

# User Manual

# 3GSM

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## SMX MultiPhoto



**User Manual  
for Version 4.11**

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Project ID: 6100  
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*Subject to change without notice*

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## 1 Introduction

The *SMX MultiPhoto* is an easy to handle software component for the reconstruction of 3D models from multiple overlapping single images typically gained from aerial imaging using UAV systems. Once all input parameters have been defined by the user, the reconstruction is performed automatically. In addition, *SMX MultiPhoto* features referencing of the 3D model to a superior co-ordinate system by the use of externally surveyed *Ground Control Points (GCP)*. *SMX MultiPhoto* generates a quality report (".pdf" file) for the reconstruction and an ortho-photo (".png" file) fully automatically after reconstruction.

**Definition:**

A 3D model is a digital photograph combined with spatial information on the objects/surfaces shown within the picture.

**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 *SMX 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 *SMX MultiPhoto*.

The Team of 3GSM

Graz, October 2024

## 2 General

The *SMX MultiPhoto* is part of the *ShapeMetriX/BlastMetriX* package and not available as a stand-alone program. The installation takes place during the installation of *ShapeMetriX/BlastMetriX* and is described in the corresponding user manual.

**Note:**

The *SMX MultiPhoto* software component is used under this name in *ShapeMetriX* and *BlastMetriX* packages, i.e. there is no dedicated *BMX MultiPhoto*. The same may apply to other software components.

**Note:**

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

**Attention:**

3D models (“.jm3” files) generated with the *SMX MultiPhoto v4.9* are not supported by software components older than version 4.1. The *SMX SurfaceTrimmer* provides a conversion of 3D models into former version (*ShapeMetriX UAV / BlastMetriX UAV v2.1 - v4.0*). However, the current version reads files (“.smm” and “.jm3” files) from former *SMX MultiPhoto* versions. Note, that referencing of such 3D models is not supported.

## 3 Software layout, features and use

### 3.1 Procedure

SMX 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*  
SMX 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 SMX 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 (".jm3" file)
- *Referencing and/or scaling*  
SMX 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.

### 3.2 Reconstruction features

SMX MultiPhoto support 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 3.1 may differ due to the selected mode.

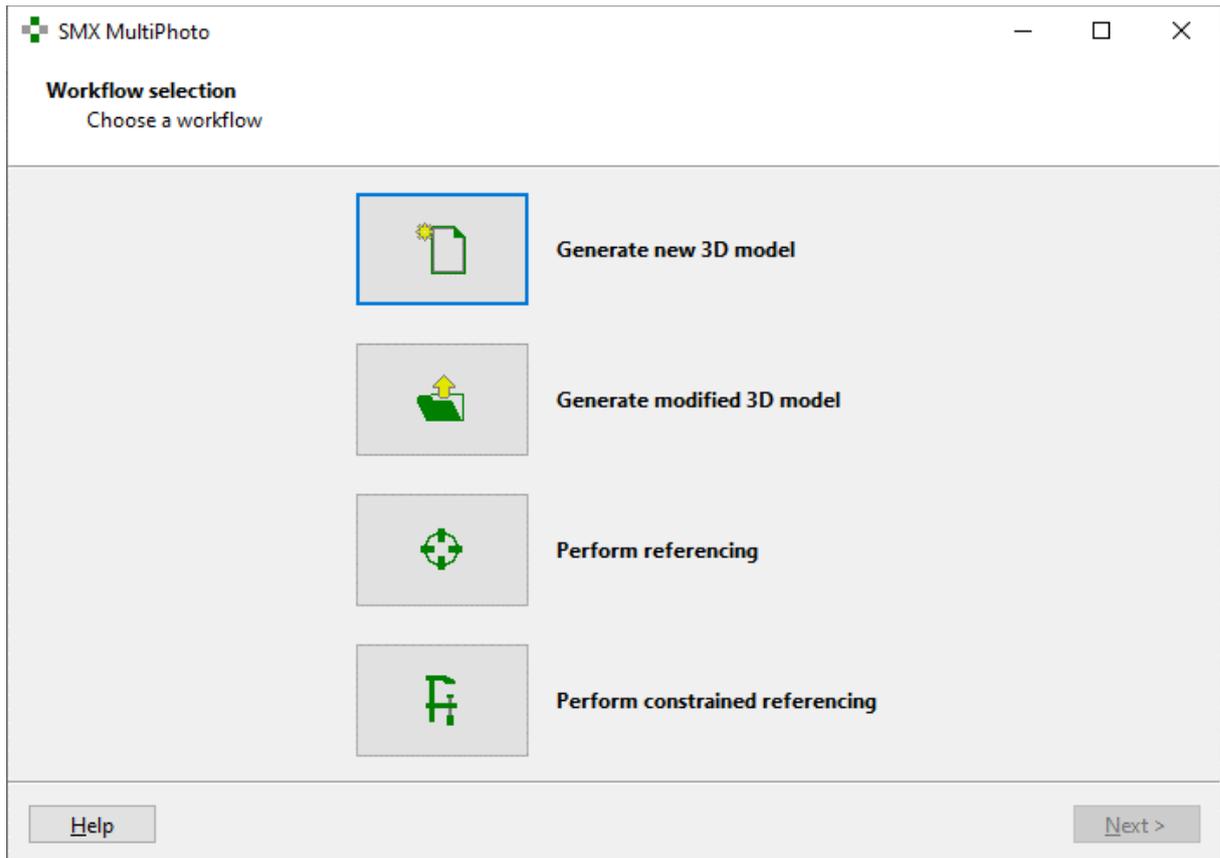


Figure 1: Start interface

### 3.2.1 **Generate new 3D model**

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

1. Open *SMX MultiPhoto*
2. Select the workflow “Generate new 3D model” by clicking the corresponding icon 
3. Follow the standard operation procedure as described in Chapter 5

