Tutorial (Beginner level):
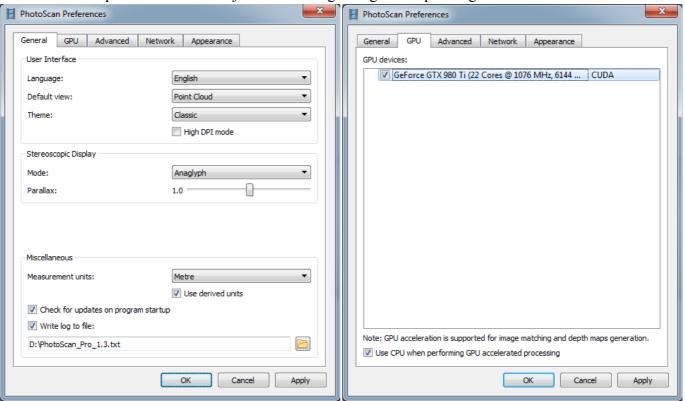## Orthomosaic and DEM Generation with Agisoft PhotoScan Pro 1.3 (without Ground Control Points)
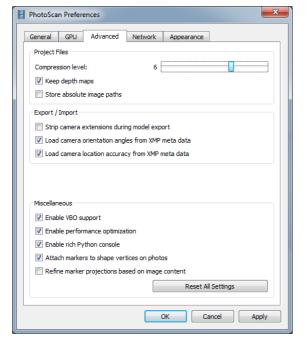
Overview

Agisoft PhotoScan Professional allows to generate georeferenced dense point clouds, textured polygonal models, digital elevation models and orthomosaics from a set of overlapping images with the corresponding referencing information. This tutorial describes the main processing steps of DEM/Orthomosaic generation workflow for a set of images without ground control points.

PhotoScan Preferences

Open *PhotoScan Preferences* dialog using corresponding command from the *Tools* menu:

Set the following values for the parameters on the *General* tab:

Stereo Mode: *Anaglyph* (use *Hardware* if your graphic card supports Quad Buffered Stereo)

Stereo Parallax: *1.0*

Write log to file: *specify directory where Agisoft PhotoScan log will be stored* (in case of contacting the software support team it could be required)

Set the parameters in the *GPU* tab as following: *Check on any GPU devices detected by PhotoScan in the dialog. Check on "Use CPU" option when less than two GPU are used.*

Set the following values for the parameters on the *Advanced* tab:

Project compression level: *6*

Keep depth maps: *enabled*

Store absolute image paths: *disabled*

Check for updates on program startup: *enabled*

Enable VBO support: *enabled*

Add Photos

To add photos select *Add Photos...* command from the *Workflow* menu or [icon] click *Add Photos* button located on *Workspace* toolbar.

In the *Add Photos* dialog browse the source folder and select files to be processed. Click *Open* button.

Load Camera Positions

At this step coordinate system for the future model is set using camera positions.

Note: If camera positions are unknown this step could be skipped. The align photos procedure, however, will take more time in this case.
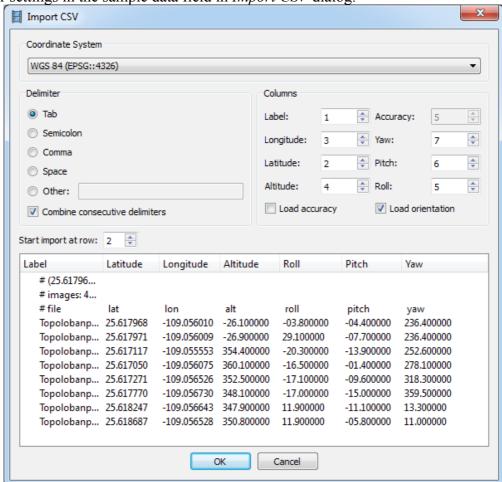
Open *Reference* pane using the corresponding command from the *View* menu.

Click [icon] *Import* button on the *Reference* pane toolbar and select the file containing camera positions information in the *Open* dialog.

The easiest way is to load simple character-separated file (*.txt, *.csv) that contains x- and y-coordinates and height for each camera position (camera orientation data, i.e. pitch, roll and yaw values, could also be imported, but the data is not obligatory to reference the model).

