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ShapeMetriX



FragMetriX

MultiPhoto



**User Manual
for Version 5.0**

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1 Introduction

The *MultiPhoto* is an easy to handle software component for the reconstruction of 3D models from multiple overlapping single images. Once all input parameters have been defined by the user, the reconstruction is performed automatically. In addition, *MultiPhoto* features scaling a generic 3D model to a metric (scaled one) in a local coordinate system or referencing of the 3D model to a superior co-ordinate system by the use of externally surveyed *Ground Control Points (GCP)*. *MultiPhoto* generates a quality report (".pdf" file) for the reconstruction and an ortho-photo (".png" file) fully automatically after reconstruction.

Definition:

A *GCP* is an externally surveyed 3D point with known co-ordinates. Note that the absolute accuracy of the final result is directly related to the accuracy of the *GCP*.

This user manual addresses all topics related to the *MultiPhoto* i.e. installation, user interfaces, features and operations. Let us know if we can support you, and give us your valuable feedback. Only this way it remains possible to keep the system both, flexible enough for broad usage and sufficiently specific for your applications.

We wish you success with the *MultiPhoto*.

The Team of 3GSM

Graz, August 2025

2 Software layout, features and use

2.1 General

Attention:

The present version of *MultiPhoto* comes with the file format “.jm3x”, 3D model files from previous versions (“jm3” files) are not supported in the current version. Models from previous versions (“.jm3”) can be converted in the ModelEditor (see corresponding user manual). Note, *Project Files* (“.smm” files) generated with former versions can be used to generate a new 3D model with the file format “.jm3x”. The work flows “*Generate modified 3D model*” and “*Perform constrained referencing*” are supported; see Chapter 2.3.).

Note:

A “*Help*”  button is provided in the lower left corner of the user interface, which opens the user manual of the *MultiPhoto*.

2.2 Procedure

MultiPhoto processes the data in a sequential procedure. The essential steps include:

- *Coarse Reconstruction*
The *Coarse Reconstruction* determines the camera orientations and positions among all photographs relative to each other and relative to the coarsely reconstructed object. The result of the *Coarse Reconstruction* is the *Project File* (“.smm” file).
- (Optional) *Region of Interest*
MultiPhoto features the definition of a *Region of Interest (ROI)*, which limits the generation of the 3D model (*Dense Reconstruction*) to a selected area. The definition of the *ROI* is an intermediate step in the *MultiPhoto* and it has to be outlined on the coarse point cloud after the *Coarse Reconstruction*.
- *Dense Reconstruction*
The *Dense Reconstruction* calculates the detailed object geometry including a detailed point cloud, surface mesh and texture. The result of the *Dense Reconstruction* is the 3D model file (“.jm3x” file)
- *Referencing and Scaling*
MultiPhoto supports referencing by the use of *Ground Control Points (GCP)* as well as scaling of 3D models in a local co-ordinate system. Several options are provided described in the following chapter.

2.3 Reconstruction features

MultiPhoto supports four different workflows that can be selected by the user (Figure 1):

1. *Generate new 3D model*
2. *Generate modified 3D model*
3. *Perform referencing*
4. *Perform constrained referencing*

Note:

The sequential procedure described in Chapter 2.2 may differ due to the selected mode.

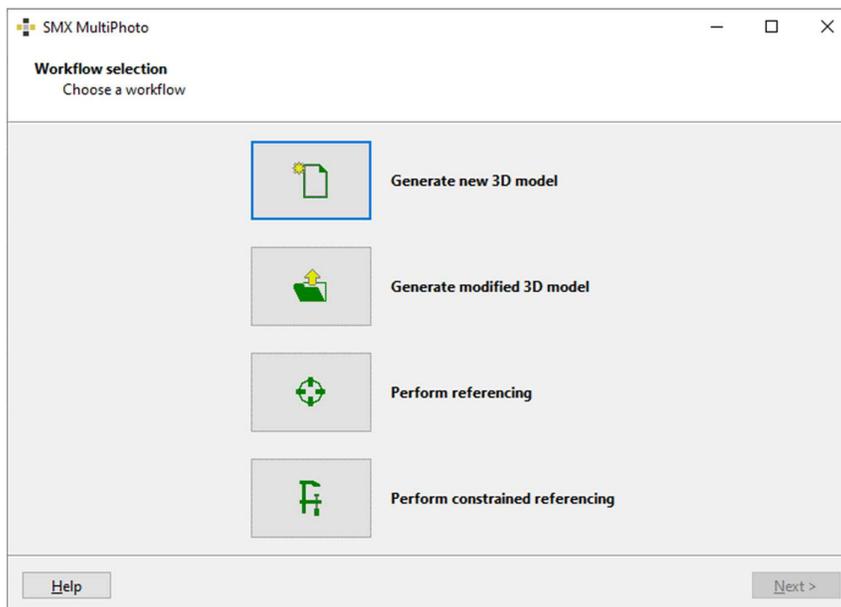


Figure 1: Start interface

2.3.1 Generate new 3D model

Load photos, define the co-ordinate system (optional) and perform 3D model reconstruction (coarse and dense reconstruction). Standard operation procedure:

1. Open *MultiPhoto*
2. Select the workflow “*Generate new 3D model*” by clicking the corresponding icon 
3. Follow the standard operating procedure as described in Chapter 4.

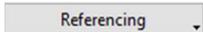
2.3.2 Generate modified 3D model

Load a *Project File* (".smm" file; coarse reconstruction), modify the settings and perform 3D model reconstruction. Standard operation procedure:

1. Open *MultiPhoto*
2. Select the workflow "Generate modified 3D model" by clicking the corresponding icon 
3. Load the ".smm" file and the software automatically switches to the *Select Scene Region of Interest* window.
4. Follow the standard operating procedure as described in Chapter 4.2

2.3.3 Perform referencing

Load a *Project File* (".smm" file; coarse reconstruction) and 3D model file (".jm3x"; dense reconstruction) and perform referencing using surveyed *Ground Control Points* or scaling of the 3D model. Standard operation procedure:

1. Open *MultiPhoto*
2. Select the workflow "Perform referencing" by clicking the corresponding icon 
3. Load the ".smm" and the corresponding ".jm3x" file (Figure 2). The *Project File* and the 3D model is loaded and the software automatically switches to the *3D Model* window.
4. Choose the action "Control Points" from the pull down menu "Referencing"  and follow the standard operating procedure as described in Chapter 5.

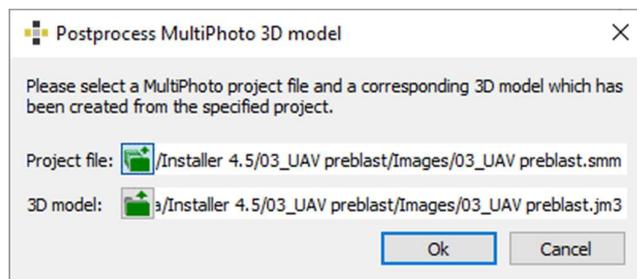


Figure 2: Loading Project File

2.3.4 Perform constrained referencing

Load a *Project File* (".smm" file; coarse reconstruction), modify the settings, optimize the reconstruction using surveyed *Ground Control Points* and perform 3D model reconstruction (".jm3x"; dense reconstruction). Standard operating procedure:

1. Open *MultiPhoto*

2. Select the workflow “*Perform constrained referencing*” by clicking the corresponding icon 
3. Load the “.smm” file and the software automatically switches to the *Select Scene Region of Interest* window.
4. Follow the standard operating procedure as described in Chapters 5.2

2.4 Referencing using GCP

MultiPhoto features referencing using externally surveyed *GCP* by two methods, i.e. *Standard Referencing (Full Reference Mode)* and *Constrained Referencing*. *GCP* should comply following conditions:

- Surveyed points are visible in the images
- Surveying grade accuracy is in the lower cm range (total station, RTK GPS, Differential GPS)
- At least three *GCP* are required, more than five are recommended
- Evenly distributed over the surveying area (**NOT** linear aligned)

Attention:

Marking and surveying of *GCP* on the model is crucial for the absolute metric accuracy of the 3D model and thus should be performed carefully.

2.4.1 Standard referencing

Note:

Standard Referencing is a post-processing step which is performed after *Dense Reconstruction* of the 3D model (“.jm3x”).

MultiPhoto provides two different modes of standard referencing:

- *Full Reference*
The 3D model is transferred into a superior co-ordinate system by using known co-ordinates of externally surveyed *GCP* (at least three) by similarity transformation. See Chapter 5.1.3.
- *Single Point Mode*
The 3D model is transferred to a co-ordinate system by using the co-ordinates of a single externally surveyed point (*GCP*) by similarity transformation. This mode is only available if the model is already referenced (*EXIF GPS*). It allows to transfer the 3D model to a user defined co-ordinate system. See Chapter 5.1.4.

Work flow (see Figure 3)

Once the data is loaded and reconstruction parameters are defined, the 3D model is generated fully automatically by the *MultiPhoto*. In principle, no user intervention is necessary during the *Coarse* and *Dense Reconstruction*. The 3D model is referenced by the use of externally surveyed *GCP* (*Standard Referencing*) in a final step.

Note:

For the definition of a *ROI*, the generation of the 3D model has to be performed by a four step procedure: *Coarse Reconstruction – Definition of ROI – Dense Reconstruction – Standard Referencing*.

2.4.2 Constrained referencing

Constrained Referencing is based on the optimization of the 3D model using the position of the externally surveyed *GCP*. Initial camera positions are re-adjusted and optimized. Generated 3D points of the dense point cloud (3D model) are forced into their position on the bases of the *GCP* co-ordinates.

Attention:

Constrained Referencing strongly depends on the accuracy of the provided geo-locations and their respective image measurements and needs **reliable** and **precise** data for a successful application.

Note:

GCP constrained optimization is an intermediate operation of the 3D model reconstruction and cannot be performed ex post.

Work flow (see Figure 3)

Constrained Referencing requires a step by step procedure for 3D model generation. Once the data is loaded, *MultiPhoto* generates the coarse 3D point cloud of the 3D model (*Coarse Reconstruction*). In an intermediate step, *GCP* constrained optimization of the model has to be performed by user interaction (*Constrained Referencing*). After optimization, the 3D model (“.jm3x”) is generated (*Dense Reconstruction*).

Note:

For the definition of a *ROI*, the 3D model generation has to be performed by a four step procedure: *Coarse Reconstruction – Definition of ROI – Constrained Referencing – Dense Reconstruction*

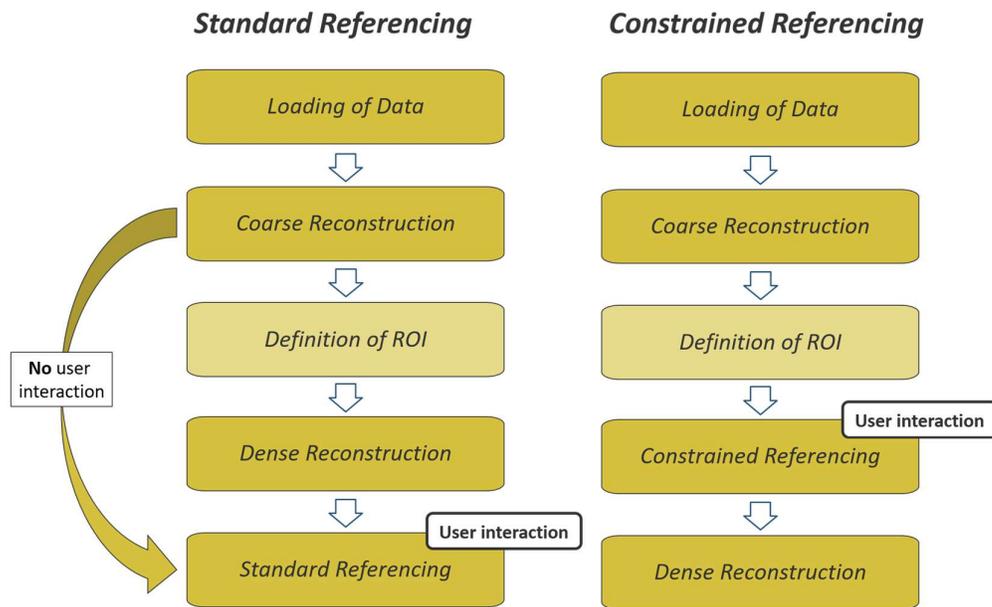


Figure 3: Different work flows in the MultiPhoto. Note that the definition of a ROI is optional and requires user interaction.

2.5 Normalize and Scaling using Targets

MultiPhoto provides three different modes:

- *One Range Pole Mode* changes the geometry of the generic 3D model into a metric 3D model. It relies on a vertically installed *Range Pole* with two targets. Additionally, the software allows one to rotate a 3D model to an externally determined azimuth and shift the co-ordinates to one known position.
- *Two Range Pole Mode* features scaling, vertically orientating, and north-correcting at the same time using two non-parallel *Range Poles*. This mode requires as input the distance between the *Range Pole* targets and the trend and plunge of the two *Range Poles*.
- *Sample Mode*
The *Sample Mode* is used to define a local co-ordinate system with a horizontal reference plane.

Note:

For field setups and the proper installation of *Range Poles* and targets please refer to the *Field Procedure* user manual.

2.5.1 One Range Pole Mode

The *One Range Pole Mode* changes the geometry of the generic 3D model into a metric 3D model. It relies on a vertically installed *Range Pole* with two targets. The distance between targets must be known and serves as the scaling distance (Figure 4). It is necessary that the *Range Pole* is visible in at least two images within a 3D model.

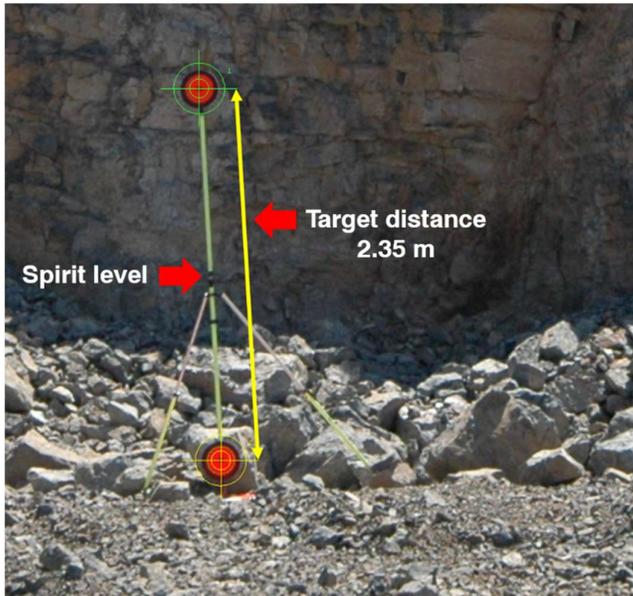


Figure 4: Vertically installed Range Pole with two targets. Note that the Range Pole might appear not to be vertical due to tilted camera when taking the picture and/or lens distortion.

North correction

The 3D model can be orientated to North using the *One Range Pole Mode with Reference Line*. The mode is used to scale and rotate a generic 3D model into its correct vertical and horizontal orientation. The rotation of the 3D model about its vertical axis is based on the measured azimuth (geographic direction) of a reference line in the field, the so-called target azimuth. The *Reference Line* in the 3D model is defined by two points - *Start Point* and *End Point* - while the direction of the *Reference Line* points from start to the end point (Figure 5).

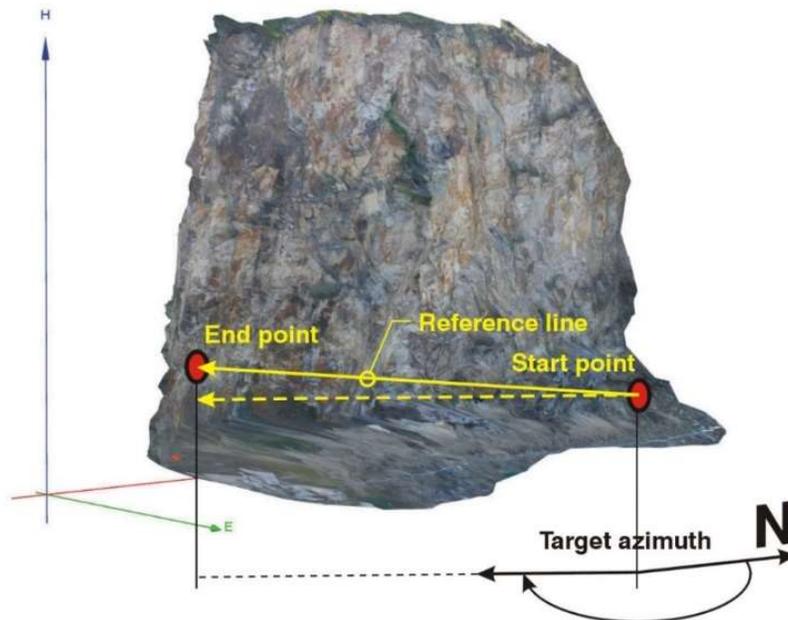


Figure 5: Definition of the target azimuth in the One Range Pole Mode with Reference Line. The target azimuth is the direction of the horizontal projection (dashed line) of the Reference Line from start point to end point relative to north.

