# <u>Tutorial (Beginner level):</u> <u>Orthomosaic and DEM Generation with Agisoft PhotoScan Pro 1.2</u> <u>(without Ground Control Points)</u>

## 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 an images set without ground control points information.

## **PhotoScan Preferences**

Open PhotoScan Preferences dialog	g from <i>Tools</i> menu using corresponding comman
PhotoScan Preferences	PhotoScan Preferences
General       OpenCL       Advanced       Network         User Interface       Language:       English          Background color:       #c2c2c2       Select         Stereoscopic Display       Mode:       Anaglyph          Parallax:       1.0	General       OpenCL       Advanced       Network         Active CPU cores:
Processing Log	
Write log to file:       D:\PhotoScan_Pro_1.2.txt	When using OpenCL, please deactivate one CPU core for each GPU in use for optimal performance.
OK Cancel Apply	OK Cancel Apply

Set the following values for the parameters on the *General* tab: <u>Stereo Mode:</u> *Anaglyph* (use *Hardware* if your graphic card supports Quad Buffered Stereo) <u>Stereo Parallax:</u> 1.0

Write log to file: specify directory where Agisoft PhotoScan log would be stored

PhotoScan Preferences
General OpenCL Advanced Network
Project Files
Compression level: 6
✓ Keep depth maps
Store absolute image paths
Miscellaneous
Check for updates on program startup
Switch to model view by default
Enable VBO support
Strip camera extensions during model export
Reset All Settings
OK Cancel Apply

(in case of contacting the software support team it could be required)

Set the parameters on the *OpenCL* tab as following: *Check on any OpenCL devices detected by PhotoScan in the dialog and reduce the number of active CPU cores by one for each OpenCL device enabled.* 

Set the following values for the parameters on the *Ad*-*vanced* 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 **R** 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.

Open *Reference* pane using the corresponding command from the *View* menu.

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

The easiest way is to load simple character-separated file (\*.txt) 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).

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 center data. Check your settings in the sample data field in *Import CSV* dialog.