In the *Import CSV* dialog indicate the delimiter according to the structure of the file and select the row to start loading from. Note that # character indicates a commented line that is not counted while numbering the rows. Indicate for the program what parameter is specified in each column through setting correct column numbers in the *Columns* section of the dialog. Also it is recommended to specify valid coordinate system in the corresponding field for the values used for camera centers data.
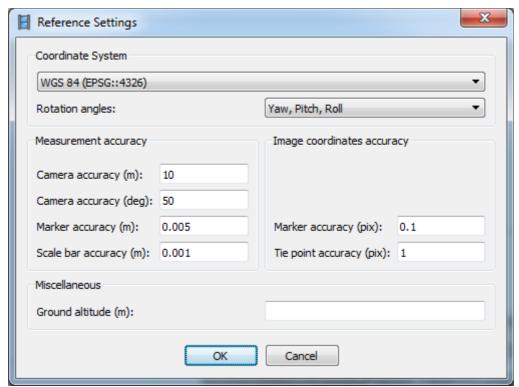
Check your settings in the sample data field in *Import CSV* dialog.

Click *OK* button. The data will be loaded into the *Reference* pane.
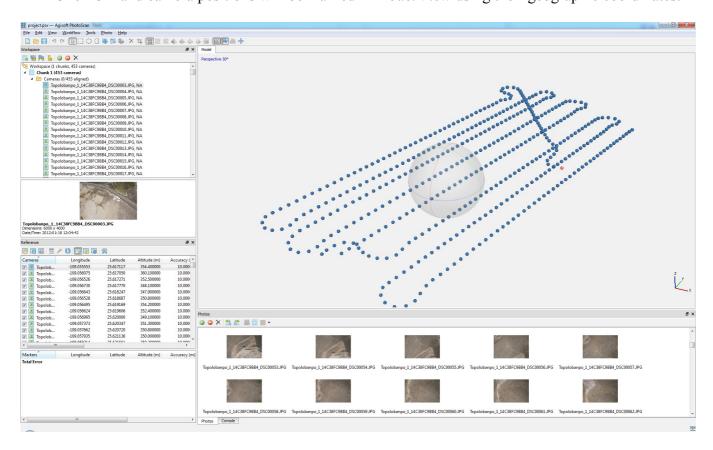
[icon] *Import EXIF* button located on the *Reference* pane can also be used to load camera positions information if EXIF meta-data is available.

Then click on the 🔧 *Settings* button in the *Reference* pane and in the *Reference Settings* dialog select corresponding coordinate system from the list, if you have not selected it in the *Import CSV* dialog yet. Set up *Camera Accuracy* in meters and degrees according to the measurement accuracy:

Ground Altitude should be specified in case of very oblique shooting and define the average ground altitude level above the ellipsoid in the selected coordinate system.

Click OK and camera positions will be marked in *Model View* using their geographic coordinates:

If you do not see anything in the Model view, even though valid camera coordinates have been imported, please check that Show Cameras button is pressed on the Toolbar. Then click Reset View button also located on the Toolbar.
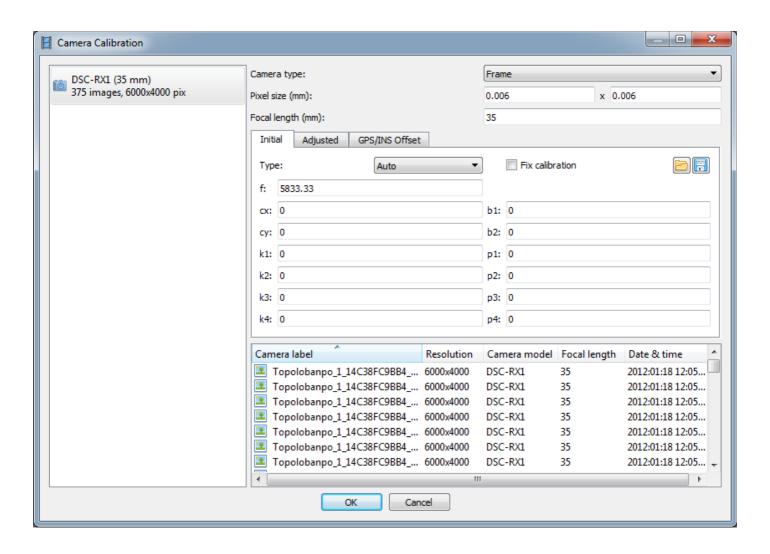
Check Camera Calibration

Open Tools Menu → Camera Calibration window.