### 3.2.2 **Generate modified 3D model**

Load a project file (“.smm” file; coarse reconstruction), modify the settings and perform 3D model reconstruction. Procedure:

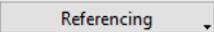
1. Open *SMX MultiPhoto*
2. Select the workflow “Generate modified 3D model” by clicking the corresponding icon 
3. Load the “.smm” file and the software automatically switches to the *Select Scene Region of Interest* window.
4. Follow the standard operation procedure as described in Chapter 5.2

### 3.2.3 Perform referencing

Load a project file (".smm" file; coarse reconstruction) and 3D model file (".jm3"; dense reconstruction) and perform referencing using surveyed *Ground Control Points* or scaling of the 3D model.

#### Standard referencing

To perform or modify the *Standard Referencing* of the 3D Model the 3D model file ".jm3" and the corresponding Project file ".smm" are required. Procedure:

1. Open *SMX MultiPhoto*
2. Select the workflow "*Perform referencing*" by clicking the corresponding icon 
3. Load the ".smm" and the corresponding ".jm3" 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 operation procedure as described in Chapter 5.4.

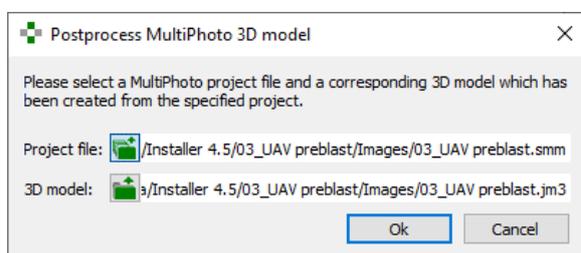
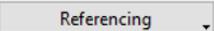


Figure 2: Loading Project File

#### Add or modify Stereo Setups

For adding or modifying *Stereo Setups* in a 3D Model the 3D model file ".jm3" and the corresponding Project file ".smm" are required. *Stereo Setups* can be added or modified by following procedure:

1. Open *SMX MultiPhoto*
2. Select the workflow "*Perform referencing*" by clicking the corresponding icon 
3. Load the ".smm" and the corresponding ".jm3" 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 "*Stereo Setup*" from the pull down menu "*Referencing*"  and follow the standard operation procedure as described in Chapter 7.

The following properties apply:

- The current list of selected *Stereo Setups* are stored in the 3D Model file always. Previously added *Stereo Setups* which are not part of the list of *Stereo Setups* are removed from the 3D Model.
- The project file contains only the last edited list of *Stereo Setups*

### 3.2.4 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 (".jm3"; dense reconstruction). Procedure:

1. Open *SMX 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 operation procedure as described in Chapters 6

## 3.3 Referencing using GCP

*SMX 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:

Referencing by GPS co-ordinates obtained by the UAV system only (*EXIF GPS Referencing*) is not recommended, as the precision is not adequate.

#### 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.

### 3.3.1 Standard referencing

#### Note:

*Standard Referencing* is a post-processing step which is performed after *Dense Reconstruction* of the 3D model (".jm3").

*SMX MultiPhoto* provides three 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 5.4.3.

- *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 5.4.4.
- *Sample Mode*  
Scaling in a local co-ordinate system; see Chapter 5.4.5

#### **Work flow** (see Figure 3)

Once the data is loaded and reconstruction parameters are defined, the 3D model is generated fully automatically by the *SMX 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*.

### **3.3.2 Constrained referencing**

*Constrained Referencing* is based on the optimization of the 3D model using the position of the externally surveyed *GCP* to obtain a better spatial accuracy of the 3D model. 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, *SMX 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 (“*.jm3*”) 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*

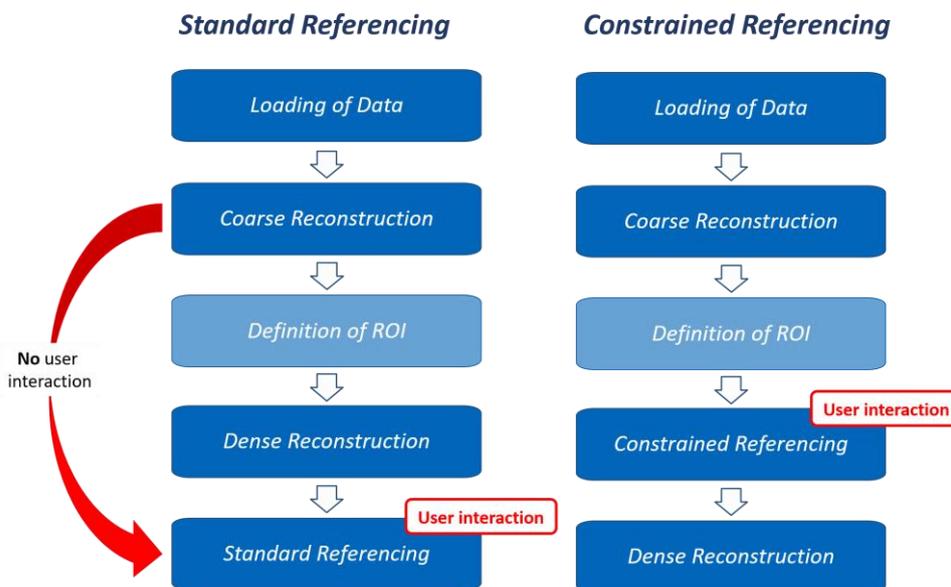


Figure 3: Different work flows in the SMX MultiPhoto. Note that the definition of a ROI is optional and requires user interaction.