	326)										•
Delimiter				Col	umns						
				0	unna				_		
Tab			Lab	pel:	1	*	Accura	acy:	5	*	
Semicolon				Lor	ngitude:	3	*	Yaw:	E	7	*
Comma					_	_				-	
Space				Lat	itude:	2	×	Pitch:	(	5	*
Other:				Alti	itude:	4	*	Roll:	!	5	*
Combine conse	a an				Load accu	iracy		<b>V</b> Io	ad orienta	ation	
Combine conse	cuuve delimite	ers				,					
tart import at row:	2 ≑										
	2 Latitude	Longitude	Altitude	2	Roll		Pitch		Yaw		
		Longitude	Altitude	2	Roll		Pitch		Yaw		
abel # (25.61796 # images: 4		Longitude	Altitude	2	Roll		Pitch		Yaw		
abel # (25.61796 # images: 4 # file	Latitude	lon	alt		roll		pitch		yaw		
abel # (25.61796 # images: 4 # file Topolobanp	Latitude lat 25.617968	lon -109.056010	alt -26.1000	000	roll -03.8000		pitch -04.40	0000	yaw 236.400		
abel # (25.61796 # images: 4 # file Topolobanp Topolobanp	Latitude lat 25.617968 25.617971	lon -109.056010 -109.056009	alt -26.1000 -26.9000	000	roll -03.8000 29.10000	0	pitch -04.40 -07.70	0000 0000	yaw 236.400 236.400	000	
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abel # (25.61796 # images: 4 # file Topolobanp Topolobanp Topolobanp Topolobanp	lat 25.617968 25.617971 25.617117 25.617050	lon -109.056010 -109.055009 -109.055553 -109.056075	alt -26.1000 -26.9000 354.4000 360.1000	000 000 000 000	roll -03.8000 29.10000 -20.3000 -16.5000	00 00 00	pitch -04.40 -07.70 -13.90 -01.40	0000 0000 0000 0000	yaw 236.400 236.400 252.600 278.100	000 000 000	
abel # (25.61796 # images: 4 # file Topolobanp Topolobanp Topolobanp Topolobanp Topolobanp	lat 25.617968 25.617971 25.617117 25.617050 25.617271	lon -109.056010 -109.056009 -109.055553 -109.056075 -109.056526	alt -26.1000 -26.9000 354.4000 360.1000 352.5000	000 000 000 000	roll -03.8000 29.10000 -20.3000 -16.5000 -17.1000	00 00 00 00	pitch -04.40 -07.70 -13.90 -01.40 -09.60	0000 0000 0000 0000 0000	yaw 236.400 236.400 252.600 278.100 318.300	000 000 000 000	
abel # (25.61796 # images: 4 # file Topolobanp Topolobanp Topolobanp Topolobanp Topolobanp Topolobanp	lat 25.617968 25.617971 25.617117 25.617050 25.617271 25.617770	lon -109.056010 -109.056009 -109.055553 -109.056526 -109.056526 -109.056730	alt -26.1000 -26.9000 354.4000 360.1000 352.5000 348.1000	000 000 000 000 000 000	roll -03.8000 29.10000 -20.3000 -16.5000 -17.1000 -17.0000	00 00 00 00 00	pitch -04.40 -07.70 -13.90 -01.40 -09.60 -15.00	0000 0000 0000 0000 0000 0000	yaw 236.400 236.400 252.600 278.100 318.300 359.500	000 000 000 000 000	
# images: 4 # file Topolobanp Topolobanp Topolobanp Topolobanp Topolobanp	Latitude lat 25.617968 25.617971 25.617177 25.617050 25.617271 25.617770 25.618247	lon -109.056010 -109.056009 -109.055553 -109.056075 -109.056526	alt -26.1000 -26.9000 354.4000 360.1000 352.5000 348.1000 347.9000	000 000 000 000 000 000 000	roll -03.8000 29.10000 -20.3000 -16.5000 -17.1000	00 00 00 00 00 00	pitch -04.40 -07.70 -13.90 -01.40 -09.60	0000 0000 0000 0000 0000 0000 0000	yaw 236.400 236.400 252.600 278.100 318.300	000 000 000 000 000 000	

Click OK button. The data will be loaded onto the Reference pane.

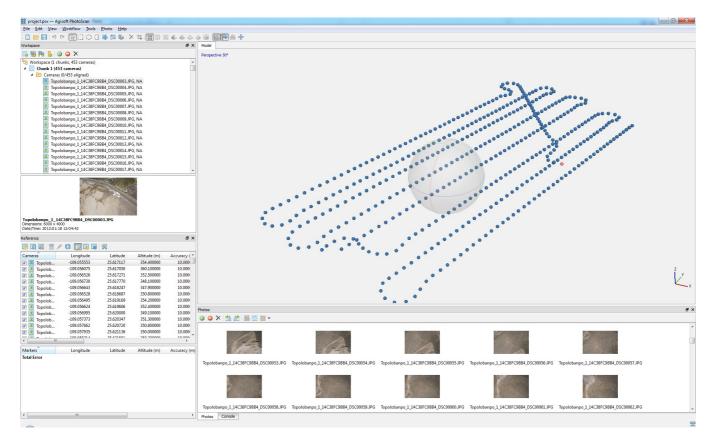
*Import EXIF* button located on the *Reference* pane can also be used to load camera positions information if EXIF meta-data is available.

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 yet selected it in the *Import CSV* dialog. Set up *Camera Accuracy* in meters and degrees according to the measurement accuracy:

Coordinate System			
WGS 84 (EPSG::4326)			•
Measurement accuracy		Image coordinates accura	су
Camera accuracy (m):	10		
Camera accuracy (deg):	2		
Marker accuracy (m):	0.005	Marker accuracy (pix):	0.1
Scale bar accuracy (m):	0.001	Tie point accuracy (pix):	4
Miscellaneous			
Ground altitude (m):			

Ground Altitude should be specified in case of very oblique shooting.

Click OK and camera positions will be marked in Model View based on their geographic coordinates :



If you cannot 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  $\rightarrow$  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.

