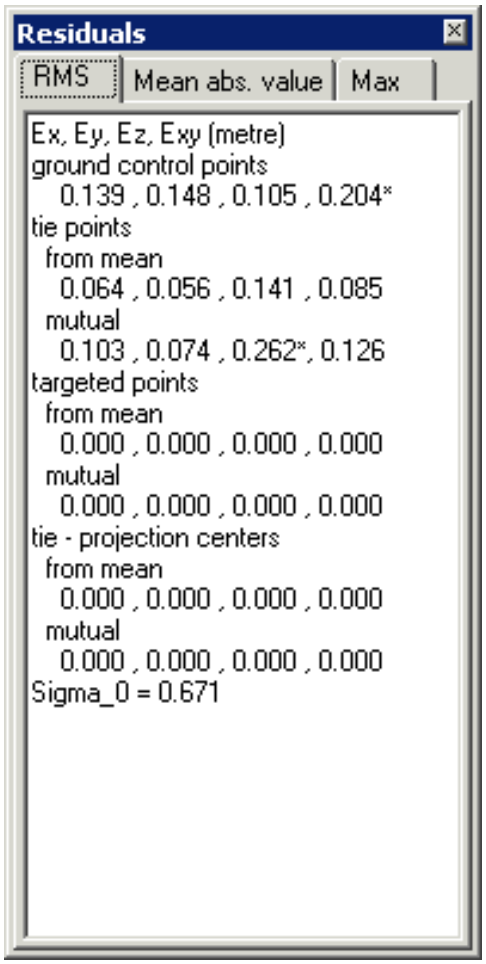


Fig. 40. The “Residuals” window

In the Stereopairs mode brief report contains information about mean absolute errors on GCP and check points (in meters), about tie and targeted points, as well as about tie residuals on projection centers (*mutual* and *from mean* residuals).

If adjustment is performed by bundle adjustment procedure, the `Sigma_0` value is calculated.

The `Sigma_0` value shows how much adjustment discrepancies correspond to specified thresholds on points coordinates measurements and input GCP data (GCP and projection centers coordinates). If the thresholds were specified correctly, the `Sigma_0` has value close to 1 (±30%).

If the `Sigma_0` is much greater than 1, there are errors in points coordinates measurements, in input GCP data or because of incorrectly specified thresholds on points coordinates measurements. If the `Sigma_0` is mush less than 1, the threshold on points coordinates measurements were specified incorrectly or there are some other errors (see Section 16.4).

16.4. Creating adjustment report

The program provides possibility to view full statistics of adjustment, summary information about adjustment residuals and control data.

To display adjustment report the button on the **Adjustment** toolbar.

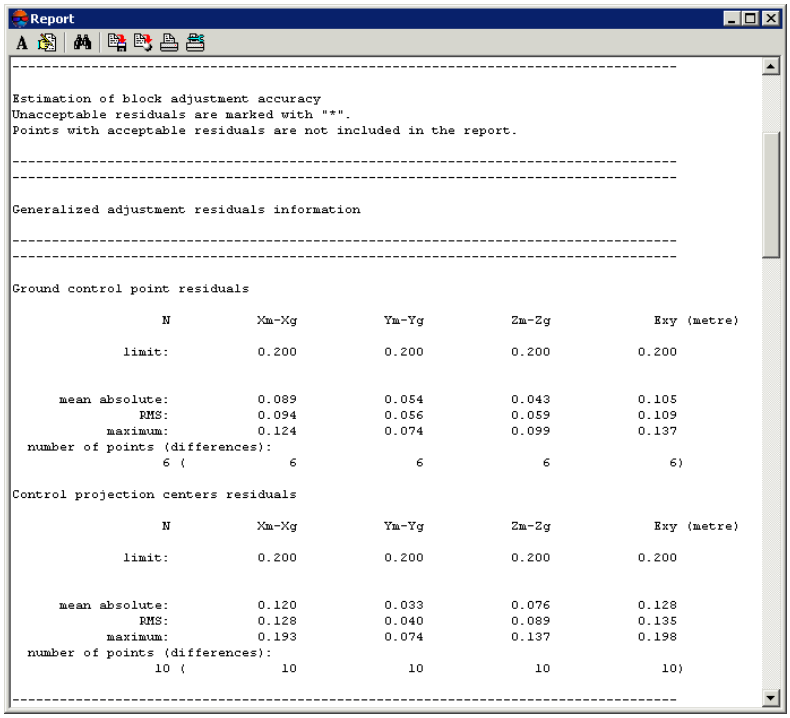


Fig. 41. The window of adjustment report

The toolbox of the **Report** window contains the following buttons:

- – allows to edit a font of report text;
- – allows to edit (make changes) a report (**F4**);
- – allows to start search in report's text (**Ctrl+F**, **Ctrl+G** and **F3**);
- – allows to save a report into text file;

  The report also saves in the *backup* project folder automatically with the adjustment results (only for central projection images).

- – allows to save a report into program resources;
- – allows to print a report;
- – allows to setup report printing parameters.

The adjustment report displays the following values:

- residual values calculated on GCP, check, tie points, and projection centers for the whole block and for each point;

- catalogue of points coordinates;
- images exterior orientation parameters;
- GPS corrections;
- corrections for exterior orientation parameters.

Report content is setup on the **Report** tab of the **Parameters** window.

Residuals and errors are displayed in the report as follows:

- *X, Y, Z* – coordinates values taken from model (from strip when using *independent strips method*, from stereopair when using *independent stereopairs method*);
- *X1, X2, Y1, Y2, Z1, Z2* – values of points coordinates on two different models;
- *Xcp, Ycp, Zcp* – values of points coordinates, averaged over all models;
- *Xg, Yg, Zg* – geodetic value of points coordinates, specified by the user for GCP and check points;
- *Exy, Ez* – average residuals of points XY and Z coordinates;
- *dX, dY, dZ, dS* – discrepancies on GCP;
- *dX, dY, dZ, dXY* – GPS corrections on projection centers.

16.5. Adjustment accuracy control

It is recommended to perform control of block adjustment accuracy after the completion of the adjustment operation. The adjustment results are displayed in graphic form as a residuals vectors in the Stereopairs and Images modes of working windows, numeric values of residuals are included to adjustment report.

If the adjustment brought unsatisfactory results and there some blunders the program provides possibility to improve the results using editing of points position. To do this it is necessary “re-measure” points, on which the residuals vectors exceed defined threshold and are shown by red color.

The program provides two ways of points position editing:

- by change of points geodetic coordinates;
- by change of points position.

In order to change geodetic coordinates of points on image perform the following actions:

1. Select a point on a block scheme or in a list, which error exceeds specified threshold value.

2. Click the button. The **Points attributes** window opens.

3. [optional] In order to display the editor panel set the **Editing panel** checkbox in the **Information** window.

4. Click the **Coordinates** button. The **Point coordinates** window opens. For GCP and check points the **X**, **Y**, **Z**, **all** checkboxes are set, and coordinates and accuracy values (standard deviation) of these coordinates in meters are displayed in corresponding fields.

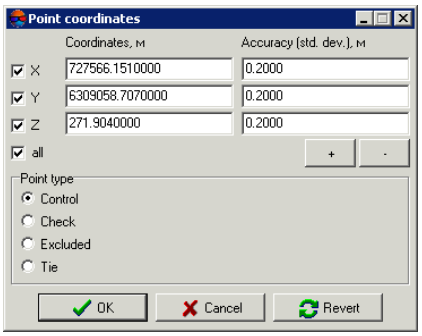


Fig. 42. Changing geodetic coordinates of selected GCP

5. [optional] To change the value of the **Accuracy** parameter use the + or − button.

6. To change a type of selected point set a type in the **Point type** section.

   If the **Tie** type is specified for GCP or check point, its geodetic coordinates will be deleted.

7. Input necessary coordinates to the **X**, **Y**, **Z** input fields or clear one or multiple checkboxes to use a point as a XY or Z.

   When working with a scanner images it is possible to use only XYZ GCP, that is why if for the GCP one of the **X**, **Y**, **Z** checkboxes is cleared, the point is used as a tie point and its coordinates are not considered during adjustment. If such points are available in a project, the program shows warning message during adjustment.

8. [optional] Click the **Revert** button to restore initial points coordinates.

9. Click OK. After that the geodetic coordinates of point will be changed.

In order to change point's position on image perform the following actions:

1. Select a point on a block scheme or in a list, which error exceeds specified threshold value.

2. Click the button. The Object attributes window opens.

3. Click the **Measure** button. The **Points measurement** window opens.

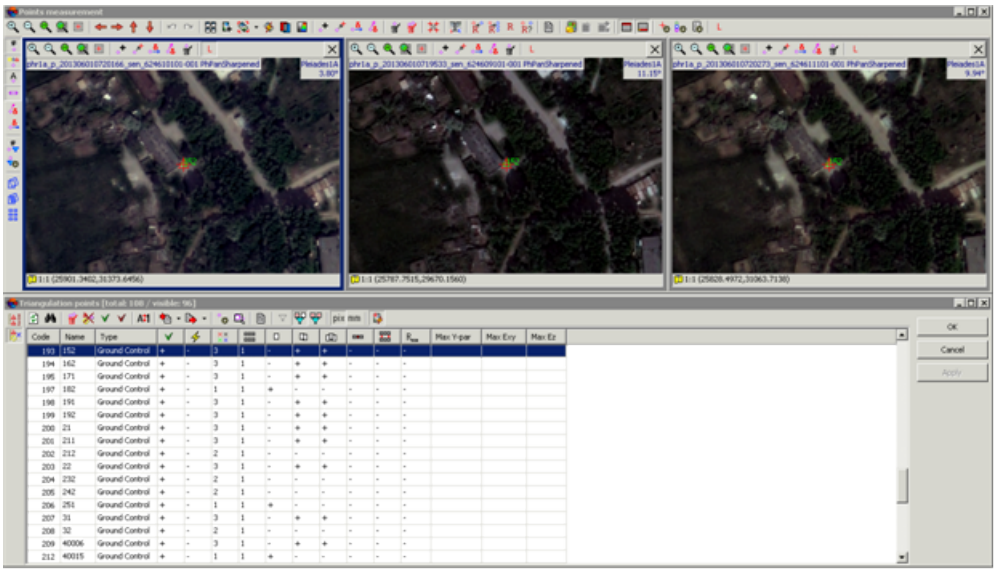


Fig. 43. Editing of selected point

4. Move a point manually or using correlator (see description of correlator work in the "Aerial triangulation" User Manual).

5. Click OK. The **Points measurement** is closed as a result.

6. Click **Compute** to complete changing point's position on image.

In order to use interstrip points and points non-transferred in some strip in the adjustment by *independent strips method* or *independent stereopairs method*, it is necessary to measure coordinates of the points on adjacent images inside the strip during aerial triangulation or in the **Points measurement** window (see the "Aerial triangulation" User Manual).

17. Preparation steps for the DEM creation

Refer to the "DTM Generation" User Manual for the detailed information about generation of digital elevation model (DEM).

17.1. Grid creation

The program provides possibility of regular *grid* creation with specified step. A grid step is used as a frequency of nodes creation, in which vicinity spatial coordinates are calculated and points are created.

The grid could be created both for the whole images block and for any part of a block or for selected stereopair. A shape of grid borders could be rectangular or as arbitrary polygon.

To create a grid select **Grid › Create** (**Ctrl+N, G**). After that a new layer *Grid* is created in the *Manager*.

Area of grid creation is determined in one of the following ways:

- in order to create a grid with specified *rectangular border*, press and hold the **Shift** key, and drag by mouse a rectangular area over images block or over selected stereopair;

- in order to create a grid with *arbitrary border*, define a grid creation area in group selection mode by polygon and while holding pressed the **Shift** key, specify by mouse all nodes of boundary of a grid creation area. Complete creation of arbitrary grid border by mouse double click.

- to use vector layer polygons as areas of grid creation, perform the following actions:

    1. Select **Vectors › Create layer** to create vector layer without classifier or load layer with polygons which could be used as a grid boundaries.

    2. Create a polygon in such a way that its boundary coincides with boundaries of area which is used for grid creation.

    3. [optional] Select polygons to be used as boundaries for a grid creation, otherwise, a grid will be created considering all polygons of the layer.

    4. Select **Grid › Create boundaries from vectors**. After that created grid boundary coincides with outline of created polygon.

- to create a grid for the whole images block without defining its boundaries, select **Grid › Properties**, specify its parameters and click OK. Grid is created automatically for the entire block and the grid boundary passes over external boundary of block images.

When a grid boundary is defined the program creates a grid of nodes with specified or default parameters.

In order to change parameters of created grid, select **Grid › Properties**. The **Grid properties** window opens.

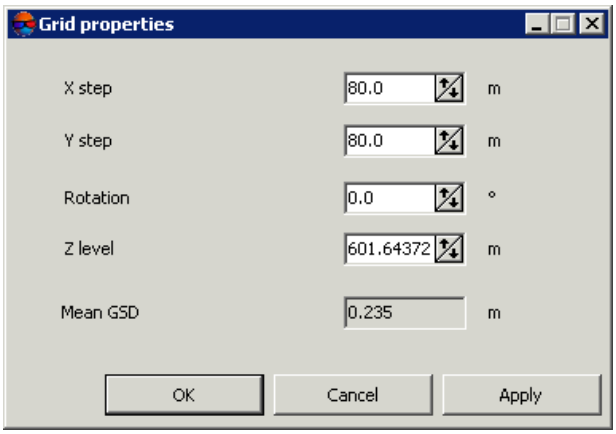


Fig. 44. Regular grid parameters

The **Grid properties** window allows to setup the following parameters:

- **X step** and **Y step** – steps for nodes creation correspondingly by X and Y axes in meters;
- **Rotation** – angle of nodes grid rotation in degrees;

Should be specified for manual work in the pathway mode.

At that, the nodes **grid only** is rotated. Area of nodes grid creation remains in initial position.

- **Z level** – a grid elevation above relief level (in meters) for visual correct display of the grid;
- **Ground sample distance (GSD)** – shows a value of average pixel size in meters, if a project contains adjustment results or pixel size is specified for at least one image.

To display a grid with specified parameters click the **Apply** button. To change parameters click OK.

To save created grid in active profile resources use **Grid › Save** and **Grid › Save as** menu items. The grid is saved to the `*.x-grid` file.

To open existing grid, select **Grid › Open**. To close a grid, select **Grid › Close**. To close all grid layers, select **Grid › Close all opened layers**.

Context menu of the *Grid* layer in the *Manager* duplicates save and load commands in the **Grid** menu, and allows to close a grid layer.

17.2. Points automatic calculating

17.2.1. Automatic calculating of points

The program provides possibility to calculate points automatically using correlator in overlap areas of stereopair images by regular nodes grid.

Because of large processing data volumes in UAS projects, it is recommended to use automatic calculating of points.

All selected stereopairs should be located on adjusted part of a block (see "Block adjustment" User Manual), otherwise, points calculation is not performed or is performed incorrectly. In the first case the system displays error message, in the second one – it is not possible to match calculated points to project coordinate system.

Acquired points are used as a vector base for DEM generation. Additional possibilities of points editing allow to obtain vector base for TIN creation and DEM generation.

The principle of automatic points calculation is as follows. For each selected oriented stereopair the system performs automatic pass of all grid nodes, located in overlap area of stereopair images, and tries to calculate spatial coordinates in vicinity of each grid node using correlator. In case of successful correlation the system performs accuracy control of each found point's coordinates, and after that the point is either added to vector layer as point object, or is excluded. If the system fails to calculate spatial coordinates in vicinity of some grid node, the node is skipped and the system passes to the next node.

Prior to start of automatic points calculation perform the following preparatory actions:

1. [optional] Define *search area*: select block stereopairs where to perform automatic points calculation.

2. Create regular nodes grid for selected *search area*.

3. Choose **Terrain › Points › Compute points automatically** or click the **Compute points** button on the **Compute DEM** tab of the main toolbar. The **Compute points** window opens.

If a grid not was not created, it is created automatically for the entire images block and the **Grid properties** window opens, that allows to specify grid parameters.

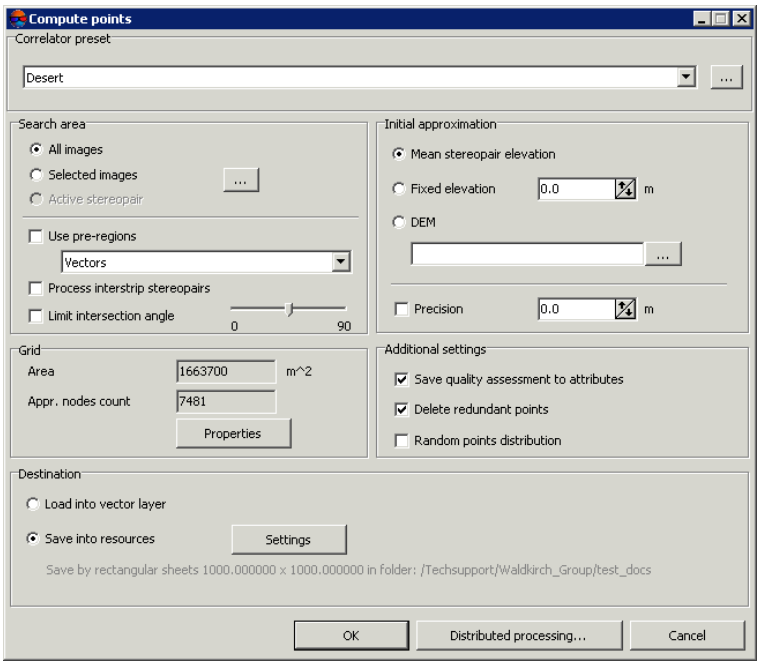


Fig. 45. The “Compute points” window

4. In the **Correlator preset** section select in the list one of the following types of terrain:

Correlator configuration – is a script of points calculation operation, that defined a number of passes of regular grid nodes and a set of correlator parameters for each pass.

- *mountainous terrain* – for automatic points calculation on images with mainly mountainous terrain with big elevation differences;
- *urban areas* – for automatic points calculation on images with mainly urban type of build-up;
- *desert* – for automatic points calculation on images with monotonously deserted terrain with rare vegetation;
- *rural area* – for automatic points calculation on images with rural areas with with minor amounts of buildings and infrastructure;
- *rural area 2* – for automatic points calculation for “rural” area with heterogeneous parts of relief. If there are images with big intersection angle the configuration uses a mask of larger size. Accuracy of points calculation is less then when using rural area type.

To view and edit parameters values and to setup *correlator configuration* the list, to create new or delete configurations from the list click the ... button.

5. In the **Search area** section specify a search area, which will be used for automatic points calculation:

   - **All images** – allows to select all images of a block;
   - **Selected images** – allows to select block images highlighted in 2D-window;

     To view and change a set of highlighted images in block 2D-window click the ... button.

   - **Active stereopair** – allows to select images of a stereopair opened in active 2D-window.

     All selected stereopairs should be located on adjusted part of a block (see "Block adjustment" User Manual), otherwise, points calculation is not performed or is performed incorrectly. In the first case the system displays error message, in the second one – it is not possible to match calculated points to project coordinate system.

6. [optional] Points calculation is performed by default for strip stereopairs. To calculate points for inter-strip stereopairs, formed by selected images set the **Process inter-strip stereopairs** checkbox on.

7. [optional] To filter blunders by Z on images with intersection angle of small or null value, set the **Limit intersection angle** checkbox on and define a value of minimal angle using the slider.

8. [optional] In the **Grid** section the **Area** of the grid layer in m^2, as well as **Appr. nodes count** in a grid are displayed in appropriate fields. To change a grid layer parameters click the **Properties** button.

   To change grid boundaries it is necessary to close the **Compute points** window.

9. In the **Initial approximation** section specify initial value of Z coordinate of a grid node for correlator work:

   Initial approximation defines a value of Z coordinate of grid node, that is used to calculate initial coordinates of point on the left and right images of a stereopair.

   - **Mean stereopair elevation** – mean elevation of each stereopair, calculated using exterior orientation parameters, is used as initial approximation;
   - **Fixed elevation** – input elevation value in meters to be used as initial approximation;
   - **DEM** – a value of elevation of selected DEM in point with XY coordinates of grid node is used as initial approximation.

If grid node falls into null cell of DEM, the system uses average elevation of corresponding stereopair. To select DEM in active profile resources click the ... button.

To specify value of acceptable deviation of Z-coordinate of calculated points from initial approximation set the **Precision** checkbox on and input value of acceptable deviation in meters to the input field.

If the **Precision** checkbox is off, acceptable deviation is calculated automatically according to selected configuration of correlator.

10. [optional] To thin nearest points, acquired during passing the same grid nodes on different stereopairs, the **Delete redundant points** checkbox is on in the system by default.

    Thinning is performed after completion of points calculation operation according to specified radius value, set by used correlator configuration.

    When the **Save quality assessment to attributes** checkbox is on, points with minimal correlation coefficient (minimal value of "*corr*" attribute) are removed from several found nearest points.

11. [optional] To distribute points randomly in area of halfsize of grid cell from grid node, set the **Random points distribution** checkbox on.

12. In the **Destination** section define parameters of loading and saving of calculated points:

    - **Load into vector layer** – allows to load points into active vector layer;

      If there is no active vector layer, points are loaded to a new vector layer.

    - **Save into resources** – allows to save points into active profile resources without loading. Click the **Settings** button to specify parameters of points saving. The **Settings for saving points** window opens.

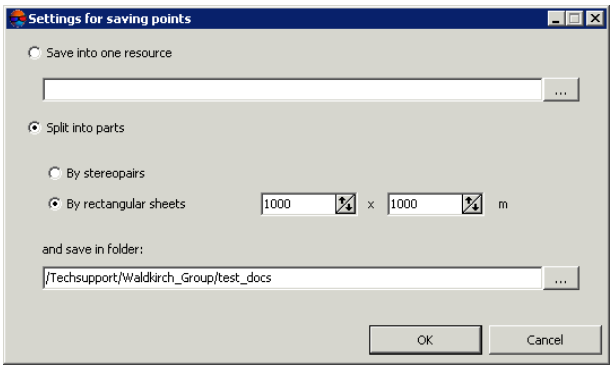


Fig. 46. The “Settings for saving points” window

To save points in one vector file of active profile perform the following actions:

1. Select the **Save into one resource** option and click the ... button. The **Save** window opens.

2. Select a folder in the active profile resources and input a name of vector file in the **Resource name** field. Click OK to create a new vector file and to return to the **Settings for saving points** window.

3. The input field of the **Settings for saving points** window shows path and name of new vector file. Click OK to return to the **Compute points** window.

To save points in parts into several vector files of active profile perform the following actions:

1. Choose the **Split into parts** option.

2. Select one of the ways of points splitting – **By rectangular sheets** and input a size of rectangular area in meters or **By stereopairs**.

3. Input path to save file to the **Save in folder** field or click the ... button, to select name and path in active profile resources to save points in parts to corresponding vector files and click OK.

4. The input field of the **Settings for saving points** window shows path and name of new vector file. Click OK to return to the **Compute points** window.

13. Click OK. The points calculation operation starts.

In some cases operation of automatic points calculation takes a lot of time.

To setup points calculation in distributed mode click the **Distributed processing…** button and specify parameters of tasks distribution.

17.2.2. Points calculation in distributed processing mode

To calculate points in distributed processing mode, perform the following actions:

1. Change settings and run the distributed processing server/client.

2. Choose **Terrain › Points › Compute points automatically** or click the **Compute points** button on the **Compute DEM** tab of the main toolbar. The **Compute points** window opens.

   If a grid not was not created, it is created automatically for the entire images block and the **Grid properties** window opens, that allows to specify grid parameters.