Surveyed Control Point (optional)

This mode is also used to shift the 3D model to a position in space using a surveyed *Ground Control Point* (GCP). The *Ground Control Point* be an artificial target or natural or marked points on the rock face. Coordinates (Easting, Northing, Height) must be known for using a *Ground Control Point*.

2.5.2 Two Range Pole Mode

The *Two Range Pole Mode* features scaling, vertically orientating, and north-correcting at the same time using two non-parallel *Range Poles* visible in the photos (Figure 6). This mode requires as input the distance between the *Range Pole* targets and the trend and plunge of the two *Range Poles*. It is possible to have the same target distances for both, *Range Poles* or different target distances, for each of the *Range Poles*. The trend and plunge of the *Range Poles* have to be determined in the field, e.g. using a geologic compass (Clar or Brunton).



- 1 Range Pole target distance
- 2 Trend of Range Poles
- 3 Plunge of Range Poles

Figure 6: Functional principle of the Two Range Poles Mode

Surveyed Control Point (optional)

Co-ordinates of a surveyed *Ground Control Point* can be defined. This mode is also used to shift the 3D model to a position in space. The *Ground Control Point* might be an artificial target or natural or marked points on the rock face. Co-ordinates (Easting, Northing, Height) must be known for using a surveyed *Ground Control Point* can.

2.5.3 Sample Mode

The mode is used to scale the 3D model in a local co-ordinate system with a horizontal reference plane. It is especially suitable for underground environment. The mode requires defining three points, two points provide scale and orientation of the x-axis while the third point defines the xy plane. The *Sample Mode* is based in a right handed co-ordinate system and requires a *First Point*, a *Second Point* and a *Plane Point*. The local co-ordinate system is defined as follows:

- The x-axis points from the *Second Point* to the *First Point*
- The *Plane Point* defines the orientation of the xy-plane by fixing the orientation around the x-axis
- The y-axis points from the *Plane Point* into the direction of the x-axis
- The z-direction is either to the observer or away from the observer, respectively, depending from orientation of the other axis

In addition, the *Sample Mode* requires the input of the point distance between the *First* and the *Second Point*. According to the setup of the three points, four scenarios of co-ordinate system are possible (Figure 7).

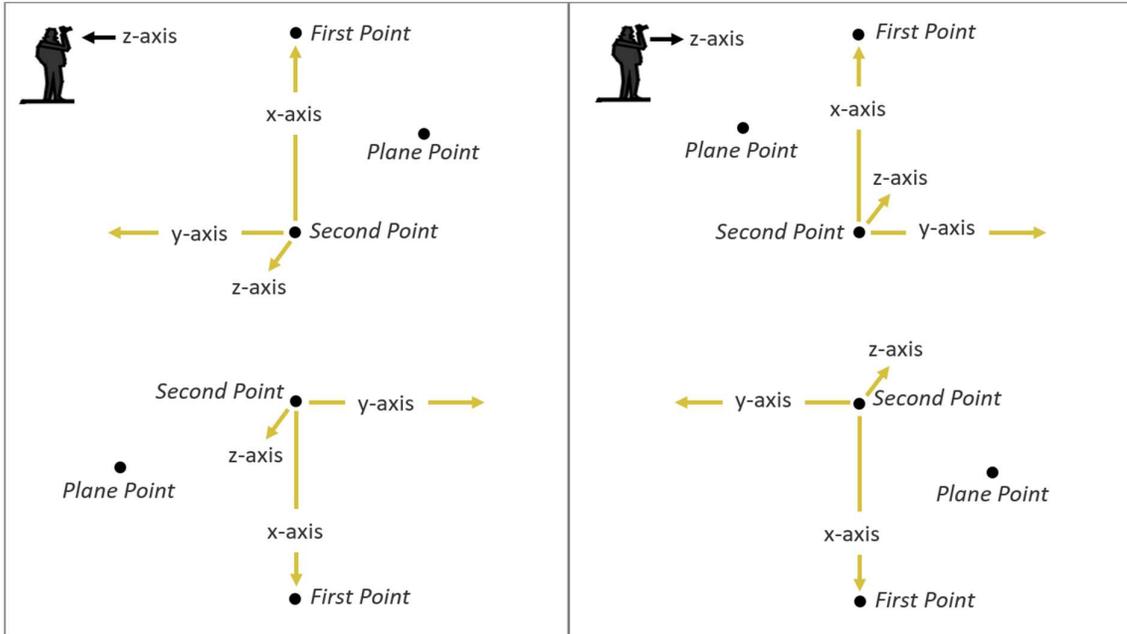


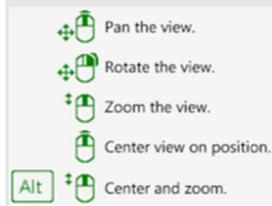
Figure 7: Orientation possibilities of the Sample Mode as a result of the marker setup

3 3D viewer

The 3D viewer allows the inspection the coarse point cloud (*Coarse Reconstruction*) and the finally generated 3D model (*Dense Reconstruction*). In addition, the viewer serves for outlining the *ROI* and for the localization of *GCP* positions required for *Standard* as well as for *Constrained Referencing*.

Attention:

By pressing *F1* on the keyboard tooltips for navigation as well as for editing annotations are available in the 3D viewer. The tooltips may differ in respect to the active item. Example:



3.1 Toolbar of the 3D viewer

3D View Options

Move to Home Position



Sets the viewer to its initial position

View All



Zooms out from the current view. Zooms to the previous view again

Top Down View



Orientates the 3D model from the camera view (top down)

Auto Rotate (fixed or view)



Rotates the 3D model from a fixed point (top down) or from the current point of view

Projection type



Toggles between perspective and orthographic projection

Fullscreen



Switches between the fullscreen display and the windowed display

Mesh Draw Mode

Draw as is



The 3D topography is completely overlaid by the digital photograph

Wireframe



A triangulated red coloured point cloud is forming the topography

Wireframe Overlay



The 3D model and a red coloured overlay of the wireframe is forming the topography

Points



The point cloud of the scene shown

Show Texture

Displays the 3D model with texture in the viewer (shortcut key “Ctrl” T)

3.2 Navigation

Mouse navigation

Pan View



The middle mouse button is used to pan the 3D model

Rotate View



The right mouse button rotates the 3D model. Just keep the right button pressed and move the mouse around to see the 3D model rotating.

Zoom View



When turning the wheel of a mouse the 3D model is zoomed

Center View on Position



Centers to the current position

Center and Zoom



Pressing “Alt” and turn the mouse wheel centers the and zoom to the current position

Keyboard navigation

- Straight motion is performed by pressing the corresponding arrow key “Left”, “Right”, “Up” or “Down”.
- Zooming is performed by pressing “Ctrl” simultaneously with the arrow key “Up” for zooming in and the arrow key “Down” for zooming out.
- Rotation of the 3D model in a desired direction is performed with the corresponding arrow key “Left”, “Right”, “Up” or “Down”.

Hint:

It is preferred to have a mouse with 3 buttons, or a wheel mouse. Usually the wheel acts as the third mouse button.

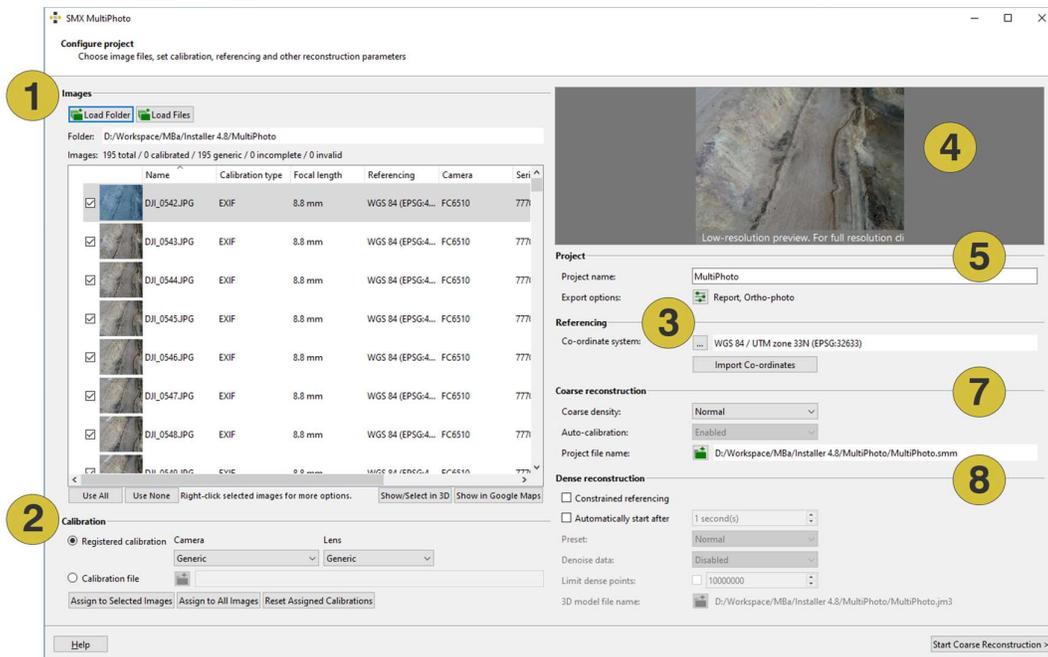
4 3D model generation

4.1 Data input and Coarse Reconstruction

In the start window “*Configure Project*” allows for loading images for processing as well as defining parameters for the *Coarse* and *Dense Reconstruction*. Additionally, the user can modify the camera calibration of the photos and visualize positional information stored in the photos.

4.1.1 User interface

The user interface “*Configure Project*” comprises several features shown in Figure 8. On the left hand side, it consists of the list of loaded images and functions for defining and modifying camera calibration data, and visualising positional (GPS) information. On the right hand side, it consists of a viewer showing a preview of the selected image and functions for defining projects settings. In addition, GPS referencing possibilities and settings for the *Coarse Reconstruction* and *Dense Reconstruction* are available.



- 1 Image data
- 2 Calibration
- 3 GPS data – Previews and Referencing
- 4 Image preview
- 5 Project settings
- 6 *Coarse Reconstruction* settings
- 7 *Dense Reconstruction* settings
- 8 GCP referencing

Figure 8: User interface *Configure Project* of the MultiPhoto

List of loaded images

The list of the loaded images (number 5 in Figure 8) shows the following information for each entry:

- Picture thumbnail
- Name of the image
- Calibration type:
 - *EXIF* - *MultiPhoto* uses calibration information from the “.exif” file (extended image information)
 - *Specific Calibration Name* - *MultiPhoto* uses calibration information from a registered calibration installed via the Start Window Settings dialog or uploaded by clicking the “*Calibration File*”  icon
- Focal length
- Referencing - GPS data and co-ordinate system
- Camera information
- Serial number
- Additional information

The following information on the loaded images is given at the top of the list:

- image(s): total number of images
- calibrated: number of images with registered calibration
- generic: number of images with calibration information gained from the “.exif” file (extended image information)
- incomplete: number of images without calibration (neither registered calibration nor calibration information from the “.exif” file is available)
- invalid: number of defective images

4.1.2 Features

The following section describes the available functions of the *Load Data* window.

Images

Load Folder



Opens a dialog to load a series of photos (stored in one folder)

Load Files

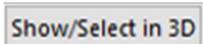
Opens a dialog to load photos individually

Use All

Selects all photos from the list of loaded images for reconstruction

Use None

Deselects all photos from the list of loaded images for reconstruction

Show/Select in 3D

GPS co-ordinates of the individual images are shown in a 3D viewer (Figure 9). The dialog supports the selection of images that should be used for 3D model generation directly in the viewer (see Chapter 4.1.3).

Show in Google Maps

The location of the images are shown in *Google Maps*

A click on the right mouse button on a loaded image in the list opens the context window providing following options:

Use Selected

Enables the checkbox in front of individual images; the image will be included in 3D model generation

Don't Use Selected

Disables the checkbox in front of individual images; the image will be excluded in 3D model generation

Remove Referencing Data

Excludes the GPS measurements of individual images. The image is included in 3D model generation.

Show in Google Maps

Shows the location of the individual images in *Google Maps*



- 1 3D viewer
- 2 Navigation bar
- 3 Image selection by multiple selection of images in the list
- 4 Image selection in 3D with the computer mouse (lasso function)

Figure 9: Dialog window with GPS co-ordinates of the individual images

Calibration

Registered calibration Allows using a registered (installed) or generic calibration

Calibration File  Opens a dialog for selecting a calibration file ("cam.dat" file)

Assign to Selected Images

Assign to Selected Images

Assigns the selected calibration to selected images

Assign to All Images

Assign to All Images

Assigns the selected calibration to all images

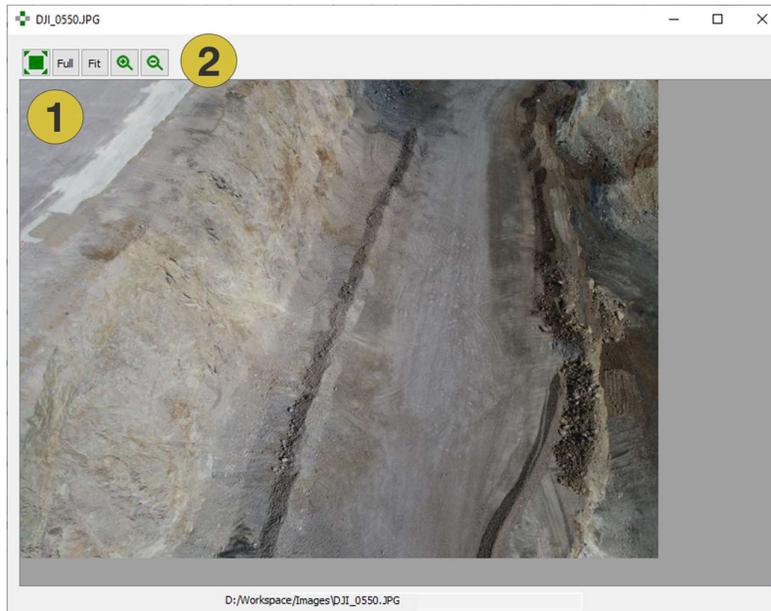
Reset Assigned Calibrations

Reset Assigned Calibrations

Removes the calibration assigned to all images

Image viewer

The image viewer (Figure 10) allows a detailed view of the selected image and comprises two scroll bars and a toolbar supporting the image display.



- 1 Viewer
- 2 Toolbar with zoom functions

Figure 10: Single image viewer opened in the context menu of the image data list

Project settings

<i>Project name</i>	Title of the project (optional). Updating the project name updates also the <i>Project File</i> name and the <i>Output File</i> name.
<i>Export options</i>	 Opens a dialog for selecting export possibilities; i.e. the reconstruction report (“.pdf”), ortho-photo (“.png”), GeoTIFF (“.tif”) and “.obj” export. See Chapter 7.

Referencing (only if positional information is available)

<i>Co-ordinate system</i>	The UTM zone is auto-detected from the referencing information of images (WGS 84). The user can select a user defined co-ordinate system by clicking on the  button and selecting “Browse Co-ordinate System”. The dialog “Select Co-ordinate Reference System” appears which allows for the selection of a specific co-ordinate system (Figure 11). The 3D model is transferred automatically into the desired co-ordinate system after 3D model generation.
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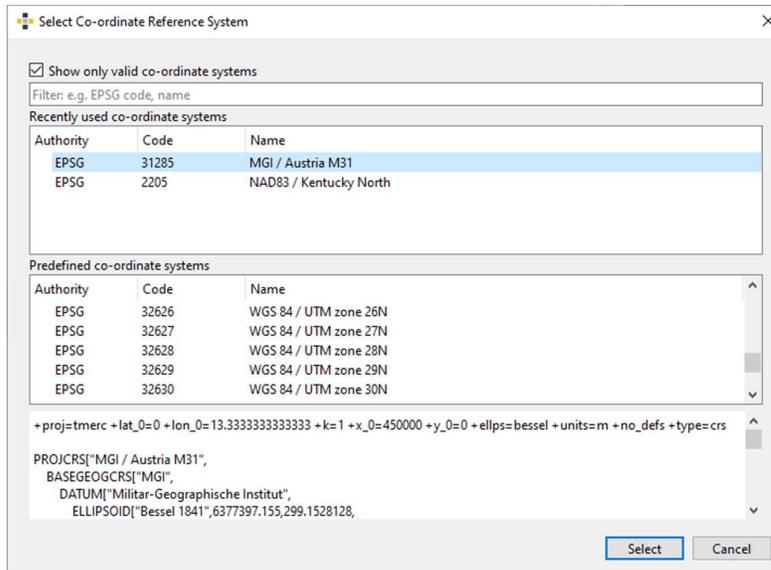


Figure 11: Select Co-ordinate Reference System

Import Co-ordinates

Import Co-ordinates

Imports GPS co-ordinates from a “.txt” file (Figure 12).