### 3.4 Scaling

#### 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 the definition of three points; i.e. *First Point*, *Second Point* and *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 (see Figure 4).

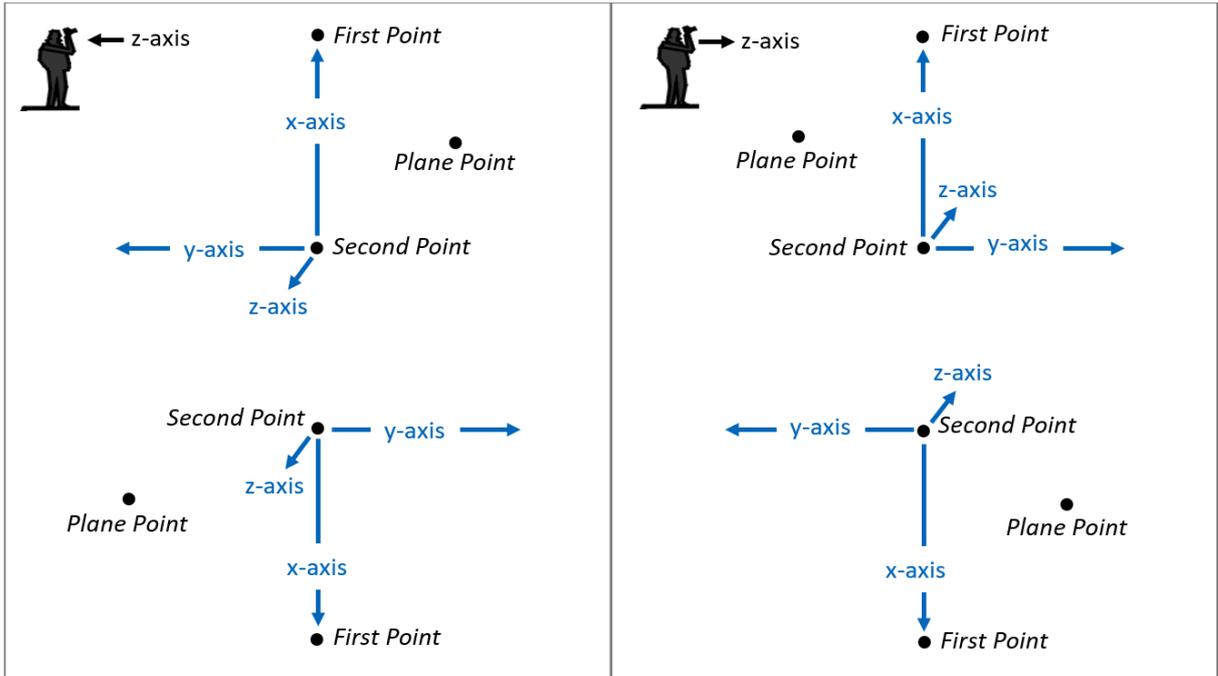


Figure 4: Orientation possibilities of the Sample Mode as a result of the marker setup

## 4 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*.

### 4.1.1 Navigation bar

#### Hint:

The *SMX MultiPhoto* toggles between the *Edit* and *Navigate* mode by pressing the “*Esc*” key.

#### *Edit*



Performs actions within the 3D model such as marking annotations, etc. (active = blue)

#### *Navigate*



Controls the motion and inspection of a 3D model (active = blue)

#### *Seek to a Selected Point*



Zooms towards the selected location on the 3D model

#### *Move to Home Position*



Sets the viewer to its initial position

#### *Zoom out / Zoom in*



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

### Toggle Perspective/Parallel Projection



Toggles between perspective and parallel projection

### Thumb wheels

The thumb wheels are used for rotation and zooming

#### 4.1.2 Navigation mode

The devices used in the *Navigate* mode are the mouse and/or the keyboard.

#### Mouse navigation

- Rotation: The left mouse button rotates the 3D model. Just keep the left button pressed and move the mouse around to see the 3D model rotating.
- Context menu: The right mouse button opens a context menu where the representation of the 3D model can be influenced.
- Panning: The middle mouse button is used to pan the 3D model. The same can be done by pressing “*Ctrl*” or “*Shift*” and using the left mouse button.
- Zooming: Pressing the left and middle mouse button at the same time is used to zoom. The same can be done by pressing “*Ctrl*” and “*Shift*” and using the left mouse button. When turning the wheel of a wheel mouse the 3D model is also zoomed.

#### Hint:

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

#### Keyboard navigation

- Straight motion is performed by pressing the corresponding arrow key “*Left*”, “*Right*”, “*Up*” or “*Down*”.
- Zooming is performed by pressing “*Shift*” 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 by pressing “*Ctrl*” simultaneously with the corresponding arrow key “*Left*”, “*Right*”, “*Up*” or “*Down*”.