3. Setup parameters of automatic points calculation.

4. Click the **Distributed processing** button. The **Compute points Distributed Processing** window opens.

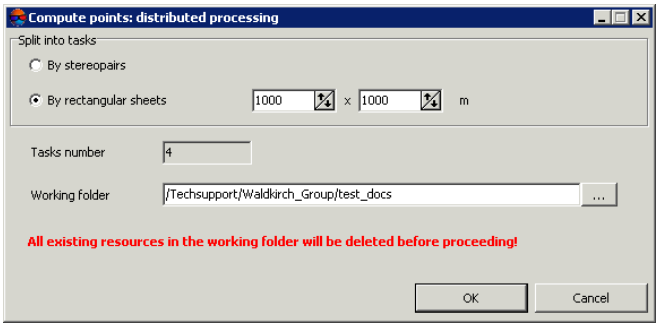


Fig. 47. Parameters of distributed processing of points calculation

5. In the **Split into tasks** section select a way of splitting of processing operation into tasks:

   - **By stereopairs** – allows to process each stereopair in a separate task;

     Since tasks are executed independently from each other, the system doesn't remove points, falling into the same grid nodes from different stereopairs (for example, during filtering of nearest points).

   - **By rectangular sheets** – it is necessary to specify in the fields a size of rectangles, into which the entire search area is split (in meters). Filtering of nearest points is not performed in this case. The result of each task processing is saved to the file with name like `Sheet_X_Y.x-data`.

     Rectangle, circumscribing grid boundaries in project coordinates system, is split by rectangular sheets of a size specified in the fields. Each sheet includes images parts from all stereopairs, into which it falls.

If stereopairs are processed in separate tasks, after that it is necessary to perform manual data correction. Calculated points are saved in resources, named by stereopairs names.

The **Tasks number** field displays calculated number of tasks depending on selected way of workflow split and/or size of specified areas.

It is not possible to define number of tasks manually.

6. In the **Working folder** section click the ... button and select **empty** folder in active profile resources to save output DEM.

Before operation is performed all data from selected folder is removed. It is strongly not recommended to specify a project folder as a working folder, especially when there are no saved project backups.

7. Click OK. Distributed processing tasks are created and the system shows a message about number of created tasks.

When using distributed points calculation, the result of each task is saved to separate file with `tsk` extension in specified **Working folder** of a project.

17.3. Points filtering

The system provides deletion, correction or recognizing points which have fallen on buildings, trees, cars, in pits during automatic points calculation, and during filtering of accident surges. For that filter of buildings and vegetation id used. After its work only points that describe terrain relief are remain in the system.

In this document all points not lying on the relief surface (average smoothed terrain surface), are called *surges*.

Filter of buildings and vegetation allows to apply step-by-step points filtering using particular script, i.e. to apply points filtering in multiple passes with different parameter sets.

It is possible to develop customized script of filter workflow or to use default script. Creating script of buildings and vegetation filtering means specifying of passes set, order of their passing and setup the parameters for each pass.

Step-by-step filtering allows to achieve optimal results of objects filtering on any type of terrain to acquire points, that correctly describe terrain relief, and that could be used to generate high quality DEM.

By default, the system uses standard script that includes three passes in the following order:

1. **Basic** – main pass with parameters configured for filtering points not lying on the relief surface (surges). On this step the system rejects majority of points on buildings, and also correlators blunders (sharp spikes).

2. **Additional** – additional pass with parameters configured for searching surges, missed during basic step.

3. **Detailed** (off by default) – the pass with parameters configured for filtering points located on low objects, such as small buildings, cars, and so on.

After filtering the system may perform the following actions with points found (surges):

- rejecting surges from initial points layer;
- correction of surges found on initial points layer, that means editing of surges Z-co-ordinates;
- search for surges to analyse them with saving of found points to new vector layers without changing initial points layer.

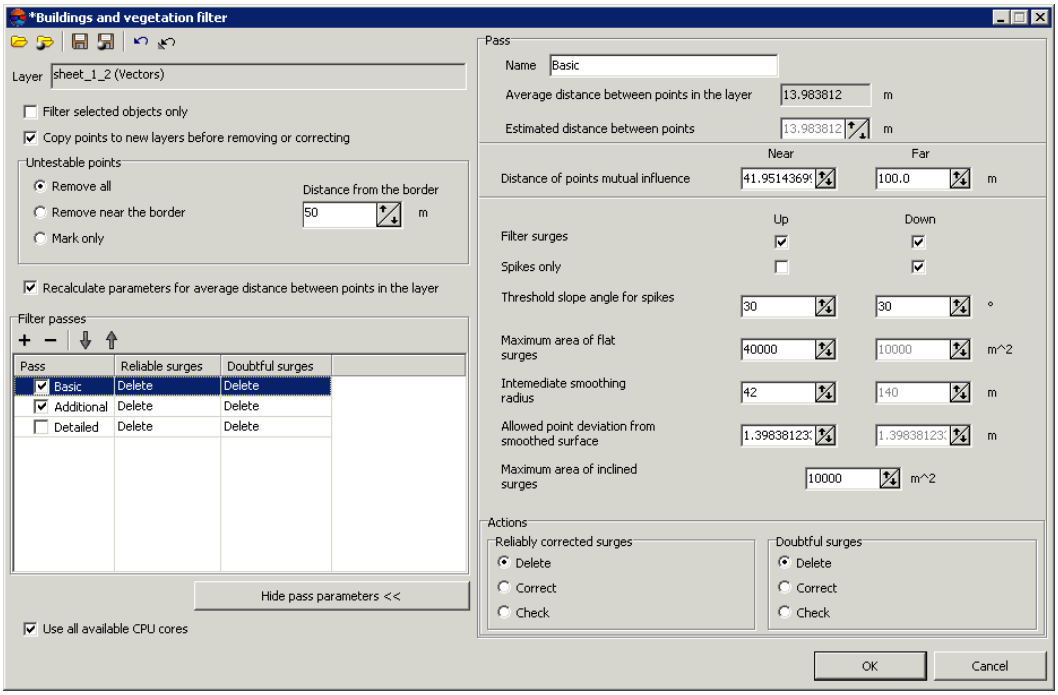


Fig. 48. Parameters of buildings and vegetation filter

The **Buildings and vegetation filter** window allows to specify filtering parameters and setup a number of filter passes. The **Layer** field displays a name of active vector layer. The window contains a standard toolbar.

Buttons	Function
	allows to load a script of filter work from `*.x-filter` resource located out of active profile resources
	allows to load a script of filter work from `*.x-filter` resource located in active profile resources
	allows to save a current script of filter work to `*.x-filter` resource located out of active profile resources
	allows to save a current script of filter work to `*.x-filter` resource located in active profile resources
	allows to cancel all changes made to a script
	allows to go back to a standard script that includes two passes with default settings (regardless of which script has been loaded)

To filter objects on surface perform the following actions:

1. Make active a points layer.

   To avoid loss of data, it is recommended to use a copy of initial layer during filtering.

   To create a copy select **Vectors › Save as** and specify new name of points file.

   If a layer contains linear or area vector objects the filter may not work properly.

2. Select **Terrain › Points › Filter › Buildings and vegetation filter**. The **Buildings and vegetation filter** window opens.

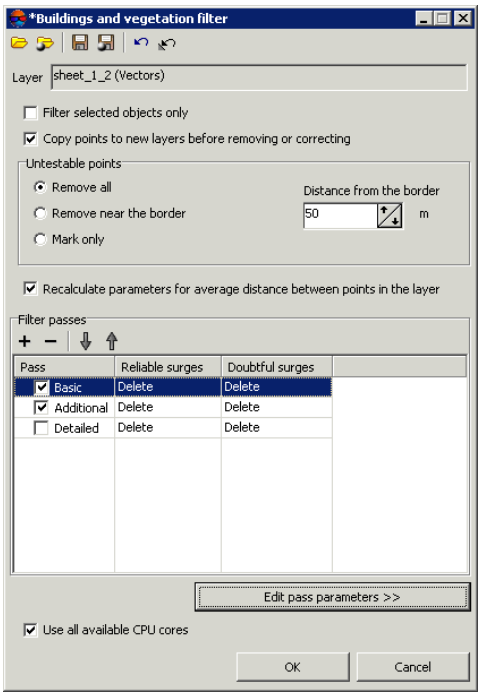


Fig. 49. Parameters of buildings and vegetation filter

3. [optional] In order to use filtering for selected objects (points group), set the **Filter selected objects only** checkbox on. Otherwise, filter is applied to all points of the layer.

   To filter a group of points, select it by mouse in 2D-window prior to start configuring the **buildings and vegetation filter**.

   When using filter for selected objects only, it is not recommended to set the **Remove near the border** option in the **Untestable points** section.

4. [optional] To increase the filtering operation performance set the **Copy points to new layers before removing or correcting** checkbox off. By default, the system saves removed or corrected points in new vector layers used for analysis of filtering results. These layers could be used to restore basic points layer (using operation of layers merging), if the copy of initial points layer was not created prior to filtering start.

   If the **Copy points to new layers before removing or correcting** checkbox is off, it is highly not recommended to apply filtering to initial points layer, since it is impossible to restore the initial layer after filtering.

5. In the **Untestable points** section specify one of the following actions with untestable points found after filtering:

Some points can be *untestable* – the points, in which vicinity there is not enough 'neighbour' points. For example, points located on the edge of the whole layer or in areas of low density of points (fields, forests, water bodies).

- **Remove all** – allows to remove all found untested points;
- **Remove near the border** – allows to set a value of distance in meters from the edge of the whole vector layer, at which all untestable points will be removed. The **Distance from the border** field is used to do this;
- **Mark only** – allows to save untested points to separate vector layer for further analysis.

6. [optional] The **Recalculate parameters for average distance between points in the layer** checkbox is set by default. After that the system calculates automatically values of average distance between points in active layer. This leads to automatic re-calculation of current parameters of each pass.

7. Specify a number of filter passes:

   - by default it is used two passes with standard parameters – **Basic** and **Additional**. Set off checkboxes to change set of passes.
   - the + button allows to add a new pass of filter;
   - the − button allows to remove selected pass of filter;
   - buttons and buttons allow to move selected pass up/down.

   The **Filter passes** section contains a table of passes and buttons used to change set of passes and their order with the following columns:

   - **Pass** – displays pass name and checkbox used to include a pass to script or to exclude it from filter workflow script;
   - **Reliable surges** – displays action to be applied to well-defined surges found, that are completely comply with specified filtering criteria;
   - **Doubtful surges** – displays action to be applied to ambiguous surges found, in which vicinity there is no data enough for analysis.

   It is necessary to select an action to be applied to reliable and doubtful surges during configuring of pass parameters.

8. Select a pass name and click the **Edit pass parameters> >** button. The **Pass** section is opened and allows to display and configure the following parameters of filter pass:

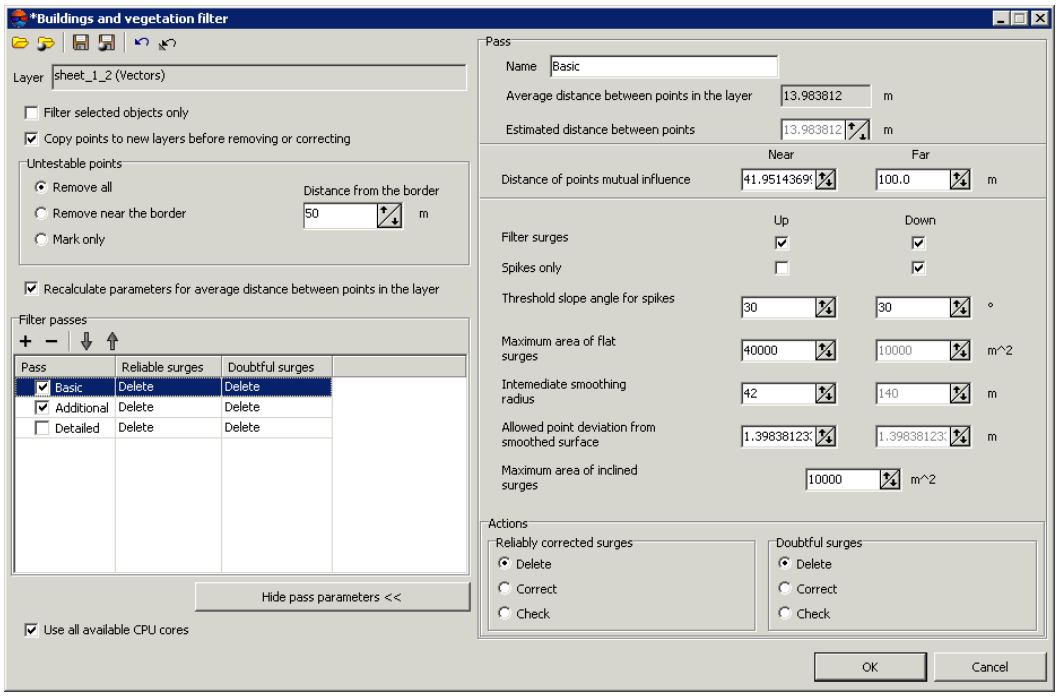


Fig. 50. Parameters of buildings and vegetation filter

- [optional] to change name of pass, input a new one in the **Name** field;
- the **Average distance between points in the layer** (in meters) and **Estimated distance between points** (in meters) after filtering are displayed in fields;
- specify **Near** and **Far distance of points mutual influence** in meters to define the circle radius. In this area points are checking for errors;

Near distance of points mutual influence – is the average radius of a circle where the points are located that are attributed to the same flat surface towering above the terrain (e.g. a flat roof).

Far distance of points mutual influence – is the average distance from points attributed to the flat surface towering above the terrain where the points attributed to the terrain are located for sure.

It is recommended to set the near distance (minimum circle radius) value as 3-5 values of **Average distance between points in the layer** parameter.

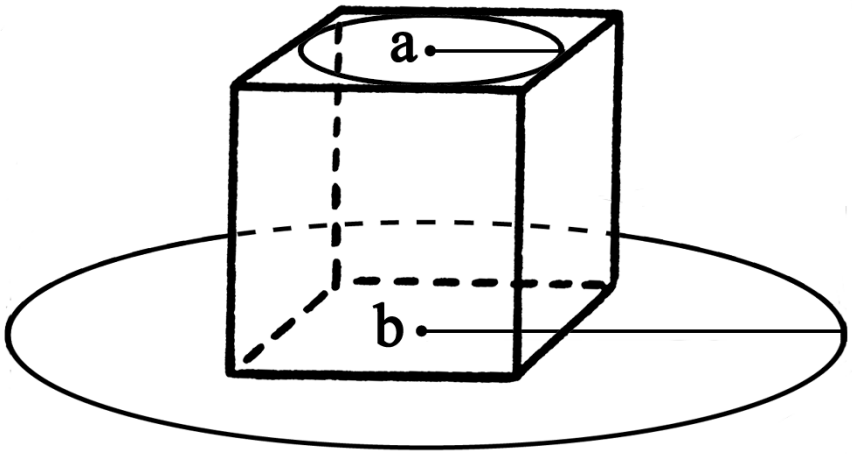


Fig. 51. Near distance of points mutual influence (a) and far distance of points mutual influence (b)

- specify the following filtering parameters **Up** (above surface) and/or **Down** (below surface):
  - **Filter surges** – allows to select points to be filtered: points on surface (high objects) and/or points below surface (pits);

    For filter operating it is necessary to set at least one checkbox on.

  - **Spikes only** – is used to reject just sharp spikes above/below surface, that are defined by values of the **Threshold slope angle for spikes** and **Distance of points** parameters. The rest of parameters are not considered;

    In an angle between three points exceeds in relation to selected measuring plane a value of the **Threshold slope angle for spikes** parameter, then the surge is called *spike*.

  - **Threshold slope angle for spikes** – allows to specify angle of slope in relation to selected measuring plane (above and/or below surface) to define sharp spikes;
  - **Maximum area of flat surges** – allows to define maximal area of plane surges (above/below surface) – points groups, that form smooth surfaces and are distant from some plane of neighbour points. Generally, the points are located on buildings roofs, and are lying on the same plane;

The filter is not applied to plane surface, which area exceeds the specified value.

- **Intermediate smoothing radius** – allows to specify a sphere radius (above/below surface), that defines a level of intermediate smoothing of surface;
- **Allowed point deviation from from smoothed surface** – allows to specify criterion, according which the filter is applied to all points with elevations that differ from smoothed surface more then on specified value;
- **Maximum area of flat surges** – allows to define maximal area of plane surges (above/below surface) – points groups, that form smooth surfaces and are distant from some plane of neighbour points.

The button allows to go back to a standard script that includes two passes with all default settings (regardless of which script has been loaded)

9. In the **Actions** section specify actions for reliable and doubtful surges found after any step of filtering:

   - **Delete** – deleting of points found from base points layer;
   - **Correct** – editing in base layer Z-coordinates of points found;
   - **Check** – saving of found points in a new layer without change of base layer.

   Reliable corrected surges – found well-defined surges that satisfy completely to all specified filtering criteria.

   Doubtful surges – ambiguous surges in which vicinity there is no data enough to analyse filtering operation possibility.

   If the **Delete** or **Correct** option is selected, the system allows to edit base points layer.

   In order to save deleted or corrected points to new layers it is recommended to set the **Copy points to new layers before removing or correcting** checkbox on.

   If the **Check** option is selected the initial points layer remains unchanged, and found reliable or doubtful surges are copied to a new layer *Surges*.

10. [optional] To use all cores of workstation CPU for calculation operation, the **Use all available CPU cores** checkbox is set on in the system by default. It is necessary to set the checkbox off to use only one core.

11. Click OK. The system starts DEM filtering operation. When the filtering operation is completed the system displays information message about number of used basic points and filtered points.

There are the following recommendations concerning use of buildings and vegetation filter:

- it is recommended to use step-by-step filtering (in multiple passes with different parameter sets);
- the passes should be formed in ascending order of the following parameters: distances of mutual influence, radius of intermediate smoothing, and decreasing of allowed deviation of point from smoothed surface;
- value of intermediate smoothing radius directly describes terrain relief features, that it why it is necessary to specify the radius value not exceeding 1500 meters;
- it is recommended to perform preliminary analysis of maximal area of flat surges on given territory (to measure it in a stereopair window) and then to compare it with area, calculated automatically for passes. If the measured area is bigger than calculated one, it is necessary to increase it;
- it is highly not recommended to specify a distance of mutual influence of points exceeding a step between points in more than 20 times, since it leads to considerable slowdown of filtering operation.

17.4. Building TIN

Perform the following actions to build TIN:

1. Choose the **Terrain › TIN › Build...** (**Ctrl+N, T**) or click the **Build TIN** button on the **Compute DEM** tab of the main toolbar. The **Create TIN** window opens.

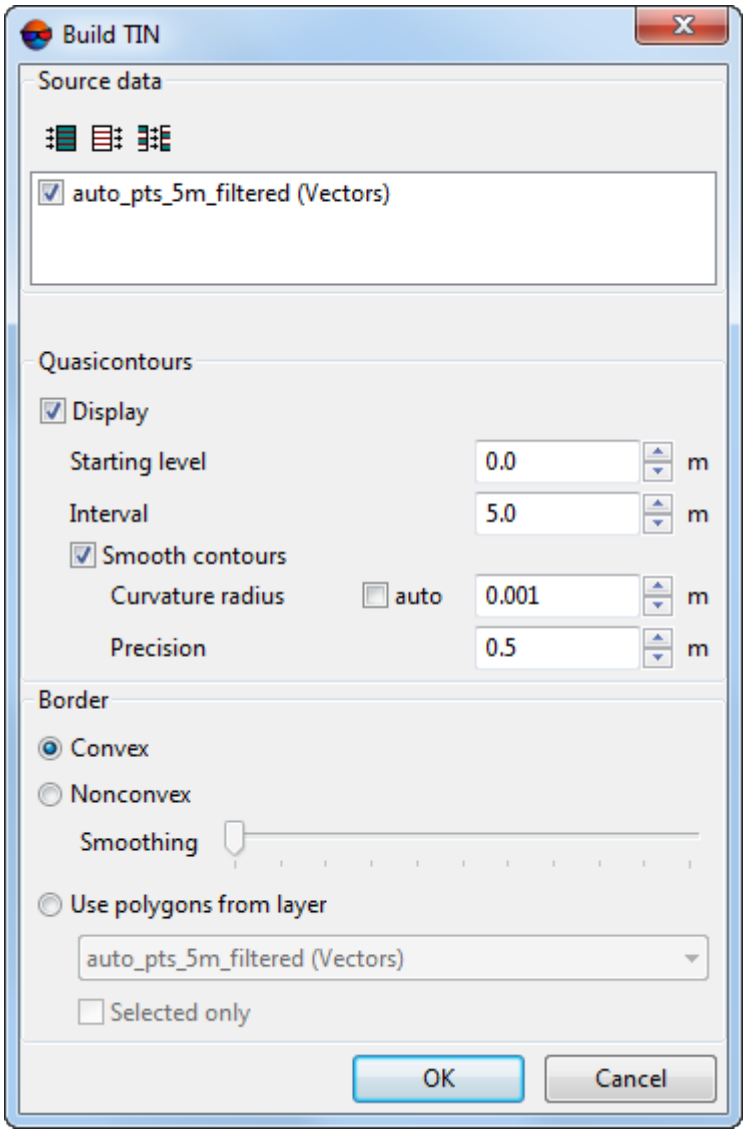


Fig. 52. The “Create TIN” window

2. [optional] By default in the **Source data** section set on checkboxes for all opened layers to use them in TIN creation. Set of checkboxes if there are open layers not for TIN.

   To select all available layers, click the button, to unselect all layers – click the button. To invert selecting layers it is used the button.

3. [optional] In the **Quasi-contours** section the **Display** checkbox on and in the **Starting level** filed specify minimal Z level (Zmin), from which to start quasi-contours creation.

4. [optional] Set the **Interval** of quoasicontours in meters.

5. [optional] In order to create quasi-contours as smoothed curves, set the **Smooth contours** checkbox on and specify the smoothing parameters.

   - Input the **Curvature radius** for smoothing curve.
   - Specify in the input field the **Precision** parameter – maximal distance from polyline segment to a curve in the area between the two closest vertices.

6. In the **Border** section set on the following:

   - **Convex** – the convex border of TIN is created;

     It is recommended to create convex border, when some part of vector objects does not cover all area of TIN creation (for example, when there are lakes and rivers on large scale images).

   - **Nonconvex** – the nonconvex border of TIN is created;

     It is recommended to place the **Smoothing** slider in the middle and smoothly move it to the left to get the best results.

   - **Use polygons from layer** – to create a TIN with convex border in limits of area of polygon(s) selected in the layers list. Select from the list the layer with polygons, which is used as a border. In order to define a border of TIN creation area, just from selected polygons, set the **Selected only** checkbox on.

7. Click OK. The TIN is created in the new *TIN* layer.

18. Digital Elevation Model

Refer to the “DTM Generation” User Manual for the detailed information about generation of digital elevation model (DEM).

18.1. The ’DEM’ menu

The **DEM** menu contains standard menu items used to load and save DEM layers, as well as menu items used to perform various operations on DEM creation, accuracy control, filtering and editing.

The **DEM** menu is located in the **Terrain** menu.