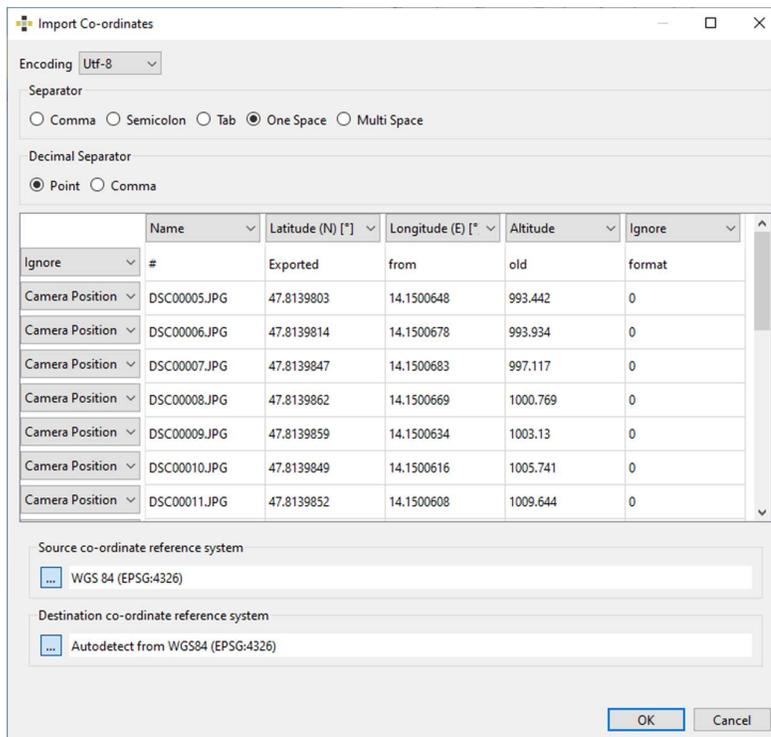


Figure 12: Import Co-ordinates. See Chapter 4.1.3 for further information.

Coarse Reconstruction Settings

<i>Coarse Density</i>	<p><i>Normal</i>: Normal feature density; used for photos with reasonably high overlap</p> <p><i>High</i>: High feature density; used for photos with low overlap or strong angular changes</p>
<i>Auto-Calibration</i>	Enables or disables auto-calibration: Auto-calibration is mandatory if uncalibrated photos are used (generic entry). If photos from pre-calibrated cameras are used (calibration entry), auto-calibration can be enabled or disabled.
<i>Project File Name</i>	 Opens a dialog for entering the directory and name of the generated <i>Project File</i> (".smm" file)

Dense Reconstruction

Constrained referencing

Enables *Constrained Referencing*

<i>Automatically start after ...</i>	The reconstruction process continues automatically after a user-defined time from <i>Coarse Reconstruction</i> into <i>Dense Reconstruction</i> , if no user interaction has been registered by the software during the waiting period. Enabling also activates <i>Dense Reconstruction</i> settings (see below).
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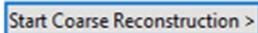
Note:

Automatically Continue Reconstruction is only possible if *Standard Referencing* is enabled.

<i>Preset</i>	<p><i>Fast</i>: Preset for fast Dense Reconstruction Low resolution topography, low resolution texture (for e.g. volume calculations)</p> <p><i>Normal</i>: Default Dense Reconstruction settings Medium resolution topography, high resolution texture (for e.g. blast design)</p> <p><i>High</i>: Preset for high detail Dense Reconstruction settings High resolution topography, high resolution texture (for e.g. rock mass characterisation, fragmentation analysis)</p>
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<i>De-noise data</i>	<p><i>Disabling</i> noise suppression. The point cloud should be used for applications with standard requirements on surface quality. No special geometric resolution preset is needed. (e.g. for blast design, volume calculations)</p> <p><i>Enabling</i> noise suppression. The point cloud can be used for application with enhanced requirements on surface quality.</p>
<i>Limit dense points</i>	Defines the upper limit of points which generates the reconstructed 3D model. Default value is 10.000.000 points.
<i>3D model file name</i>	 Opens a dialog for entering the directory and name of the final 3D model (".jm3x" file)

Start Coarse Reconstruction



Starts the reconstruction process and continues to the next step

4.1.3 Standard operating procedure

Coarse Reconstruction

1. Load image data by clicking the "Load folder" or "Load Files"  icon. A progress window (Figure 13) appears during scanning and loading.

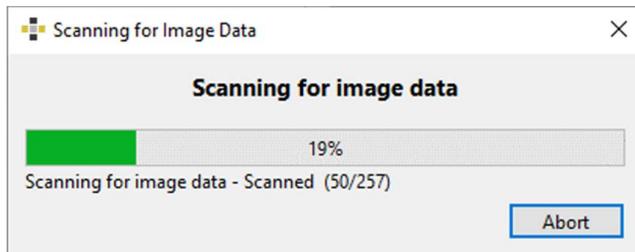
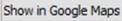
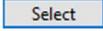


Figure 13: Progress window - Scanning for image data

2. Check if all required images for processing are selected. If not, adapt the list of images by enabling or disabling the checkbox in front of the images, respectively, or use the buttons "Use all"  or "Use none" . In addition, images for processing can be selected directly in the 3D viewer in the "Show/Select in 3D" opened by clicking the corresponding button  (see below).
3. Check if the pictures for processing have a generic (EXIF) or calibration entry assigned.

4. If GPS co-ordinates are available, the user can check the relative camera positions and geographical position by clicking the “Show/Select in 3D”  button. In addition, the dialog supports the selection of images directly in the 3D viewer by using the computer mouse (refer to end of chapter for further information). The position of the images can also be displayed in Google Maps using the “Show in Google Maps”  button.
5. GPS co-ordinates can be imported from a “.txt” file also (refer to end of chapter for further information).
6. Enter a project name and select the desired export possibilities by clicking the “Export Options”  button (see Chapter 7). The export start automatically when leaving the *MultiPhoto* after 3D model generation.
7. Select the co-ordinate reference system: *UTM Autozone* (default) or select a specific co-ordinate system by clicking the  button. Select “Browse Co-ordinate System” and the “Select Co-ordinate Reference System” dialog appears (Figure 11). Select the reference system from the list and confirm the selection by clicking the “Select”  button.
8. Choose *Coarse Reconstruction* settings “Normal” (default).
9. Rename the *Project File* (“.smm”) and select the directory to save by clicking the “Project File Name”  icon in *General Settings*.
10. Start the reconstruction process by a click on the “Start Coarse Reconstruction”  button. The progress window reveals the current status of reconstruction including a live display (Figure 14).

Note:

Auto-calibration is enabled by default if uncalibrated photos are used (generic entry). If photos from pre-calibrated cameras are used (calibration entry), auto-calibration can be enabled or disabled.



- 1 Current status
- 2 Progress bar
- 3 Pause/Abort process
- 4 Number of cameras/points reconstructed
- 5 Live display of cameras and points
- 6 Activates/deactivates the live display

Figure 14: Progress window of Coarse Reconstruction. Note, the live display starts at “Camera alignment” (blue arrow).

Coarse and Dense Reconstruction

10. Follow steps 1 to 9 in the procedure *Coarse Reconstruction*.
11. Enable the checkbox “*Automatically continue reconstruction after xxx seconds*”. The *Dense Reconstruction* process and generation of the “.jm3x” file will start automatically after the user-defined time. Enabling the checkbox activates the *Dense Reconstruction Settings*.
12. Choose the reconstruction mode i.e. “*Fast*”, “*Normal*” or “*High*” (for details see Chapter 4.1.2).
13. Optionally, limit the number of 3D points by enabling the checkbox “*Limit Dense Points*”.
14. If necessary, rename and select the directory of the output file (“.jm3x”) by clicking the “*Output File Name*”  icon.
15. Start the reconstruction process by clicking the “*Start Coarse Reconstruction*”  button. The appearing progress window reveals the current status of reconstruction including a live display (Figure 14).

Note:

Select Scene Region of Interest is skipped when *Dense Reconstruction* continues automatically after *Coarse Reconstruction*. The automatic mode can be interrupted by the user by an interaction on the computer; i.e. movement of computer mouse or keyboard entry; after *Coarse Reconstruction*.

Selection of images in the GPS viewer

Images for processing can be selected directly in the 3D viewer in the “*Show/Select in 3D*” opened by clicking the corresponding button **Show/Select in 3D**. The images represented by their GPS position as dots in the viewer. Standard operating procedure (see Figure 15):

1. Activate the user selection In the viewer by clicking the button “*Select in 3D*” 
2. Select the images to be processed by using the lasso-function in the 3D viewer. Selected images are highlighted in the viewer and in the image list (right hand side) immediately after releasing the mouse button.
3. Click on the “*Apply*” button to confirm the selection. The dialog closes and the selection is applies to the *Configure project* interface.
4. Follow the standard operating procedure

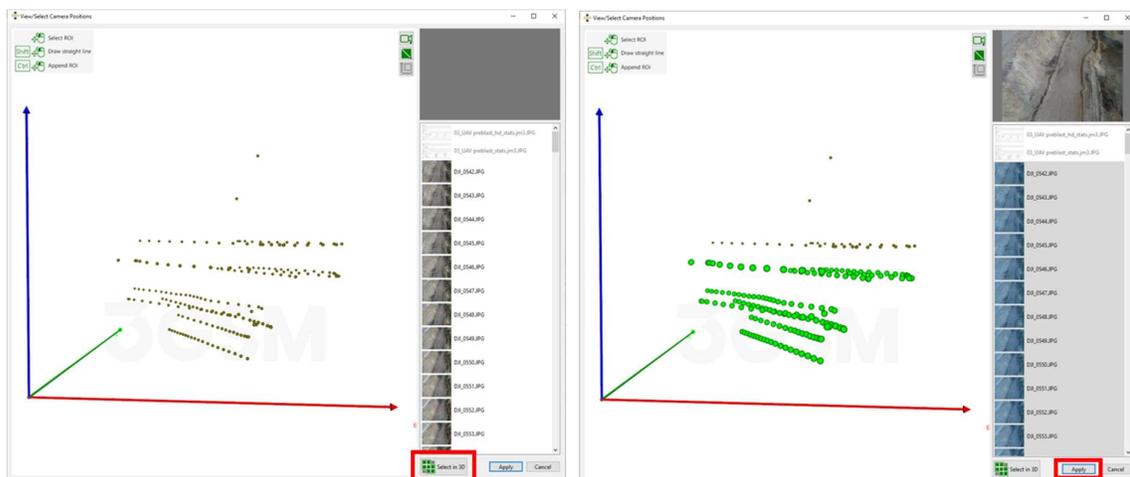


Figure 15: Image selection in the GPS viewer

Import of co-ordinates

GPS data can be imported separately to individual pictures by selecting the “*Import Co-ordinates*” **Import Co-ordinates** button. Standard operating procedure:

1. Choose a text file containing the positional information and a dialog appears (Figure 12) requiring following input:

- a. Character encoding
 - b. Used separator
 - c. Data classification (E/N/H and name **or** latitude/longitude/altitude and name)
 - d. Select the source and destination co-ordinate reference system:
 - i. Select the unit from the pull-down menu for undefined source co-ordinate reference systems. Available units are (millimeter [mm], meter [m], inch [in], international foot [ft], US survey foot [ft])
 - ii. Select a customized source and destination co-ordinate reference systems by selecting the radio button *WGS 84* or *Custom* and click in the  button and select the system in dialog (see Figure 11).
2. Click the “OK” button to import the co-ordinates

Note:

For a successful import the picture name of the loaded images and the imported co-ordinates have to match.

4.2 Select Scene Region of Interest

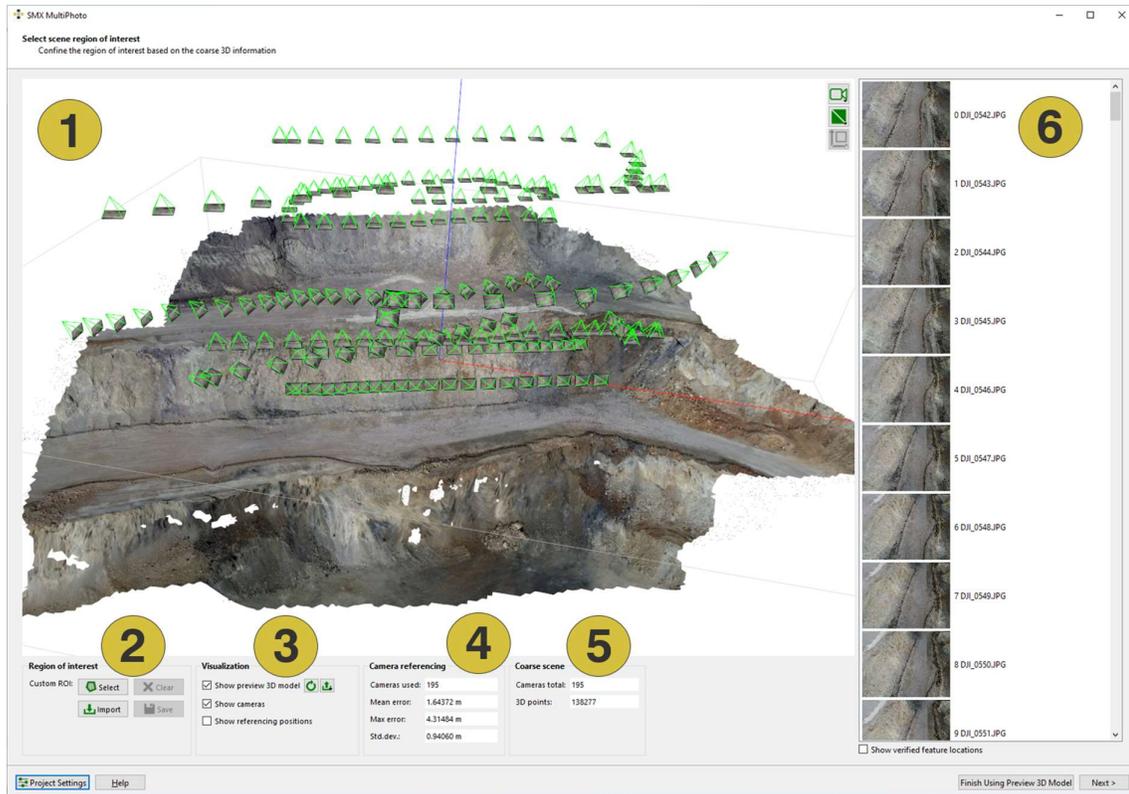
Select Scene Region of Interest allows to confine the reconstruction area to a *Region of Interest (ROI)*. The definition of the *Region of Interest* is optional. It is skipped by clicking the “Next”  button. If no *ROI* is defined, the entire 3D point cloud of the *Coarse Reconstruction* is used for *Dense Reconstruction*.

Note:

It is not mandatory, that the *ROI* includes the images with the *GCP* locations. *GCP* can be located outside the *ROI* (see Chapter 5 for further information).

4.2.1 User interface

The user interface comprises the features shown in Figure 16. It consists of the 3D viewer, which displays the coarse 3D point cloud and the coarse 3D model with corresponding camera and GPS positions. The list on the right hand side shows the pictures used for *Coarse Reconstruction*. Data on *Camera Referencing* is only available if positional information of the images is available (EXIF information or import of co-ordinates). The number of points used for referencing as well as statistic parameters are given.



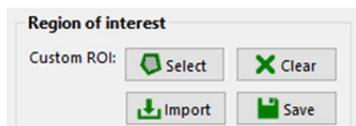
- 1 3D viewer with point cloud and cameras
- 2 Features for defining the ROI
- 3 Visualization in the 3D viewer
- 4 Camera referencing
- 5 Information of the coarse scene
- 6 List of images

Figure 16: User interface Select scene region of interest of the MultiPhoto

4.2.2 Features

The following section describes the available functions of *Select Scene Region of Interest* window.

Region of Interest



Custom ROI

The *ROI* can be defined with a drawn polygon by the user

Select

Activates the drawing mode

Clear

Clears the defined *ROI*

Import ROI

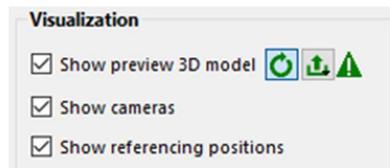
Imports a *ROI* (".xml" file)

Save ROI

Saves the current *ROI* to an ".xml" file

Note:

A specific *ROI* can be saved (".xml" format) and imported at later stages and supports thereby a repeated reconstruction of exactly the same area at different time steps. This features are only available for 3D models with GPS information and enhances the processing of monitoring rock masses.