By default PhotoScan estimates intrinsic camera parameters during the camera alignment and optimization steps based on the Initial values derived from EXIF. In case *pixel size* and *focal length* (both in mm) are missing in the image EXIF and therefore in the camera calibration window, they can be input manually prior to the processing according to the data derived from the camera and lens specifications.

If precalibrated camera is used, it is possible to load calibration data in one of the supported formats using Load button in the window. To prevent the precalibrated values from being adjusted by PhotoScan during processing, it is necessary to check on *Fix Calibration* flag.

PhotoScan can process the images taken by different cameras in the same project. In this case in the left frame of the *Camera Calibration* window multiple camera groups will appear, split by default according to the image resolution, focal length and pixel size. Calibration groups may also be split manually if it is necessary.
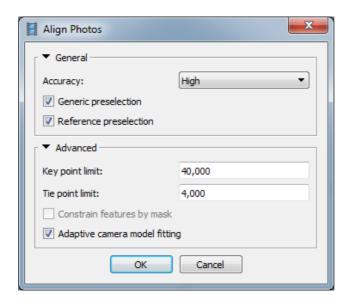
In case ultra-wide or fisheye angle lens is used, it is recommended to switch camera type from *Frame* (default) to *Fisheye* value prior to processing.

Align Photos

At this stage PhotoScan finds matching points between overlapping images, estimates camera position for each photo and builds sparse point cloud model.

Select *Align Photos* command from the *Workflow* menu.

Set the following recommended values for the parameters in the *Align Photos* dialog:

> **<u>Accuracy:</u>** *High* (lower accuracy setting can be used to get rough camera positions in a shorter time)
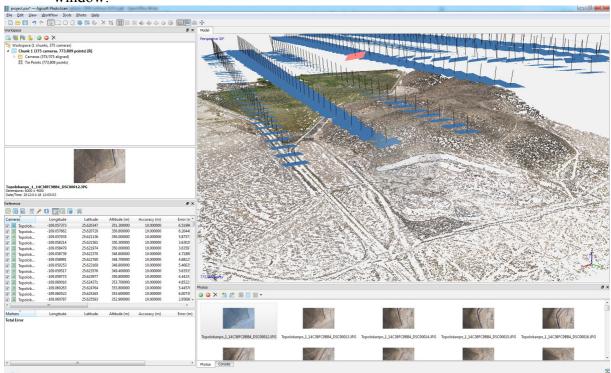>
> **<u>Pair preselection:</u>** *Reference + Generic* (in case camera positions are unknown – only *Generic* preselection mode should be used)
>
> **<u>Constrain features by mask:</u>** *Disabled* (*Enabled* in case any areas have been masked)
>
> **<u>Key point limit:</u>** *40,000*
>
> **<u>Tie point limit:</u>** *4,000*
>
> **<u>Adaptive camera model fitting:</u>** *Enabled* (to let PhotoScan distortion parameters estimation).

Click *OK* button to start photo alignment. In a short period of time (depends on the number of images in the project and their resolution) you will get sparse point cloud model shown in the Model view. Camera positions and orientations are indicated by blue rectangles in the view window:
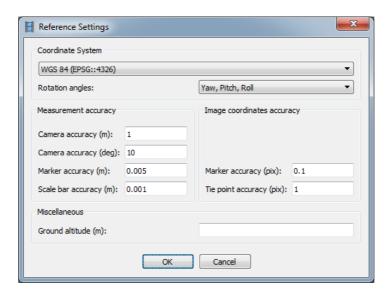
Optimize Camera Alignment

To achieve higher accuracy in calculating camera external and internal parameters and to correct possible distortion (e.g. "bowl effect" and etc.), optimization procedure should be run.