Table 17. Brief description of the “DEM” menu

Menu items	Function
Load DEM... (**Ctrl+O, D**)	allows to load DEM from `*.x-dem` file
Recent	allows to get quick access to the recently loaded DEM files

Menu items	Function
Save copy	allows to save opened DEM to a new file
Save selection	allows to save DEM area
Close	allows to close a DEM layer
Close all opened layers	allows to close all DEM layers
Layers visibility	contains menu items which allow to perform batch management of TIN layers visibility in the *Layer manager*
Build DEM...	contains menu items used to create DEM with help of various source data
Filter	contains menu items used to filter DEMs using different ways
Fill null cells	contains menu items used to restore blank cells of DEM using various methods
Export...	contains menu items used to perform export of DEM to different formats
Import...	contains items used to import DEM from files with `grd`, `asc`, `tif`, `dem`, `mtw`, `dt1`, `dt2`, `img`, `pix`, `hgt` extensions
Additional	contains the **Additional** menu

Table 18. Brief description of the “DEM” menu (Additional)

Menu items	Function
Save as georeferenced raster...	allows to save a DEM as a raster file with geodetic reference
Build DEM...	contains menu items used to create DEM with help of various source data
Rebuild by TIN	allows to recreate DEM after changing of TIN base layer
Restore	is used to restoring of DEM consistency, which may be disrupted by applying various operations or DEM filtering
Slope based filter	allows to filter objects based on slope angle
Filter by image properties	allows to filter DEMs depending on image characteristics
Convert cells to null	allows to convert DEM cells with specified elevation to null ones
Set elevation in selected polygons...	allows to set the same elevation of DEM cells inside and outside of selected polygons
Interpolate elevation in selected polygons...	allows to interpolate a value of DEM cells inside and outside of selected polygons
Cut by selected polygons	is used to edit coverage area of DEM
Cut null edges	is used to remove edge areas of DEM, that include blank cells

Menu items	Function
Transpose	is used to transpose DEM from the left coordinate system to the right one and vice versa
Transform to another coordinate system	allows to change coordinate system of DEM
Rebuild considering last adjustment	allows to recreate DEM considering results of the last adjustment (if the project was adjusted after DEM creation once more)
Shift	is used to parallel displacement of DEM by axes
Split DEM into sheets	allows to split DEM into sheet to save DEM in parts in separate files
Create histogram by DEM	allows to create histogram by DEM
Merge DEMs	allows to merge DEMs, that have overlap area
Accuracy control	is used to perform accuracy control DEM creation using various data
Compute volumes	allows to calculate a volume (i.e. *embankment* or *excavation*) located between DEM surface and **arbitrary** Z-plane or in a more complex case, the volume which is the overlap between the two (roughly, “top” and “bottom”) DEM surfaces.
Convert to points...	allows to convert DEM cells to points with specified simplifying
Write points to DEM...	allows to add points to DEM that helps to refine DEM cells values
Batch import	is used to simultaneous import of multiple DEM

18.2. General information

DEM (Digital Elevation Model) – is digital cartographic representation of the earth’s surface in the form of a regular grid of height values.

A source data for DEM creation is the following data, taken individually or in combination:

- TIN (Triangulated Irregular Network);
- regular or irregular points (point objects);
- vector objects (see the *Vector objects creation* chapter in the ’Vectorization’ User Manual).

DEM is displayed in 2D-window, and also could be opened to view in 3D-window or in 2D-window of stereopair in stereo mode.

DEM in stereo mode may be displayed inaccurately.

To view information about DEM select **Information** item in the *Manager*. The system displays information window which includes the following information about the layer:

- layer name;
- full path to layer file;
- presence of data and changes in the layer;
- possibility to change the layer;
- coordinates of DEM border nodes, including Z-coordinate;
- ground sample distance;
- DEM size (number of cells);
- layer coordinate system.

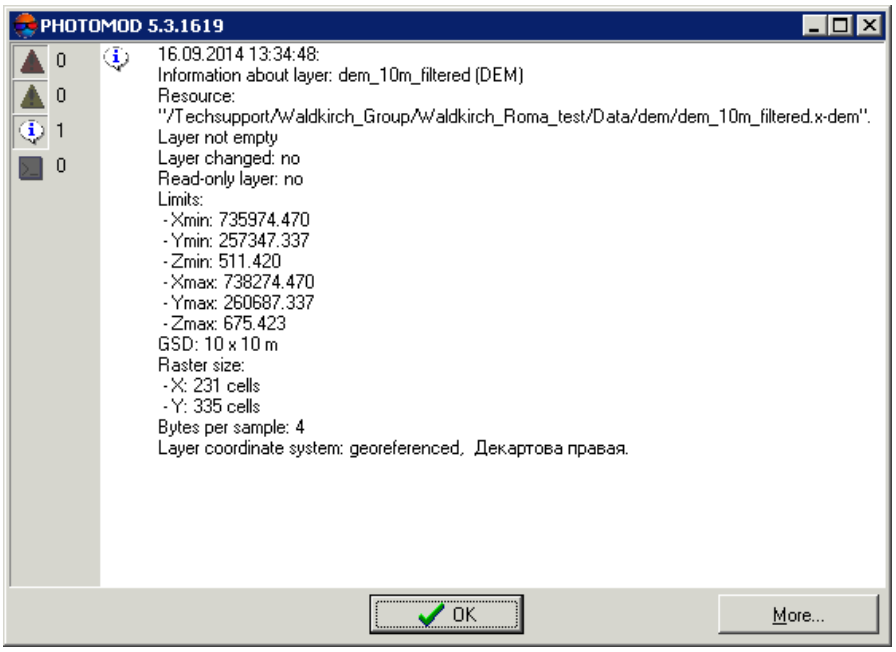


Fig. 53. Information about DEM layer

18.3. DEM creation

18.3.1. DEM creation by TIN

The system provides possibility to create DEM using irregular spatial triangles network (TIN). Perform the following actions to do this:

1. Create or load source TIN.
2. Choose **Terrain › DEM › Build DEM › From TIN** (**Ctrl+N, D**). The **DEM by TIN creation parameters** window opens.

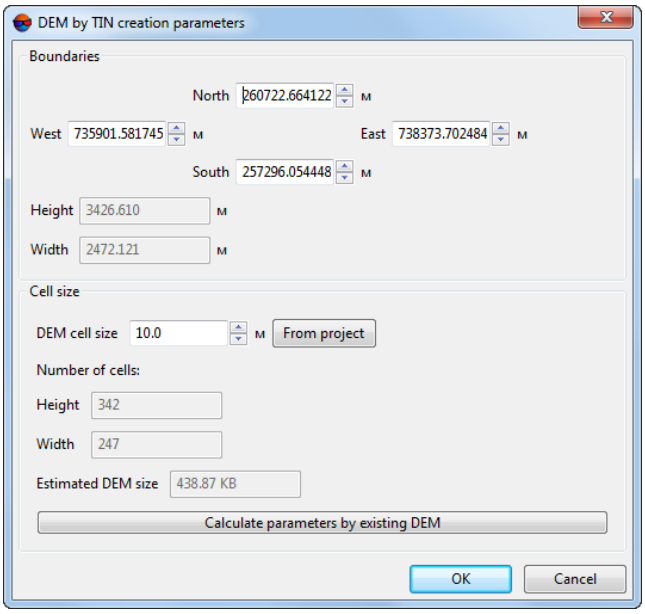


Fig. 54. DEM by TIN creation parameters

3. Specify DEM borders in the **North**, **West**, **East**, **South** fields. In the **Height** and **Width** fields the system displays calculated size of DEM border in meters.

   Default values are coordinates of rectangle corners, which generate TIN creation area.

4. In the **Cell size** specify the **DEM cell size** in meters to define cell size of output DEM. The **Cells number**, calculated considering specified cell size, displays in the **Height** and **Width** fields. Also the **Approximately DEM size** in megabytes displays in the appropriate field.

   DEM cell size should be comparable to average distance between points of base TIN layer. If less cell size is used, the time of DEM creation and size of output file increase, but accuracy is not.

   Click the **From project** button to setup DEM cell size that equals to average GSD value in the project.

5. [optional] It is possible to use parameters of existed DEM to calculate parameters of output DEM. To do that, click the **Calculate parameters by existing DEM** button and choose DEM file in active profile resources.

6. Click OK. Specify DEM file name, define a folder in active profile resources and click **Save**. The system starts DEM creation operation. After that the system creates new layer in the *Manager* and shows a message about operation successful or unsuccessful completion.

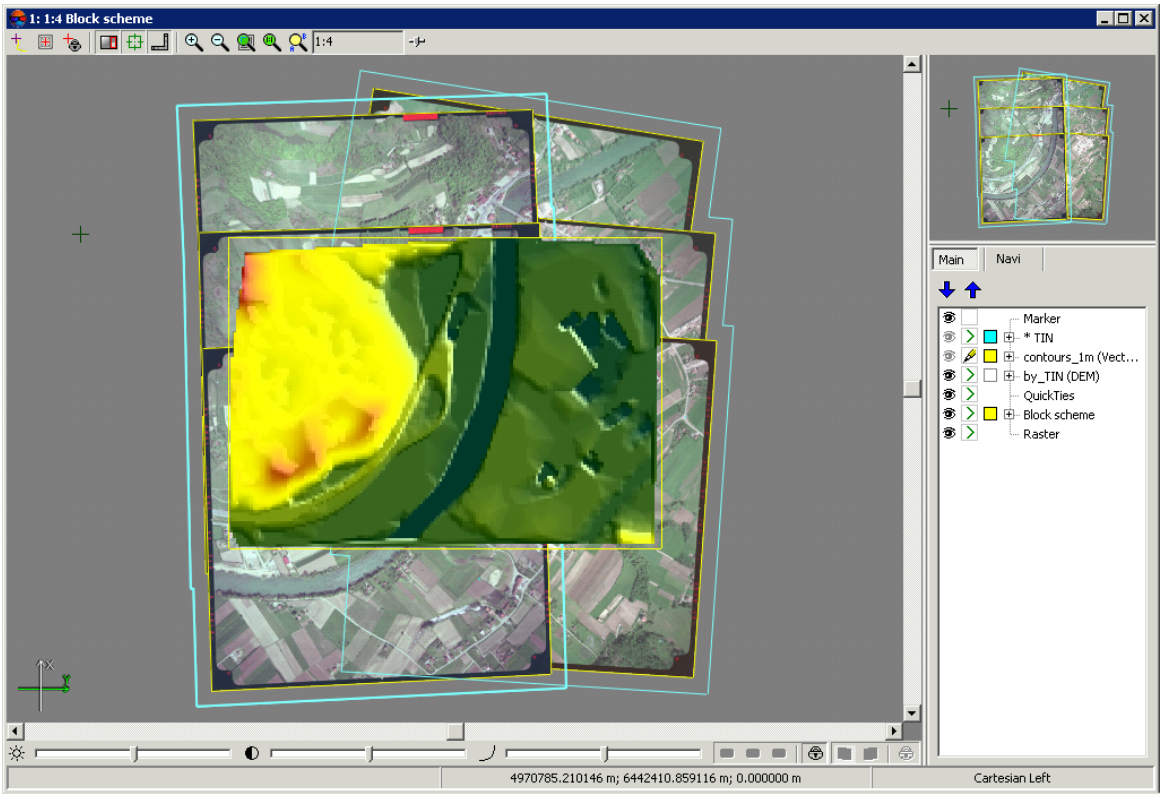


Fig. 55. DEM built from TIN

When marker is moving over DEM, the status panel in 2D-window displays XYZ-coordinates of DEM points.

The system allows to recreate DEM after changing of TIN base layer. To do this use the **Terrain › DEM › Additional › Rebuild by TIN** menu item.

18.3.2. Dense DEM generation using SGM method

The system provides possibility of generation of dense digital elevation model (DTM) using SGM method.

DEM creation using dense model is executed for adjusted images block only (see "Block adjustment" User Manual). Otherwise the DEM generation is not performed or is performed incorrectly.

Before generating dense DSM by SGM method in Pushbroom scanner imagery types of projects (see the "Satellite scanner imagery" chapter of the "Creating project" User Manual) it is recommended to build useful areas (see the "Building useful areas" chapter of the "Creating project" User Manual).

For dense DEM generation using SGM method the system allows the following workflow:

1. DEM generation for a predetermined area.

2. Main processing: applying buildings and vegetation filters to created DEM and/or performing empty cells restoring.

3. [optional] Additional processing — median and/or smoothing filtering.

If intermediate data is not deleted after operation completing, the system allows to run individual stages of the processing (filtering and smoothing) without re-calculation of the source DEM.

4. [optional] Point cloud (LAS) generation for an area limited by DEM boundaries;

5. [optional] True Ortho creation for an area limited by DEM boundaries.

To generate dense digital elevation model using SGM method perform the following actions:

1. Specify a grid to define DEM creation area.

Since the coordinates calculation is performed in each pixel of the selected area, the grid nodes are not considered. The grid is used just as a border of DEM creation area.

2. Select **Terrain › DEM › Build DEM › Dense DSM (SGM method)...**. The **SGM parameters** window opens.

If a grid not was not created in advance, the **Grid properties** window opens, that allows to create a grid for the entire images block.

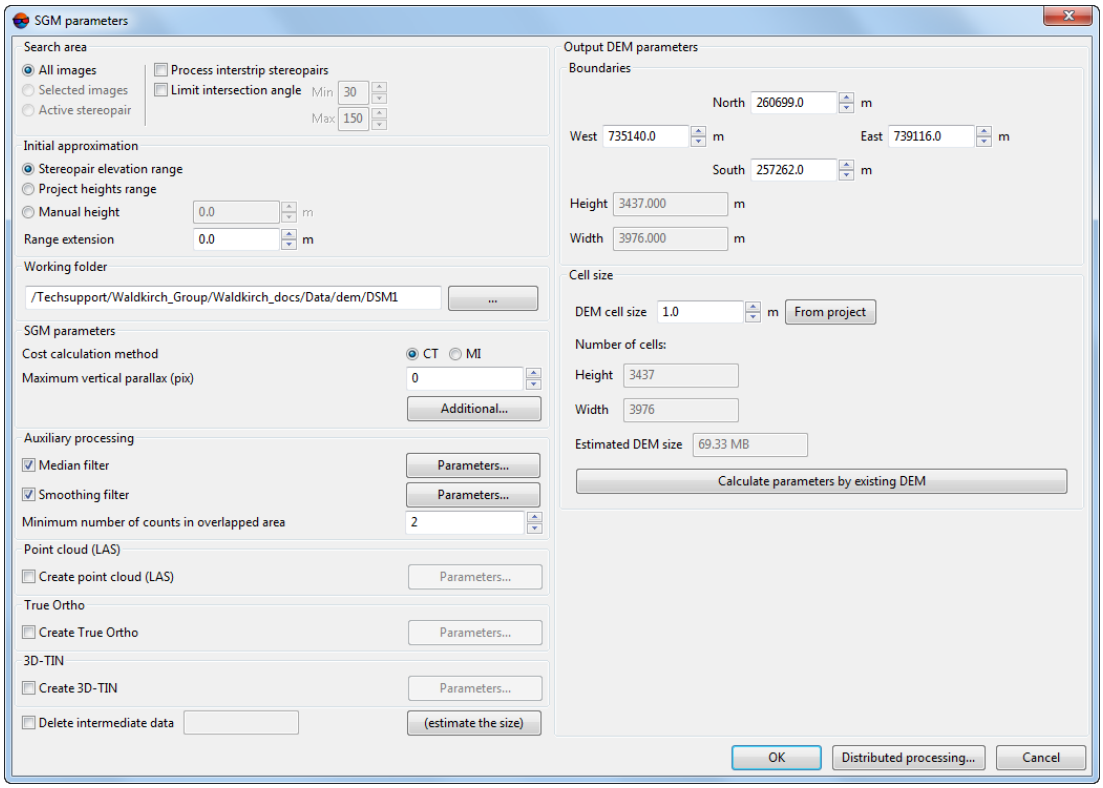


Fig. 56. SGM parameters

3. In the **Search area** section define one of the following searching areas:

   - **All images** – allows to select all images of a block;
   - **Selected images** – allows to select block images highlighted in 2D-window;
   - **Active stereopair** – allows to select images of a stereopair opened in active 2D-window.

   All selected stereopairs should be located on adjusted part of a block (see "Block adjustment" User Manual). Otherwise, the calculation is not performed or is performed incorrectly. In the first case the system displays error message, in the second one – it is not possible to match calculated points to project coordinate system.

4. [optional] Specify additional parameters of search area:

   - set the **Process interstrip stereopairs** checkbox on to calculate DTM on inter-strip stereopairs during UAS projects processing. This option is also used in cases where source images geometric and radiometric parameters allow to use inter-strip stereopairs.

By default DEM generation is performed for strip stereopairs (recommended method). For DEM creation in **Vision Map** projects it is recommended to use strip stereopairs *only*.

- set the **Limit intersection angle** checkbox on to filter blunders by Z on images with intersection angle of small or null value, and define a value of minimal and maximal angles;

To evaluate intersection angles in the images of the project, perform the following:

1. Create a "stereo quality" map for the block of images (see Section "Creation of "stereo quality" map" in the "Vectorization" User Manual). .
2. Change "stereo quality" map coloring according to the `st_ang` attribute values (**Vectors › Attributes › Color by attribute value**, see Sections "Creation of "stereo quality" map" and "Custom object paint" in the "Vectorization" User Manual).
3. To obtain information on the `st_ang` attribute value for the selected stereo quality map node, select the appropriate stereo quality map node and choose **Window › Objects attributes**.

5. In the **Initial approximation** section select a method of heights range calculation for DEM generation:

   - **Stereopair heights range** – heights range is calculated for each stereopair individually using heights of project tie points measured earlier;
   - **Project heights range** – heights range is taken from the **Relief elevation** value in project properties or is calculated using heights of project points measured earlier;
   - **Manual height** – input a height value in meters to be used as initial approximation;

   The **Range extension** field allows to increase height range by a predetermined value to create a DEM. If the **Manual height** mode is on the option specifies working range of heights (search area).

6. In the **Working folder** section click the ... button and choose an *empty* target folder in active profile resources to save the output DEM.

The system removes all data from the target folder prior to perform the save operation.

The name of output DEM is *final_dem.x-dem* (automatically set). The name of output DEM with filled null cells (see paragraph **12**) is *final_dem_tmp.x-dem* (automatically set).

7. In the **SGM parameters** section select the cost calculation method:

- **CT** – method selected by default;
- **MI** – method is less sensitive to non-linear values of images brightness, but more demanding in performance (duration of DEM generation becomes 2-3 times longer).

8. [optional] Setup the **Maximum vertical parallax** value.
9. For more detailed settings of SGM cost calculation click **Additional...**. The **SGM parameters** window opens.

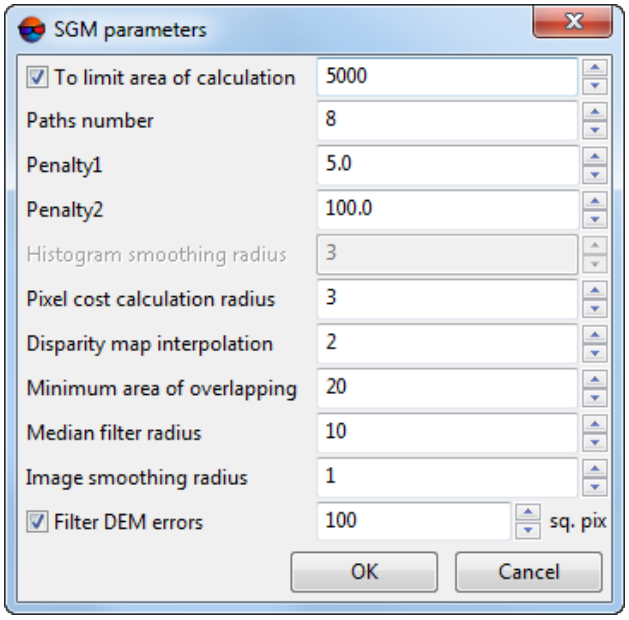


Fig. 57. SGM parameters

Parameters	Description
To limit area of calculation	Specifies a size of parts that epipolar images will be splitted to. The parameter's value affects processing performance.
Paths number	Number of calculation directions. It affects DEM accuracy and generation time. Recommended values: 8, 16, 32.
Penalty 1	Penalty for parallax change by 1 pixel. It is recommended to increase this value when using extensively noisy images. The value may be reduced to improve the accuracy of the DEM when using qualitative data.
Penalty 2	Penalty for parallax change by more than 1 pixel. It is recommended to increase this value when using extensively noisy images. The value may be reduced to improve the accuracy of the DEM when using qualitative data.

Parameters	Description
Histogram smoothing radius	Parameters used just for calculation by **MI** method (see above). Defines smoothing level of epipolar images histogram.
Pixel cost calculation radius	Half-size of rectangular correlation mask in pixels by X and Y axes.
Disparity map interpolation	Interpolation distance when auto-filling missed results («holes») by adjacent pixels.
Minimum area of overlapping	Minimal overlap area of epipolar image parts in pixels. Recommended value: not less than 20.
Median filter radius	Median filter radius used for filtering of parallaxes map of *individual* stereopair.
Image smoothing radius	Smoothing filter parameter used to epipolar images preprocessing.
Filter DEM errors	Allows us to delete isolated DEM areas (having sizes lesser than set ones) during individual processing of each stereopair

Isolated DEM areas – the cells with values beyond the boundaries of the main DEM or among null cells.

10. [optional] In the **Auxiliary processing** section specify the following filtering parameters:

    - set the **Median filter** checkbox to use median filtering during DEM creation and specify **parameters** of filter usage;
    - set the **Smooth filter** checkbox to use smooth filtering during DEM creation and specify **parameters** of filter usage.
    - specify the **Minimum number of counts in overlapped area** parameter value to setup counts reliability in DEM.

      This parameter determines the minimum number of overlapped stereopairs required for calculating the resulting DEM cell value.

      The cell of the final DEM will be recorded if the number of overlapped stereopairs used for its calculation is equal to the preset value (or exceeds it).

      Correct choice of this parameter value depends on minimum stereopair overlap in a block and on using interstrip stereopairs during DEM calculation (see paragraph **4**).

      Recommended default value is 2. In case of a small overlap of stereopairs, it is recommended to lower the value of the **Minimum number of counts in overlapped area** to 1.

      To *estimate* stereopair overlap area in the project, choose **Block › Create overlap map...** (see “Creating overlap map” of the “Creating project” User Manual).

Function **Block › Create overlap map...** allows only to *estimate* stereopair overlap in the project, since map creation is carried out for *images* but not for *stereopairs*.

11. [optional] Set the **Create point cloud (LAS)** checkbox to record a LAS file with a point cloud (see the "LIDAR Data processing" User Manual). For more detailed setting of point cloud creation parameters, click **Parameters...** button. The **LAS creation parameters** window opens:

This function is available only for projects of the "Central projection" type (see the "Project types" chapter of the "Creating project" User Manual).

If the **Create point cloud (LAS)** checkbox is set, it is recommended to use the distributed processing mode for dense DTM creation using the SGM method.

Points cloud will be saved in the separate LAS directory in the folder chosen for output DEM saving in the active profile's resources.

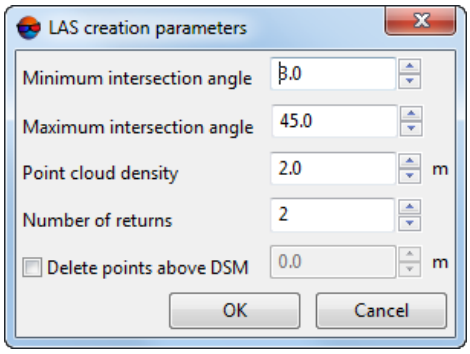


Fig. 58. The "Create LAS parameters" window

- Set **Minimum** and **Maximum intersection angle** in degrees;

To evaluate intersection angles in the images of the project, perform the following:

1. Create a "stereo quality" map for the block of images (see Section "Creation of "stereo quality" map" in the "Vectorization" User Manual). .
2. Change "stereo quality" map coloring according to the `st_ang` attribute values (**Vectors › Attributes › Color by attribute value**, see Sections "Creation of "stereo quality" map" and "Custom object paint" in the "Vectorization" User Manual).
3. To obtain information on the `st_ang` attribute value for the selected stereo quality map node, select the appropriate stereo quality map node and choose **Window › Objects attributes**.

- Set **Point cloud density** in meters;

By default, **Point cloud resolution** is twice as large as the **DEM cell size** (see below).

It is not recommended to set **Point cloud resolution** lesser than the **DEM cell size**.

- Specify the **Number of returns** – the minimum number of stereopairs required for point calculation;
- Set the **Delete points above DSM** checkbox to remove points above DEM. Enter the permissible elevation above the DEM surface, in meters.

  Hence, when the LAS point cloud creating, all points above the DEM surface will be removed, except for those not exceeding the given permissible elevation;

  Too low or zero values of the permissible elevation may cause removal of "good" points, and hence, "sparse" point cloud.

  Recommended value is no less than RMS by Z in stereopairs (see the "Brief residuals report" chapter in the "Block adjustment" User Manual).

  This function is identical to the **Delete points above › DEM** function in the **Filter LAS** window (See the "LIDAR data filtering" chapter of the "LIDAR Data processing" User Manual).

12. [optional] in the **True Ortho** section, set the **Create True Ortho** checkbox to create true ortho limited by DEM boundaries. The true ortho will be created in the work folder (see above), in the PHOTOMOD MegaTIFF (`*.prf`) format;

    Creating the true ortho will notably (approximately 2-fold) increase the time required for DEM creation.