E Camera Calibration							x
DSC-RX1 (35 mm)	Camera t	ype:	Frame				•
453 images, 6000x400	Pixel size	(mm):	0.006		x 0.	.006	
	Focal len	gth (mm):	35				
	Initial	Adjusted	GPS/INS Offset				
	Type:	Auto	•				
	fx:	5833.33		cx:	3000		
	fy:	5833.33		cy:	2000		
	k1:	0		p1:	0		
	k2:	0		p2:	0		
	k3:	0		p3:	0		
	k4:	0		p4:	0		
	skew:	0		F	Fix calibration	1	
	Image	Resolutio	on Camera m	od Fo	ocal length	Date & time	<b>^</b>
		olo 6000x400		35		2012:01:18 12:06	
		olo 6000x400 olo 6000x400		35 35		2012:01:18 12:06 2012:01:18 12:06	
		olo 6000x400		35		2012:01:18 12:06	
		olo 6000x400		35		2012:01:18 12:07	Ŧ
		ОК	Cancel	)			

## **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.

Align Photos	×		
✓ General			
Accuracy:	High 💌		
Pair preselection:	Reference 🔻		
▼ Advanced			
Key point limit:	40000		
Tie point limit:	10000		
Constrain features by mask			
ОК	Cancel		

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

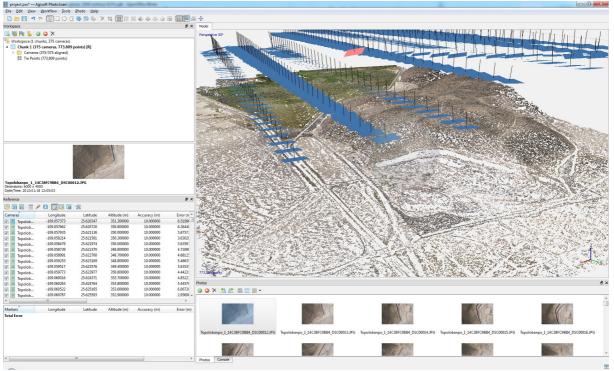
Accuracy: *High* (lower accuracy setting can be used to get rough camera positions in a shorter time)

**<u>Pair preselection:</u>** *Reference* (in case camera positions are unknown *Generic* preselection mode should be used)

<u>Constrain features by mask:</u> *Disabled (Enabled* in case any areas have been masked prior to processing)

Key point limit: 40000 Tie point limit: 10000

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 on 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 points with the highest reprojection error values using corresponding criterion in the Edit Menu  $\rightarrow$  Gradual Selection dialog.

Set the following values for the parameters in *Measurement accuracy* section and check that valid coordinate system is selected:

Reference Settings			X
Coordinate System			
WGS 84 (EPSG::4326)			•
Measurement accuracy		Image coordinates accura	асу
Camera accuracy (m):	10		
Camera accuracy (deg):	5		
Marker accuracy (m):	0.005	Marker accuracy (pix):	0.1
Scale bar accuracy (m):	0.001	Tie point accuracy (pix):	4
Miscellaneous			
Ground altitude (m):			
	ОК	Cancel	

<u>Camera accuracy (m)</u>: 10 (specify value according to the measurement accuracy). <u>Camera accuracy (deg)</u>: 5 (specify value according to the measurement accuracy). <u>Tie point accuracy</u>: 4

Click OK button.

Click *POptimize* button on the *Reference* pane toolbar.

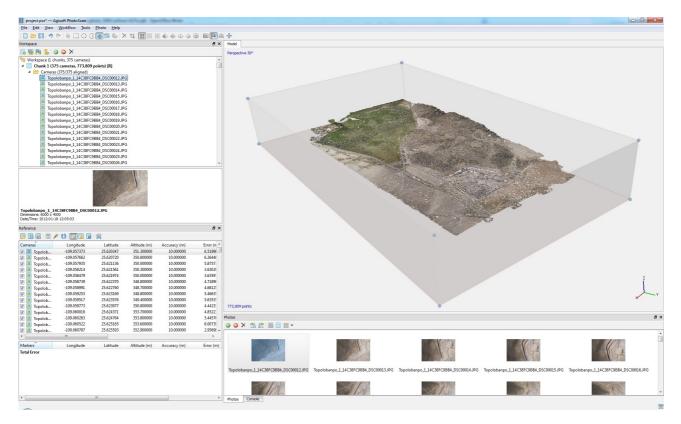
General	
🔽 Fit f	🔽 Fit k1, k2, k3
Fit aspect	🔲 Fit k4
Fit cx, cy	V Fit p1, p2
Fit skew	Fit p3
	Fit p4