Click the ⚒ *Settings* button in the *Reference* pane and in the *Reference Settings* dialog select corresponding coordinate system from the list according to the GCP coordinates data.

Prior to optimization it is also possible to remove the points with the highest reprojection error values using corresponding criterion in Edit Menu → Gradual Selection dialog.
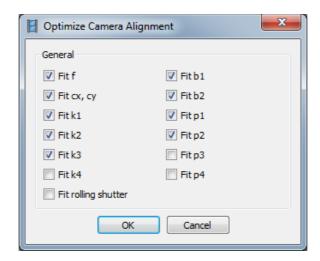
Set the following values for the parameters in *Measurement accuracy* section and check that valid coordinate system is selected that corresponds to the system that was used to survey GCPs:

Camera accuracy (m): *1* (specify value according to the measurement accuracy).
Camera accuracy (deg): *10* (specify value according to the measurement accuracy).
Projection accuracy: *0.1*
Tie point accuracy: *1*

Click OK button.

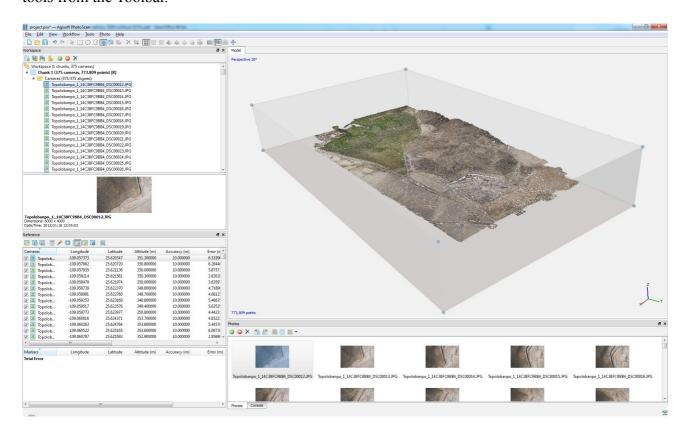Click 🔧 *Optimize* button on the *Reference* pane toolbar.

Select camera parameters you would like to optimize. Click *OK* button to start optimization process. (For DJI drone cameras it is usually suggested to optimize the rolling shutter).

Set Bounding Box

Bounding Box is used to define the reconstruction area.

Bounding box is resizable and rotatable with the help of ⊕ Resize Region and ⬌ Rotate Region tools from the Toolbar.
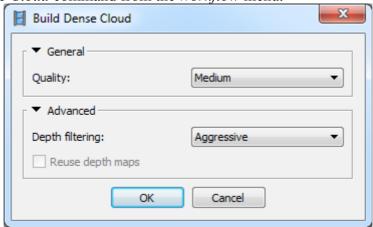

Important: The colored side of the bounding box indicates the plane that would be treated as ground plane and has to be set **under** the model and **parallel** to the XY plane. This is important if mesh is to be built in Height Field mode, which is reasonable for aerial data processing workflow.

Build Dense Point Cloud

Based on the estimated camera positions the program calculates depth information for each camera to be combined into a single dense point cloud.
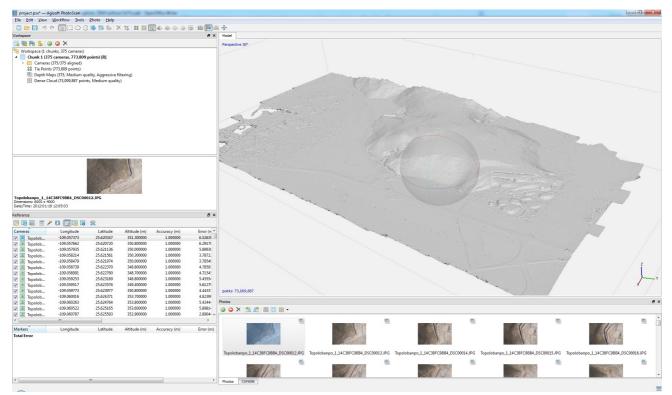
Select *Build Dense Cloud* command from the *Workflow* menu.