    PHOTOMOD GeoMosaic program allows to save later the obtained true ortho in any of available formats (see the "Orthophotomaps creation" User Manual).

    The name of output orthoimage is *final_ortho.prf* (automatically set). The name of output orthoimage with interpolated null areas is *final_ortho_tmp.prf* (automatically set).

    For more detailed setting of true ortho creation options, click the **Parameters…** button. The **Fill NULL cells** window opens.

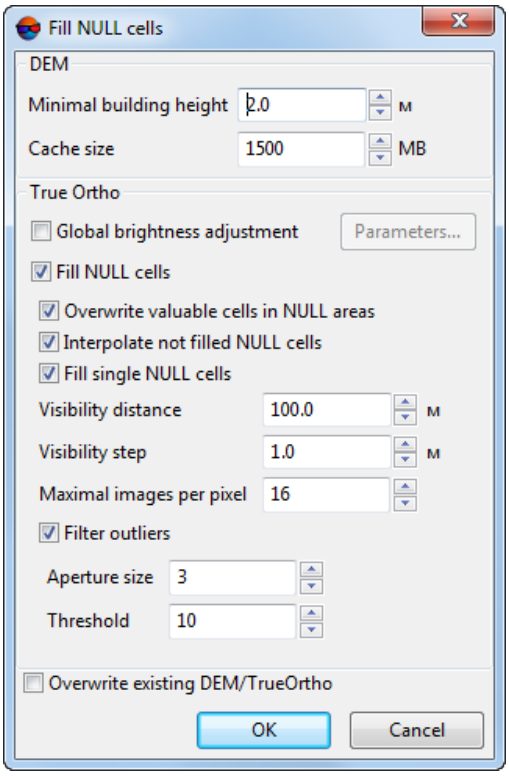


Fig. 59. The “Fill NULL cells” window

- In **DEM** section, set **Minimum building height** in meters to exclude buildings from interpolation of DEM null cells (see the figure below);
- In **DEM** section, set **Cache size** when filling option in megabytes – maximum cache size allocated for a single task when creating true ortho;
- In the **True Ortho** section, set the **Global brightness adjustment** checkbox to apply global brightness adjustment over image overlapping areas when creating an orthophotomap. For more detailed setting of brightness adjustment options, click the **Parameters…** button. The **Parameters** window opens:

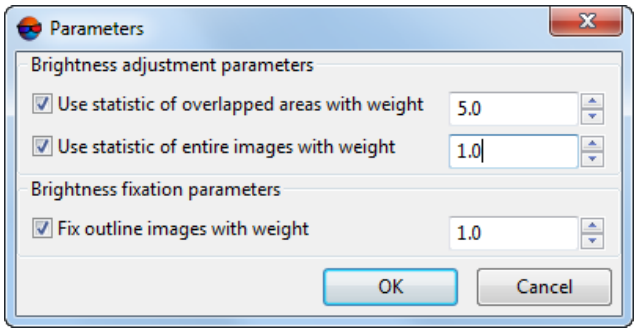


Fig. 60. Brightness adjustment parameters

The opening window allows us to change the following settings of global brightness adjustment:

- **Use statistic of overlapped areas with weight** – allows to use the weight of the images' overlapping areas only;
- **Use statistic of entire images with weight** – allows to use the weight of all the pictures in the block;

  If the images' brightness in a block significantly differ, it is recommended to set a small value.

- **Fix outline images with weight** – allows the user to omit global alignment for pictures on the block borders;

  See the detailed description of brightness adjustment processes when creating an orthophotomap in the "Orthophotomaps creation" User Manual.

- [optional] clear the **Fill NULL cells** checkbox in the **True Ortho** section in order not to fill null cells when creating a DEM (what can lead to creation of unfilled areas when creating an orthophotomap) or specify the following parameters:
  - **Overwrite valuable cells in NULL areas** – allows to exclude *isolated DEM areas* from interpolation of DEM null cells (i.e. interpolate these areas as a NULL cells);

    Isolated DEM areas – the cells with values beyond the boundaries of the main DEM or among null cells.

  - **Interpolate not filled NULL cells** – allows to interpolate unfilled DEM/orthophotomap areas;
  - **Fill single NULL cells** – allows to interpolate areas without data having one pixel size in a DEM or orthophotomap;
  - **Visibility distance** – the distance within which the visibility of points located in unfilled areas of an orthophotomap is checked in the project's images;
  - **Visibility step** – an increment with which the visibility of points located in unfilled areas of an orthophotomap is checked in the project's images;
  - **Maximum images per pixel** – maximum number of images of the project where the visibility of points located in unfilled areas of an orthophotomap is checked;

- **Filter outliers** – allows to perform orthophotomap median filtering with preset **Threshold**. The statistics is collected in the neighborhood whose area is determined by the **Aperture size**. This filter is used for removing single pixels with unnatural brightness.

- [optional] set the **Overwrite existing DTM/TrueOrtho** checkbox in order not to use intermediate data from the working folder (if DEM and orthophotomap has already been created) but overwrite them.

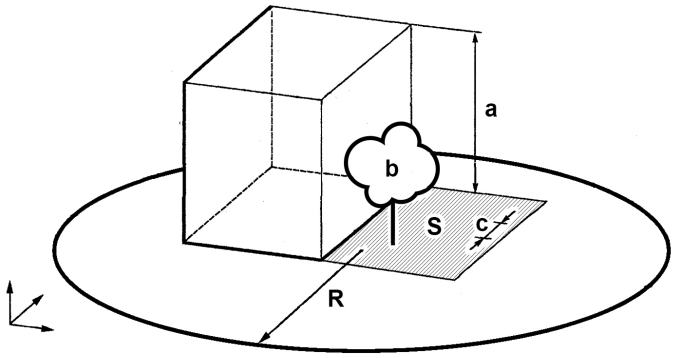


Fig. 61. An example of unfilled area on true ortho, where **a** is the building height (see **Minimum building height** parameter), **b** is the "isolated DEM area" among DEM NULL cells (see **Overwrite valuable cells in NULL areas** checkbox), **c** is the **Visibility step**, **R** is the **Visibility distance**, **S** is the unfilled DEM/orthophotomap area (due to the fact that the image is the central projection of terrain and objects towering above the Earth surface hide some terrain areas, thus they are not seen on the image). Also, the quality of an orthophotomap is affected by the zones hidden by the object's shadow, and brightness adjustment is required.

13. [optional] in the **3D-TIN** section, set the **Create 3D-TIN** checkbox to create textured 3D-TIN surface limited by DEM boundaries. The 3D-TIN will be created in the work folder (see above), in the `*.tx3` format;

For further work with 3D-TIN, the *PHOTOMOD 3D-Mod* program is used (see more details in the "Three-dimensional modeling" User Manual).

The name of output 3D-TIN is *tin.tx3* (automatically set).

For more detailed setting of 3D-TIN creation options, click the **Parameters…** button. The **Creation 3D-TIN by DEM** window opens.

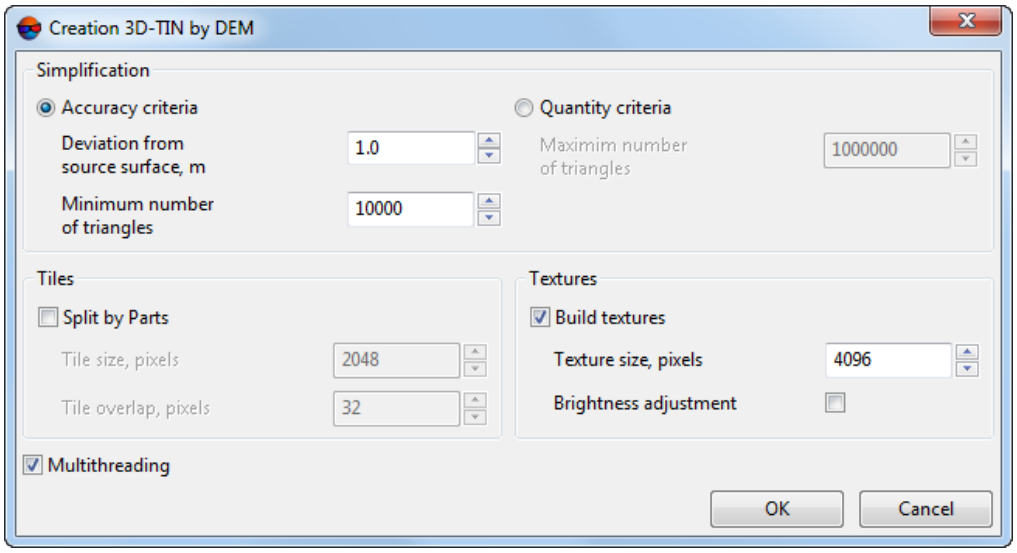


Fig. 62. The “Creation 3D-TIN by DEM” window

- In the **Simplification** section, select the method of simplification of the source 3D-TIN surface built by the input DEM:
  - **Accuracy criteria** – set the **Minimum number of triangles** in the final 3D-TIN and its maximum allowable **Deviation from source surface**, in meters;
  - **Quantity criteria** – set the **Maximum number of triangles** in the final 3D-TIN.
- [optional] In the **Tiles** section, set the **Split by parts** checkbox, to split the 3D-TIN surface and its textures into fragments;

  To increase the system’s performance, it is recommended to set the **Split by parts** checkbox when creating 3D-TIN for large areas.

  - In the **Tile size** field, set the size of 3D-TIN texture fragments, in pixels;
  - In the **Tile overlap** field, set the 3D-TIN fragment overlap, in pixels.

    It is not recommended to set null overlaps.

- [optional] In the **Textures** section, set the **Build textures** checkbox to create a textured 3D-TIN surface:
  - Set the **Texture size**;

    It is recommended to set the **Texture size** exceeding the **Tile size** at list twice. Increasing of this parameter results in increased texture resolution and increased time of 3D-TIN building.

- [optional] Set the **Brightness adjustment** checkbox to adjust brightness between triangle textures;

- [optional] To use all cores of workstation CPU for calculation operation, the **Use all available CPU cores** checkbox is set on in the system by default. It is necessary to set the checkbox off to use only one core.

14. [optional] To remove processing data after the calculation is completed set the **Delete intermediate data** checkbox on. Click the **(estimate the size)** button to get information about disk space occupied by intermediate data.

It is not recommended to remove intermediate data up to final creation of DEM. After removing of intermediate data it is impossible to start separate steps (filtering or smoothing) without DEM re-calculation.

15. In the **Output DEM parameters** section specify DEM boundaries in the **North**, **West**, **East**, **South**. In the **Height** and **Width** fields the system displays calculated size of DEM border in meters.

16. Specify **DEM cell size** in meters to change size of output DEM cell. In the **Height** and **Width** fields of the **Cell size** section the system displays nodes number calculated with specified DEM cell size. There is also displayed the **Appr DEM size** in megabytes.

The value of **the DEM cell size** parameter should not be less than average pixel size (GSD). When using cell size with smaller size the time of DEM creation and a size of output file are increasing, however, the processing accuracy is not improved at that.

Click the **From project** button to setup DEM cell size that equals to average GSD value in the project.

17. [optional] In order to calculate parameters of output DEM using parameters of the existing DEM, click the **Calculate parameters by existing DEM** button and select file with DEM in active profile resources.

18. Click OK to start dense DEM generation operation in normal mode.

In order to generate DEM using distributed processing, perform the following actions:

While building DSM by SGM method in distributed processing mode, stereopairs are processed separately in different tasks (see the **Searching area** section). The last task is responsible for merging data acquired.

1. Start the server/client of distributed processing mode (see the “Distributed processing” chapter in the “General information” User Manual).

2. Open the **Monitor for distributed processing** and specify the **Maximum tasks quantity** value not more than one for each client.

3. Click the **Distributed processing...** button.

Depending on the size of creation area the operation can take a long time.

To provide a system performance while building dense DSM by SGM method it is recommended to use Distributed processing mode.

18.4. DEM filtering

The system allows to filter DEMs. The following filters are provided for editing DEMs:

- Building and vegetation filter as well as Slope based filter are designed for searching and correcting DEM areas that cover buildings, vegetation, man-made objects and accident spikes. As a result of filtering DEM contains heights of “true relief” only;
- Median filter and Smooth filter are designed for filtering accident spikes – points that are placed far from the average smooth relief surface. As a result of filtering DEM contains heights of “true relief” only;
- Filter by image texture is designed for deleting areas of DEM depending on characteristics of image texture. At the preliminary step (so-called «Learning») an operator manually collects specific areas of images as samples for filtering

18.4.1. Buildings and vegetation filter

The system allows to use filtering of buildings and vegetation of DEM. Such filtering includes calculation of base points with specified coefficient of DEM subsampling. The operation includes deletion, correction or recognizing points which have fallen on buildings, trees, cars, in pits, etc. during automatic points calculation, as well as filtering of accident spikes. After the filtering output DTM contains just terrain relief model.

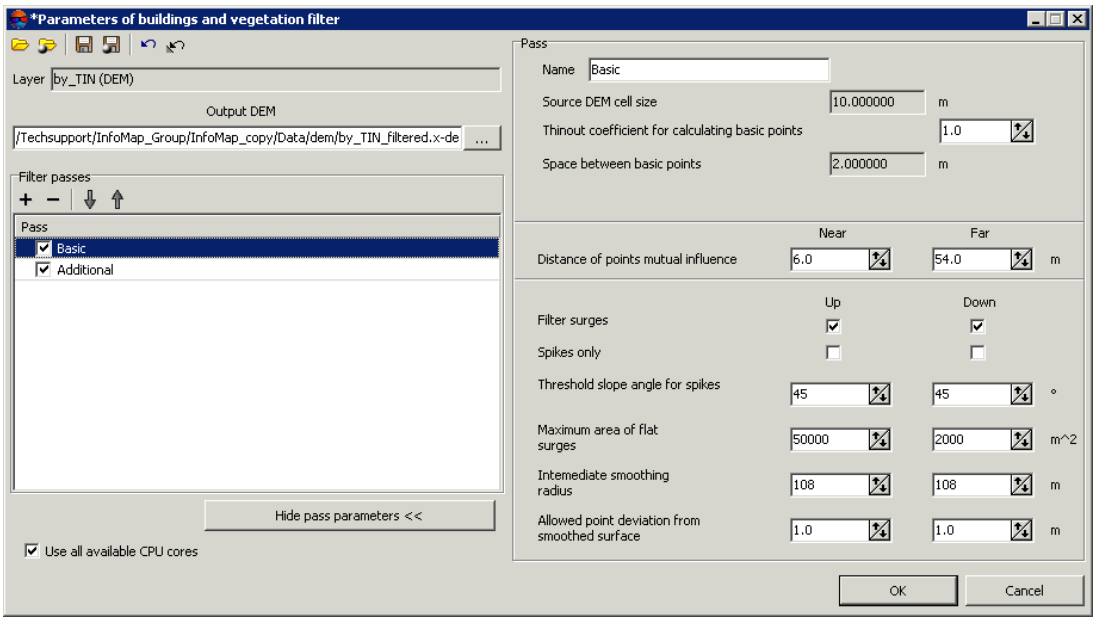


Fig. 63. Buildings and vegetation filtering from DEM

The **Buildings and vegetation filter** window allows to specify filtering parameters and setup a number of filter passes. The **Layer** field displays a name of active vector layer. The window contains a standard toolbar.

Button	Function
	allows to load a script of filter work from `*.x-filter` resource located out of active profile resources
	allows to load a script of filter work from `*.x-filter` resource located in active profile resources
	allows to save a current script of filter work to `*.x-filter` resource located out of active profile resources
	allows to save a current script of filter work to `*.x-filter` resource located in active profile resources
	allows to cancel all changes made to a script
	allows to go back to a standard script that includes two passes with default settings (regardless of which script has been loaded)

To filter buildings and vegetation on DEM perform the following actions:

1. Make active a DEM layer.

2. Select **Terrain › DEM › Filter › Buildings and vegetation filter**. The **Buildings and vegetation filter** window opens.

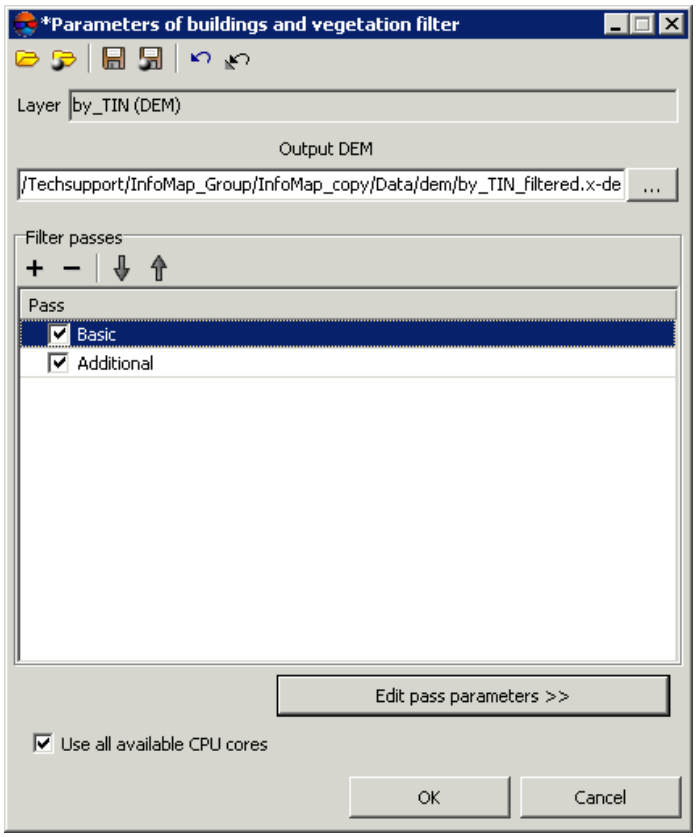


Fig. 64. Buildings and vegetation filtering from DEM

3. In the **Output DEM** section click the ... button and specify name and target folder of output DTM in active profile resources.

4. [optional] Specify a number of filter passes:

   - by default it is used two passes with standard parameters – **Basic** and **Additional**. Set off checkboxes to change number of passes;
   - the + button allows to add a new pass of filter;
   - the − button allows to remove selected pass of filter;
   - the ↓ and ↑ buttons allow to move selected pass up/down.

5. Select a name of pass and click the **Edit pass parameters** button to display and configure the following parameters of filter pass:

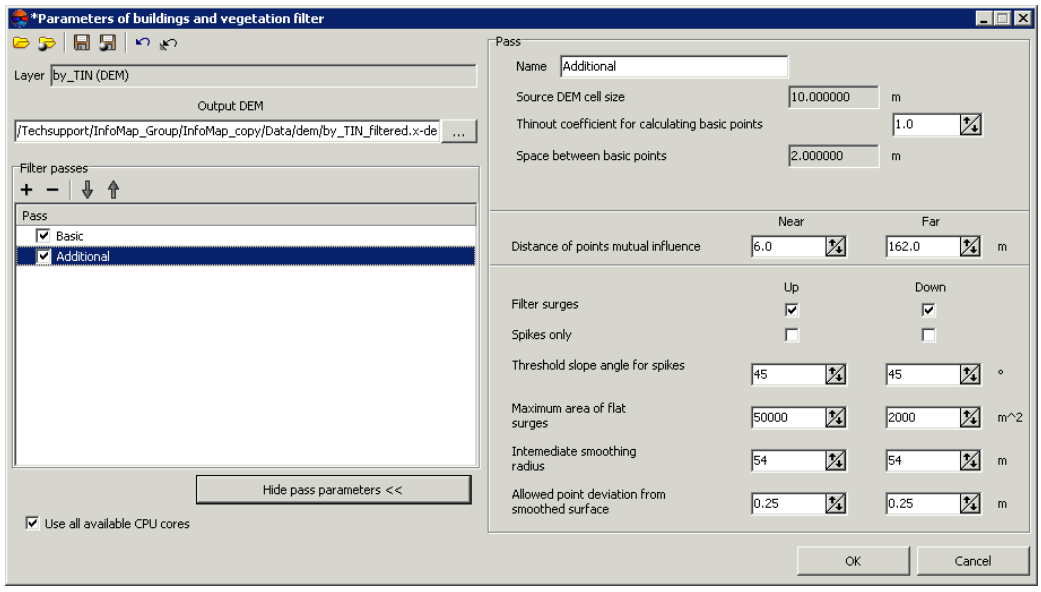


Fig. 65. Configuration of buildings and vegetation filter

- [optional] to change a filter pass name, input new name to the **Name** field;
- the **Source DEM cell size** field shows DEM cell size in meters before filter applying;
- specify **Thinout coefficient for calculating basic points** by DEM. From the specified value and the **Source DEM cell size** parameter depends the **Space between basic points** parameter in meters;
- specify **Near** and **Far distance of mutual points influence** in meters to define the radius of the circle, in which the values of points are analysed for errors. For near distance (minimal circle radius) it is recommended to set a value of 3-5 values of the average distances between points;
- specify the following filtering parameters **Up** (above surface) and/or **Down** (below surface):
  - **Filter surges** – allows to select points to be filtered: points on surface (high objects) and/or points below surface (pits);

    For filter operating it is necessary to set at least one checkbox on.

  - **Spikes only** – is used to reject just sharp spikes above/below surface, that are defined by values of the **Threshold slope angle for spikes** and **Distance of points** parameters. The rest of parameters are not considered;

In an angle between three points exceeds a value of the **Threshold slope angle for spikes** parameter, then the surge is called *spike*.

- **Threshold slope angle for spikes** – allows to specify angle of slope in relation to selected measuring plane (above and/or below surface) to define sharp spikes;
- **Maximum area of flat surges** – allows to define maximal area of plane surges (above/below surface) – points groups, that form smooth surfaces and are distant from some plane of neighbour points. Generally, the points are located on buildings roofs, and are lying on the same plane;

The filter is not applied to plane surface, which area exceeds the specified value.

- **Intermediate smoothing radius** – allows to specify a sphere radius (above/below surface), that defines a level of intermediate smoothing of surface;
- **Allowed point deviation from from smoothed surface** – allows to specify criterion, according which the filter is applied to all points with elevations that differ from smoothed surface more then on specified value.

The button allows to go back to a standard script that includes two passes with all default settings (regardless of which script has been loaded).

6. [optional] To use all cores of used computer, the **Use all available CPU cores** checkbox is set on in the system by default. It is necessary to set the checkbox off to use only one core.
7. Click OK. The system starts DEM filtering operation. When the filtering operation is completed the system displays information message about number of used basic points and points being filtered.

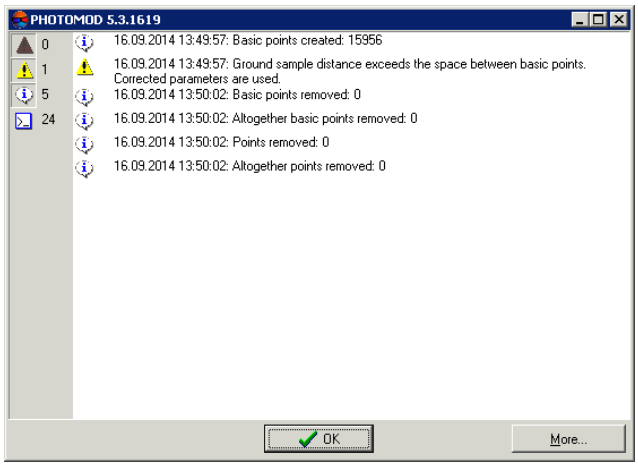


Fig. 66. Filtering results

18.4.2. Median filter

The system allows to use median filtering of DEM cells.

The *median filtering* contains the following sequence of actions:

1. Sequential scanning of DEM by mask with specified size. Size of scanning mask is defined by the **Aperture** parameter (in DEM cells).

2. The system replaces current cell elevation values by median values, if a difference between them is not more than specified **Threshold** in meters.