### 4.1.3 Context menu

The context menu of the 3D viewer allows the change in the display of the 3D model. A click on the right mouse button in the viewer opens a pop up window and several options can be chosen:

<i>Draw as is</i>	The 3D topography is completely overlaid by the digital photograph (3D model)
<i>Wireframe</i>	A triangulated red coloured point cloud is forming the topography
<i>Wireframe Overlay</i>	The 3D model and a red coloured overlay of the wireframe is forming the topography
<i>Points</i>	The point cloud of the scene according to the topography is shown
<i>All Points</i>	All available points of the 3D model according to the photograph are shown
<i>Show Texture</i>	Displays the 3D model with texture in the viewer
<i>Fullscreen</i>	Switches between the fullscreen display and the windowed display

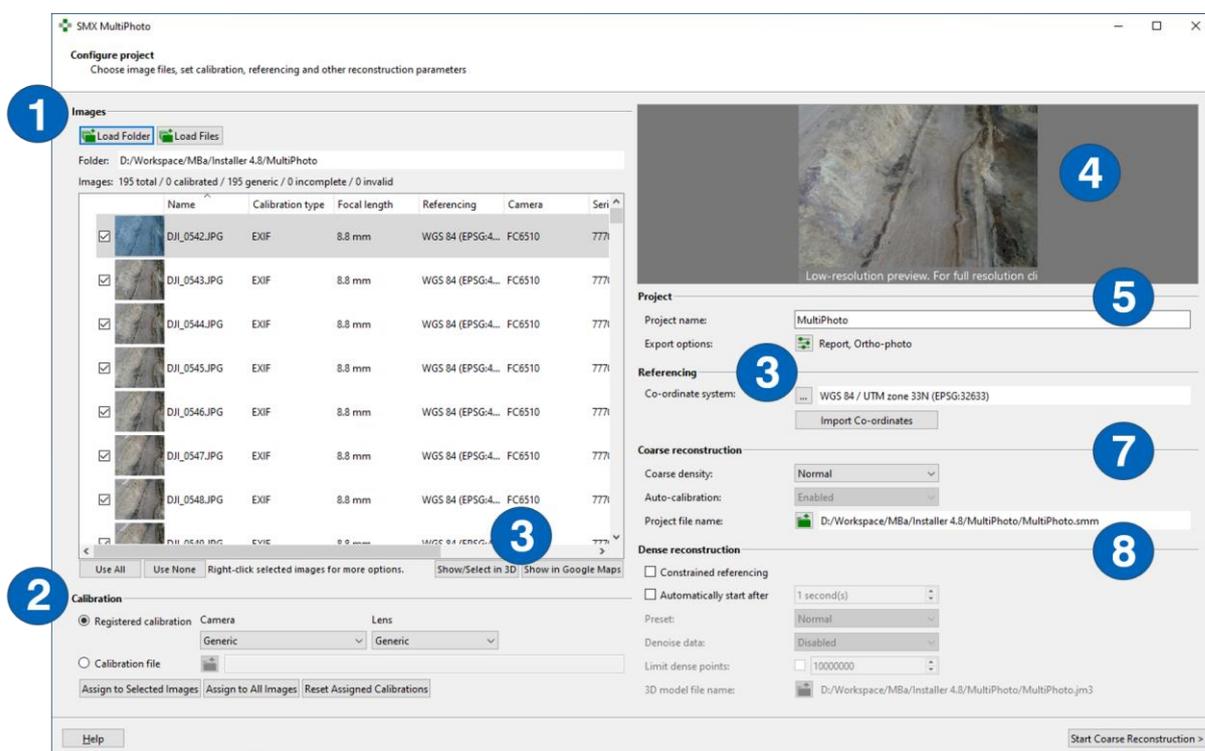
## 5 Generate new 3D model

### 5.1 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.

#### 5.1.1 User interface

The user interface “Configure Project” comprises several features shown in Figure 5. 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 5: User interface Configure Project of the SMX MultiPhoto

### List of loaded images

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

- Picture thumbnail
- Name of the image
- Calibration type:
  - *EXIF* - *SMX MultiPhoto* uses calibration information from the “.exif” file (extended image information)
  - *Specific Calibration Name* - *SMX 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

#### 5.1.2 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*



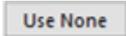
Opens a dialog to load photos individually

*Use All*



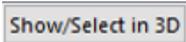
Selects all photos from the list of loaded images for reconstruction

*Use None*



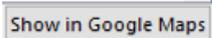
Deselects all photos from the list of loaded images for reconstruction

*Show/Select in 3D*



GPS co-ordinates of the individual images are shown in a 3D viewer (Figure 6). The dialog supports the selection of images that should be used for 3D model generation directly in the viewer (see Chapter 5.1.3).

*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 Thumb wheels
- 4 Image selection by multiple selection of images in the list
- 5 Image selection in 3D with the computer mouse (lasso function)