Set the following recommended values for the parameters in the *Build Dense Cloud* dialog:

Quality: *Medium* (higher quality takes quite a long time and demands more computational resources, lower quality can be used for fast processing)

Depth filtering: *Aggressive* (if the geometry of the scene to be reconstructed is complex with numerous small details or untextured surfaces, like roofs, it is recommended to set *Mild* depth filtering mode, for important features not to be sorted out)
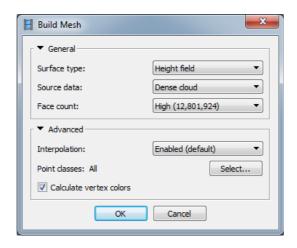
Points from the dense cloud can be removed with the help of selection tools and *Delete/Crop* instruments located on the Toolbar.

Build Mesh (optional: can be skipped if polygonal model is not required as a final result)

After dense point cloud has been reconstructed it is possible to generate polygonal mesh model based on the dense cloud data.
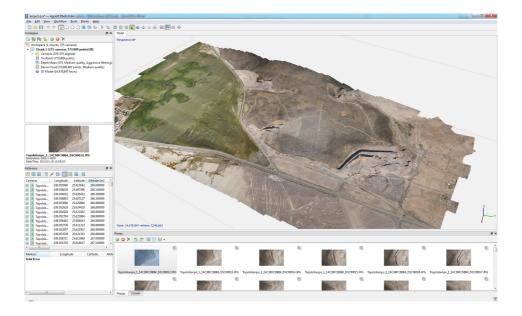
Select Build Mesh command from the Workflow menu.

Set the following recommended values for the parameters in the *Build Mesh* dialog:

Surface type: *Height Field*

Source data: *Dense cloud*

Polygon count: *Medium* (maximum number of faces in the resulting model. The values indicated next to *High/Medium/Low* preset labels are based on the number of points in the dense cloud. Custom values could be used for more detailed surface reconstruction).

Interpolation: *Enabled*

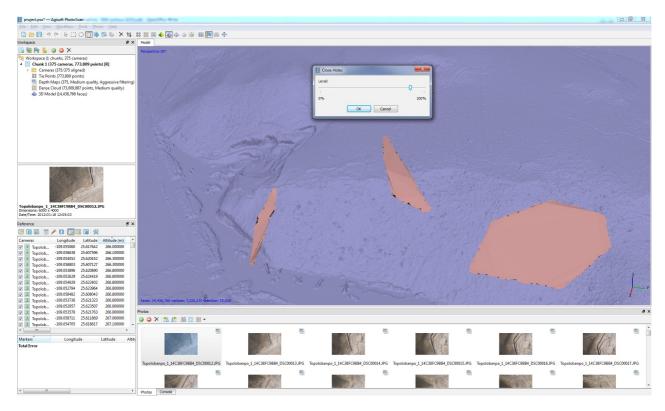Click *OK* button to start mesh reconstruction.

Edit Geometry

Sometimes it is necessary to edit geometry before building texture atlas and exporting the model.

Unwanted faces could be removed from the model. Firstly, you need to indicate the faces to be deleted using selection tools from the toolbar. Selected areas are highlighted with red color in the Model View. Then, to remove the selection use Delete Selection button on the Toolbar (or Del key) or use Crop Selection button on the Toolbar to remove all but selected faces.
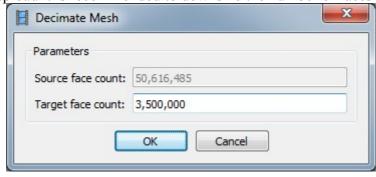
If the overlap of the original images was not sufficient, it may be required to use *Close Holes* command from the *Tools* menu at geometry editing stage to produced holeless model. In *Close Holes* dialog select the size of the largest hole to be closed (in percentage of the total model size).

PhotoScan tends to produce 3D models with excessive geometry resolution. That's why it is recommended to decimate mesh before exporting it to a different editing tool to avoid performance decrease of the external program.