Visualization*Show preview 3D model*

Shows/Hides the coarse 3D model in the viewer

Update

Updates the coarse 3D model to the outlined *ROI*

Export



Exports the preview 3D model to ".jm3x" or ".obj"

Show cameras

Shows/hides the position of the camera in the 3D viewer

Show referencing positions

Shows/hides the position of the GPS measuring points in the 3D viewer

Camera Referencing

Camera referencing	
Cameras used:	195
Mean error:	1.64328 m
Max error:	4.31496 m
Std.dev.:	0.94041 m

Camera used

Number of camera position used for referencing

Statistics

Mean error, maximum error and standard deviation

Coarse Scene

Coarse scene	
Cameras total:	195
3D points:	134873

Cameras total

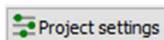
Number of camera positions (images) used for generating the scene

3D points

Number of 3D points of the coarse scene

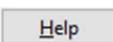
General

Project Settings



Allows to adapt the export settings of the current project (generation of the reconstruction report, ortho-photo, GeoTIFF and ".obj" export). See Chapter 7.

Help



Opens the user manual

Finish using preview 3D model

Finish Using Preview 3D Model

Skips the *Dense Reconstruction*. The coarse 3D model is saved as “jm3x” and is ready for referencing in a final step

Next

Next >

Continues to the *Dense Reconstruction*

Show verified feature locations

Show verified feature locations

Shows/hides feature locations in the individual images (Figure 17)

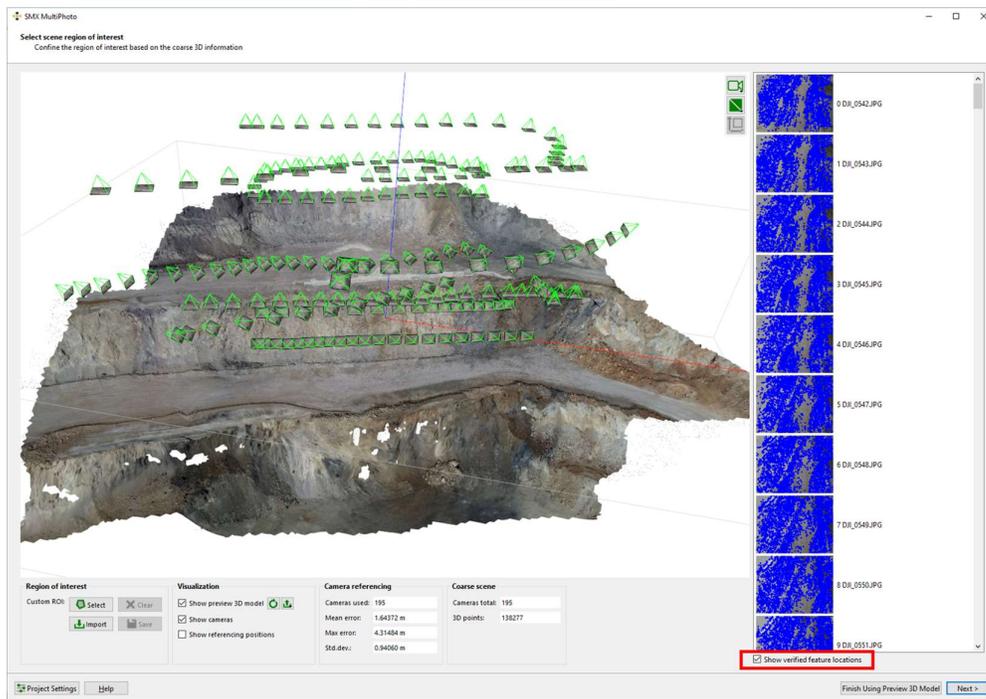


Figure 17: Verified feature locations are outlined in blue in the individual images by activating the corresponding checkbox

Note:

A click on a single image in the image list allows the localisation of its camera position (Figure 18).

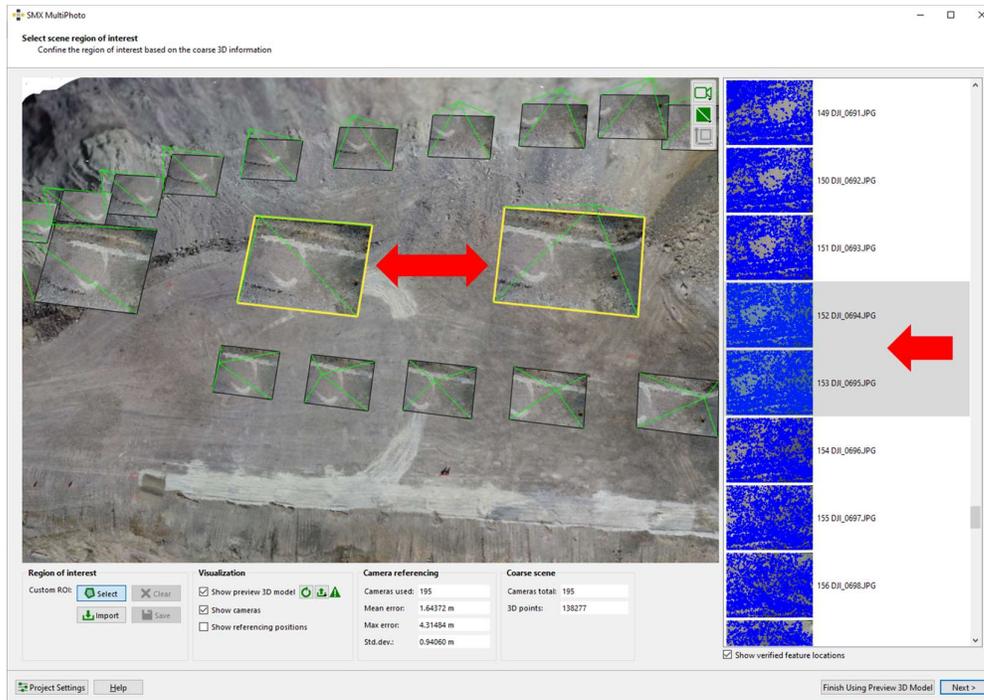


Figure 18: Highlighted camera position of selected images

4.2.3 Standard operating procedure:

1. Check the coarse 3D point cloud for plausibility
2. Define Region of Interest
 - a. using the sliders next to “Camera distance based” or “Scene centre based”
 - b. directly in the viewer using a boundary polygon:
 - i. Click on the “Select”  button
 - ii. Click with the left mouse held down in the 3D viewer and draw a polygon (Figure 19). The polygon should define the desired ROI.
 - iii. Release the mouse button and the point cloud is reduced to the outlined ROI (Figure 20).
 - iv. The ROI can be deleted with a click on the “Clear”  button
3. Click on the “Next”  button to continue to the next step

Hint:

Press “Shift” while keeping the left mouse button pressed to draw a straight line.

Note:

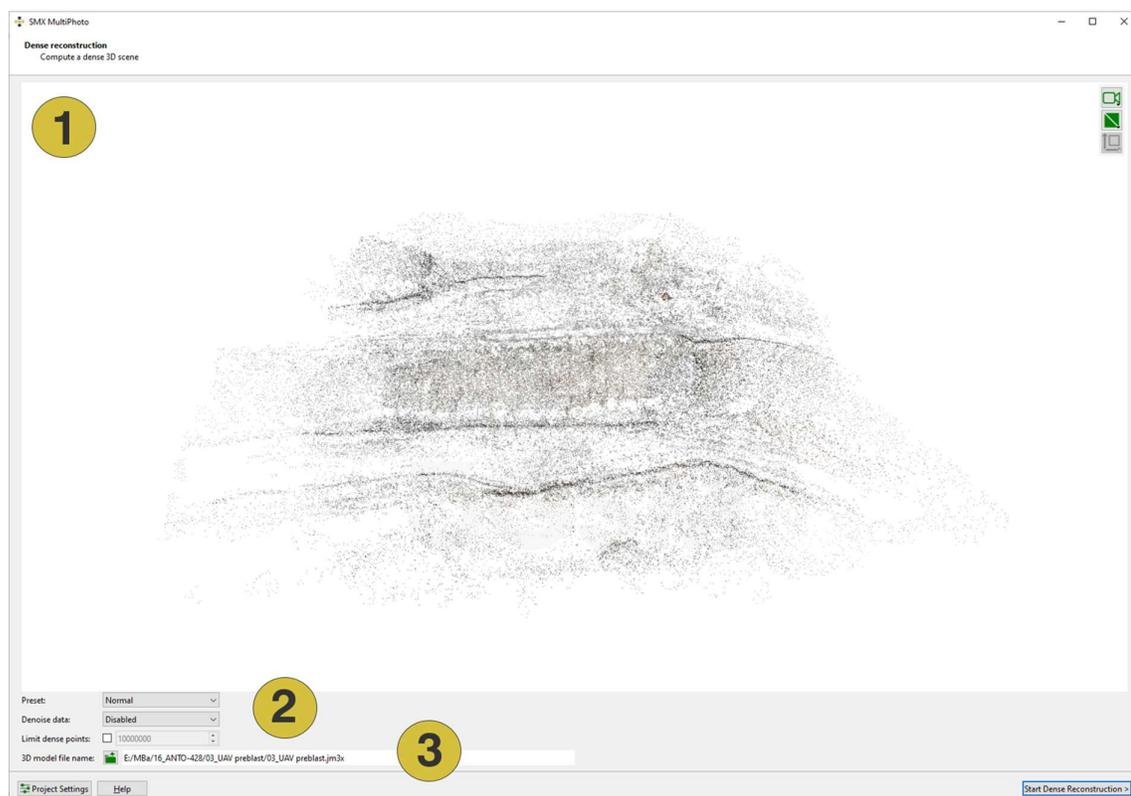
The update of the preview 3D model by using the “*Update Preview 3D Model*” button is not mandatory. It should be performed only if the coarse 3D model shows distorted or unwanted surface measurements (e.g. sky or floor at border regions). The ROI is considered even for the Dense Reconstruction without updating the preview 3D model.

4.3 Dense Reconstruction

The *Dense Reconstruction* calculates the detailed object geometry including a detailed point cloud, surface mesh and texture.

4.3.1 User interface

The user interface *Dense Reconstruction* of the *MultiPhoto* comprises the 3D viewer with the navigation bar displaying the coarse 3D point cloud and the settings for *Dense Reconstruction* (Figure 21).



- 1 3D viewer with coarse 3D point cloud
- 2 *Dense Reconstruction* settings
- 3 Output file (“.jm3x”)

Figure 21: User interface *Dense Reconstruction*

4.3.2 Features

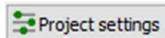
The following section describes the available functions of *the Dense Reconstruction* interface.

Dense Reconstruction Settings

<i>Preset</i>	<p><i>Fast:</i> Preset for fast <i>Dense Reconstruction</i> Low resolution topography, low resolution texture (for e.g. volume calculations)</p> <p><i>Normal:</i> Default <i>Dense Reconstruction</i> settings Medium resolution topography, high resolution texture (for e.g. blast design)</p> <p><i>High:</i> Preset for high detail <i>Dense Reconstruction</i> settings High resolution topography, high resolution texture (for e.g. rock mass characterisation)</p>
<i>Limit dense points</i>	Defines the upper limit of points which generates the reconstructed 3D model. Default value is 10.000.000 points.
<i>De-noise depth maps</i>	<p><i>Disable:</i> Disables noise suppression. The point cloud should be used for applications with standard requirements on surface quality. No special geometric resolution <i>Preset</i> is needed. (e.g. for blast design, volume calculations)</p> <p><i>Enable:</i> Enables noise suppression. The point cloud can be used for application with enhanced requirements on surface quality. <i>Normal</i> or is required (e.g. for rock mass characterisation).</p>
Output file name	 Opens a dialog for entering the directory and name of the final 3D model (“.jm3x” file)

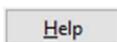
General

Project Settings



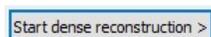
Allows to adapt the export settings of the current project (generation of the reconstruction report, ortho-photo, GeoTIFF and “.obj” export). See Chapter 7.

Help



Opens the user manual

Start Dense Reconstruction



Starts the reconstruction process and continues to the next step

4.3.3 Standard operating procedure:

1. Check the coarse 3D point cloud for plausibility
2. Choose the *Dense Reconstruction* mode - *Fast*, *Normal* or *High*
3. Disable or enable “*De-noise depth maps*”
4. Optionally, limit the number of 3D points by enabling the checkbox “*Limit Dense Points*”.
5. If necessary, rename and select the directory of the output file (“.”) by clicking the “*Output File Name*”  icon
6. Start the reconstruction process by a click on the “*Start Dense Reconstruction*”  button. The appearing progress window shows the current status of reconstruction (Figure 22).
7. Inspect the 3D model in the 3D viewer

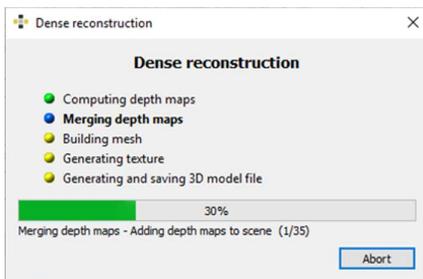


Figure 22: Progress window: Dense Reconstruction

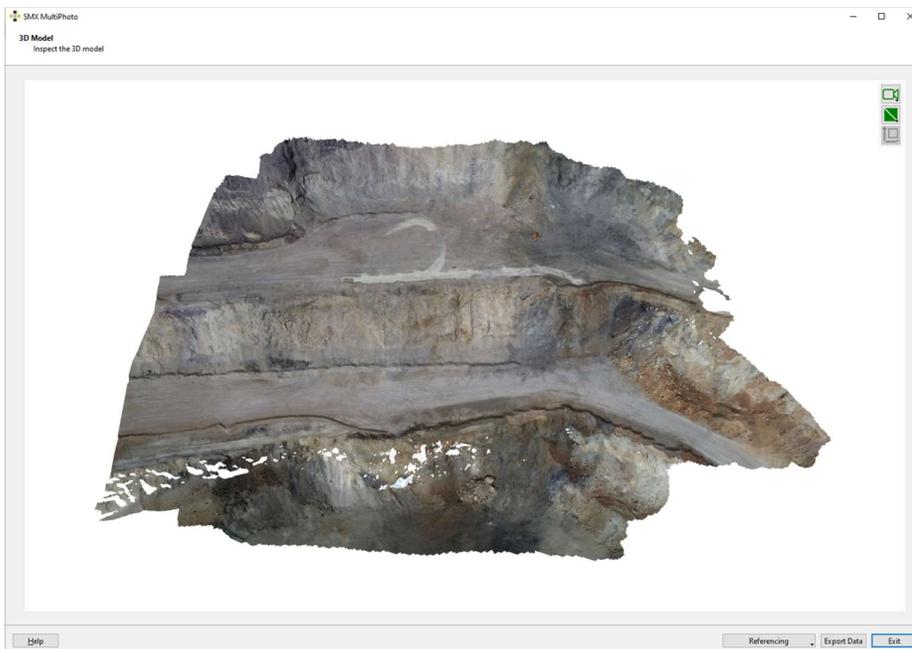


Figure 23: Final 3D model

5 Referencing

5.1 Standard Referencing

MultiPhoto provides two different modes of standard referencing:

- *Full Reference*
The 3D model is transferred into a superior co-ordinate system by using known co-ordinates of externally surveyed *GCP* (at least three) by similarity transformation.
- *Single Point Mode*
The 3D model is transferred to a co-ordinate system by using the co-ordinates of a single externally surveyed point (*GCP*) by similarity transformation. This mode is only available if the model is already referenced (*EXIF GPS*). It allows to transfer the 3D model to a user defined co-ordinate system.

To enter the referencing interface the button  “Referencing” and “Control Points” from the pull down menu (Figure 24) has to be selected.

Note:

The action *Control Points* marked with asterisk pointing out unsaved data.



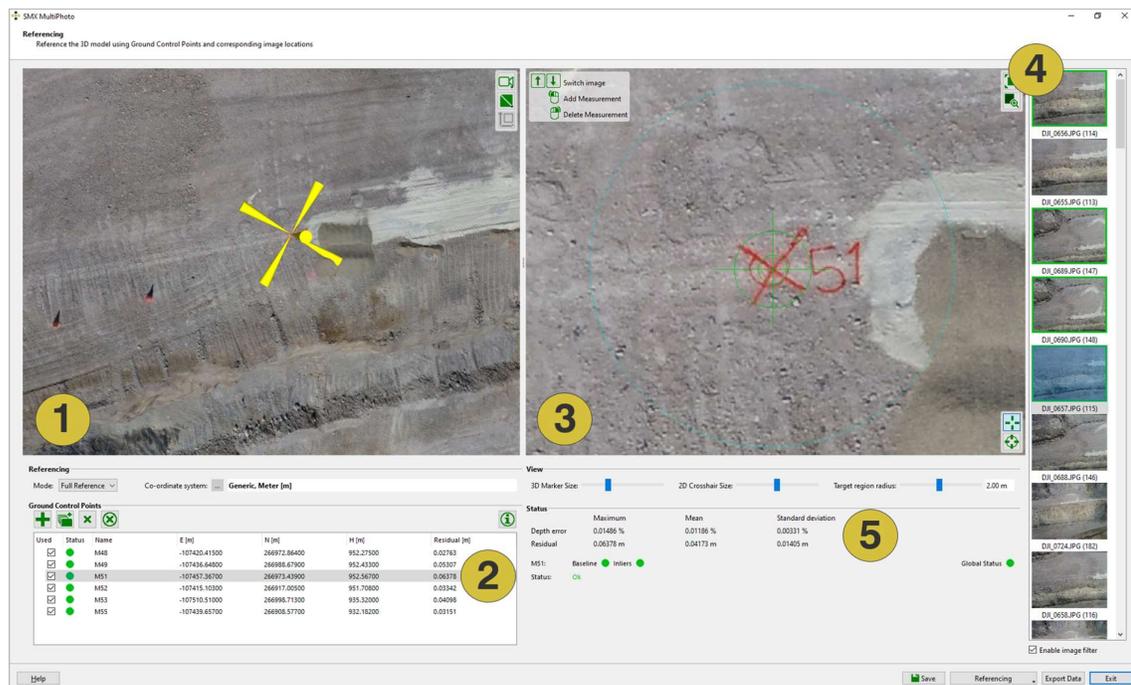
Figure 24: Action Control Points from the pull-down menu to transfer the model into a superior co-ordinate system

5.1.1 User interface

The user interface *Referencing* of the *MultiPhoto* comprises the 3D viewer, the list of *GCP* and statistic parameters at the left hand side. On the right hand side it consists of a viewer showing the currently selected image for referencing and corresponding partner images.