Figure 6: 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*



Assigns the selected calibration to selected images

*Assign to All Images*



Assigns the selected calibration to all images

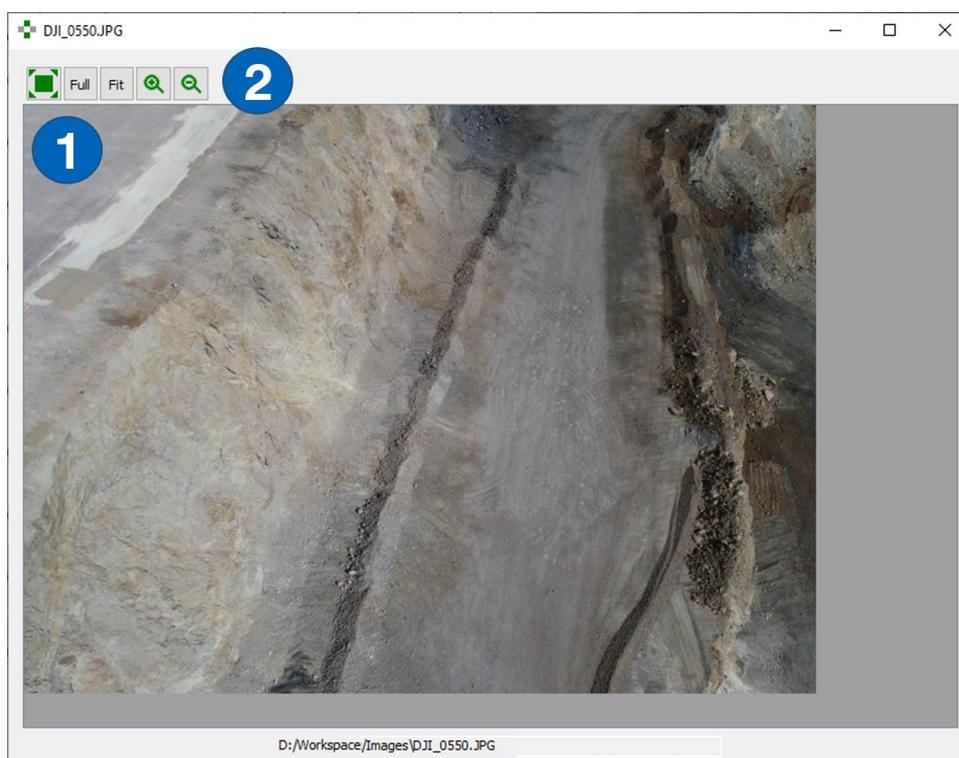
*Reset Assigned Calibrations*



Removes the calibration assigned to all images

## Image viewer

The image viewer (Figure 7) 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 7: 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 8.

## 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 8). The 3D model is transferred automatically into the desired co-ordinate system after 3D model generation.
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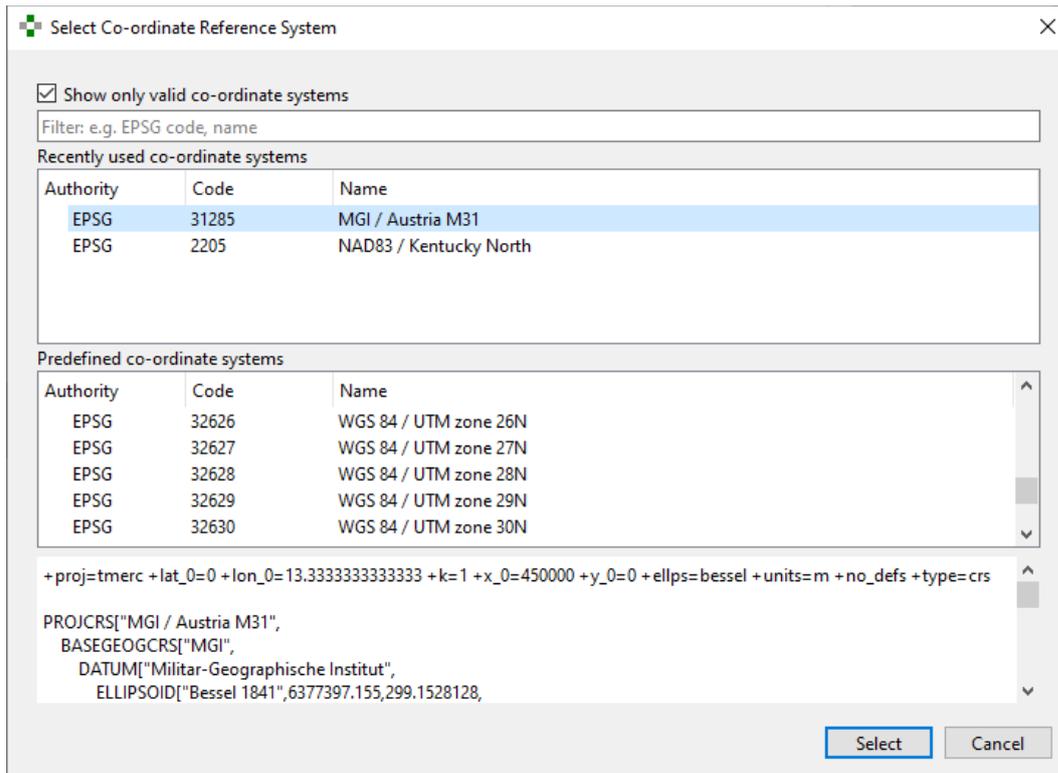


Figure 8: Select Co-ordinate Reference System

### Import Co-ordinates



Imports GPS co-ordinates from a “.txt” file (Figure 9).