To decimate 3D model select *Decimate Mesh...* command from the Tools menu. In the *Decimate Mesh* dialog specify the target number of faces that should remain in the final model. For PDF export task or web-viewer upload it is recommended to downsize the number of faces to 100,000 - 200,000.
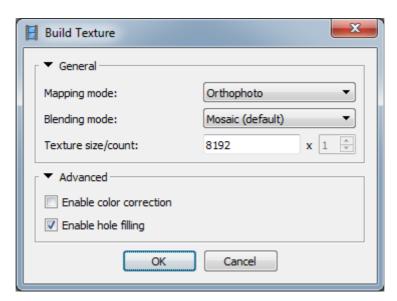

Click *OK* button to start mesh decimation procedure.

Build Texture (optional; applicable only to polygonal models)

This step is not really needed in the orthomosaic export workflow, but it might be necessary to inspect a textured model before exporting it or it might be helpful for precise marker placement.

Select *Build Texture* command from the *Workflow* menu.

Set the following recommended values for the parameters in the *Build Texture* dialog:

Mapping mode: Orthophoto
Blending mode: *Mosaic*
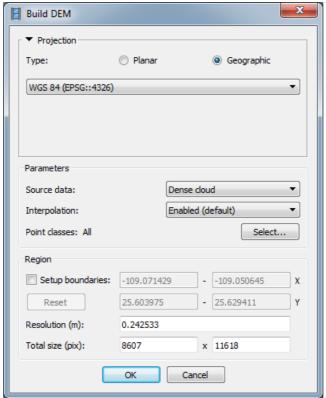**Texture size/count:** 8192 (width & height of the texture atlas in pixels)
Enable color correction: *disabled* (the feature is useful for processing of data sets with extreme brightness variation, but for general case it could be left unchecked to save the processing time)

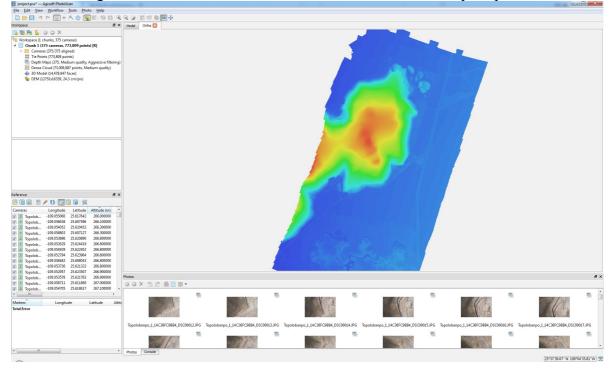Click *OK* button to start texture generation.

Build DEM

Digital elevation model can be generated based on the dense cloud or mesh model. Usually first option is preferred, as it provides more accurate results (low-poly model, being used as a source data, may result in inaccurate DEM) and allows for faster processing, since mesh generation step can be skipped.

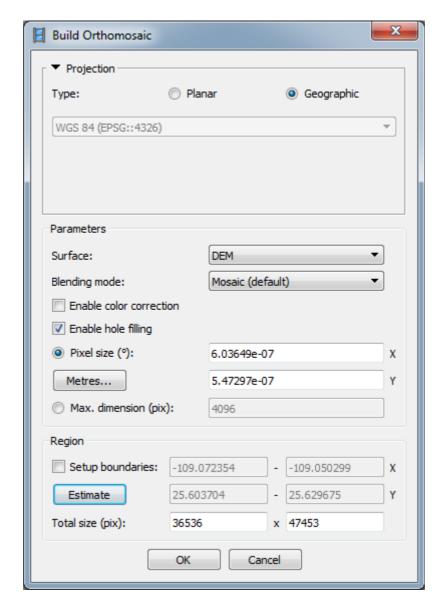Select *Build DEM* command from the Workflow menu:

Coordinate system should be specified in accordance with the system used for the model referencing. At the export stage it will be possible to project the results to a different geographical coordinate system.