To apply median filtering perform the following actions:

1. Make active a DEM layer.

2. Select **Terrain › DEM › Filter › Median filter**. The **Median filter parameters** window opens.

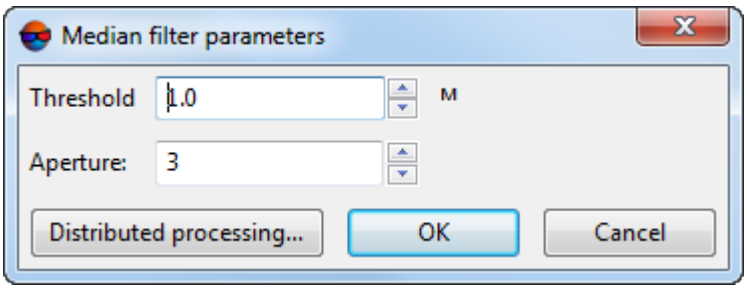


Fig. 67. Median filter parameters

3. In the **Threshold** field specify a value of threshold in meters, which is used to compare difference value between current and median elevation.

4. In the **Aperture** field specify a size of scanning mask.

5. Click OK. After that current values of DEM cells are replaced by median values, if difference value between current and median elevation does not exceed specified **Threshold**.

   To use distributed processing for DEM median filtering, do the following:

   1. Change settings and run the distributed processing server/client (see the "*Distributed processing*" chapter in the "General information about system" User Manual).

   2. Click the **Distributed processing** button. The **DEM distributed processing** window opens.

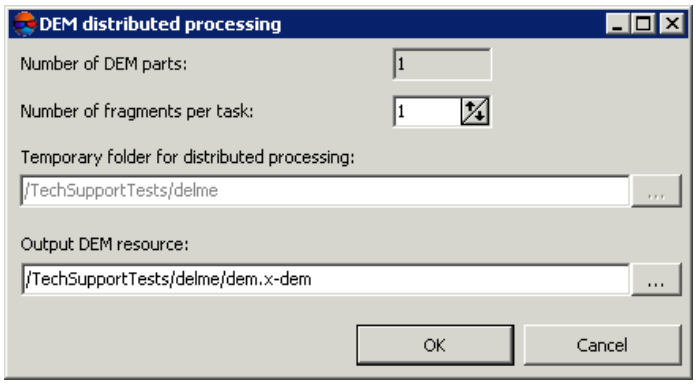


Fig. 68. Parameters of distributed DEM filtering

   3. The **number of DEM parts**, which the DEM is split on during distributed processing, is calculated automatically and depends on the size of the matrix. It is recommended to specify **Number of fragments per task** assuming one task per one computer.

   4. Select the **Temporary folder for distributed processing** for temporary data storing.

   5. Define the output file name and path.

   6. Click OK. Distributed processing tasks are created and the system shows a message about number of created tasks.

18.4.3. Smooth filter

The system allows to use smooth filtering of DEM cells values.

To execute smooth filtering perform the following actions:

1. Make active a DEM layer.

2. Select **Terrain › DEM › Filter › Smooth filter**. The **Smooth filter parameters** window opens.

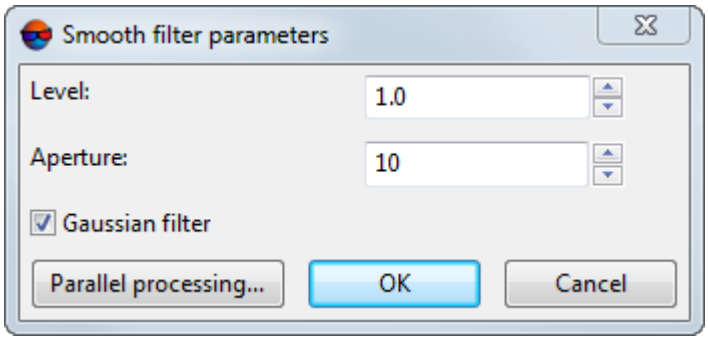


Fig. 69. Smooth filter parameters

3. In the **Level** field specify filtering coefficient value from 0 to 1.

4. In the **Aperture** field specify a size of scanning mask.

5. [optional] To apply Gauss smoothing algorithm the **Gaussian filter** checkbox is set on by default.

6. Click OK. After that current values of DEM cells elevation are replaced by filtered values.

   To use distributed processing for DEM smooth filtering, do the following:

   1. Change settings and run the distributed processing server/client (see the "*Distributed processing*" chapter in the "General information about system" User Manual).

   2. Click the **Distributed processing** button. The **DEM distributed processing** window opens.

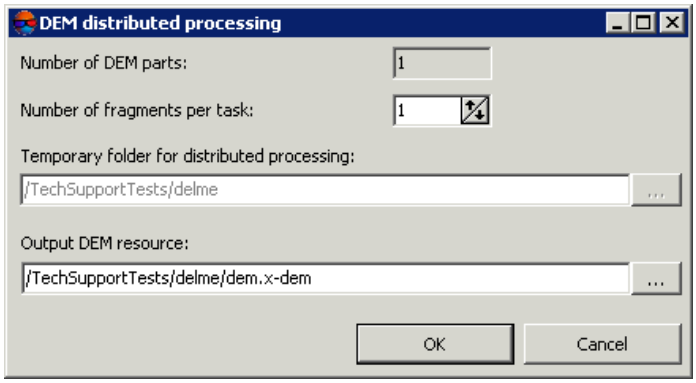


Fig. 70. Parameters of distributed DEM filtering

3. The **number of DEM parts**, which the DEM is split on during distributed processing, is calculated automatically and depends on the size of the matrix. It is recommended to specify **Number of fragments per task** assuming one task per one computer.

4. Select the **Temporary folder for distributed processing** for temporary data storing.

5. Define the output file name and path.

6. Click OK. Distributed processing tasks are created and the system shows a message about number of created tasks.

18.5. Null cells in DEM

18.5.1. General information

During automatic creation of regular relief model (DEM) some part of the cells can not be defined. Such DEM cells ('gaps'), which elevation is not known, are called *null cells*.

The system provides possibility to restore null cells of DEM using the following methods of null cells filling:

- linear interpolation method (see the "DTM Generation" User Manual);
- smooth interpolation method (see Section 18.5.2);
- filling with constant value (see the "DTM Generation" User Manual).
- filling with minimum value (see Section 18.5.3).

The system also allows to transform DEM cells with specified elevation to null cells.

Filling DEM null cells is also used to change input DEM cell size.

18.5.2. Filling null cells using smooth interpolation

The system provides possibility to restore null cells of DEM using the smooth interpolation method. When applying the method of smooth interpolation the system evaluates the factor of input DEM thinning to obtain auxiliary DEM. An auxiliary DEM is used to calculate elevation values of null cells, and DEM cells with filled elevations are not re-calculated. Borders and cell size of output DEM are fully correspond to the boundary and the cell size of the input DEM.

This method is recommended for a sufficiently dense DEM.

To fill DEM null cells by smooth interpolation method perform the following methods:

1. Select **Terrain › DEM › Fill null cells › Smooth interpolation...**. The **Parameters of filling null cells in DEM** window opens.

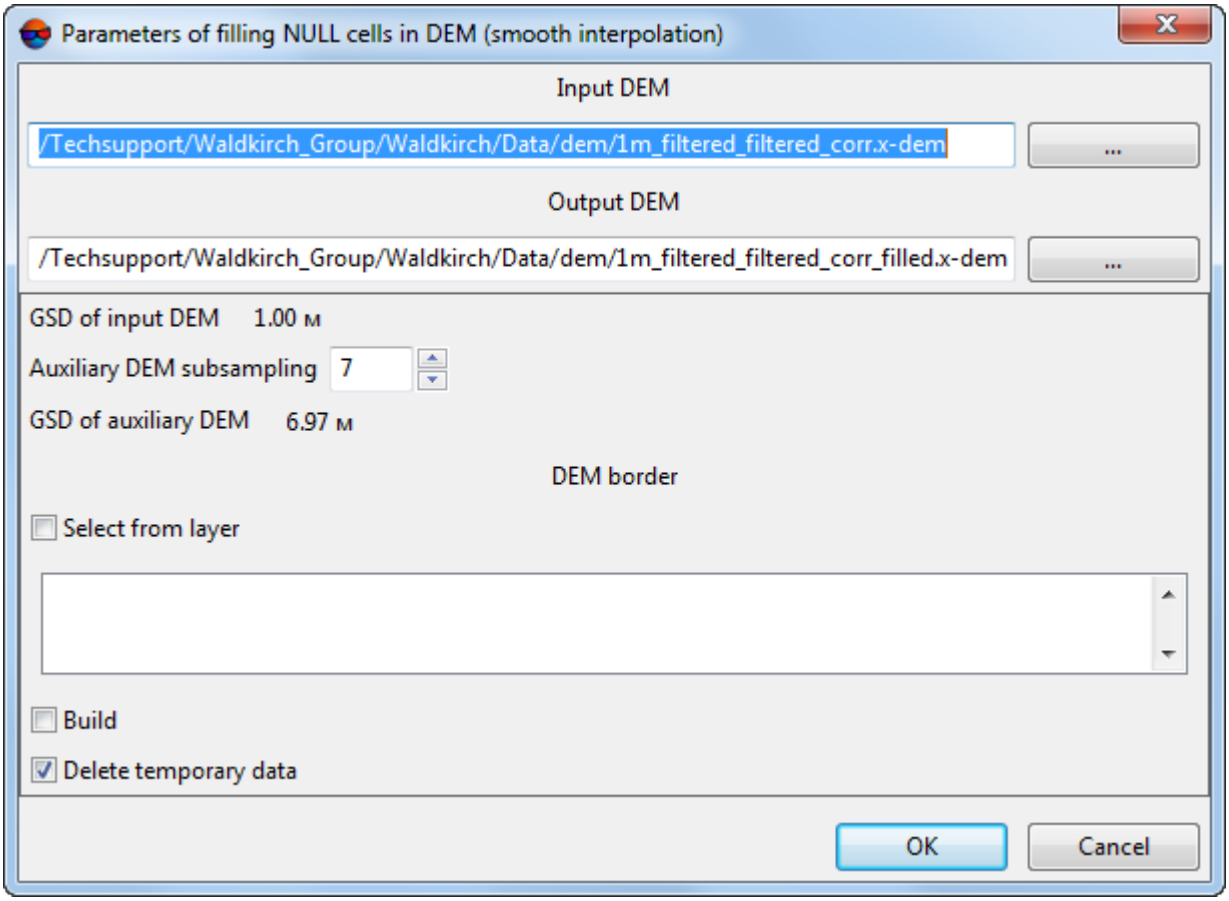


Fig. 71. Parameters of filling null cells using smooth interpolation

The window displays the **ground sample distance (GSD)** of input DEM in meters.

2. In the **Input DEM** section click the ... button to select input DEM in active profile resources.

   The DEM loaded to the project is selected by default.

3. [optional] To define name and target folder of output DEM in active profile resources, click the ... button.

   By default the system suggests the *<input dem name>_filled.x-dem* name for output DEM and to place it to the folder, containing input DEM file.

4. Input the **Auxiliary DEM subsampling**. After that the **GSD of auxiliary DEM** is calculated automatically.

5. [optional] In the **DEM border** section, set the **Select from layer** checkbox to set border of the output DEM using a vector polygon.

   It is required to create in advance a vector layer with *one* polygon which sets borders of the output DEM.

   From the opened list of downloaded vector layers, select *one* vector layer that contains a polygon limiting a DEM;

6. [optional] In the **DEM border** section, set the **Build** checkbox to create borders of the output DEM automatically;

7. [optional] To remove processing data after the calculation is completed set the **Delete intermediate data** checkbox on;

8. Click OK. The system starts calculation of null cells elevation using smooth interpolation method. After that the system creates new DEM layer in the *Manager*.

18.5.3. Filling null cells by minimum values

The system provides possibility to fill null cells of DEM by minimum values.

The system also provides possibility to interpolate areas without data on orthophotomap (true ortho) created together with the DEM.

To fill DEM null cells with minimum values perform the following:

1. Select **Terrain › DEM › Fill null cells › By minimum values...**. The **Fill NULL cells** window opens.

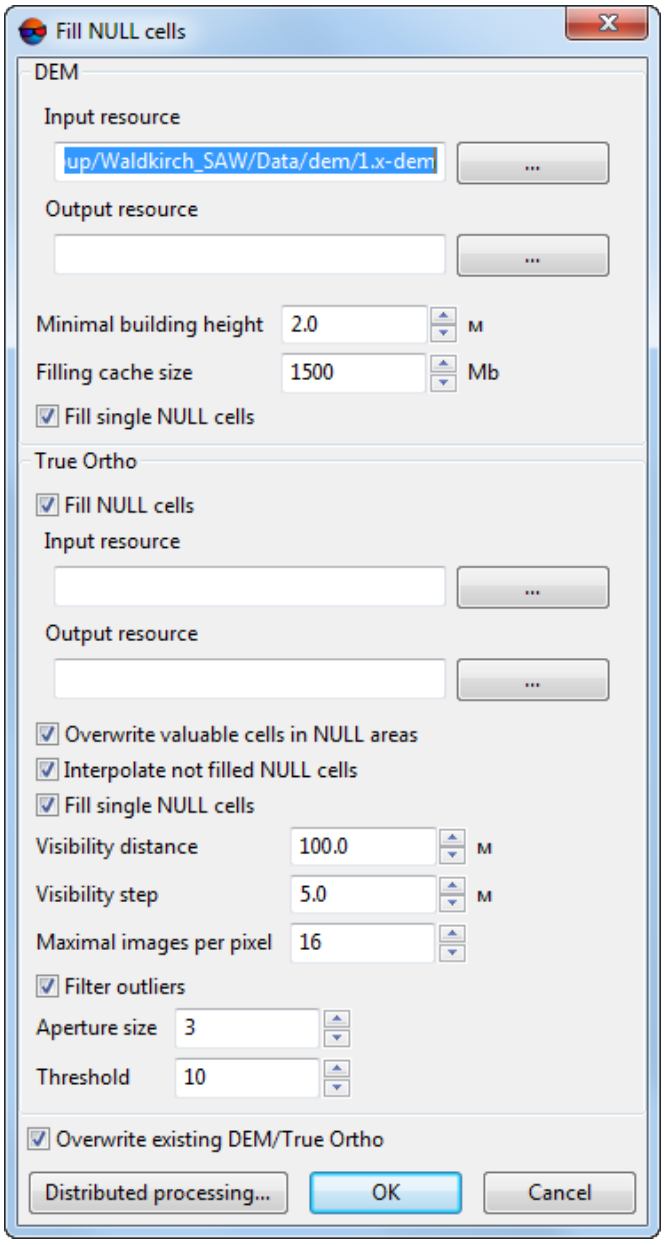


Fig. 72. Parameters of filling null cells of DEM by minimum values

2. In the **DEM** section click the ... button to select input DEM in active profile resources.

3. [optional] To define name and target folder of output DEM in active profile resources, click the ... button.

4. In **DEM** section, set **Minimum building height** in meters to exclude buildings from interpolation of DEM null cells (see the figure below);

5. In **DEM** section, set **Cache size** when filling option in megabytes – maximum cache size allocated for a single task when creating true ortho;

6. [optional] In **DEM** section, clear the **Fill single NULL cells** checkbox in order not to interpolate single DEM NULL cells;

7. [optional] In **True Ortho** section, clear the **Fill NULL cells** checkbox in order not to interpolate unfilled areas on orthophotomap;

8. In the **True Ortho** section click the ... button to select input true ortho in active profile resources.

   For correct work of interpolation algorithm it is required to select the orthophotomap that was created together with the DEM in the same boundaries (see step **2**).

9. [optional] To define name and target folder of output true ortho in active profile resources, click the ... button.

10. [optional] Set the following parameters of unfilled areas interpolation on orthophotomap:

    - **Overwrite valuable cells in NULL areas** – allows to exclude *isolated DEM areas* from interpolation of unfilled true ortho areas;

      Isolated DEM areas – the cells with values beyond the boundaries of the main DEM or among null cells.

    - **Interpolate not filled NULL cells** – allows to interpolate unfilled orthophotomap areas;

    - **Fill single NULL cells** – allows to interpolate areas without data having one pixel size on orthophotomap;

    - **Visibility distance** – the distance within which the visibility of points located in unfilled areas of an orthophotomap is checked in the project's images;

    - **Visibility step** – an increment with which the visibility of points located in unfilled areas of an orthophotomap is checked in the project's images;

    - **Maximum images per pixel** – maximum number of images of the project where the visibility of points located in unfilled areas of an orthophotomap is checked;

    - **Filter outliers** – allows to perform orthophotomap median filtering with preset **Threshold**. The statistics is collected in the neighborhood whose area is determined by the **Aperture size**. This filter is used for removing single pixels with unnatural brightness.

11. [optional] set the **Overwrite existing DTM/TrueOrtho** checkbox in order not to use intermediate data from the working folder but overwrite them.

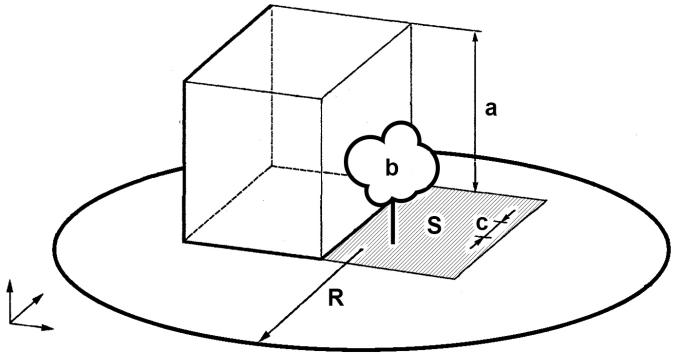


Fig. 73. An example of unfilled area on true ortho, where **a** is the building height (see **Minimum building height** parameter), **b** is the “isolated DEM area” among DEM NULL cells (see **Overwrite valuable cells in NULL areas** checkbox), **c** is the **Visibility step**, **R** is the **Visibility distance**, **S** is the unfilled DEM/orthophotomap area (due to the fact that the image is the central projection of terrain and objects towering above the Earth surface hide some terrain areas, thus they are not seen on the image).

12. Click OK. The system starts filling of null cells operation. After that the system displays a message about number of changed cells and creates new DEM layer in the *Manager*.

    To use distributed processing for DEM null cells filling, do the following:

    1. Change settings and run the distributed processing server/client (see the ’*Distributed processing*’ chapter in the ’General information about system’ User Manual).

    2. Click the **Distributed processing** button. The **DEM distributed processing** window opens.

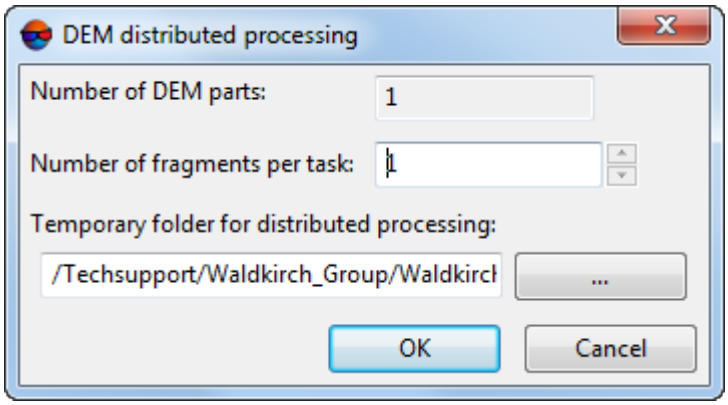


Fig. 74. DEM distributed processing

3. The **number of DEM parts**, which the DEM is split on during distributed processing, is calculated automatically and depends on the size of the matrix. It is recommended to specify **Number of fragments per task** assuming one task per one computer.

4. Select the **Temporary folder for distributed processing** for temporary data storing.

5. Click OK. Distributed processing tasks are created and the system shows a message about number of created tasks.

19. Contour lines

Refer to the "DTM Generation" User Manual for the detailed information about contours generation.

19.1. The "Contours" menu

The **Contours** menu contains usual menu items used for contours generating, editing, import and export.

The **Contours** menu is located in the **Terrain** menu.

Table 19. Brief description of the "Contours" menu

Menu items	Function
Load... (Ctrl+O, V)	allows to load contour lines from `*.x-data` file (see the "Vectorization" User Manual)
Recent	allows to perform the quick access to recently loaded contour lines
Save	allows save or rewrite active contours layer
Save as...	allows to save active layer with new name

Menu items	Function
Save selected as...	allows to save *just* selected contours
Close	allows to close contour lines layer
Build contours	contains menu items used to create contour lines with help of various source data
Import	contains items used to import contour lines from files with different extensions (see the "*Import of vector objects*" chapter of the "Vectorization" User Manual)
Export	contains menu items used to perform export of contour lines to files with different extensions (see the "*Export of vector objects*" chapter of the "Vectorization" User Manual)
Additional	contains the **Additional** menu

Table 20. Brief description of the "Contours" menu (Additional)

Menu items	Function
Build contours	contains menu items used to create contour lines with help of various source data
Check contours intersections...	allows to check created contours for crossing/self-crossing, that occur after operation of contours smoothing
Check contours by points	allows to perform quality control of contours creation using regular points, if they were not used for contours creation
Merge contours...	allows to merge created contours in automatic or manual mode
Check merging contours...	allows to check contours for breaks that occur after manual or automatic contours merging
Contours connecting	allows to connect created contours automatically or manually (without merging into a single vector object)
Check contours vertices	allows to check elevations of created contours vertices
Precision of objects coordinates	allows to set a precision of vector objects coordinates at level of decimal places

19.2. Generation contour lines by DEM

The system provides possibility to create contour lines by digital elevation model (DEM).

In order to build contours using DEM perform the following actions:

1. Load a DEM layer.

2. [optional] Create and select one or multiple vector polygons, if it is needed to build a contours inside selected polygons;

3. Choose **Terrain › Contours › Build contours › From DEM...**. The **Contours creation parameters** window opens.

   The **DEM parameters** section displays information about elevation difference (**Min. elevation**, **Max. elevation**) in DEM.

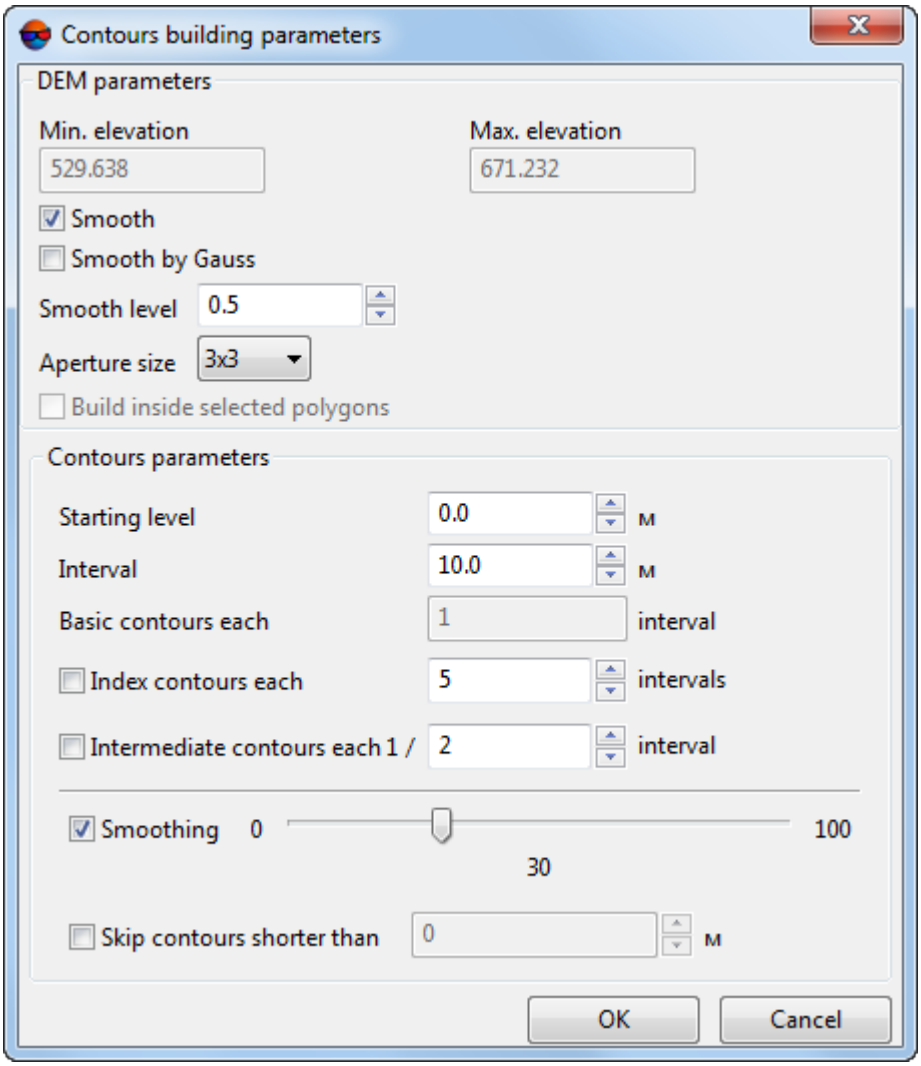


Fig. 75. Parameters of contour lines generation by DEM

4. [optional] In order to create contours as smoothed curves it is needed perform operation of DEM smoothing prior to contours creation. To do this set the **Smooth** checkbox on in the **DEM** section. Specify smoothing level in the **Smooth level** field (maximal smoothing is applied at 1 value).