Note:

The *Status Information* provides hints and guides the user through the referencing procedure.



- 1 3D viewer
- 2 GCP list
- 3 Viewer with selected image
- 4 Partner images
- 5 Statistics

Figure 25: User interface Referencing

5.1.2 Features

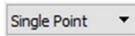
The following section describes the available functions of the *Referencing* window.

Ground Control Points

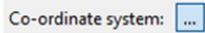
Full Reference

Full Reference ▾

Mode for referencing the 3D model using three or more *GCP*

Single Point

Mode for referencing the 3D model using a single *GCP*. Only available if the 3D model is already GPS referenced.

Co-ordinate System

Browse a specific co-ordinate system (Figure 11) or choose *Generic*

Ground Control Points**Add GCP**

Adds a new *GCP*

Load GCP From Text File

Import co-ordinates from a text based file (".csv", ".txt", ".dat", ".prt")

Remove Selected GCP

Removes the selected *GCP*

Remove All GCP

Removes all *GCP*

Show Advanced Statistics

Statistics is extended *with the reprojection and depth error*

View (2D Viewer)**View full image**

Fits the size of the image to the size of the viewer

Zoom to Target Region

Zooms to the target region

Manual Target Mode

Activates manual targeting

Automatic Target Mode

Activates automatic targeting

Sliders*3D Marker Size*

Changes the size of the target in the 3D viewer

2D Crosshair Size

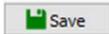
Changes the size of the crosshair in the 3D viewer

Target Region Radius

Defines the zoom (radius) to the target region

Enable Image Filter

De/activates the image filter. Enabled filter: Images of the currently clicked position in the 3D viewer are listed. Disabled filter: All images used for 3D model generation are listed.

General*Save*

References and saves the 3D model (".jm3x")

ReferencingChoose another action: *Inspect 3D Model*

Export Data

Export Data

Opens a dialog for selecting export possibilities; i.e. the reconstruction report (“.pdf”), ortho-photo (“.png”), GeoTIFF (“.tif”) and “.obj” export. See Chapter 7.

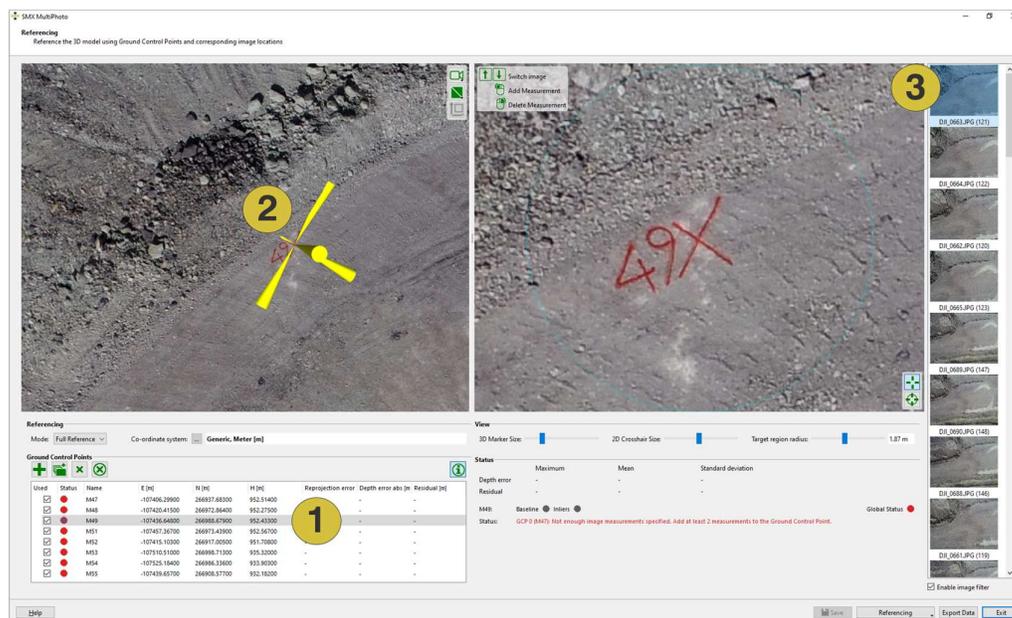
Exit

Exit

Closes the *MultiPhoto*

5.1.3 Full Reference Mode

- Choose the mode “*Full Reference*” Full Reference from the pull down menu.
- Add *GCP* by
 - clicking the “*Add GCP*” icon  and entering the name and co-ordinates in the *GCP* list.
 - clicking the “*Read GCP from Text File*”  button and choose the text based file (“.csv”, “.txt”, “.dat”, “.prt”). See Chapter 5.1.5 for further details.
- Activate one *GCP* in the list and localize its position in the 3D viewer by clicking the left mouse button. The list of reference images is updated and the active image is shown in the viewer. See Figure 26.



- Active *GCP* in the list
- Localization of the *GCP* on the 3D model
- Active image

Figure 26: Localizing *GCP* in the 3D viewer

4. Choose the “Manual Target Mode”  or the “Automatic Mode”  and centre the target by clicking with the mouse in the viewer. For locating the target discs the image should be zoomed as much as reasonable for visual interpretation. Check the position of the center by changing the size of the reticule. The reticule is well-centered if the circles touch the target’s boundary simultaneously at two opposing points and in two perpendicular directions (Figure 27).
5. Choose at least 2 images (3 or more are recommended) showing the same GCP and click the center of target. The status signals *Baseline* and the *Inliers* turn into green and the error of re-projection and depth is displayed in the GCP list. See Figure 28.

Hint:

Switch between the individual images in the list by using the arrow keys “Up” and “Down”.

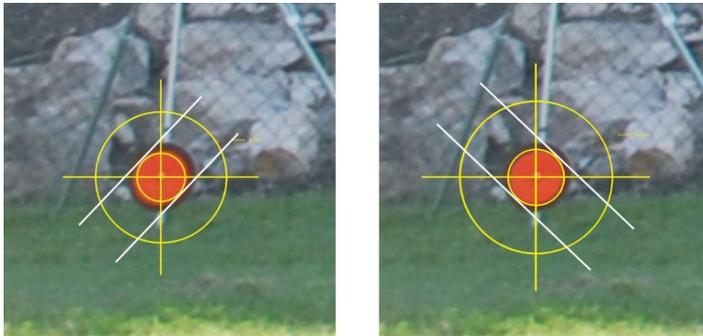


Figure 27: Check of the target center

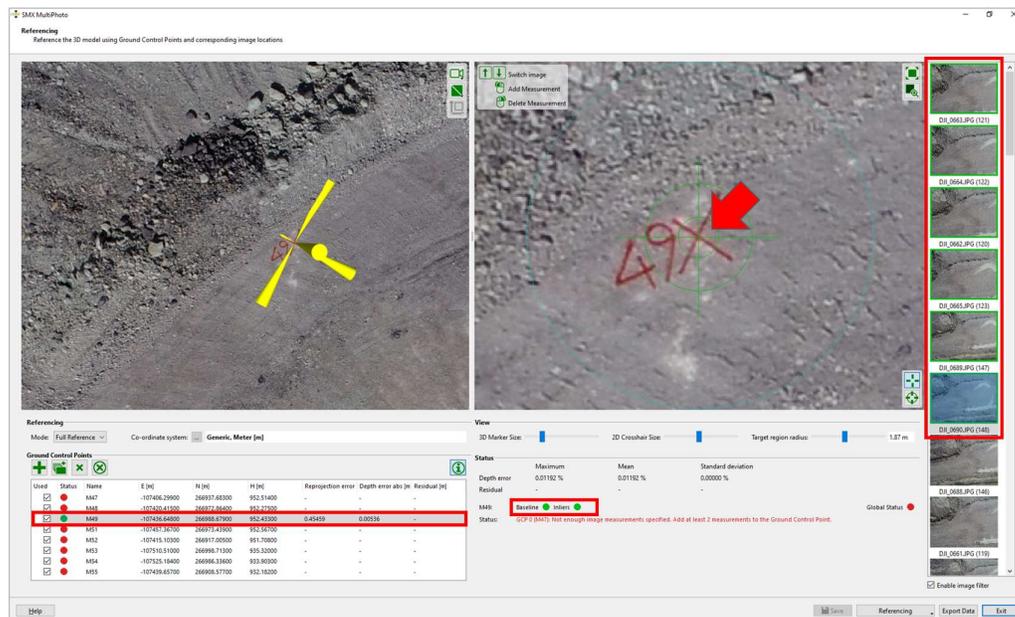


Figure 28: Targeting of GCP

Note:

Refer to the hints given in the *Status Information*, if one of status signals *Baseline* (distant ratio between images) and *Inliers* turn into orange or red.

Attention:

Marking of *GCP* positions is crucial for the metric accuracy of the 3D model and thus should be performed carefully.

6. Activate the next *GCP* in the list and repeat steps 2 – 4. Continue until all *GCP* positions are localized.
7. Check the error statistics and the *Status Information* (green status signals) and enable referencing by clicking the “Save”  button. See Figure 29.
8. Choose an action from the pull down menu “Referencing”  or close the *MultiPhoto* by clicking the “Exit”  button.

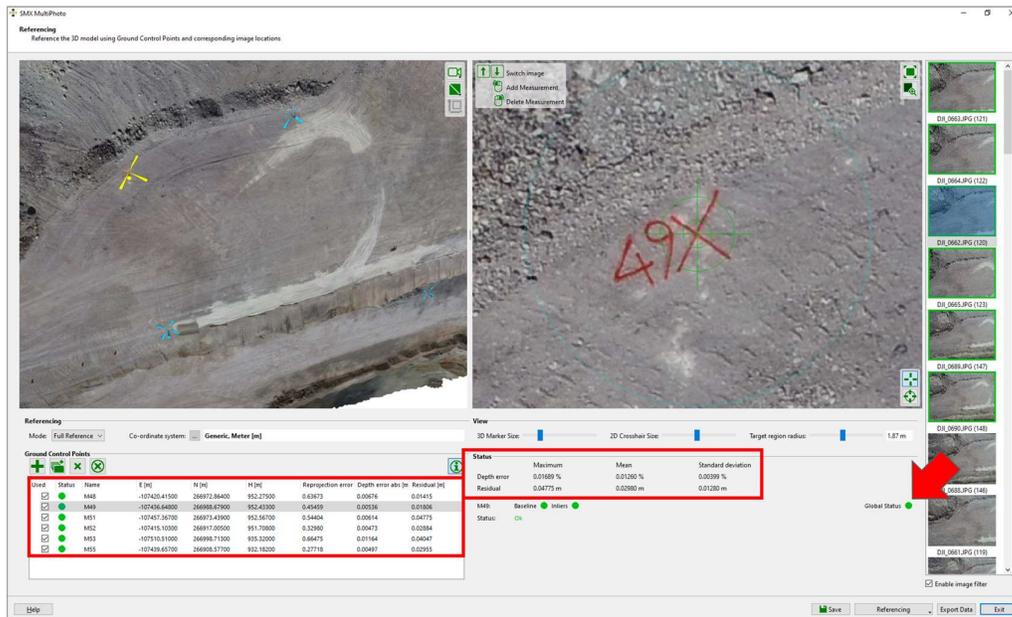


Figure 29: Valid *GCP* and error statistics

Note:

A defined *ROI* (Chapter 4.2) does not limit the localization of *GCP* in the images. *GCP* may be located in images outside the generated 3D model by deactivating the “*Enable image filter*” checkbox. The whole set of images used for the generation of the 3D model, including images for *Coarse Reconstruction*, will be listed. The user has to select the images showing the *GCP* manually from the list.

Note:

GCP are excluded for referencing by clicking the corresponding checkboxes in front of their names in the *GCP* list.

5.1.4 Single Point Mode

1. Choose the mode “*Single Point*”  from the pull down menu.
2. Add the *GCP (Offset)* by:
 - a. entering the *Offset* co-ordinate in the *GCP* list
 - b. clicking the “*Read GCP from Text File*”  button and choose the text based file (“.csv”, “.txt”, “.dat”, “.prt”). See Chapter 5.1.5 for further details.
3. Localize the position in the 3D viewer by clicking the left mouse button. The list of reference images is updated and the active image is shown in the viewer. See Figure 26.
4. Choose the “*Manual Target Mode*” icon or the “*Automatic Mode Icon*” and centre the target by clicking with the mouse in the viewer. For locating the target discs the image should be zoomed as much as reasonable for visual interpretation. Check the position of the center by changing the size of the reticule. The reticule is well-centered if the circles touch the target’s boundary simultaneously at two opposing points and in two perpendicular directions (Figure 27).
5. Choose at least 2 images (3 or more are recommended) showing the same *GCP* and click the center of target. The status signals *Baseline* and the *Inliers* turn into green and the error of re-projection and depth is displayed in the *GCP* list. See Figure 28.
6. Check the *Status Information* (green status signals) and enable referencing by clicking the “*Save*”  button. See Figure 30.
7. Choose an action from the pull down menu “*Referencing*”  or close the *MultiPhoto* by clicking the “*Exit*”  button.

Note:

Refer to the hints given in the *Status Information*, if one of status signals *Baseline* (distant ratio between images) and *Inliers* turn into orange or red.

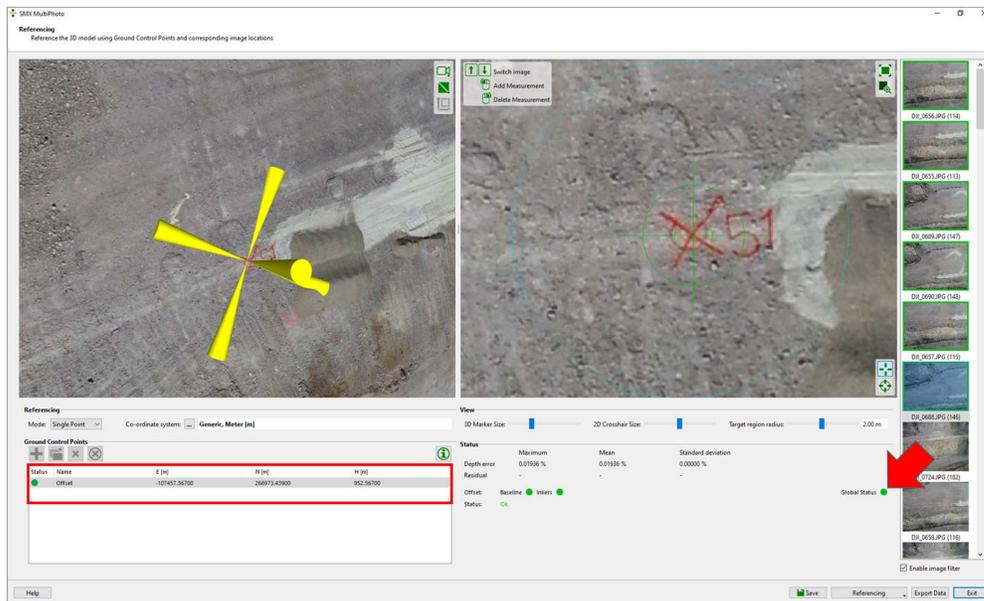


Figure 30: Single Point mode

5.1.5 Import of co-ordinates

The co-ordinates (E/N/H or latitude/longitude/altitude) of the GCP (Full Reference mode and Single Point mode) can be loaded from a “.txt” file or other text based files (e.g. “.csv”, “.prt”, “.dat”). The format has to be defined correctly during the import process (see Figure 31).