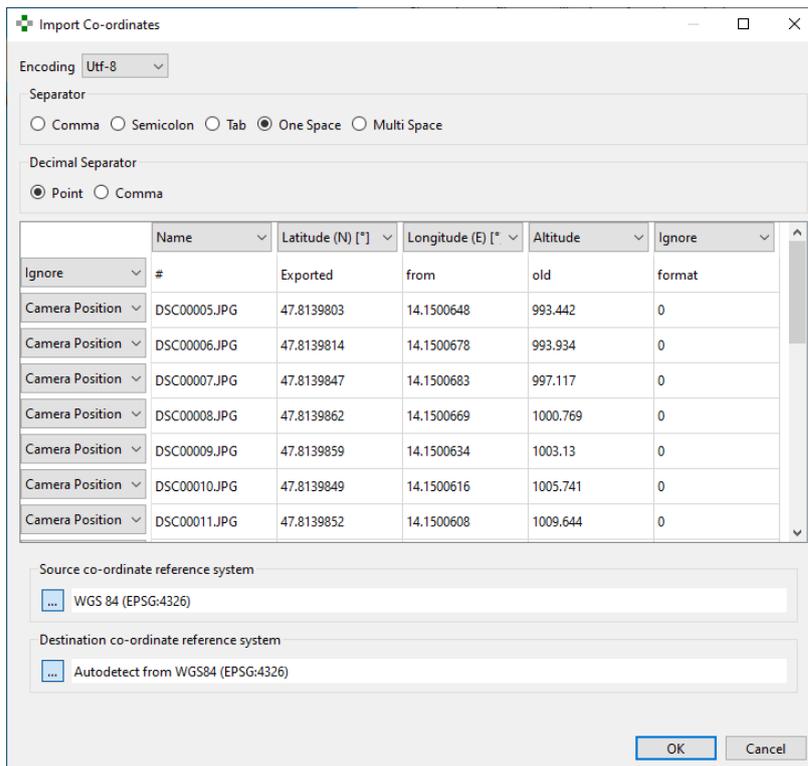


Figure 9: Import Co-ordinates. See Chapter 5.1.3 for further information.

### 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

<input type="checkbox"/> <b>Constrained referencing</b>	Enables <i>Constrained Referencing</i>
<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).

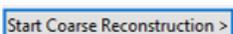
#### Note:

*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>
<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>Output file name</i>	 Opens a dialog for entering the directory and name of the final 3D model (".jm3" file)

### Start Coarse Reconstruction



Starts the reconstruction process and continues to the next step

## 5.1.3 Standard operation procedure

### Coarse Reconstruction

1. Load image data by clicking the “Load folder” or “Load Files”  icon. A progress window (Figure 10) appears during scanning and loading.

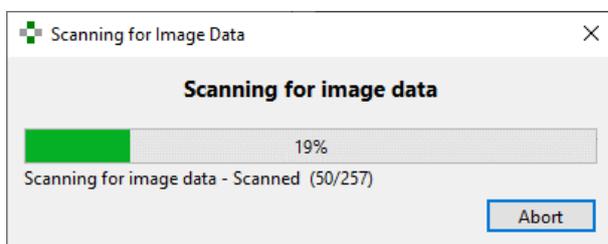
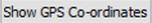
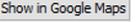


Figure 10: Progress window - Scanning for image data

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” .
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 8). The export start automatically when leaving the SMX 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 8). 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" Start coarse reconstruction > button. The progress window reveals the current status of reconstruction including a live display (Figure 11).

**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.

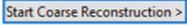


- 1 Current status
- 2 Progress bar
- 3 Pause/Abort process
- 4 Number of cameras/points reconstructed
- 5 Live display of cameras and points
- 6 Activates/deactivates the live display

Figure 11: Progress window of Coarse Reconstruction. Note, the live display starts at "Camera alignment" (blue arrow).

### Coarse and Dense Reconstruction

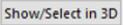
10. Follow steps 1 to 9 in the procedure *Coarse Reconstruction*.
11. Enable the checkbox "Automatically continue reconstruction after xxx seconds". The *Dense Reconstruction* process and generation of the ".jm3" file will start automatically after the user-defined time. Enabling the checkbox activates the *Dense Reconstruction Settings*.
12. Choose the reconstruction mode i.e. "Fast", "Normal" or "High" (for details see Chapter 5.1.2).
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 (".jm3") 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 11).

**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 . The images represented by their GPS position as dots in the viewer. Procedure (see Figure 12):