   During smoothing the system uses information about adjacent nodes in each DEM node. In order to specify number of adjacent nodes of DEM, select the **Aperture size** in the list.

5. [optional] To apply Gauss smoothing algorithm set the **Smooth by Gauss** checkbox;

6. [optional] Set the **Build inside selected polygons** checkbox to create a contours within the selected polygons;

7. [optional] Input minimal elevation level (Zmin), which will be zero-level for contours creation, to the **Starting level** field.

   In order to obtain information about about elevation difference (Zmin, Zmax), click the DEM layer by mouse right button in the *Manager* and select **Information**. The system displays the information window that contains information about the layer.

8. In the **Interval** field specify contours interval in meters. Interval of **Basic contours** equals to 1 contours **Interval** (displayed in the **Basic contours** field).

9. [optional] To create index contour lines the **Index contour lines** checkbox is on by default. Set the checkbox off to cancel index contour lines creation.

   The interval of **index contour lines** equals to five intervals of basic contours by default. The system allows to set arbitrary interval of **index contour lines** manually.

10. [optional] To create intermediate contour lines the **Intermediate contour lines** checkbox is on by default. Set the checkbox off to cancel intermediate contour lines creation.

    The interval of **intermediate contour lines** equals to half of basic contours interval by default. The system allows to set arbitrary interval of **intermediate contour lines** manually.

11. [optional] For the additional smoothing of created contours, set the **Smoothing** checkbox on and specify a level of smoothing using the slider.

12. [optional] In order to cancel creation of short contours, set the **Skip contour lines shorter than** checkbox on and input minimal contour length in meters.

13. Click OK. After that the system starts to create contours in a new layer *Contours*.

To edit created contours select **Window › Additional › Contours classifier table**.

20. Additional features

20.1. Creating overlap map

For visual analysis of images and strips overlap in a block the program provides a feature of overlap map creating. After creating of such a map the overlap areas are created as kind of vector polygons on a new vector layer.

Perform the following actions to create overlap map:

1. Choose **Block › Create overlap map**. The **Create “heat map”** window opens.

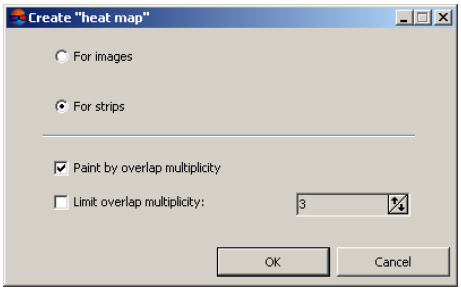


Fig. 76. Parameters of overlap map creating

2. Choose elements of a block to be used for overlap map creating: **For images** or **For strips**.

3. [optional] Set on the **Paint by overlap multiplicity** checkbox to color overlap areas depending on overlap multiplicity, i.e. on number of images/strips that fall into the overlap. When the option is disabled overlap areas are not colored.

4. [optional] Set on the **Limit overlap multiplicity** checkbox and input number of images/strips in overlap area, and when the value will be exceeded the fill color will be not changed.

5. Click OK. A new vector layer containing overlap map is created.

In order to obtain information about number of images that fall to chosen overlap area, allocate a part of overlap map and choose the **Window › Objects attributes**. You can export overlap map using the **Vectors › Export** menu item to choose export format.

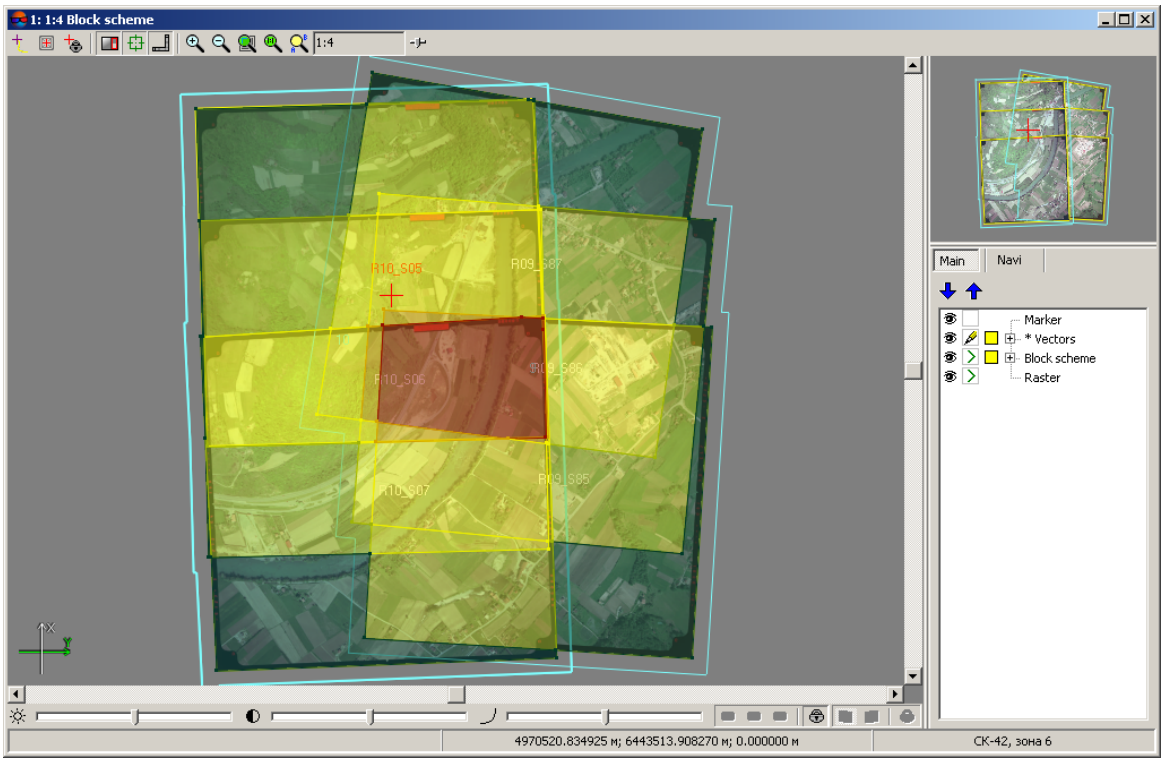


Fig. 77. Overlap map

20.2. Deleting images selectively

The program allows to delete images selectively using specified selection criteria. Perform the following actions to do this:

If images were removed from project, the do not remove from the *Windows* file system.

1. Choose **Block › Additional › Delete images selectively...**. The **Selective delete images** window opens.

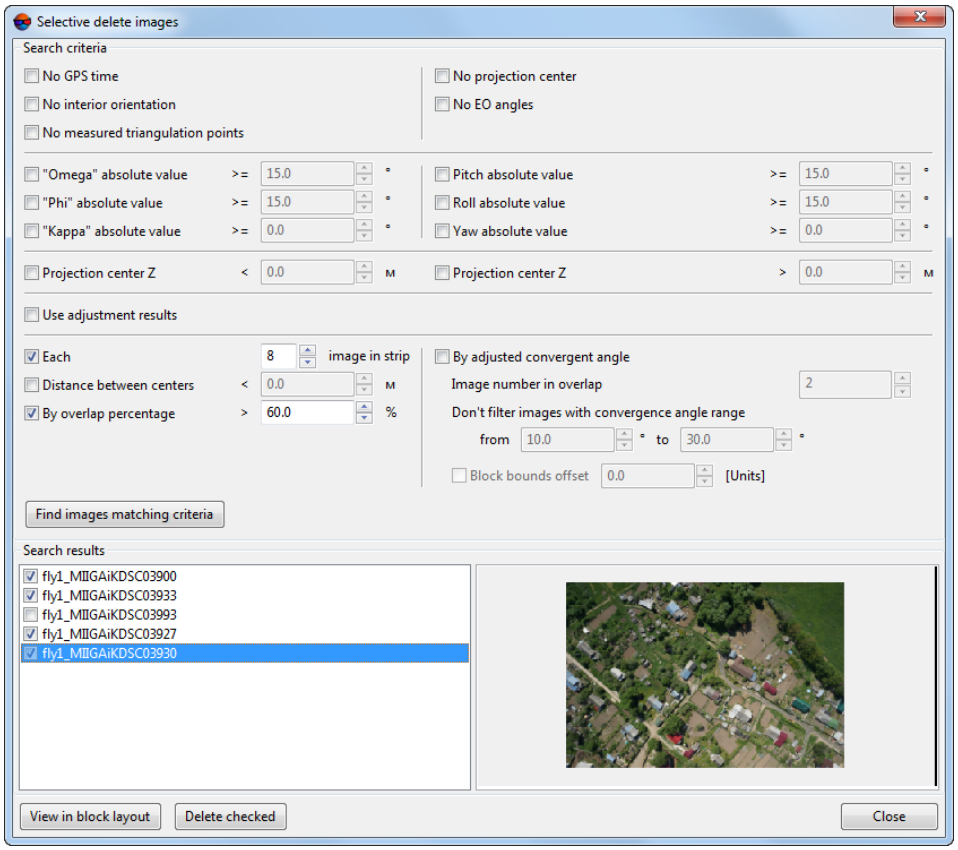


Fig. 78. Setting of images selection criteria for deleting

2. Set on one or more checkboxes to search images by chosen parameters:

   - to search images with omega, phi or pitch/roll angles absolute values greater than specified value (in degrees), set on the **"Omega" absolute value**, **"Phi" absolute value**, **Pitch absolute value** and **Roll absolute value** checkboxes accordingly;

   - to search images where not specified projection centers and/or not specified exterior orientation angles set on the **No projection center** ot **No EO angles** checkboxes;

   - to search images with projection center hight more or less specified value (in meters), set on the **Projection center Z <** or **Projection center Z >** accordingly;

   - to search images with **Distance between centers** in strip less than specified value, set on the appropriate checkbox;

   - set on the appropriate checkboxes to search images with **No GPS time**, **No interior orientation** or **No measured triangulation points**.

3. Click the **Find images matching criteria** button. Images found are shown in the **Search results** list.

4. [optional] To cancel deleting image set of the checkbox near to image name in the **Search results** section.

5. [optional] Click the **View in block layout** button to analyse images selection using block layout. Images selected in the **Search results** list are highlighted in the block layout.

6. Click the **Delete checked** button to delete images selected in the list.

20.3. Import of triangulation points from X-Points

The system provides possibility of import of tie *and* GCP points coordinates from X-Points files.

To perform measurements import perform the following actions:

1. Click the **Tie points list** button or the **GCP list** button on the **Aerial Triangulation** tab of the main toolbar. The **Triangulation points** window opens;

2. Click the button (on the **Tie points list** tab or on the **GCP list** tab) of the **Triangulation points** window (choose **Import from X-points** option in the drop-down list). The **Input file** window opens.

3. Choose triangulation points file `*.x-points` and click the **Open** button. The **Import measurements from X-Points format** window opens.

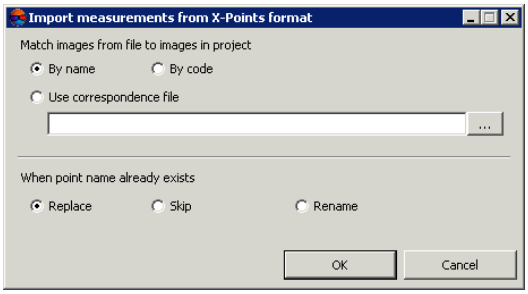


Fig. 79. Import measurements from X-Points format

4. When using points import from another project specify the way of matching images names in the X-Points file and images names in the project:

   - **By name**;
   - **By code**;

- **Use correspondence file**.

In order to use correspondence file click the ... button and select file with filenames.

5. Select actions to be performed in case of coincidence of images/points names in file with existing images/points names in a project: **Replace**, **Skip**, **Rename**.

6. Click OK. Imported points are added to triangulation points list.

20.4. Batch export of vector objects

The system provides possibility of batch vector objects export to separate files with the same extension.

To export several vector layers to separate files, perform the following actions:

1. Open some vector layers.

2. Select **Vectors › Export › Batch export**. The **Batch object export** window opens.

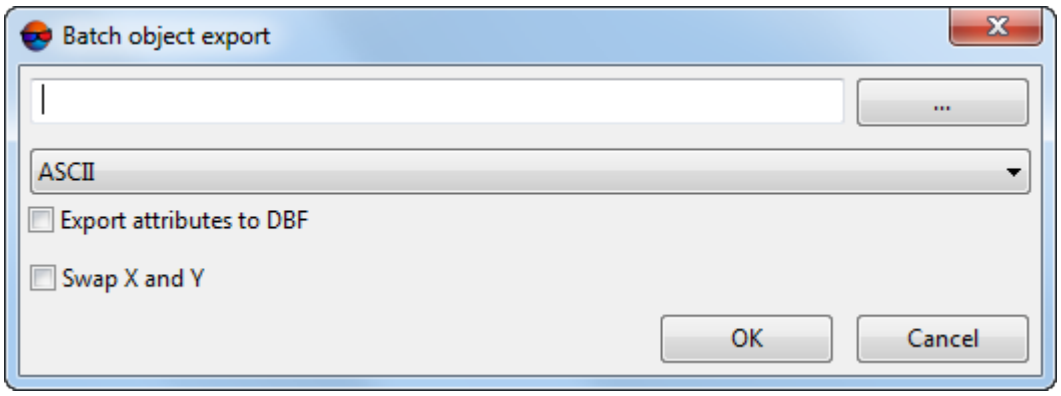


Fig. 80. Batch object export

3. Click the ... button to choose destination folder for files export.

4. Select one extension from the list below:

   - ASCII;
   - ASCII-A;
   - CSV;
   - DGN;

- DXF;
- Generate;
- ATLAS_KLT;
- KML;
- LIG;
- MIF/MID;
- PLY;
- Shape;
- Panorama;

5. Set the export parameters, according to the chosen extension.
6. Click OK to export several vector objects to separate files with te same extension.

21. Processing report

The system provides possibility for viewing the results of block processing after automatic tie point measurement in the UAS project and its adjustment.

Processing report contains data on the project's properties, parameters of automatic tie point measurement and adjustment, lens calibration, and summary on block errors.

The system allows to create the *processing report* also for projects of the "Central projection" type (with lesser amount of data). Creation of block processing reports for projects of "Satellite scanner imagery", "Airborne Digital Sensor ADS", and "VisionMap A3" types (see the "Project types" section in the "Creating project" User Manual) is not provided.

It is necessary to perform automatic tie point measurement and adjustment before the processing report creation.

In order to open the *processing report* choose **Orientation › Processing report**. The **Report** window opens.

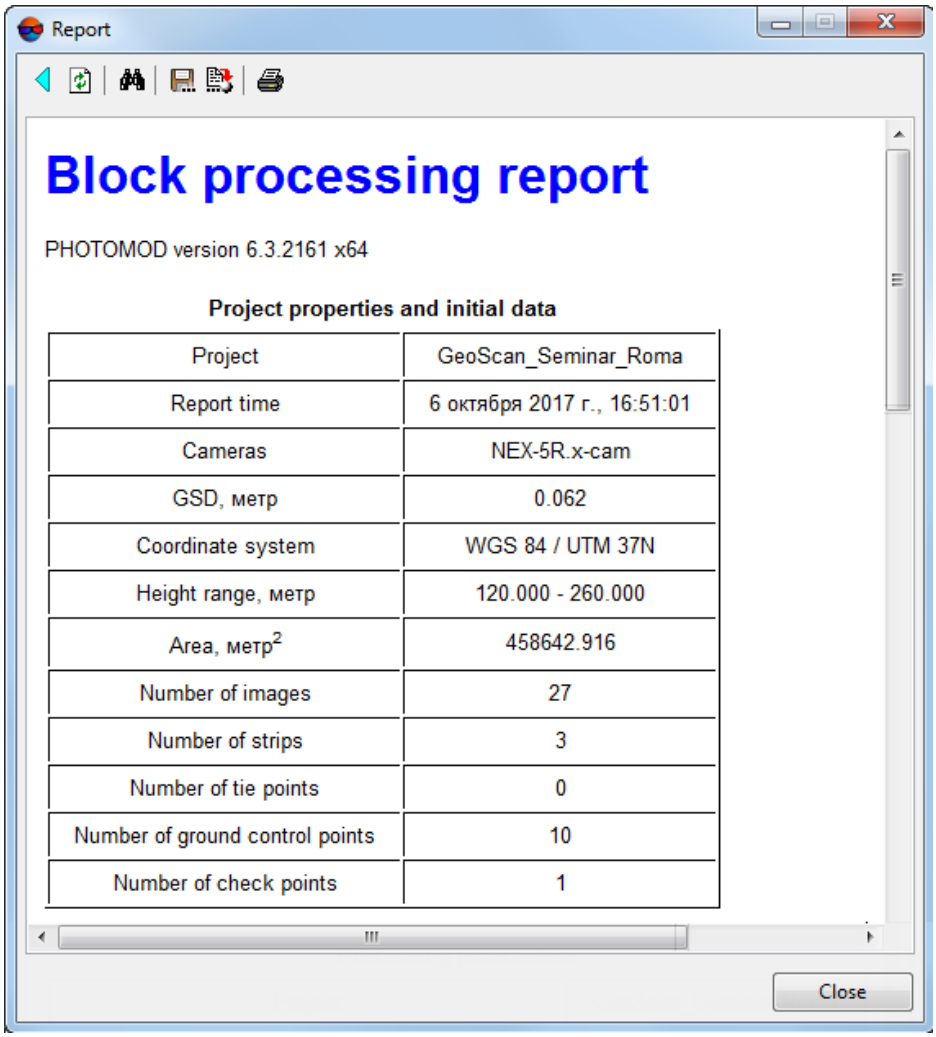


Fig. 81. Processing report

Block processing report contains the following main elements and sections:

- the toolbar with buttons used to perform the following operations:
  - – allows to return to previous view of the report;
  - – allows to refresh results in the report after editing of tie points in the **Points measurement** module;
  - – allows to perform a search for information in the report;
  - – allows to save report data to files with `*.htm`, `*.html` extensions out of active profile resources;
  - – allows to save report data to files with `*.htm`, `*.html` extensions in active profile resources;

  -  – allows to print a report;

- the **Project properties and initial data** section of a report used to view general statistics (see also the “Project properties” chapter of the “Creating project” User Manual) and contains the following information:
  - a project name;
  - report generating date.
  - camera data;
  - GSD (Ground Sample Distance) – a pixel size on ground for digital images;
  - project coordinate system;
  - project heights range in meters;
  - area of the in m^2;
  - a total number of project strips/images;
  - a number of tie/check/groud control points;
- the **Processing parameters** section of a report used to view the parameters of automatic tie point measurement and block adjustment;

Processing parameters	
Project	GeoScan
Report type	Detailed
Correlator configuration	*Medium
Calibrate camera	On
Make an adjustment	On
Apriori accuracy of measurements on images, pix	2.500
Assign the camera after calibration	On
Delete temporary data	On
Adjustment parameters	
Initial approximation method:	By block scheme
Adjustment method:	Bundle adjustment
Systematic error compensation	For block
Calibration type:	Physical
Time of processing	6m 6.155s

Fig. 82. The “Processing parameters” section

- the **Processing results** section, containing the following information:
  - **Results of camera calibration** (see the “Project cameras management” chapter of the “Aerial triangulation” User Manual).

Results of camera calibration

	Initial data	Optimized data
Camera	NEX-5R.x-cam	NEX-5R[poly] [selfcal].x-cam
Focal length, mm	16.000	16.228
Principal point (X/Y), mm	0.000 / 0.000	0.127 / 0.110
Pixel size, mm	0.005	0.005
Type of distortion	----	Formula
Point of symmetry (X/Y), mm	0.000 / 0.000	0.127 / 0.110
K1	0.000000e+000	0.000000e+000
K2	0.000000e+000	0.000000e+000
K3	0.000000e+000	0.000000e+000
P1	0.000000e+000	0.000272
P2	0.000000e+000	-1.622380e-006
b1	0.000000e+000	8.850811e-010
b2	0.000000e+000	-8.483819e-005

Fig. 83. The “Processing results” section

- the **Ground control and check points accuracy** section of a report used to view and analyse the block adjustment results (see the “Brief residuals report” chapter of the “Block adjustment” User Manual) and contains the following tables:
  - **Ground control point residuals** – adjustment residuals on GC points;
  - **Check point residuals** – adjustment residuals on check points.

Ground control point residuals

N	Apriori X/Y/Z accuracy	Ex, metre	Ey, metre	Ez, metre	Exy, metre
OP04	0.050000/0.050000/0.050000	-0.003323	0.003039	0.001553	0.004503
OP05	0.050000/0.050000/0.050000	0.006404	0.001790	-0.003474	0.006649
OP17	0.050000/0.050000/0.050000	-0.007287	0.004899	0.000388	0.008781
OP40	0.050000/0.050000/0.050000	0.009954	-0.020141	-0.005445	0.022467
OP60	0.050000/0.050000/0.050000	-0.008350	0.009347	-0.003857	0.012533
OP62	0.050000/0.050000/0.050000	-0.012834	-0.002289	0.007696	0.013037
OP63	0.050000/0.050000/0.050000	-0.004010	0.015828	-0.002332	0.016328
OP65	0.050000/0.050000/0.050000	-0.001682	-0.009741	-0.004276	0.009885
OP66	0.050000/0.050000/0.050000	0.021095	0.001286	0.009757	0.021135
RMS , metre	----	0.010	0.010	0.005	0.014
Mean absolute value , metre	----	0.008	0.008	0.004	0.013
Maximum, metre	----	0.021	0.020	0.010	0.022

Check point residuals

N	Apriori X/Y/Z accuracy	Ex, metre	Ey, metre	Ez, metre	Exy, metre
OP16	0.050000/0.050000/0.050000	-0.000053	0.049360	0.017538	0.049360
OP61	0.050000/0.050000/0.050000	-0.020458	-0.029665	-0.093207	0.036035
RMS , metre	----	0.014	0.041	0.067	0.043
Mean absolute value , metre	----	0.010	0.040	0.055	0.043
Maximum, metre	----	0.020	0.049	0.093	0.049

Fig. 84. The “Ground control and check points accuracy” section

- the **Exterior orientation parameters accuracy** section of a report used to view residuals on linear and angle exterior orientation parameters (see the “The “Report” tab” chapter of the “Block adjustment” User Manual);

Exterior orientation parameters accuracy

	X, metre	Y, metre	Z, metre	Omega, Degree	Phi, D
RMS , metre	0.196	1.627	1.071	0.135	0.0
Mean absolute value , metre	0.161	1.466	0.900	0.131	0.0
Maximum, metre	0.404	3.200	2.123	0.182	0.1
			Systematic error, metre		
Global per block	-0.612027	0.169457	20.099086	----	--

Fig. 85. The “Exterior orientation parameters accuracy” section

- **Stereopairs residuals** – a table containing tie point measurement difference between stereopairs (see “Brief residuals report” in the “Block adjustment” User Manual).