Examples for “.csv” files:

Point – Comma

XX.XXX,YY.YYY,ZZ.ZZZ

Comma – Semicolon

XX,XXX;YY,YYY;ZZ,ZZZ

Point – Space

XX.XXX YY.YYY ZZ.ZZZ

Co-ordinates:

Easting / Northing / Elevation

9453674.75 456235.21 248.45

9452978.18 456576.89 223.15

9458763.65 456832.76 287.83

Point name and co-ordinates:

GCP_Name / Easting / Northing / Elevation

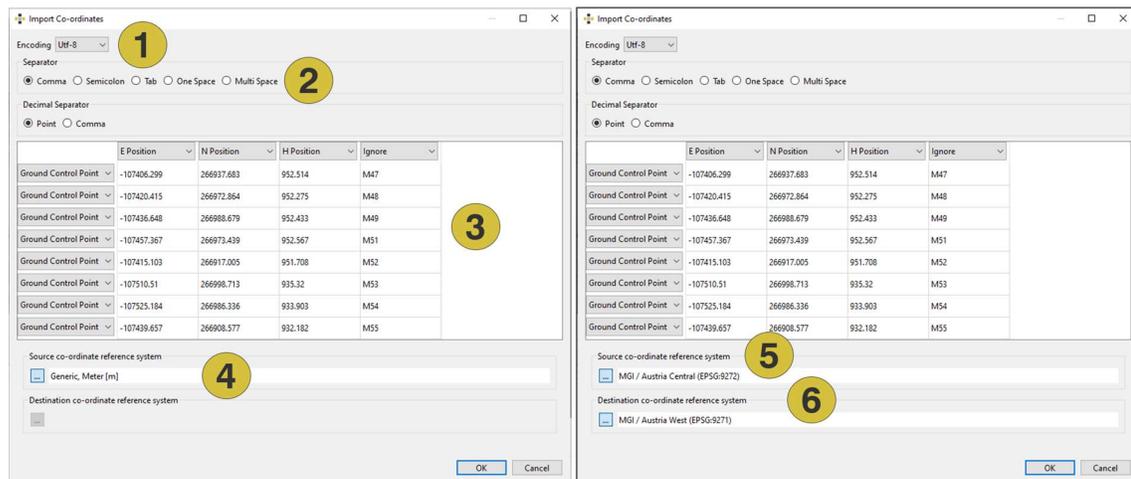
GCP1 9453674.75 456235.21 248.45

GCP2 9452978.18 456576.89 223.15

GCP3 9458763.65 456832.76 287.83

Standard operating procedure:

1. Click on the “Read GCP from text file” button.
2. A dialog window (Figure 31) appears requiring following inputs:
 - a. Character encoding
 - b. Used separator
 - c. Data classification (E/N/H and name **or** latitude/longitude/altitude and name)
 - d. Select the source and destination co-ordinate reference system (see Figure 31):
 - iii. Select the unit from the pull-down menu for undefined source co-ordinate reference systems. Available units are (millimeter [mm], meter [m], inch [in], international foot [ft], US survey foot [ft])
 - iv. Select a customized source and destination co-ordinate reference systems by selecting the radio button *WGS 84* or *Custom* and click in the button and select the system in dialog
3. Click the “OK” button to import the co-ordinates



- 1 Character encoding
- 2 Separators
- 3 Data
- 4 Generic import in units (undefined source co-ordinate reference system)
- 5 Custom source co-ordinate reference system
- 6 Custom destination co-ordinate reference system

Figure 31: Import of co-ordinates. Left: generic data import. Right: customized co-ordinate system

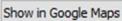
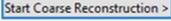
5.2 Constrained Referencing

For the description of user interfaces and corresponding features of the individual steps refer to Chapters 4.1 (Data input and *Coarse Reconstruction*), 4.2 (*Select scene Region of Interest*) and 4.3 (*Dense Reconstruction*).

Note:

Constrained referencing may be applied with an existing *Project File*. The file can be loaded by the selection “*Perform constrained referencing*” icon  when starting *MultiPhoto* (see Chapter 2.3.4).

5.2.1 Data input and Coarse Reconstruction

1. Load image data by clicking the “*Load folder*” or “*Load Files*”  icon. A progress window appears during scanning and loading.
2. Check if all required images for processing are selected. If not, adapt the list of images by enabling or disabling the checkbox in front of the images, respectively, or use the buttons “*Use all*”  or “*Use none*” .
3. Check if the pictures for processing have a generic (*EXIF*) or calibration entry assigned.
4. If GPS co-ordinates are available, the user can check the relative camera positions and geographical position by clicking the “*Show/Select in 3D*”  button. In addition, the dialog supports the selection of images directly in the 3D viewer by using the computer mouse (refer to end of chapter for further information). The position of the images can also be displayed in Google Maps using the “*Show in Google Maps*”  button.
5. Enter a project name and select the desired export possibilities by clicking the “*Export Options*”  button (see Chapter 7). The export start automatically when leaving the *MultiPhoto* after 3D model generation.
6. Choose *Coarse Reconstruction* settings “*Normal*” (default).
7. Rename the *Project File* (“*.smm*”) and select the directory to save by clicking the “*Project File Name*”  icon in *General Settings*.
8. Enable the reference mode *Constrained Referencing* (Figure 32)
9. Start the reconstruction process by a click on the “*Start Coarse Reconstruction*”  button. The progress window reveals the current status of reconstruction including a live display.

Note:

The *Automatically Continue Reconstruction* does not feature the use of *Constrained Referencing* (see Chapter 2).

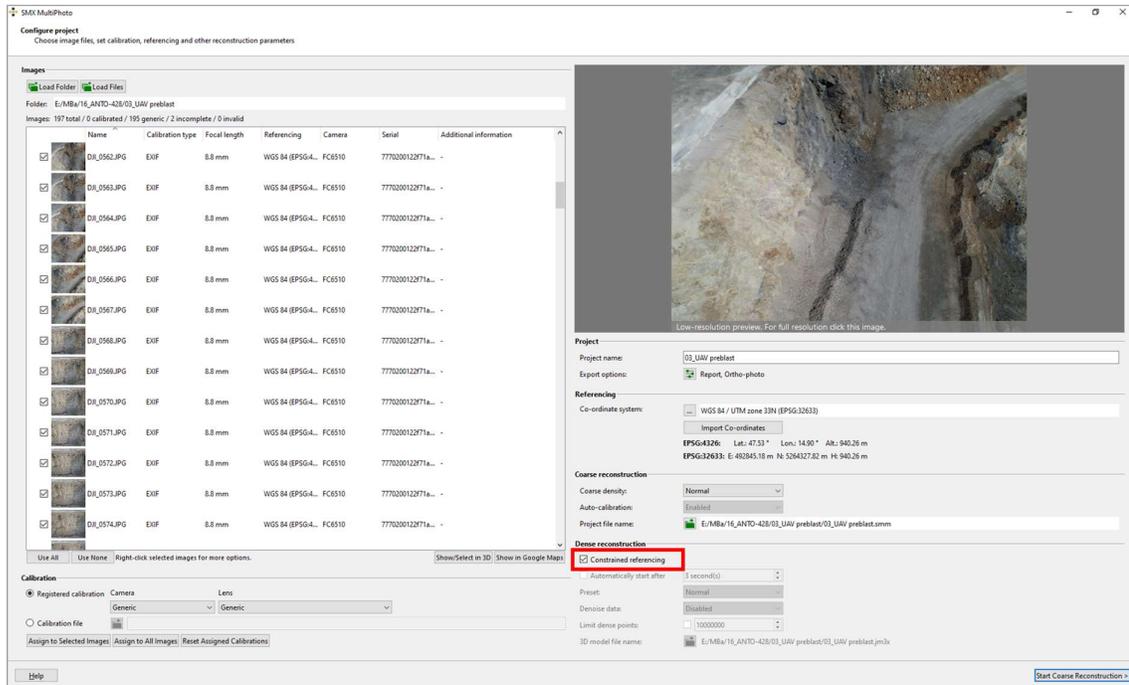


Figure 32: Enabling of the Constrained Referencing Mode

5.2.2 Select scene Region of Interest

The definition of a *ROI* is optional. It is skipped by clicking the “Next” button. If no *ROI* is defined, the outlined coarse 3D model is used for *Dense Reconstruction*. See Chapter 4.2 for detailed description.

Standard operating procedure:

1. Check the coarse 3D point cloud for plausibility
2. *Define Region of Interest*
 - a. using the sliders next to “*Camera distance based*” or “*Scene centre based*”
 - b. directly in the viewer using a boundary polygon:
 - i. Click on the “*Select*” button
 - ii. Click with the left mouse held down in the 3D viewer and draw a polygon (Figure 19). The polygon should define the desired *ROI*.
 - iii. Relieve the mouse button and the point cloud is reduced to the outlined *ROI*.
 - iv. The *ROI* can be deleted with a click on the “*Clear*” button
3. Click on the “Next” button to continue to the next step

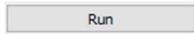
Hint:

Press “*Shift*” while keeping the left mouse button pressed to draw a straight line.

5.2.3 Referencing

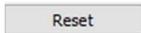
The interface of *Constrained Referencing* (Figure 33) is similar to the *Referencing* interface (see Figure 25) whereby two additional feature are provided:

Run



Runs GCP optimization

Reset



Resets GCP optimization

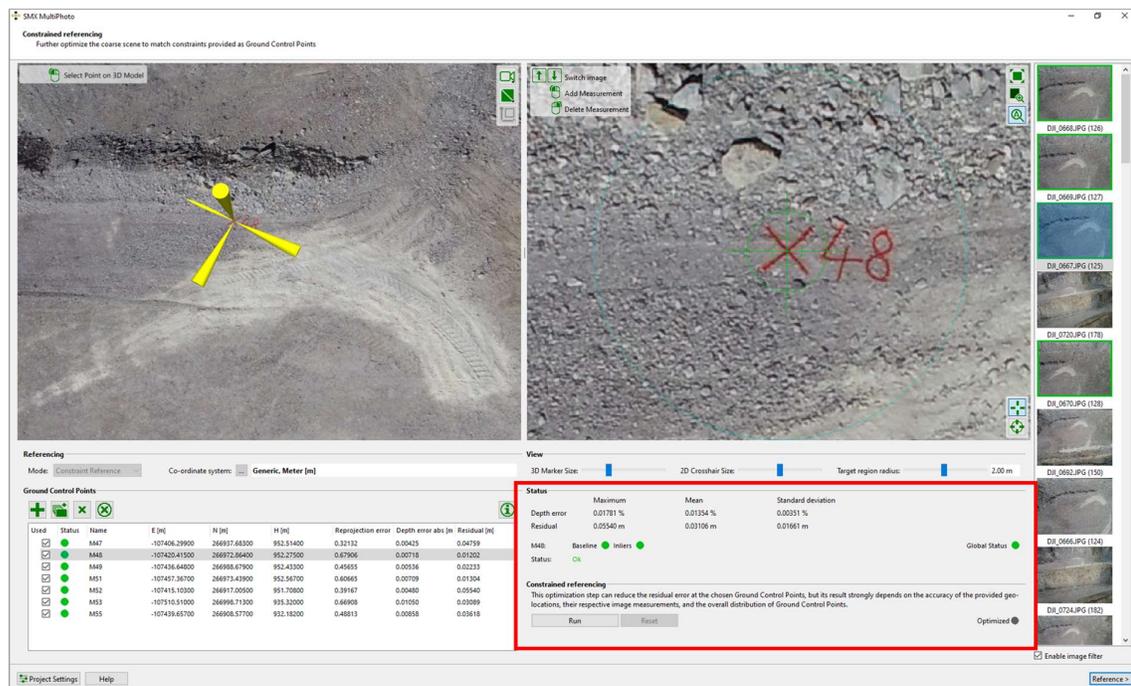
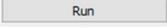


Figure 33: Interface of Constrained Referencing

Standard operating procedure:

1. Add GCP by
 - a. clicking the “Add GCP” icon  and entering the name and co-ordinates in the GCP list.
 - b. clicking the “Read GCP from Text File”  button and choose the text based files (“.csv”, “.txt”, “.dat”, “.prt”). See Chapter 5.1.5 for further details.
2. Activate one GCP in the list and localize its position in the 3D viewer by clicking the left mouse button. The list of reference images is updated and the active image is shown in the viewer.

- Choose the “Manual Target Mode” icon or the “Automatic Mode Icon” and centre the target by clicking with the mouse in the viewer. For locating the target discs the image should be zoomed as much as reasonable for visual interpretation. Check the position of the center by changing the size of the reticule. The reticule is well-centered if the circles touch the target’s boundary simultaneously at two opposing points and in two perpendicular directions.
- Choose at least 2 images (3 or more are recommended) showing the same GCP and click the center of target. The status signals *Baseline* and the *Inliers* turn into green and the error of re-projection and depth is displayed in the GCP list.
- Activate the next GCP in the list and repeat steps 2 – 4. Continue until all GCP positions are localized.
- Check the *Status Information* (green status signals) and enable referencing by clicking the “Run”  button. The *Optimized* signal turn into green (Figure 34).
- Check the error statistics and confirm referencing by clicking the “Reference”  button.

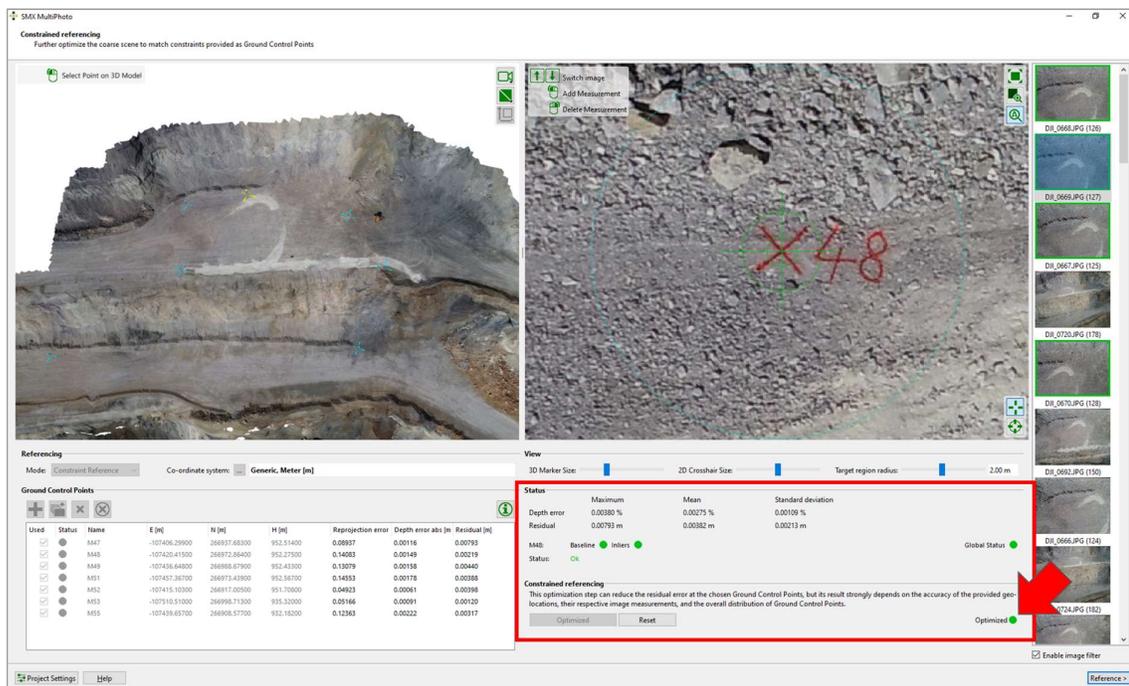


Figure 34: GCP positions and optimized error statistics

5.2.4 Dense Reconstruction

See Chapter 4.3 for detailed description.

- Check the coarse 3D point cloud for plausibility
- Choose the *Dense Reconstruction* mode - *Fast*, *Normal* or *High*
- Disable or enable “*De-noise depth maps*”

4. Optionally, limit the number of 3D points by enabling the checkbox “*Limit Dense Points*”.
5. If necessary, rename and select the directory of the output file (“.jm3x”) by clicking the “*Output File Name*”  icon
6. Start the reconstruction process by a click on the “*Start Dense Reconstruction*”  button. The appearing progress window shows the current status of reconstruction (Figure 22).
7. Inspect the 3D model in the 3D viewer
8. Close the *MultiPhoto* by clicking the “*Exit*”  button.

6 Normalize and Scaling

The provided modes are used for scaling a generic 3D model to a metric (scaled one) in a local coordinate system. Additionally, the software allows one to rotate a 3D model to an externally determined azimuth and shift the co-ordinates to one known position (*One Range Pole Mode with Reference Line*). Furthermore, the *Two Range Pole Mode* features scaling, vertically orientating, and north-correcting at the same time using two non-parallel *Range Poles*. Finally, the software offers a procedure to scale the 3D model in a local co-ordinate system with a horizontal reference plane (*Sample Mode*).

To enter the interface the button Referencing “Referencing” and “Normalize” from the pull down menu (Figure 35) has to be selected.