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 operation procedure

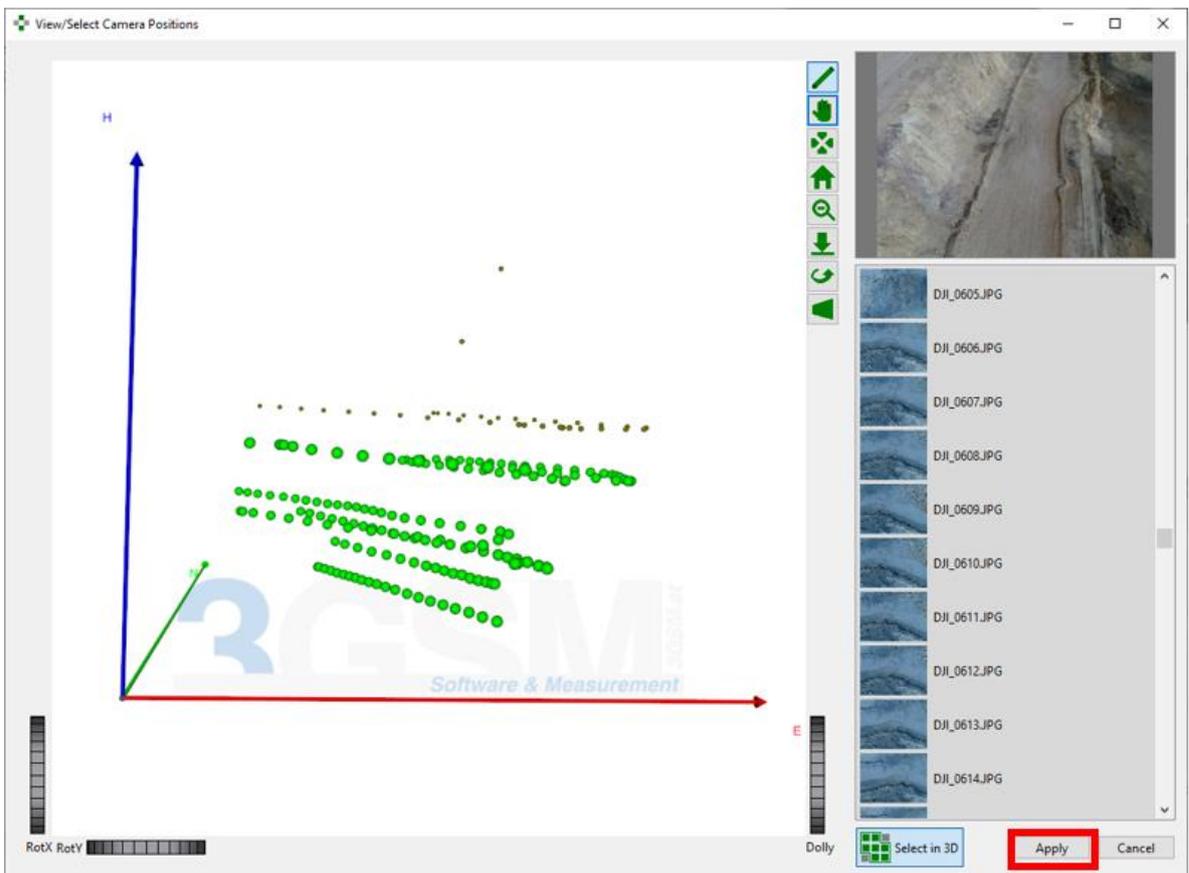
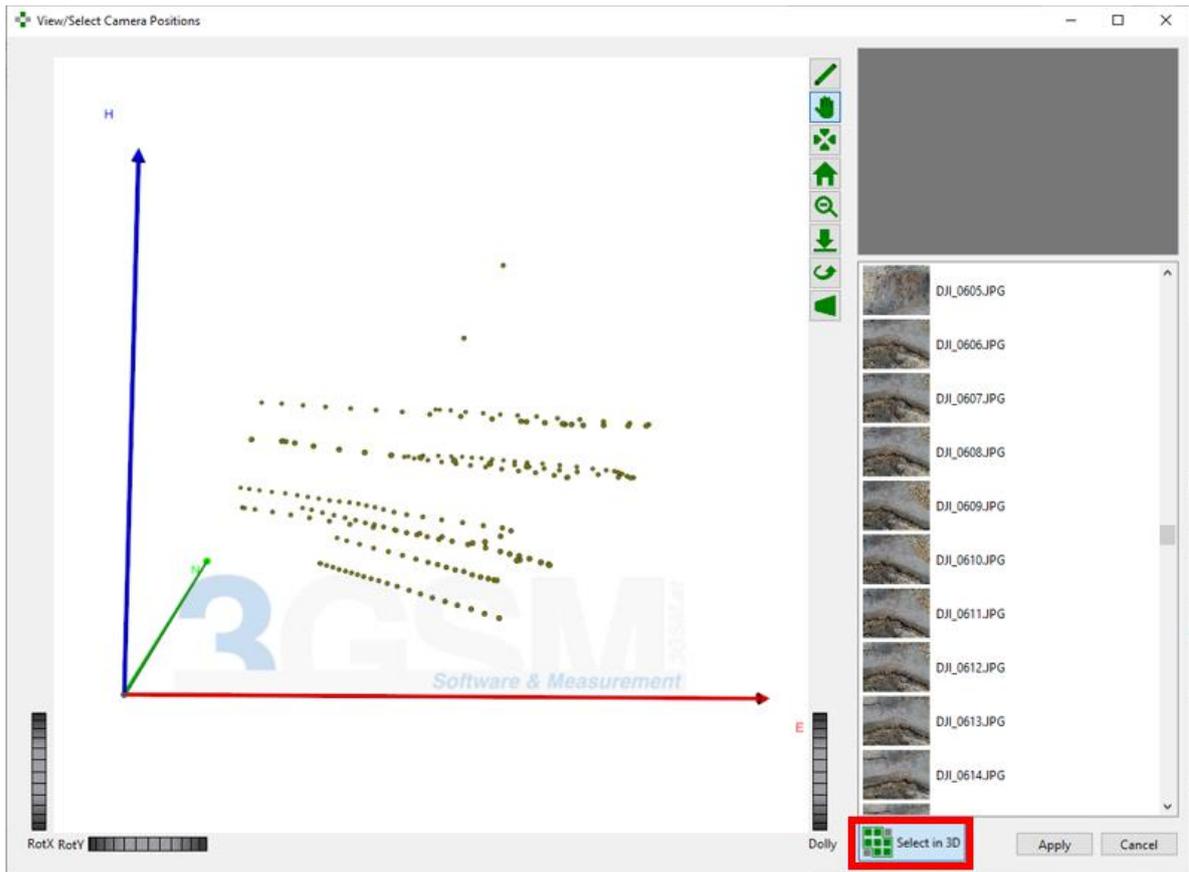


Figure 12: Image selection in the GPS viewer

## Import of co-ordinates

GPS data can be imported separately to individual pictures by selecting the “*Import Co-ordinates*”

button. Procedure:

1. Choose a text file containing the positional information and a dialog appears (Figure 9) 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 8).
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.