Stereopair residuals

Error type	EX	EY	EZ
From mean			
RMS, metre	0.040	0.027	0.093
Mean, metre	0.023	0.015	0.059
Max, metre	0.544	0.313	0.869
Mutual			
RMS, metre	0.083	0.043	0.194
Mean, metre	0.056	0.030	0.138
Max, metre	1.076	0.320	1.703
Errors in images			
RMS, mm	----	----	----
Mean, mm	----	----	----
Max, mm	----	----	----

Fig. 86. The “Stereopair residuals” section

22. Relative orientation report

22.1. Report parameters and output

The program allows to view the results of relative orientation operation after measurement of tie points coordinates. To view and analyse the data, and control accuracy of relative orientation the program allows to generate a report, that is formed considering specified parameters of accuracy control, residuals threshold and data output format.

Relative orientation and accuracy control includes the following steps:

- accuracy control for measurements on stereopairs using residual vertical parallaxes;
- accuracy control for measurements in triple overlap zones using discrepancies in tie points measurements taken on two adjacent stereopairs (models);
- control of tie points number and uniformity of their distribution on stereopairs and in triplets;

- control of difference between kappa angle and a block scheme.

It is possible to view the relative orientation report in the **Automatic tie point measurement**, **Triangulation points** windows, and in the **Points measurement** module after clicking the button. Prior to the report appearing the **Relative orientation report settings** window opens.

When the report is opened in the **Points measurement** module, the **Relative orientation report settings** window in not opened, and the report is opened only for images opened in the module considering preset or default parameters. To view and edit the parameters it is possible to use the link in the report window [*Report parameters*].

In order to open the relative orientation report perform the following actions:

1. Choose **Orientation › Additional › Relative orientation report** or click the button in the toolbar of the **Triangulation** window. The **Relative orientation report settings** window opens. It is used to specify parameters of accuracy control and format of output results of relative orientation in report.

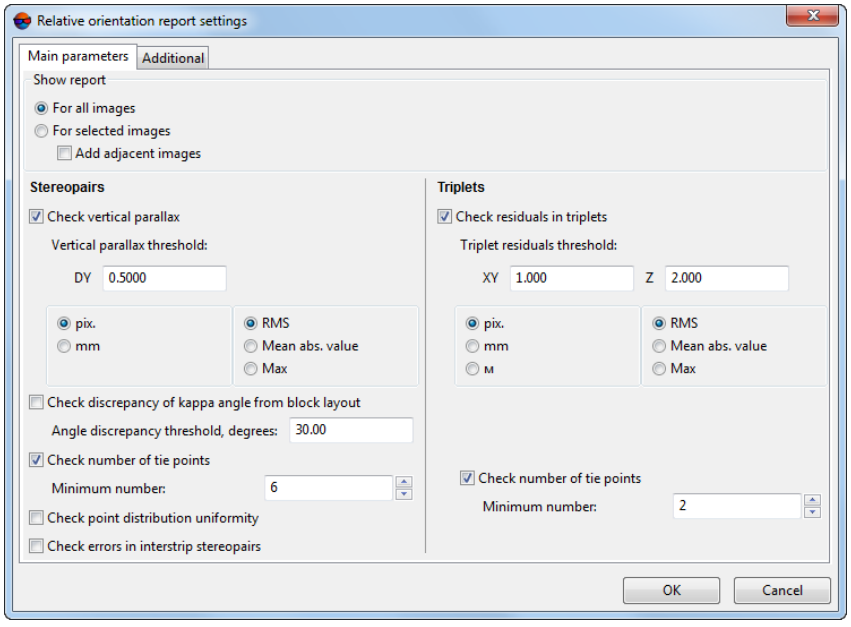


Fig. 87. Parameters of relative orientation report

2. Select the **Main parameters** tab (it is selected by default).

3. In the **Show report** section specify block images to be included to relative orientation report:

   - to view a general report for the whole images block select the **for all images** option;

- to view a report for *selected* images select the **for selected images** option;
- to view a report for *selected* and their *adjacent* images select the **for selected images** option and set the **add adjacent images** checkbox.

4. In the **Stereopairs** section specify the following parameters of accuracy control for points measurements on block stereopairs:

   - to check measurements for vertical parallax error select the **Check vertical parallax** checkbox and input acceptable threshold value (in pixels or mm) for selected error type (RMS, mean or maximal error);

     It is recommended to set the threshold value of maximal error equal to the pixel size.

   - to check discrepancy of kappa angle from block layout set on the **Check discrepancy of kappa angle from block layout** checkbox and specify a threshold value of angles discrepancy in degrees;

     It is recommended to specify **Angle discrepancy threshold** values from 30 to 45 degrees.

   - to check stereopairs for sufficient measurements number set the **Check number of tie points** checkbox and specify minimal number of tie points per stereopair;

     It is recommended to specify **Minimal number** value not less than 12 point per in-strip stereopair (2 points per each of 6 standard zones) and at least 2 points per inter-strip stereopair.

   - to check distribution uniformity of tie points on stereopairs set on the **Check point distribution uniformity** checkbox;

     There is *non-uniform* points distribution on a stereopair, if in each of 6 standard zones a number of points differs more than 2 times from average amount of points in zone.

   - to check number of tie points and their distribution uniformity on inter-strip stereopairs set on the **Check errors in inter-strip stereopairs** checkbox.

     The checkbox is cleared by default, since an analysis of points in 6 standard zones for *inter-strip* stereopair is not necessary in many cases.

5. In the **Triplets** section specify the following parameters of accuracy control for points measurements in triplets:

- to check measurement errors in triplets set on the **Check residuals in triplets** checkbox and input threshold value by XY and by Z (in pix, mm or meters) for selected residual type (RMS, mean or maximal error);
- to check triplets for sufficient number of measured tie points set the **Check number of tie points** checkbox and specify minimal number of points.

It is recommended to specify a **Minimal number** at least 3 points per each triplet.

6. Open the **Additional** tab, that includes sections used to setup data view parameters in the report.

   The **Residuals format** section is used to setup format of errors numeric values in the report:

   - **fixed point** – is used to set format of errors numeric values accurate within 3 decimal places;
   - **exponential** – is used to set format of errors numeric values in exponential notation, where a part of number is replaced with symbols E+n, where E (exponent) means multiplying the preceding number by 10 to the power n.

   The **Precision** section is used to setup output data accuracy, select: **normal**, **high** or **maximal**.

   The **Angles** section is used to setup angles format in the report:

   - **Alpha, omega, kappa** – angular elements of image exterior orientation (are used in Russian coordinate systems);
   - **omega, phi, kappa** – angular elements of image exterior orientation (are used in International coordinate systems (see the “Block adjustment” User Manual)).

   The **Angle units** section is used to setup format of angles measurements units:

   - **radians**;
   - **degrees**;
   - **gons** – plane angle measurement unit that equals to 1/100 of flat right angle measurement unit, and full angle is 400 gons.

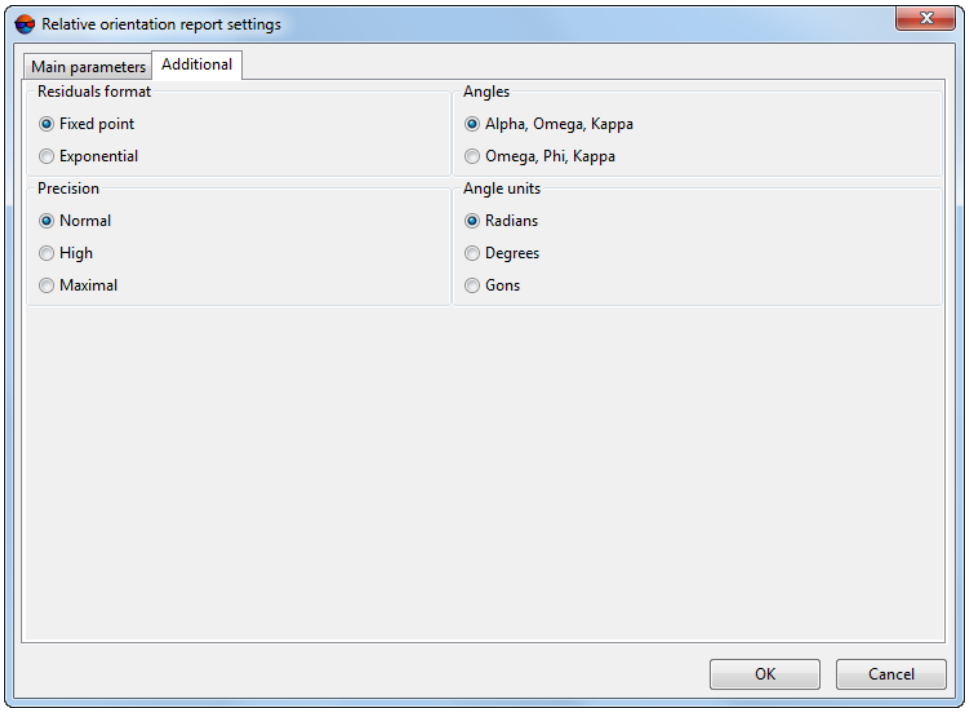


Fig. 88. Additional report parameters

7. Click OK. The report on relative orientation results is opened. It considers all specified main and additional parameters (see the Section 22.2).

22.2. Report view and analysis

Report on relative orientation includes results of relative orientation operation, displays statistics of tie points measurement, and allows to reveal and eliminate errors of points measurement. The report is generated for all or for selected project images considering parameters specified in the **Relative orientation report settings** window.

A feature of relative orientation report is the ability to pass to the **Points measurement** module directly from the report that allows to eliminate detected measurement errors.

It is possible to view relative orientation report from different windows of the program using the button. Prior to the report appearing the **Relative orientation report settings** window opens.

When the report is opened from the **Points measurement** module, the **Relative orientation report settings** window is not opened, and the report is shown only for images opened in the module considering previously set or default parameters. To view and edit the parameters it is possible to use the link in the report window [*Report parameters*].

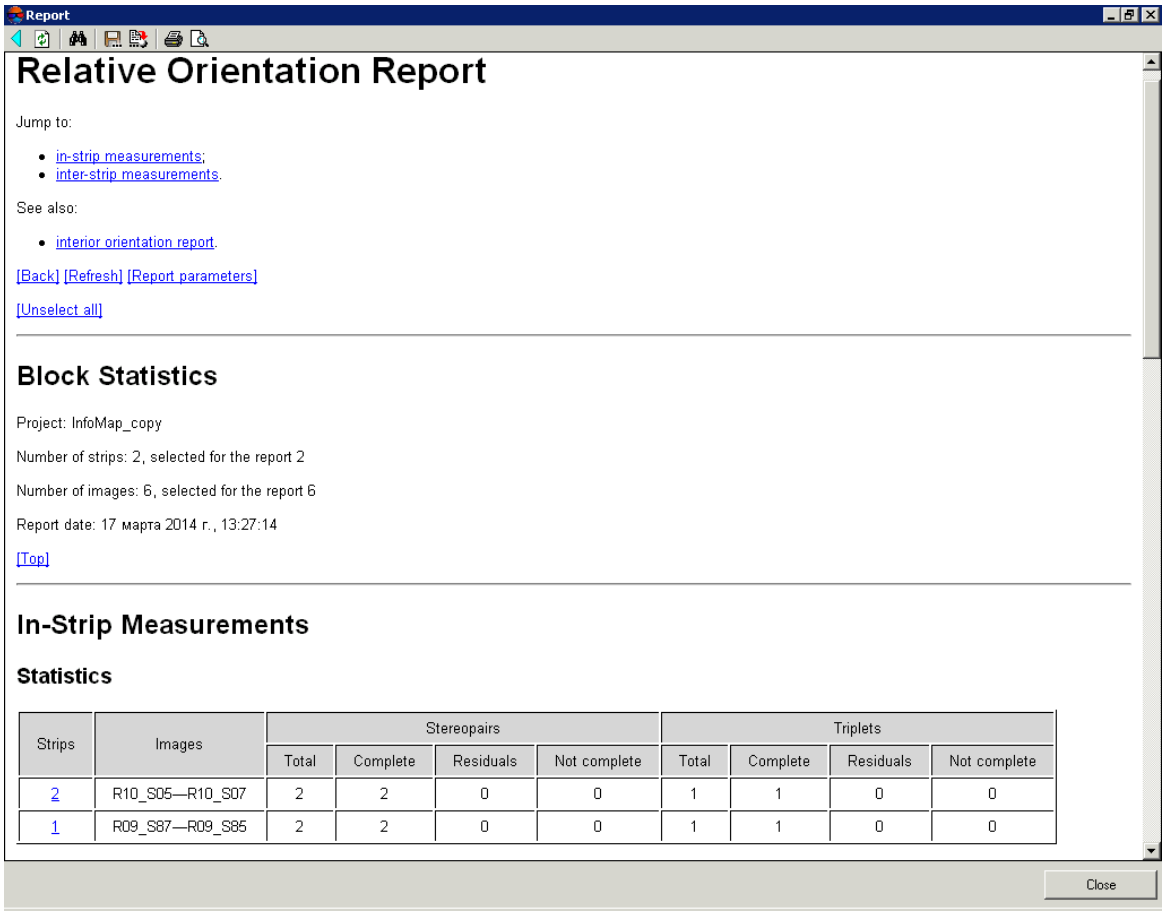


Fig. 89. Relative orientation report

Relative orientation report contains the following main elements and sections:

- the toolbar with buttons used to perform the following operations:
  - – allows to return to previous view of the report;
  - – allows to refresh relative orientation results in the report after editing of tie points in the **Points measurement** module;
  - – allows to perform a search for information in the report;
  - – allows to save report data to files with `*.htm`, `*.html` extensions out of active profile resources;
  - – allows to save report data to files with `*.htm`, `*.html` extensions in active profile resources;
  - – allows to print a report;
- the links in upper part of a report:

- jump to [*in-strip measurements*] – allows to view the points measurements inside strips;
- jump to [*inter-strip measurements*] – allows to view the points measurements between strips;
- see also the [*interior orientation report*] – allows to open report on interior orientation;
- [*Back*] – allows to go back to previous report view;
- [*Refresh*] – allows to refresh relative orientation results in the report after tie points editing in the **Points measurement** module;
- [*Report parameters*] – allows to change the parameters and refresh the report;
- [*Unselect all*] – allows to cancel data selection in the report;
- [Top] – allows to go to the report top.

- the **Block statistics** section of a report used to view general statistics, contains the following information:
  - a project name;
  - a total number of project strips/images;
  - a number of selected strips/images;
  - report generating date.
- the **In-strip measurements** section of a report used to view and analyse points measurements inside strips, contains the following tables:
  - statistics table on in-strip measurements (strips table);
  - table of stereopairs of each strip;
  - table of triplets of each strip.

In inter-strip stereopairs and triplets tables there is a possibility to go to the **Points measurement** module and open images of selected stereopair/triplet automatically, that allows to edit points measurements there.

- the **Inter-strip measurements** section of a report used to view and analyse points measurements between strips, contains the following tables:
  - statistics table on inter-strip measurements;

- table of inter-strip stereopairs.

In inter-strip stereopairs tables there is a possibility to open selected stereopair in the **Points measurement** module that allows to edit points measurements there.

22.3. The in-strip measurements section

The **In-strip measurements** section of report is used to view points measurements results inside a strip and contains the following data:

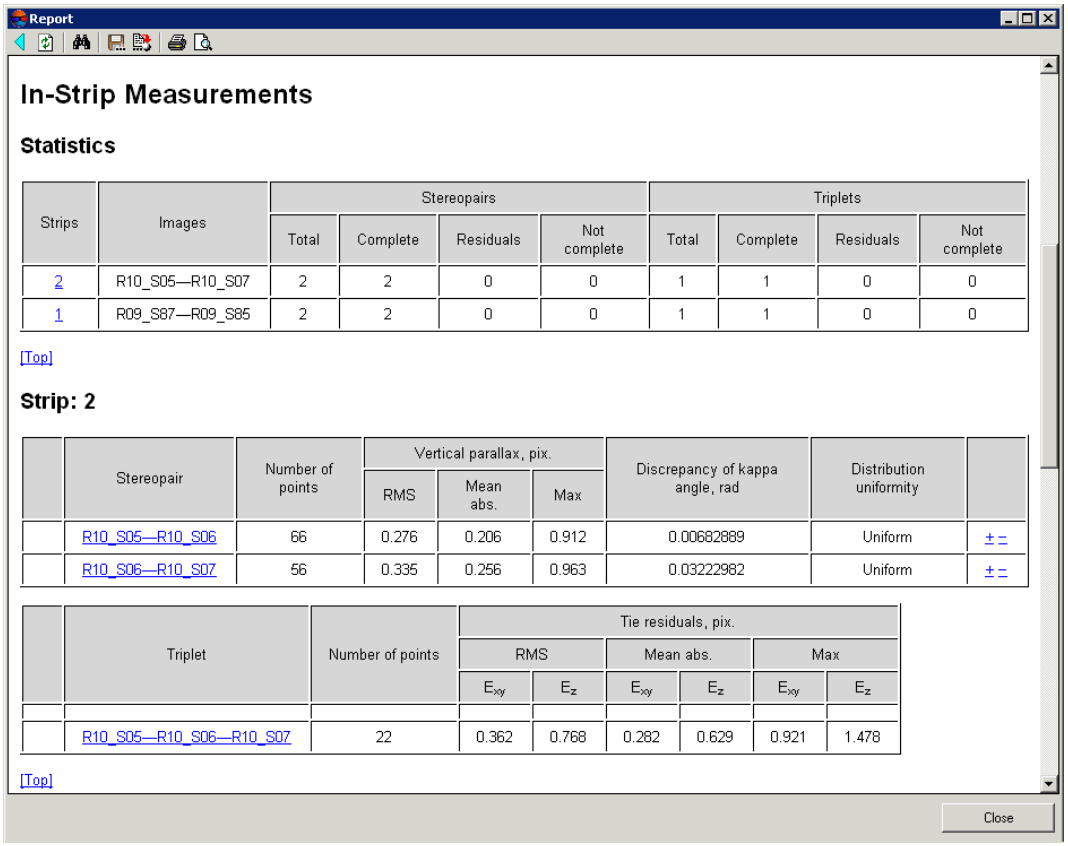


Fig. 90. The “In-strip measurements” section

- *Table of strips* (**Statistics**) contains measurements data inside each strip and includes the following columns:
  - the **Strips** column is used to display a strip name in block;
  - the **Images** column is used to display names of the first and the last images in a strip;
  - the **Total** column is used to display a number of stereopairs/triplets in each strip;

- the **Complete** column is used to display a number of stereopairs/triplets with performed relative orientation with errors within specified thresholds;
- the **Residuals** column is used to display a number of stereopairs/triplets with errors exceeding specified thresholds;
- the **Not complete** column is used to display a number of stereopairs/triplets for which relative orientation is not performed.

Yellow color highlight is used if relative orientation inside a strip is performed with errors.

Strips where there is no relative orientation results are highlighted by red color.

- *Table of stereopairs* contains points measurements data on stereopairs for each strip and includes the following columns:
  - the first column is used for points measurements editing and allows to open the**Points measurement** module with images of stereopair selected in the table;

    When editing is completed and the **Points measurement** module is closed, click the [*Refresh*] link in the report to re-calculate relative orientation and refresh the report.

  - the **Stereopair** column is used to display names of images of each stereopair of a strip;

    Click the stereopair link to open detailed report on measurements of selected stereopair (see the Section 22.5).

  - the **Number of points** column is used to display a number of points measured on a stereopair;
  - the **Vertical parallax** column is used to display a value of vertical parallax for all measurements on a stereopair (RMS, mean abs. and maximal error) considering threshold parameters, error type and measurement units specified in the **Relative orientation report settings** window;

    A row of stereopair with points which coordinates failed to be calculated, is highlighted by red color, and in the **Vertical parallax** column the warning message "*Coordinates calculation failed*" is displayed with specifying Y-parallax value in brackets.

  - the **Discrepancy of kappa angle** column is used to display a value of kappa angles difference (calculated using block scheme) between images.
  - the **Distribution uniformity** column is used to display data about uniform or non-uniform distribution of points on a stereopair;

A distribution of points on a stereopair is considered as non-uniform, when in any of 6 standard zones, a number of points differs more than twice from average number of points in zone.

- the **+/-** buttons in the last column allow to highlight/cancel highlight of stereopair on a block scheme in 2D-window for visual estimation of stereopair location in images block.

A stereopair is highlighted along with adding it to already highlighted ones in 2D-window. Cancelling of a stereopair highlighting is performed along with “subtraction” from highlighted stereopairs.

Stereopairs with measurements errors are highlighted by yellow color, stereopairs with unavailable relative orientation by red color.

The following errors are shown by red color (they are depending on parameters specified in the **Relative orientation report settings** window):

- number of points measured on a stereopair, below specified threshold;
- values of vertical parallax, exceeding specified threshold;
- non-uniformity of points distribution;

If there each standard zone contains measurements of coordinates of at least one point, then a stereopair with measurements errors is highlighted by yellow color.

- difference of kappa angles, that exceeds specified value.

- *Table of triplets* displays data on measurements in each triplet of a strip and contains the following columns:
  - The first column is used for measurements editing and allows to open the**Points measurement** module and to open automatically images of selected triplet at the same time;

When editing is completed and the **Points measurement** module is closed, click the [*Refresh*] link in the report to re-calculate relative orientation and refresh the report.

  - the **Triplet** column is used to display names of images of each triplet in a strip;

After clicking the triplet link the detailed report on selected triplet measurements is opened (see the Section 22.6).

  - the **Number of points** column is used to display number of points measured on triplet;

- the **Tie residuals** column is used to display values of tie residuals in triplet by XY and Z (RMS, mean abs. and max error) considering parameters of threshold, error type and measurement units specified in the **Relative orientation report settings** window.

Triplet errors by ties, exceeding specified thresholds, are highlight by red color.

22.4. The inter-strip measurements section

The **Inter-strip measurements** section of report is used to view points measurements results inside a strip and contains the following data:

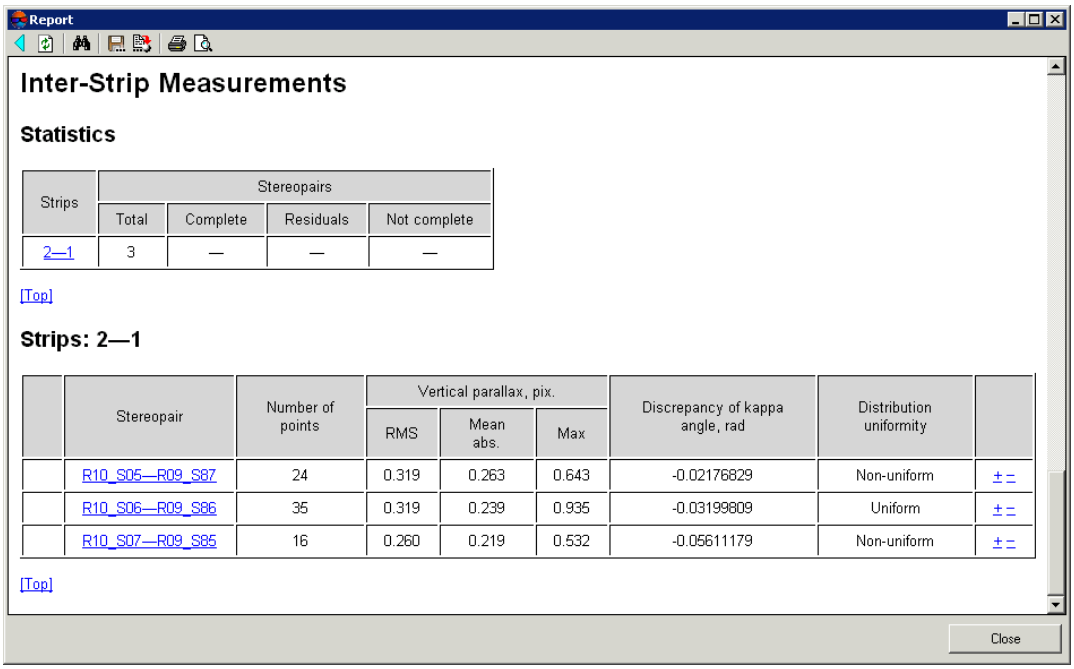


Fig. 91. The “Inter-strip measurements” section

- *The inter-strip ties table* (**Statistics**) displays a number of inter-strip stereopairs for each pair of adjacent strips and presence of measurement errors during relative orientation operation.