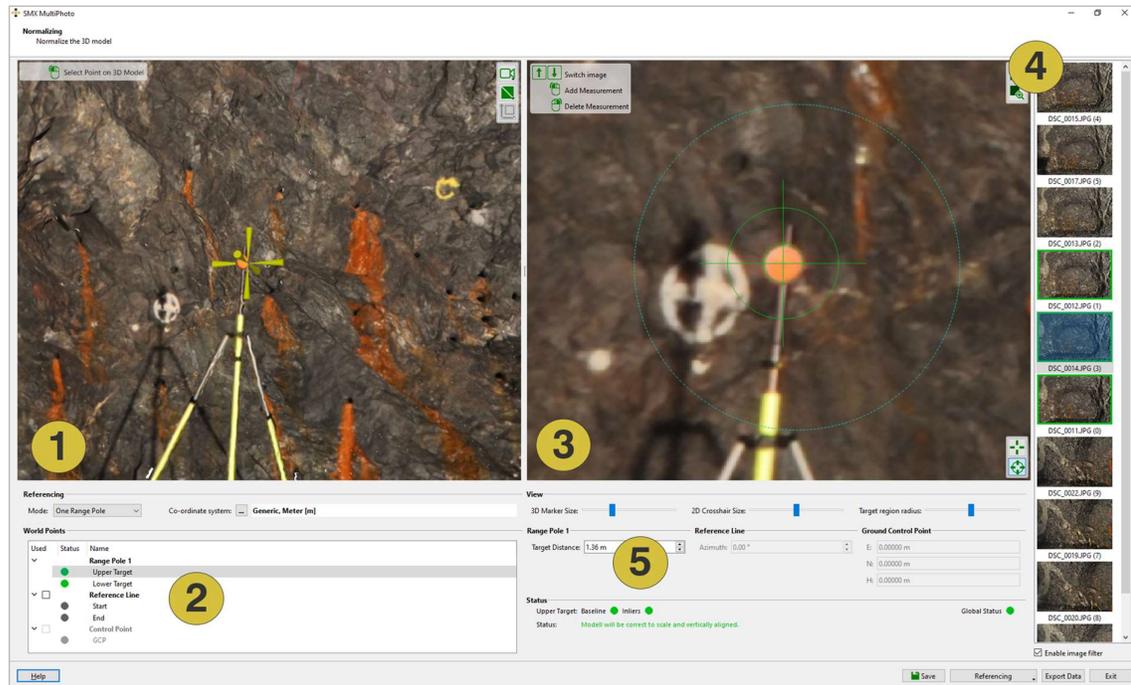
Figure 35: Action Control Points from the pull-down menu to transfer the model into a superior co-ordinate system

6.1 User interface

The user interface *Normalizing* of the *MultiPhoto* comprises the 3D viewer and the list of target points on the left hand side. On the right hand side it consists of a viewer showing the currently selected image for referencing and corresponding partner images and allows to enter diverse parameter for scaling and orientating the 3D model depending on the mode selected.

Note:

The *Status Information* provides hints and guides the user through the referencing procedure.



- 1 3D viewer
- 2 List of target points
- 3 Viewer with selected image
- 4 Partner images
- 5 Parameter for scaling and orientating

Figure 36: User interface *Normalize*

6.2 Features

The following section describes the available functions of the *Normalizing* window.

World Points

One Range Pole

One Range Pole

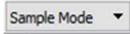
Mode for scaling and orientation the 3D model with one *Range Pole*

Two Range Poles

Two Range Poles

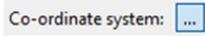
Mode for scaling and orientation the 3D model with two *Range Poles*

Sample



Mode for referencing the 3D model in a local co-ordinate system with a horizontal reference plane

Co-ordinate System



Browse a specific co-ordinate system or choose *Generic*

View (2D Viewer)

View full image



Fits the size of the image to the size of the viewer

Zoom to Target Region



Zooms to the target region

Manual Target Mode



Activates manual targeting

Automatic Target Mode



Activates automatic targeting

Sliders



3D Marker Size

Changes the size of the target in the 3D viewer

2D Crosshair Size

Changes the size of the crosshair in the 3D viewer

Target Region Radius

Defines the zoom (radius) to the target region

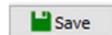
Enable Image Filter

 Enable image filter

De/activates the image filter. Enabled filter: Images of the currently clicked position in the 3D viewer are listed. Disabled filter: All images used for 3D model generation are listed.

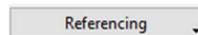
General

Save



References and saves the 3D model (".jm3x")

Referencing



Choose another action: *Inspect 3D Model*

6.3 One Range Pole Mode

The *One Range Pole Mode* requires the following parameters:

- *Upper Target*
- *Lower Target*
- *Distance between the targets*

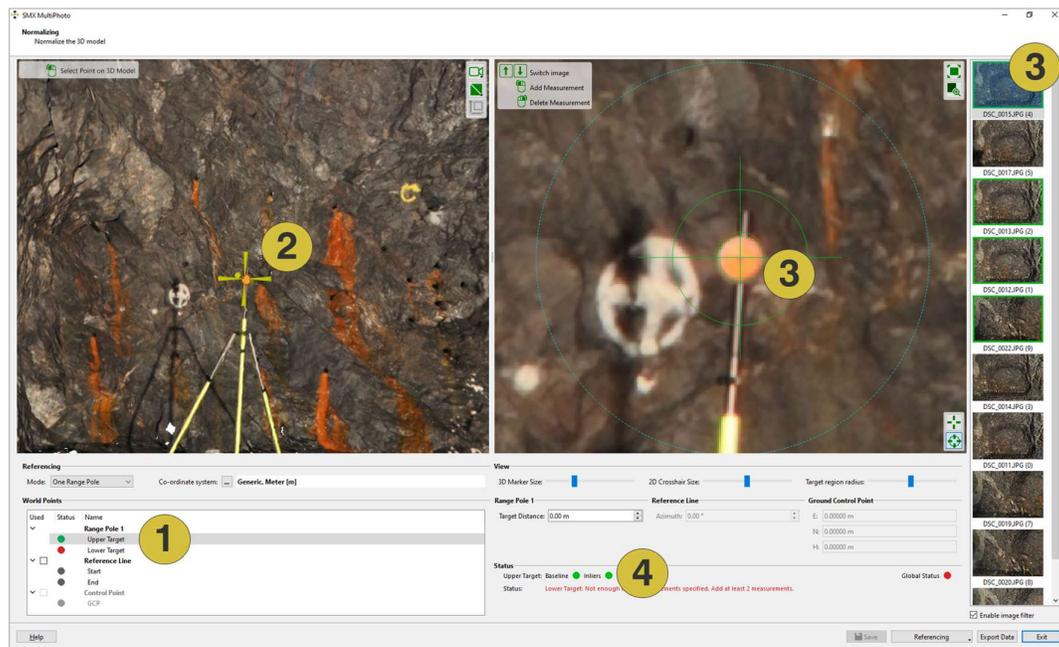
Standard operating procedure (see Figure 37 and Figure 38):

1. Choose the mode "*One Range Pole Mode*"  from the pull down menu.
2. Activate the first point by clicking the "*Upper Target*" entry in the point list.
3. Localize the position in the 3D viewer by clicking the left mouse button. The list of reference images is updated and the active image is shown in the viewer. See *Figure 37*.
4. Choose the "*Manual Target Mode*" icon or the "*Automatic Mode Icon*" and centre the target by clicking with the mouse in the viewer. For locating the target discs the image should be zoomed as much as reasonable for visual interpretation. Check the position of the center by changing the size of the reticule. The reticule is well-centered if the circles touch the target's boundary simultaneously at two opposing points and in two perpendicular directions (*Figure 27*).
5. Choose at least 2 images (3 or more are recommended) showing the same target point and click the center of target. The status signals *Baseline* and the *Inliers* turn into green.
6. Activate the "*Lower Target*" in the list and repeat steps 3 – 5.
7. Enter the distance between the *Upper* and *Lower Target* in the corresponding "*Target Distance*" field.

8. Enable referencing by clicking the “Save”  button.
9. Choose an action from the pull down menu “Referencing”  or close the *MultiPhoto* by clicking the “Exit”  button.

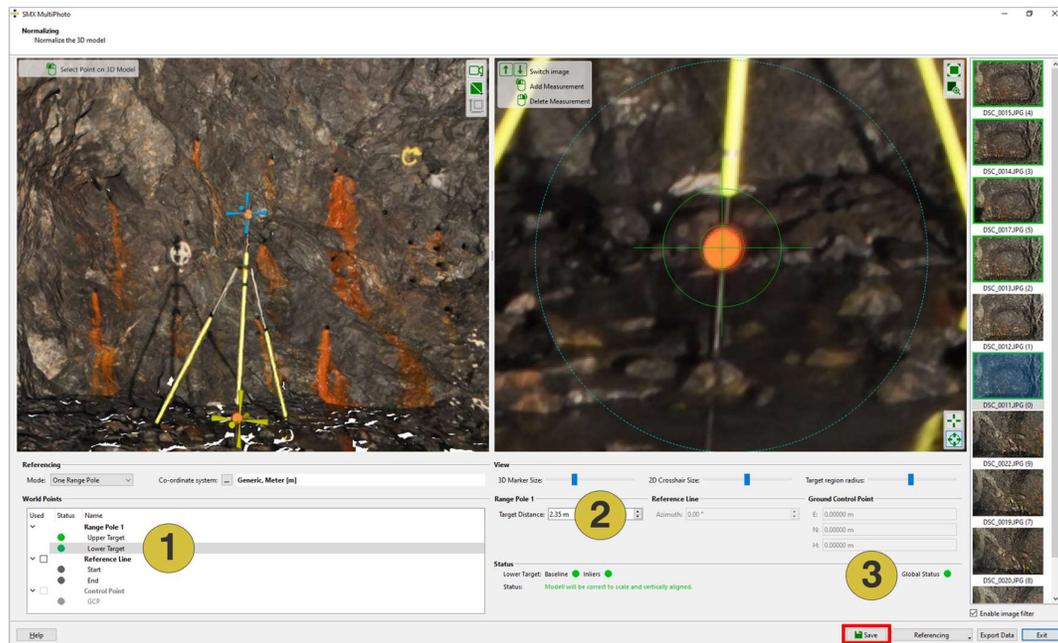
Note:

Refer to the hints given in the *Status Information*, if one of status signals *Baseline* (distant ratio between images) and *Inliers* turn into orange or red.



- 1 Targets in the list
- 2 Localization of the target in the 3D viewer
- 3 Target in individual images
- 4 Status of the individual targets

Figure 37: One Range Pole Mode - centering of the target



- 1 Upper and Lower Target centered
- 2 Distance between the two targets
- 3 Global status

Figure 38: One Range Pole Mode – scaling

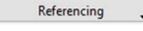
6.4 One Range Pole Mode with Reference Line

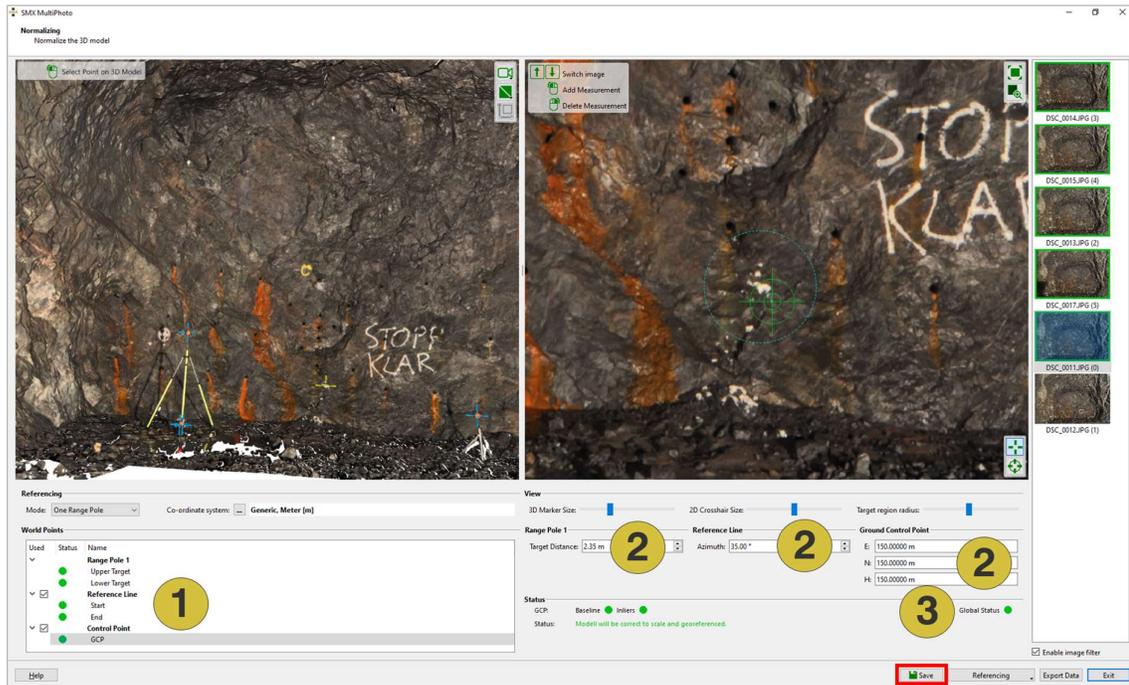
The *One Range Pole Mode with Reference Line* requires the following parameters:

- *Upper Target*
- *Lower Target*
- *Distance between the targets*
- *Start point of Reference Line*
- *End point of Reference Line*
- *Azimuth of the Reference Line*
- *Surveyed Control Point (optional)*

Standard operating procedure (see Figure 39):

1. Follow the procedure described in Chapter 6.3, and define the position of the *Upper* and *Lower Target*.
2. Activate *Reference Line* in the list and define the *Start* end the *End Point* in the same manner as done for the *Upper* and *Lower Target*.
3. Enter the azimuth between the in the corresponding “*Reference Line*” field.
4. Optionally, Activate GCP in the list and define the position as done before.

5. Enter Easting, Northing and Height the in the corresponding “Ground Control Point” field.
6. Enable referencing by clicking the “Save”  button.
7. Choose an action form the pull down menu “Referencing”  or close the *MultiPhoto* by clicking the “Exit”  button.



- 1 Defined points
- 2 Parameters for scaling and referencing
- 3 Global Status

Figure 39: One Range Pole Mode – scaling and georeferencing

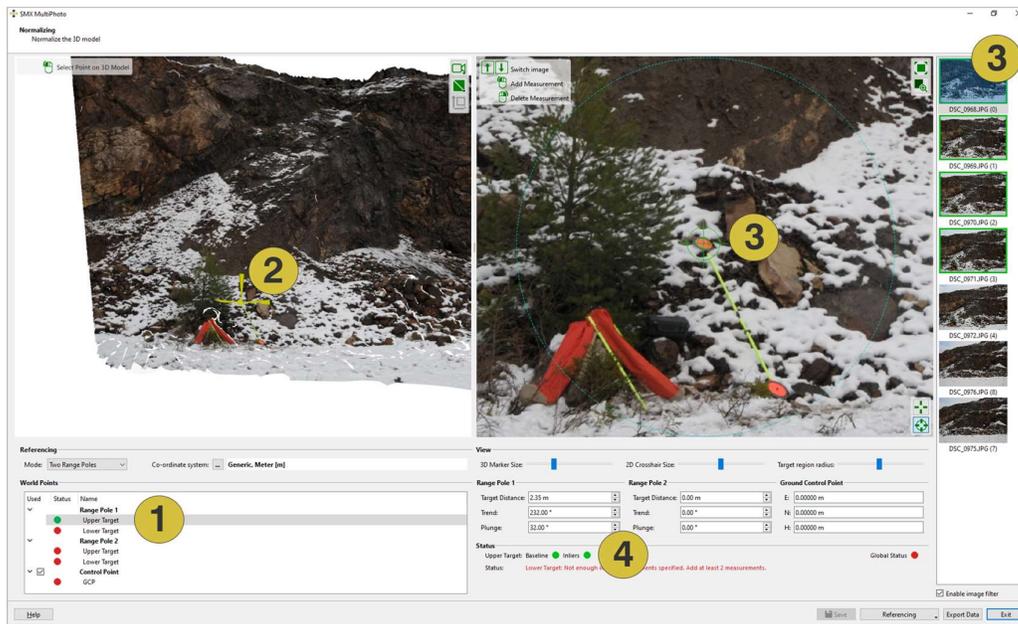
6.5 Two Range Pole Mode

The *Two Range Pole Mode* requires the following parameters:

- *Upper Target of the First Range Pole*
- *Lower Target of the First Range Pole*
- *Upper Target of the Second Range Pole*
- *Lower Target of the Second Range Pole*
- *Trend and plunge of the both Range Poles*
- *Distance between the targets*
- *Surveyed Control Point (optional)*