After DEM generation process is finished, it is possible to open the reconstructed model in Ortho view by double-clicking on the DEM label in the chunk's contents on the Workspace pane:

Build Orthomosaic

Select *Build Orthomosaic* command from the Workflow menu:
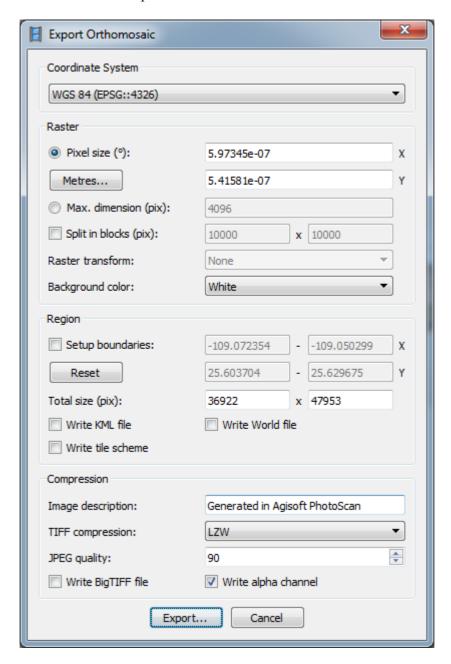

Select desired surface for orthomosaic generation process: mesh or DEM, and blending mode.

Pixel size will be suggested according to the average ground sampling resolution of the original images. According to the surface size and the input pixel size the total size of the orthomosaic (in pixels) will be calculated and shown in the bottom of the dialog box.

Generated orthomosaic can be reviewed in Ortho mode similar to the digital elevation model. It can be opened in this view mode by double-clicking on the orthomosaic label in the Workspace pane.

Export Orthomosaic

Select *Export Orthomosaic → Export JPEG/TIFF/PNG* command from *File* menu.

Set the following recommended values for the parameters in the *Export Orthomosaic* dialog:

Projection: *Desired coordinate system*

Pixel size: desired export resolution (please note that for WGS84 coordinate system units should be specified in degrees. Use *Metres* button to specify the resolution in metres).

Split in blocks: *10000* x *10000* (if the exported area is large it is recommended to enable *Split in Blocks* feature, since the memory consumption is rather high at exporting stage)
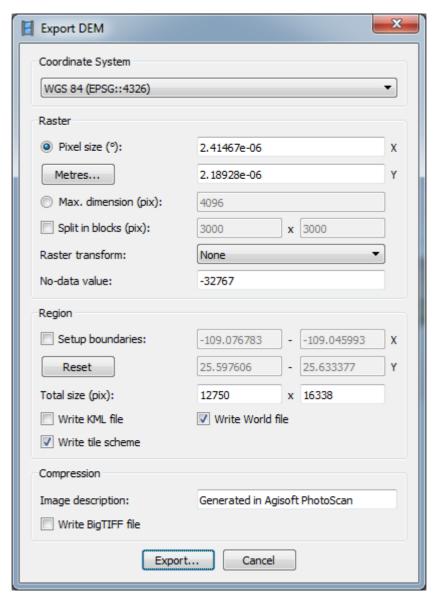
Region: set the boundaries of the model's part that should be projected and presented as orthomosaic. Also polygonal shapes drawn in the Ortho view and marked as boundaries will be taken into account for the orthomosaic export.

TIFF compression and JPEG quality should be specified according to the job requirements.

BigTIFF format allows to overcome the TIFF file size limit for the large orthomosaics, but it is not supported by some applications.

Click *Export...* button and then specify target file name and select type of the exported file (e.g. GeoTIFF). Click *Save* button to start orthomosaic generation.

Export DEM

Select *Export DEM* → Export GeoTIFF/BIL/XYZ command from *File* menu.

Set the following recommended values for the parameters in the *Export DEM* dialog:

Projection: *Desired coordinate system*

No-data value: value for not visible points; should be specified according to the requirements of the post processing application.

Pixel size: desired export resolution

Split in blocks: *10000* x *10000* (if the exported area is large, it is recommended to enable *Split in blocks* feature, since the memory consumption is rather high at exporting stage)

Region: set the boundaries of the model's part that should be projected and presented as DEM. Also polygonal shapes drawn in the Ortho view and marked as boundaries will be taken into account for the DEM export.

Click *Export...* button and then specify target file name and select type of the exported file (e.g. GeoTIFF). Click *Save* button to start DEM generation.