Select camera parameters you would like to optimize. Click OK button to start optimization process.

## **Set Bounding Box**

Bounding Box is used to define the reconstruction area.

Bounding box is resizable and rotatable with the help of  $\textcircled{3}{2}$  Resize Region and  $\textcircled{3}{2}$  Rotate Region tools from the Toolbar.



**Important:** The red-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.

ise	<i>Cloud</i> command from the <i>workflow</i> ment.
	Build Dense Cloud
	General
	Quality: Medium -
	▼ Advanced
	Depth filtering: Aggressive
	Reuse depth maps
	OK Cancel

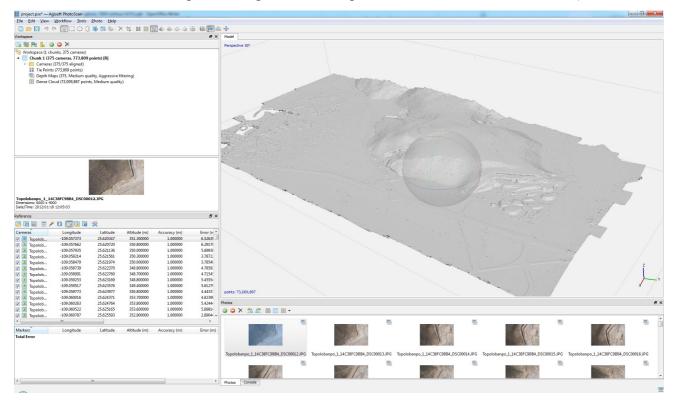
Select Build Dense Cloud command from the Workflow menu.

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

**<u>Quality</u>**: *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)

When the 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.

Build Mesh	×
▼ General	
Surface type:	Height field 🔹
Source data:	Dense cloud 💌
Face count:	High (14,601,977) 🔹
▼ Advanced	
Interpolation:	Enabled (default)
Point classes: All	Select
ОК	Cancel

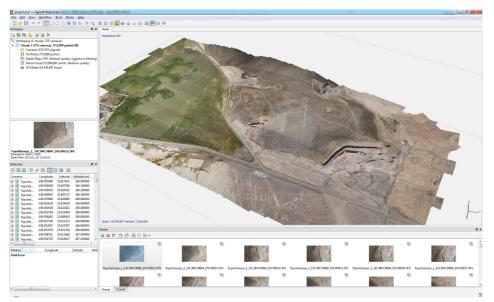
Set the following recommended values for the parameters in the Build Mesh dialog:

# Surface type: Height Field

Source data: Dense cloud

**Face count:** High (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.

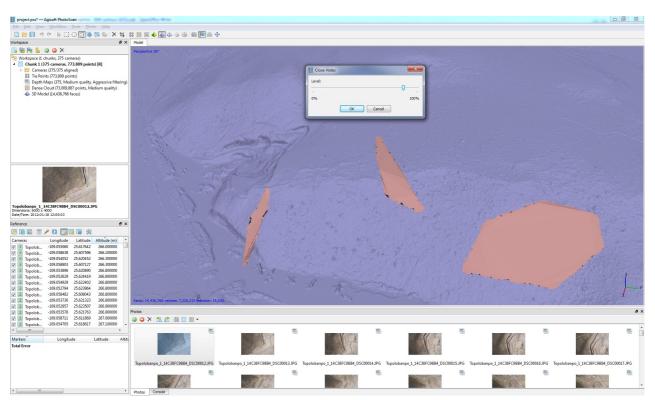


## **Edit Geometry**

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 100000-200000.