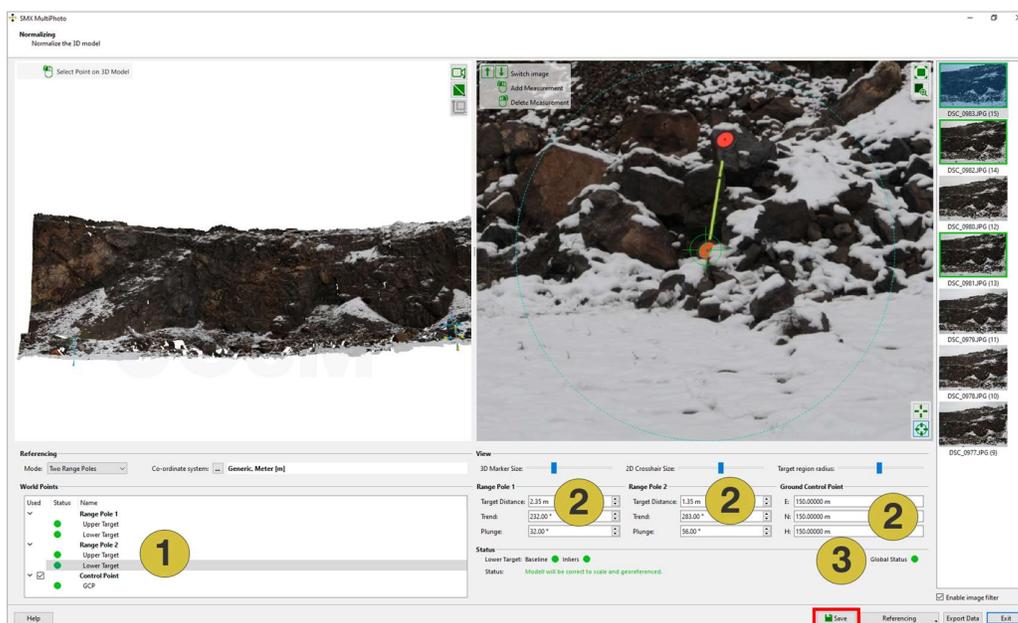
Standard operating procedure (see Figure 40 and Figure 41):

1. Choose the mode “Two Range Pole Mode”  from the pull down menu.
2. Activate the first point by clicking the “Upper Target” (*Range Pole 1*) entry in the point list.
3. Localize the position in the 3D viewer by clicking the left mouse button. The list of reference images is updated and the active image is shown in the viewer. See Figure 37.
4. Choose the “Manual Target Mode” icon or the “Automatic Mode Icon” and centre the target by clicking with the mouse in the viewer. For locating the target discs the image should be zoomed as much as reasonable for visual interpretation. Check the position of the center by changing the size of the reticule. The reticule is well-centered if the circles touch the target’s boundary simultaneously at two opposing points and in two perpendicular directions (Figure 27).
5. Choose at least 2 images (3 or more are recommended) showing the same target point and click the center of target. The status signals *Baseline* and the *Inliers* turn into green.
6. Activate the “Upper Target” (*Range Pole 1*) in the list and repeat steps 3 – 5.
7. Enter the distance between the *Upper* and *Lower Target* and the surveyed trend and plunge in the corresponding “Target Distance”, “Trend” and “Plunge” fields.
8. Repeat steps 2 – 7 for *Range Pole 2*.
9. Optionally, Activate GCP in the list and define the position as done before.
10. Enter Easting, Northing and Height the in the corresponding “Ground Control Point” field.
11. Enable referencing by clicking the “Save”  button.
12. Choose an action form the pull down menu “Referencing”  or close the *MultiPhoto* by clicking the “Exit”  button.



- 1 Targets in the list
- 2 Localization of the target in the 3D viewer
- 3 Target in individual images
- 4 Status of the individual targets

Figure 40: Two Range Pole Mode - centering of the target



- 1 Defined points
- 2 Parameters for scaling and referencing
- 3 Global Status

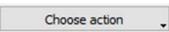
Figure 41: Two Range Pole Mode – scaling (and georeferencing)

6.6 Sample Mode

The *Sample Mode* requires the following parameters:

- *First Point*
- *Second Point*
- *Plane Point*

Standard operating procedure (see Figure 42 and Figure 43)

1. Choose the mode “*Sample Mode*”  from the pull down menu.
2. Localize the position of the *First Point* in the 3D viewer by clicking the left mouse button. The list of reference images is updated and the active image is shown in the viewer. See Figure 26.
3. Choose the “*Manual Target Mode*” icon or the “*Automatic Mode Icon*” and centre the target by clicking with the mouse in the viewer. For locating the target discs the image should be zoomed as much as reasonable for visual interpretation. Check the position of the center by changing the size of the reticule. The reticule is well-centered if the circles touch the target’s boundary simultaneously at two opposing points and in two perpendicular directions (Figure 27).
4. Choose at least 2 images (3 or more are recommended) showing the same target point and click the center of target. The status signals *Baseline* and the *Inliers* turn into green and the error of re-projection and depth is displayed in the *GCP* list. See
5. Activate *Second Point* and *Plane Point* in the list and repeat steps 2 – 4.
6. Enter the distance between the *First* and the *Second Point* in the “*Enter Point Distance*” dialog.
7. Check the Status Information (green status signals) and enable referencing by clicking the “*Save*”  button.
8. Choose an action form the pull down menu “*Choose action*”  or close the *MultiPhoto* by clicking the “*Exit*”  button.

Note:

Refer to the hints given in the *Status Information*, if one of status signals *Baseline* (distant ratio between images) and *Inliers* turn into orange or red.

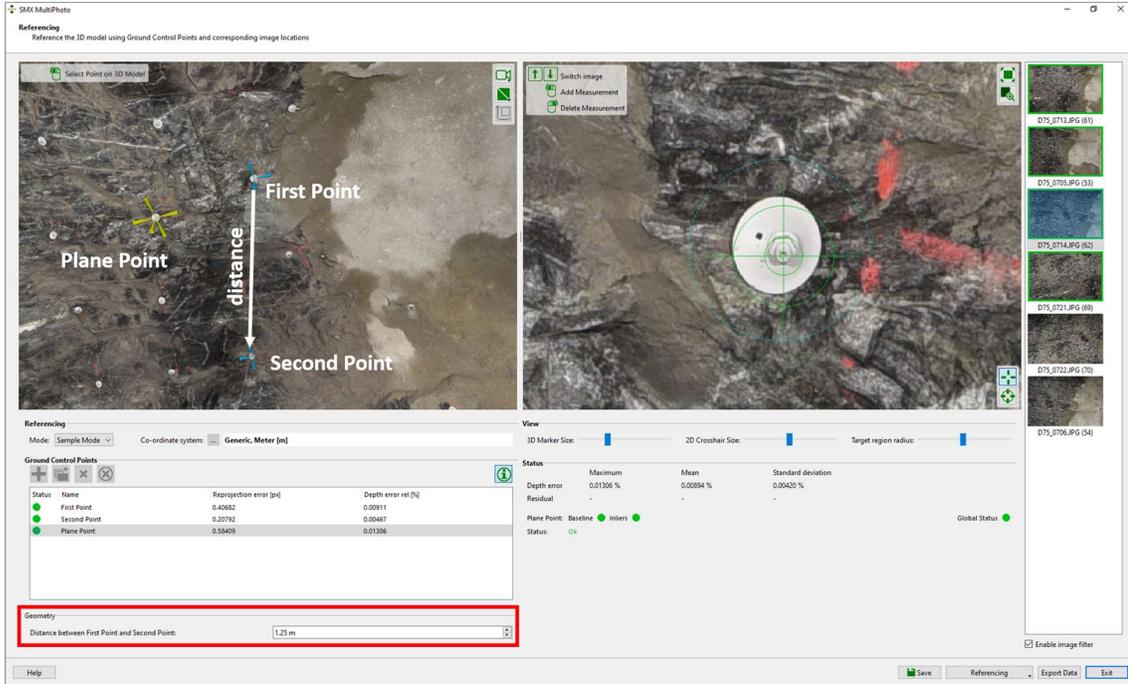


Figure 42: Localize positions and enter point distance

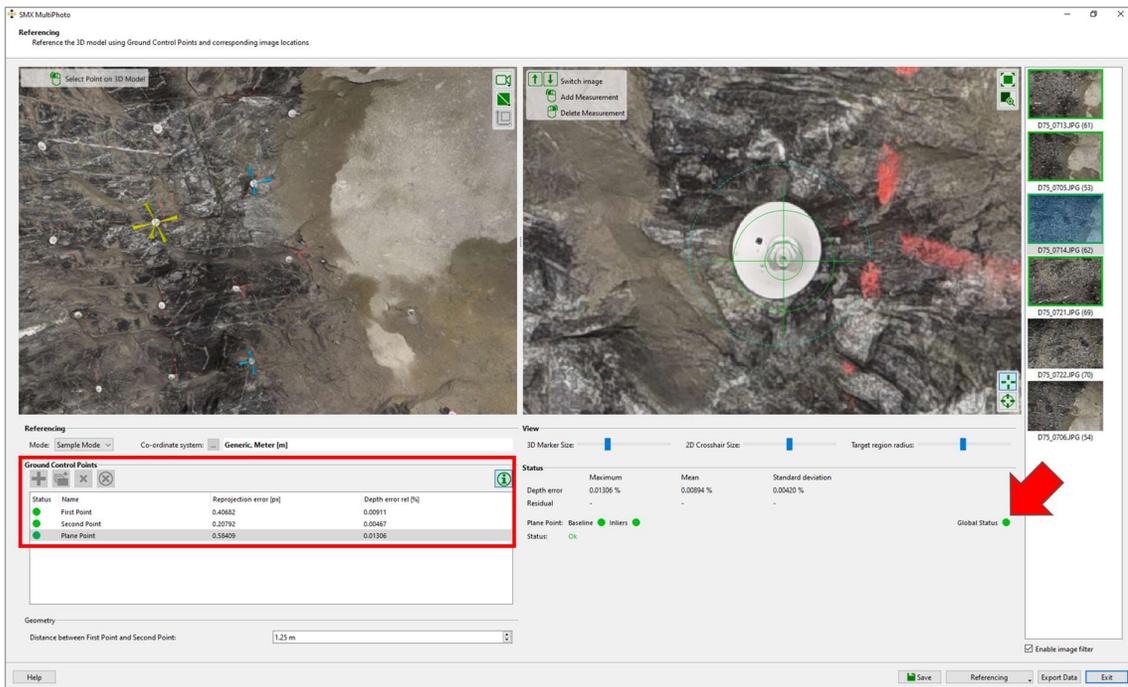
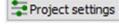


Figure 43: Standard Referencing – Sample Mode

7 Export options

The export of data is enabled in the “*Export Options*” dialog (Figure 44) opened by clicking the “*Export Data*”  button or “*Project Setting*”  button (see Chapter 4.1.2, 4.2.2 and 4.3.2) in the individual interfaces of the *MultiPhoto*. Selected exports are generated and saved automatically by the software after closing the *MultiPhoto*.

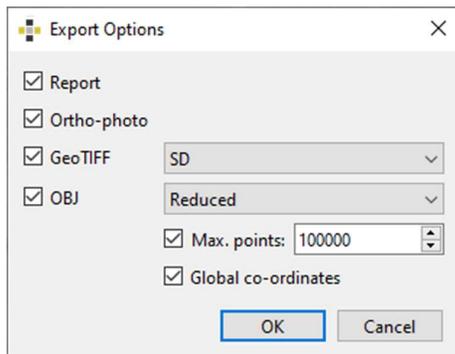


Figure 44: Export options

The *MultiPhoto* supports following export possibilities:

- Reconstruction report (“.pdf”): includes a comprehensive summary of the reconstruction (coarse and dense reconstruction) and referencing of the 3D model including statistics (Figure 45).
- Ortho-Photo (“.png”; Figure 46)
- GeoTIFF: writes a public domain metadata which has the geo-referencing information (“dem.tif”) embedded with the image file (“ortho.tif”) in standard definition (SD) or high definition (HD)
- Export into “.obj” format: writes the co-ordinates of the points and triangulation together with separate bitmap files for the texture. A reduced export is provided, whereas the number of points can be limited by the user. The export of global coordinates is optional.

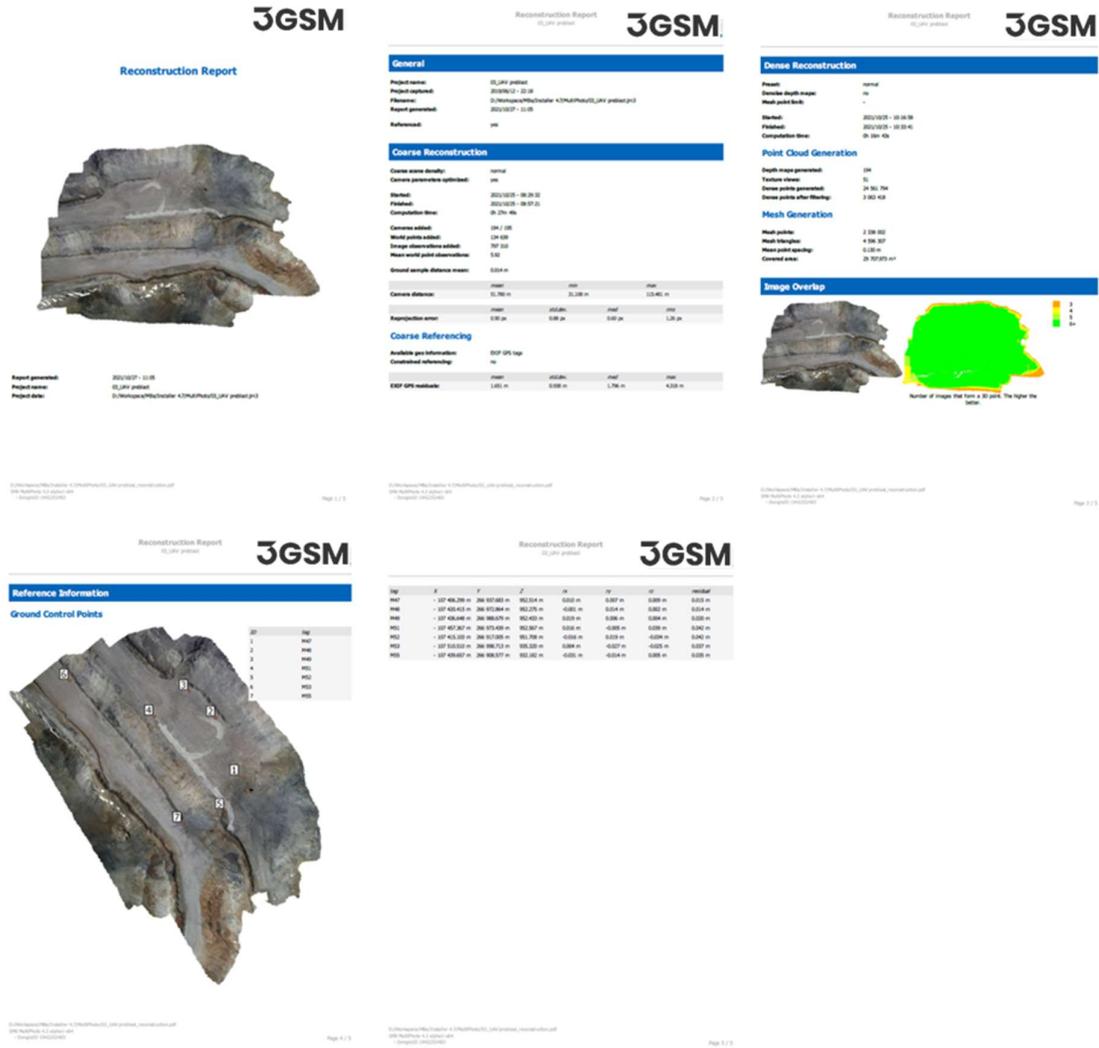


Figure 45: Reconstruction report of the MultiPhoto

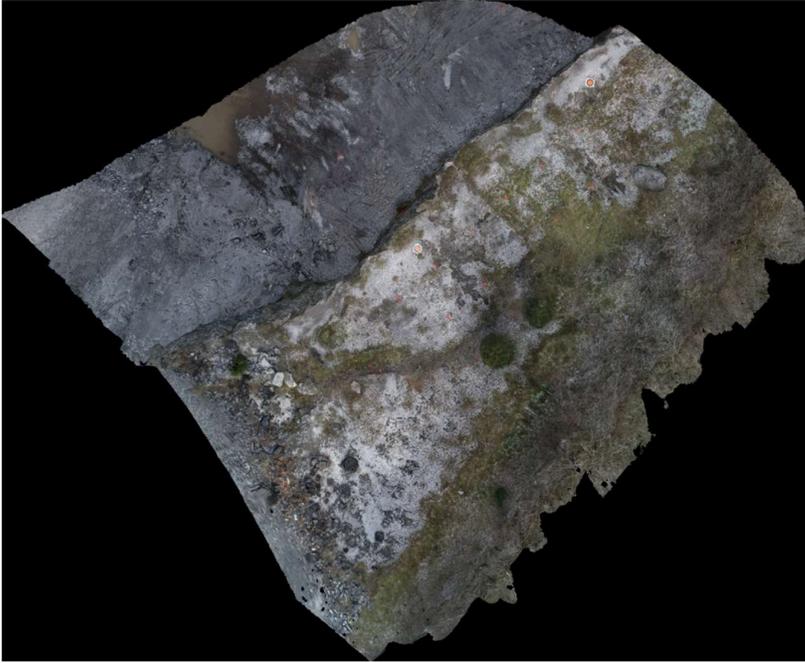


Figure 46: Ortho-photo generated by the MultiPhoto