- *The inter-strip stereopairs table* contains the following columns:

  - the first column is used to edit points measurements and allows to open the **Points measurement** module and to open automatically at the same time images of inter-strip stereopair selected in the table;

When editing is completed and the **Points measurement** module is closed, click the [*Refresh*] link in the report to re-calculate relative orientation and refresh the report.

- the **Stereopair** column is used to display names of images of each inter-strip stereopair;

  After clicking the inter-strip stereopair link the detailed report on selected stereopair measurements is opened (see the Section 22.4).

- the **Number of points** column is used to display a number of points measured on inter-strip stereopair;

- the **Vertical parallax** column is used to display a value of vertical parallax for all measurements on a inter-strip stereopair (RMS, mean abs. and maximal error) considering threshold parameters, error type and measurement units specified in the threshold parameters;

- the **Discrepancy of kappa angle** column is used to display a value of kappa angles difference (calculated using block scheme) between images.

- the **Distribution uniformity** column is used to display data about uniform or non-uniform distribution of points on a inter-strip stereopair.

- the last columns allows to highlight a stereopair (**+**) or cancel the highlighting of a stereopair (**–**) in 2D-window that allows to estimate visually whether the stereopair is located within images block.

  A stereopair is highlighted along with adding it to already highlighted ones in 2D-window. Cancelling of a stereopair highlighting is performed along with “subtraction” from highlighted stereopairs.

If in the **Relative orientation report settings** window the **Check errors in interstrip stereopairs** checkbox is set, then the errors in the report are highlighted in the following way: *yellow* color shows strips and stereopairs that contain points measurements exceeding threshold, and the errors values are shown by *red* color.

22.5. The stereopair measurements section

Relative orientation report provides possibility to view a detailed report on any selected stereopair that contains data on tie points measurements, calculated relative orientation parameters, information about kappa angles difference and uniformity of tie points distribution on a stereopair. A detailed report allows to perform control of measurement accuracy of common points of a stereopair images by values of vertical parallax residuals. To view detailed report for selected stereopair click the stereopair hyperlink in the tables of in-strip and inter-strip stereopairs.

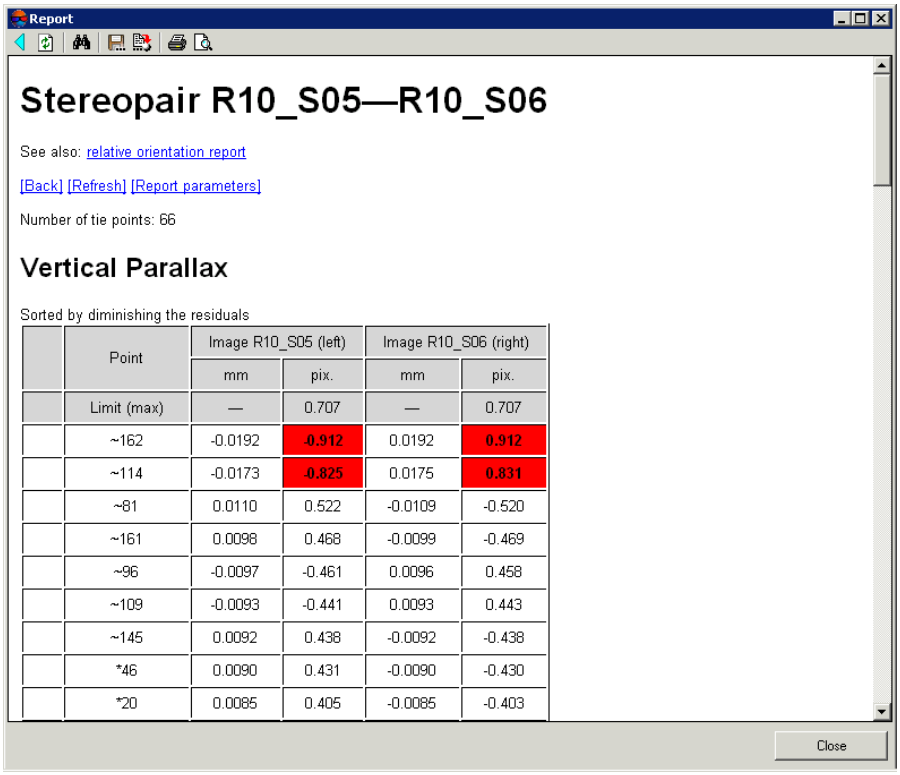


Fig. 92. Detailed report for selected stereopair

Detailed report on selected stereopair includes the following data:

- hyperlinks of detailed report:
  - [*Relative orientation report*] – the link is used to return to the first page of the common report on in-strip and inter-strip measurements;
  - [*Back*] – the link is used to return to previous view of detailed report on stereopair measurements;
  - [*Refresh*] – allows to refresh relative orientation results in the report after tie points editing in the **Points measurement** module;
  - [*Report parameters*] – the link is used to change the report parameters and to refresh the report;
  - [*Edit*] – the link is used to view and edit measurements on a stereopair in the **Points measurement** module;
  - [*Select stereopairs*] – allows to select a stereopair on a block scheme in 2D-window;
  - [*Unselect stereopairs*] – allows to unselect a stereopair on a block scheme in 2D-window;

- [*Unselect all*] – allows to unselect all previously selected stereopairs.

- information about number of measured tie points on a stereopair;

- the *Vertical parallax* table contains the following columns:

  - the first column is used to edit selected tie point and allows to open the **Points measurement** module and to open at the same time images of the stereopair automatically and place marker on selected point;

    After the point editing is completed and the **Points measurement** module is closed click the [*Refresh*] hyperlink in the report to re-calculate relative orientation and refresh the report.

  - the **Point** column displays names of tie points;

  - the **Number of points** column is used to display a number of points measured on inter-strip stereopair;

  - the **Image ... (left)** column displays a value of vertical parallax residual on the left image of stereopair (in mm and pix);

  - the **Image ... (right)** column displays a value of vertical parallax residual on the right image of stereopair (in mm and pix).

  In the *threshold* row the threshold for vertical parallax residual is displayed in accordance with specified value, measurements units and residual type (RMS, Mean abs. and max error) of the **Vertical parallax threshold** parameter in the **Relative orientation report settings** window.

  At the bottom of the table there are final values of vertical parallax residual on all measurements of the stereopair (RMS, Mean abs. and max error). The program performs control of threshold exceeding only for error type specified in the **Relative orientation report settings** window.

  Values of vertical parallax residuals exceeding specified threshold, are highlight by red color.

- the *Relative orientation parameters* table contains values of calculated relative orientation angles for the left and right images according to selected angular system and measured units on the **Additional** tab in the **Relative orientation report settings** window;

- the *Orientation 2D (by block scheme)* and *Discrepancy of kappa angles* tables contain values of kappa angles;

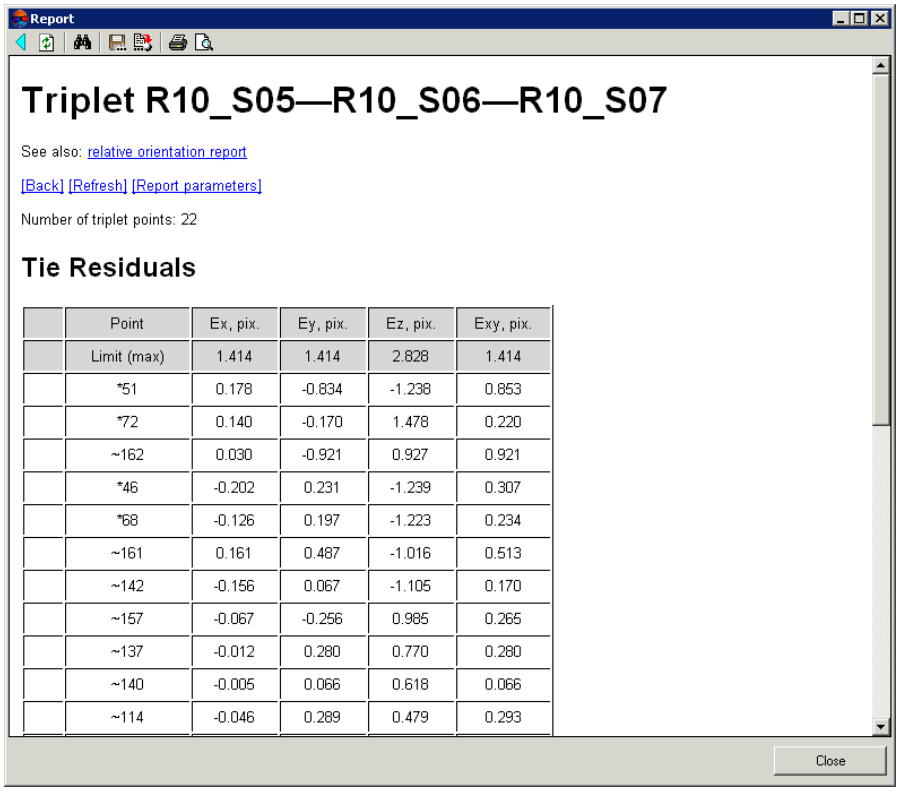
  Accuracy control of kappa angles discrepancy between images is performed if in the **Relative orientation report settings** window the appropriate checkbox is set and a threshold value for kappa angles discrepancy is specified.

- the *Distribution uniformity* tables contain information about uniformity of points distribution over standard zones. To estimate the parameter the system analyses a difference of points number in each of 6 standard zones.

Control of points number and uniformity of their distribution on stereopair's zones is performed if corresponding parameters are specified in the **Relative orientation report settings** window.

22.6. The triplet measurements section

Relative orientation report provides possibility to view a detailed report on selected triplet. A detailed report for a triplet is used to view and perform accuracy control of measurements in triplet by tie points errors. In order to view a detailed report on selected triplet click the triplet link in the *triplets table* of the **Inter-strip measurements** section of the report (see the Section 22.3).



	Point	Ex, pix.	Ey, pix.	Ez, pix.	Exy, pix.
	Limit (max)	1.414	1.414	2.828	1.414
	*51	0.178	-0.834	-1.238	0.853
	*72	0.140	-0.170	1.478	0.220
	~162	0.030	-0.921	0.927	0.921
	*46	-0.202	0.231	-1.239	0.307
	*68	-0.126	0.197	-1.223	0.234
	~161	0.161	0.487	-1.016	0.513
	~142	-0.156	0.067	-1.105	0.170
	~157	-0.067	-0.256	0.985	0.265
	~137	-0.012	0.280	0.770	0.280
	~140	-0.005	0.066	0.618	0.066
	~114	-0.046	0.289	0.479	0.293

Fig. 93. Detailed report for selected triplet

Detailed report on selected triplet includes the following data:

- hyperlinks of detailed report:
  - [*Relative orientation report*] – the link is used to return to the first page of common report on relative orientation;

- [*Back*] – the link is used to return to previous view of detailed report on measurements in triplet;
- [*Refresh*] – allows to refresh relative orientation results in the report after tie points editing in the **Points measurement** module;
- [*Report parameters*] – the link is used to change the report parameters and to refresh the report;
- [*Edit*] – the link is used to view and edit a triplet measurements in the **Points measurement** module;
- [*Stereopairs*] – two links used to proceed to detailed measurements report of points on stereopairs, that form the triplet (see the Section 22.5).

- information about number of measured tie points in a triplet;
- the *Tie residuals* table contain the following columns:
  - the first column is used to edit selected tie point and allows to open the **Points measurement** module and to open automatically at the same time triplet images and to place marker on selected point;

    After the point editing is completed and the **Points measurement** module is closed click the [*Refresh*] hyperlink in the report to re-calculate relative orientation and refresh the report.

  - the **Point** column is used to display a tie point name;
  - the **Ex**, **Ey**, **Ez**, **Exy** columns – tie residuals by X, Y, Z axes and tie residual by (XY) in measurement units specified for residuals control in triplet in the **Relative orientation report settings** window.

  In the *threshold* row there is a triplet residual threshold according to specified value, measurement units and error type (RMS, Mean abs. and max error) of the **Triplet residuals threshold** parameter in the **Relative orientation report settings** window.

  At the bottom of the table final values of tie residuals *on all triplet measurements* are shown (RMS, Mean abs. and max error). Accuracy control is performed only for the residual type that is specified for the **Triplet residuals threshold** parameter in the **Relative orientation report settings** window.

  Values of tie errors that exceed specified threshold are highlighted by red color.

23. Distributed Processing

23.1. General Information

Program includes capability of distributed processing of some tasks. This helps achieve maximum utilization of hardware resources for carrying out large projects.

Distributed tasks processing is a capability of parallel task execution with multiple processor cores or multiple computers in local network.

The program provides an opportunity only local distributed processing with using several cores of one computer.

Computers participating in the distributed processing are assigned the three following modes:

- *Server* is the control center of the distributed processing, responsible for distribution of tasks and synchronization of *Client* computers;
- *Client* is a computer, which receives tasks to process from the *Server*;

Each *Client* must be connected to the *Server.*

- *Monitor* is a computer, where the distributed processing control center is launched and the **Monitor for distributed processing** window is opened to observe task processing.

To launch the **Distributed processing control center** perform one of the following:

- in context menu of *System Monitor module*choose the **Distributed processing control center**;

The **Start automatically** menu item allows to launch the distributed processing control center automatically concurrently with launching any module of program when *System Monitor module* is also launched.

- choose the **Service › Additional › Distributed processing › Control centre**.

The distributed processing control center is launched with properties of previous working session of program in the *Windows* system tray the  icon displays. During the first launch the **Distributed processing setup** window is also opens.

The distributed processing icon in the *Windows* system tray is different depending on using computer in the distributed processing mode:

- – *Server* and *Client* are not launched (computer is not used in distributed processing);
- – *Server* connection fault;
- – only *Server* is launched;
- – *Server* and *Client* are launched;
- – only *Client* is launched, connection to *Server*.

23.2. Workflow of distributed processing

The following work flow is used to distributed tasks processing:

1. Launch the **Distributed processing control center**.
2. Choose the computer as a *Server* and *Client* of distributed processing.
3. Choose not-used **Port for incoming connections**.
4. Setup parameters of distributed processing task and click OK. The list of distributed processing task is created and displayed in the **Tasks** table.
5. Open the **Monitor for distributed processing**.
6. Choose the task for processing in the **Task** section.
7. Choose the computer as a Client to process chosen task in the **Computers** section.
8. [optional] Click the button to perform all distributed processing task automatically.
9. Click the button on the **Tasks** section toolbox to start distributed processing.

Each next task start with lagged on some seconds.

23.3. Distributed processing parameters setup

The **Distributed processing setup** window is used to setup distributed processing parameters.

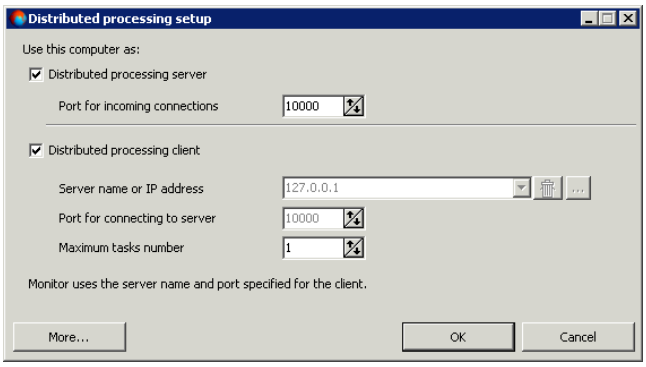


Fig. 94. Distributed processing parameters setup

The program provides an opportunity only to use local computer for distributed processing tasks with using several cores of one computer, i.e. using computer as a *Server* and *Client* at the same time.

Perform the following actions to do this:

1. Set on the **Distributed processing server** checkbox.
2. Set free port in the **Port for incoming connections** field.

   If not possible to connect with chosen port, choose another one.

3. Set on the **Distributed processing client** checkbox. Server name and port number are set automatically.
4. [optional] Set on the **Maximal number of tasks**, which are process of each *Client* at the same time. By default the value is equal to number of cores or processors of computer.
5. Click OK. During the first setup the **Monitor of distributed processing** window opens and in the *Windows* system tray the icon of distributed processing is displayed.

   It is necessary to restart the distributed processing control center if parameters were changed.

Also there is an opportunity to detail setup of distributed processing parameters. Click the **More** button of the **Distributed processing setup** window to do that.

It is strongly not recommended to change default parameters in the e **Distributed processing setup** window.

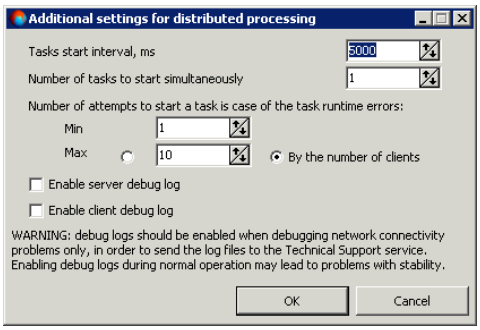


Fig. 95. Additional distributed processing parameters

The following parameters are available to setup:

- **Task start interval, ms** – allows to change the delay time between starting tasks;
- **Number of task to start simultaneously** – allows to change the number of tasks which are processing in the same time by distributed processing clients;
- **Number of attempts to start in case of the task runtime errors** – allows to change number of attempts ta start the task if there is an error;

It is reccommended to change the value in case of non-stable network or breaks in electricity supply, etc.

  - **Min\max** – range of restart attemps;
  - **by number of clients** – by default the restart attemps number is equal to number of connected distributed processing *Clients*.

- **Enable server/client debug log** – allows to create a log-file with information about distributed processing (to sent files in technical support during solving problems of Server/Client connection only).

Set on the **Enable server/client debug log** checkboxes may cause to reducing stability of program's work.

It is strongly not recommended to set on the **Enable server/client debug log** checkboxes.

23.4. Distributed processing management

The **Monitor of distributed processing** window is used for condition monitoring of distributed processing. The window opens automatically after setup distributed processing parameters.

Also the menu item **Start monitor** of context menu of the distributed processing icon and the **Service › Additional › Distributed processing › Monitor** menu items.

While the **Monitor of distributed processing** window opens, the *Monitor* status adds to computer also.

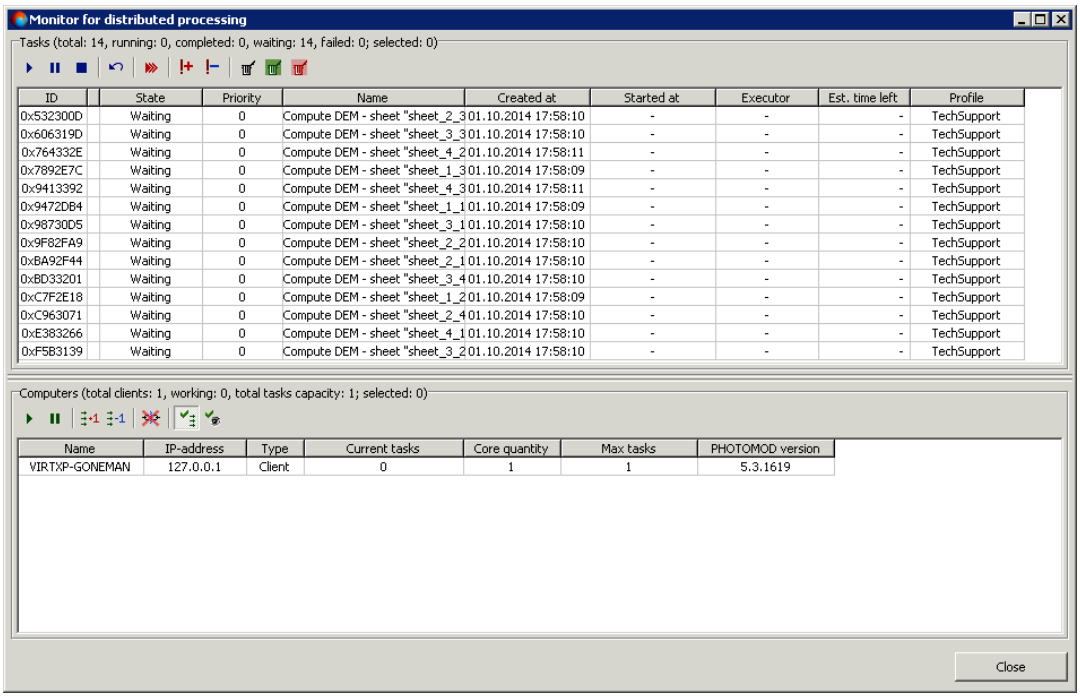


Fig. 96. Monitor for distributed processing

In the **Monitor of distributed processing** window displays information about tasks queue and *Clients* computers using. The window also allows to manage tasks processing.

The window refresh automatically each several seconds.

The **Tasks** containts toolbar and table with information about tasks. The table consists of columns with following information:

- **ID** – unique identifier for each task;
- **State** – the status of the task:
  - `waiting`;
  - `paused`;
  - `performed` – in this case shows the percentage of task completion;
  - `complete`;
  - `failed` – displayed in case of complete part or resource connection error (marks yellow);

  - `not complete` (marks red) – displayed in case of tasks didn't complete because of *Client* was disconnected during the task processing, *Server* was disconnected or task was cancelled.

- **Priority** – priority of the tasks (integer, the larger the number, the higher the priority, the tasks of higher priority are performed in the first place);
- **Name** – type of task and number in tasks list;
- **Created at** – the date and time of posting task;
- **Started at** – the data and time are displayed for started task;
- **Executor** – for started task – the name of *Client* computer, which executes it;
- **Est. time left** – the approximate time before complete processing tasks
- **Profile** – active Client profile at the time of posting of tasks. This profile must be network and connected to other Clients in order that they have been able to execute the tasks.

Points sorting in columns of the list is performed by mouse click on the column header.

If during the task execution an error occurs on any of network computers, it's highlighted in yellow in the list. In this case attempts will be made to perform the same tasks on other computers. The task will remain in the queue with a **Failed** state until it is deleted manually, if no computer in network is able to execute this task.

Table 21. The Tasks section toolbar

Buttons	Function
	allows to start selected tasks sequentially
	allows to pause selected tasks
	allows to stop selected tasks
	allows to reset selected tasks state (the **Waiting** caption appears in the **State** field)
	allows to set on the auto run tasks – automatic distribution of tasks in the queue (according to priority) between the Clients and launch of the tasks
	allows to increase priority of selected tasks by 1
	allows to decrease priority of selected tasks by 1
	allows to remove selected tasks from the queue
	allows to remove complete tasks from the queue
	allows to clear the queue of tasks

The **Computers** section contains the table of computers, which are currently in the network and configured with the same *Server*.

The table contains following parameters for each computer:

Points sorting in columns of the list is performed by mouse click on the column header.

- **Name** – shows network computer name;
- **IP-address** – IP-address of the computer;
- **Type** – *Client* or *Monitor;*
- **Current tasks** – tasks number of distributed processing, which currently performed by Client;
- **Core quantity** – the total quantity of Client CPU's cores;
- **Max tasks** – the maximum quantity of simultaneously running tasks specified during the *Client* configuration;

Maximum quantity of tasks are less than or equal to the number of CPU's cores of computer.

- **PHOTOMOD version** – the PHOTOMOD build number for control of compatibility.

It is recommended to use the same PHOTOMOD build on all computers working with the same Synchronization folder.

In the case if the computer is disconnected from the distributed processing, it's highlighted in red in the table.

To perform actions with multiple computers, select them in the table using **Shift** and **Ctrl keys**.

Table 22. The Computers section toolbar

Buttons	Function
	allow selected computers to execute new tasks (if forbidden)
	forbid selected computer to execute new tasks When current task complete, *Client* go to sleep mode and doesn't start new tasks temporary
	increase maximum number of simultaneously running tasks by 1
	decrease maximum number of simultaneously running tasks by 1
	hide disconnected computers (highlighted in red)
	display all connected and disconnected *Client* computers in the table
	display all connected and disconnected *Monitor* computers in the table