📘 Decimate Mesh	×		
Parameters			
Source face count:	4457654		
Target face count:	2000000		
OK Cancel			

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.

Select Build Texture command from the Workflow menu.

Build Texture	×	
General		
Mapping mode:	Orthophoto 💌	
Blending mode:	Mosaic (default)	
Texture size/count:	8192 x 1 🛓	
Advanced		
Enable color correction		
ОК	Cancel	

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 the data sets with extreme brightness variation, but for a general case it could be left unchecked to save up the processing time)

Click OK button to start texture generation.

## **Build DEM**

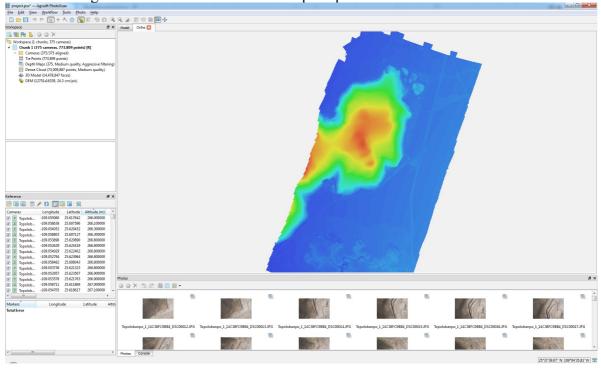
Digital elevation model can be generated based on the dense cloud or mesh model. Usually first option is preferable, as it provides more accurate results (low-poly model, being used as a source data, may result in inaccurate DEM) and allows for faster processing, since mesh generation step can be skipped.

Coordinate System					
WGS 84 (EPSG::4326)				•	
Parameters					
Source data:	Den	Dense cloud    Enabled (default)			
Interpolation:	Enal				
Point classes: All			Select.		
Region					
Setup boundaries:	-109.076783	-	-109.045992	)	
Reset	25.597606	-	25.633379	Y	
Resolution (m/pix):	0.242533				
Total size (pix):	12751	x	16340		

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 Workspace pane:



# **Build Orthomosaic**

Build Orthomosaic					×
Projection					
Type:	Plan	ar		Geographic	
WGS 84 (EPSG::4326)					-
Parameters					
Surface:		DEM			•
Blending mode:		Mosaic (de	fault	;)	•
Enable color correct	ion				
Pixel size (deg):		5.97345e-07			x
Metres		5.41581e-	Y		
Max. dimension (pix	:):	4096			
Region					
Setup boundaries:	-109.0	72354	] -	-109.050299	X
Estimate	25.603	3704	-	25.629675	Y
Total size (pix):	36921		×	47954	
	ОК	Car	ncel		

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**

WGS 84 (EPSG::4326)				Ŧ	
Raster					
Pixel size (deg):	5.97345e-07				
Metres	5.41581e-07	5.41581e-07			
Max. dimension (pix):	4096				
Split in blocks (pix):	10000	x	10000		
Raster transform:	None	None			
Region					
Setup boundaries:	-109.072354	] -	-109.050299		
Reset	25.603704	] -	25.629675		
Total size (pix):	36922	x	47953		
Write KML file	Write World	file			
Compression					
TIFF compression:	LZW			•	
JPEG quality:	90			*	
Write BigTIFF file					

Select *Export Orthomosaic*  $\rightarrow$  *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* 

- **<u>Pixel size:</u>** 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).
- <u>Split in blocks:</u> 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 may not be supported by some application.

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

## **Export DEM**

Raster					
Pixel size (deg):	2.41467e-06				
Metres	2.18928e-06				
Max. dimension (pix):	4096				
Split in blocks (pix):	3000	x	3000		
No-data value:	-32767				
Region					
Setup boundaries:	-109.076783	] -	-109.045993	X	
Reset	25.597606	] -	25.633377	Y	
Total size (pix):	12750	x	16338		
Write KML file	Write World f	ile			
Compression					

Select *Export DEM*  $\rightarrow$  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.

- **<u>Pixel size:</u>** 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)
- **<u>Region</u>**: 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 export DEM.