## 5.2 Select scene Region of Interest

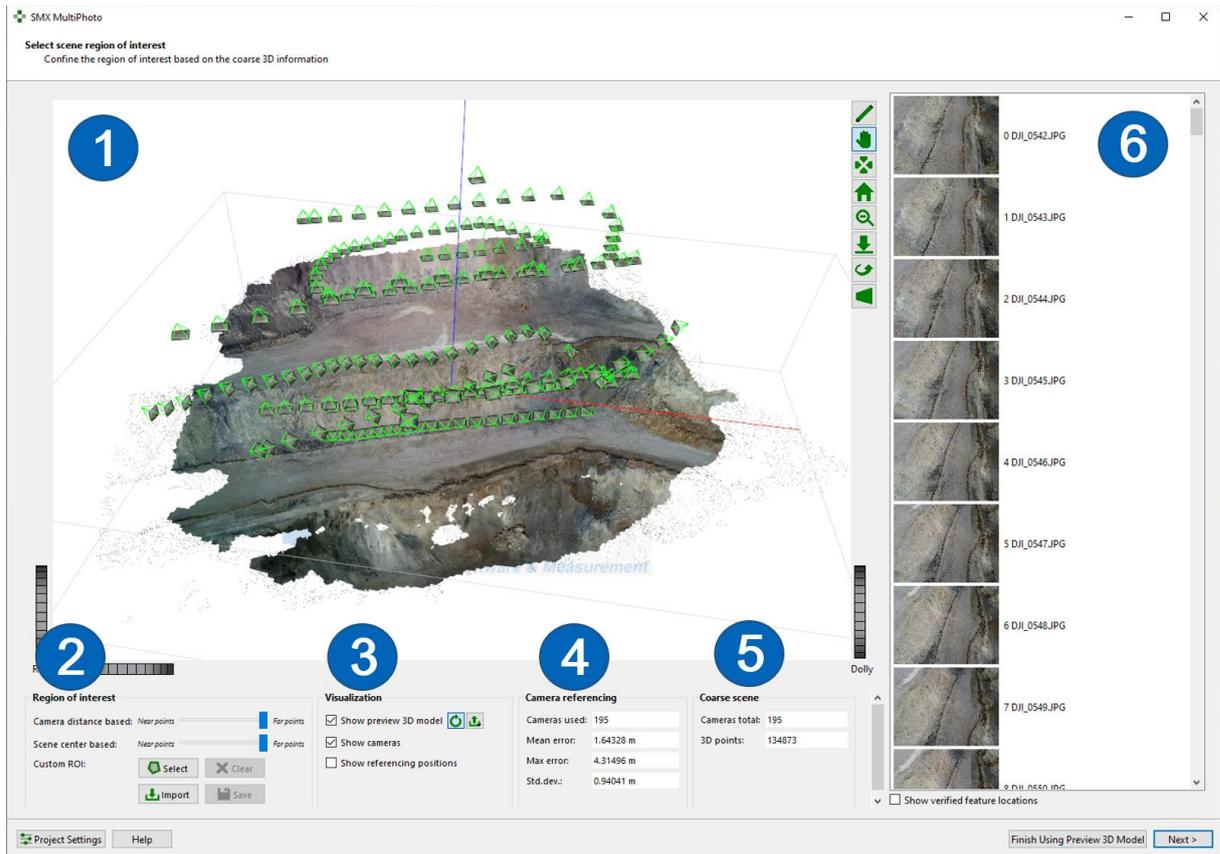
*Select Scene Region of Interest* allows to confine the reconstruction area to a *Region of Interest (ROI)*. The definition of the *Region of Interest* is optional. It is skipped by clicking the “*Next*”  button. If no *ROI* is defined, the entire 3D point cloud of the *Coarse Reconstruction* is used 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 5.4.3 for further information).

### 5.2.1 User interface

The user interface comprises the features shown in Figure 13. 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.



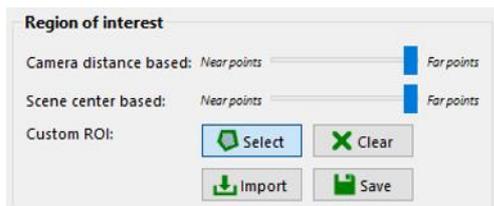
- 1 3D viewer with point cloud and cameras
- 2 Features for defining the ROI
- 3 Visualization in the 3D viewer
- 4 Camera referencing
- 5 Information of the coarse scene
- 6 List of images

Figure 13: User interface Select scene region of interest of the SMX MultiPhoto

### 5.2.2 Features

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

#### Region of Interest



#### Camera distance based

Points which exceed a certain limiting distance to the cameras are removed from the ROI. The limiting distance decreases if the slider is moved from *Far points* to *Near points*. The limiting distance is scaled relative to the size of the coarse point cloud.

*Scene center based*

Points which exceed a certain limiting distance to the scene center are removed from *ROI*. The limiting distance decreases if the slider is moved from *Far points* to *Near points*. The limiting distance is scaled relative to the size of the coarse point cloud.

*Custom ROI*

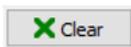
The *ROI* can be defined with a drawn polygon by the user

*Select*



Activates the drawing mode

*Clear*



Clears the defined *ROI*

*Import ROI*



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

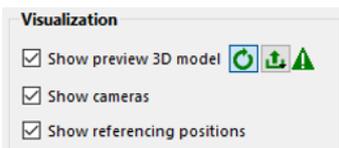
*Save ROI*



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 ".jm3" or ".obj"

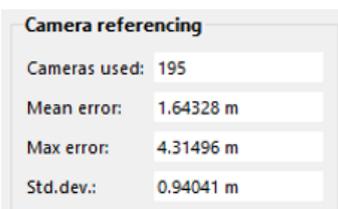
*Show cameras*

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**



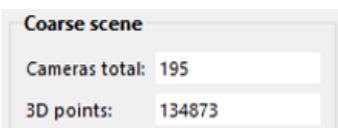
*Camera used*

Number of camera position used for referencing

*Statistics*

Mean error, maximum error and standard deviation

**Coarse Scene**



*Cameras total*

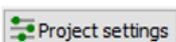
Number of camera positions (images) used for generating the scene

*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 8.

*Help*

**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 “jm3” 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 14)



Figure 14: 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 15).

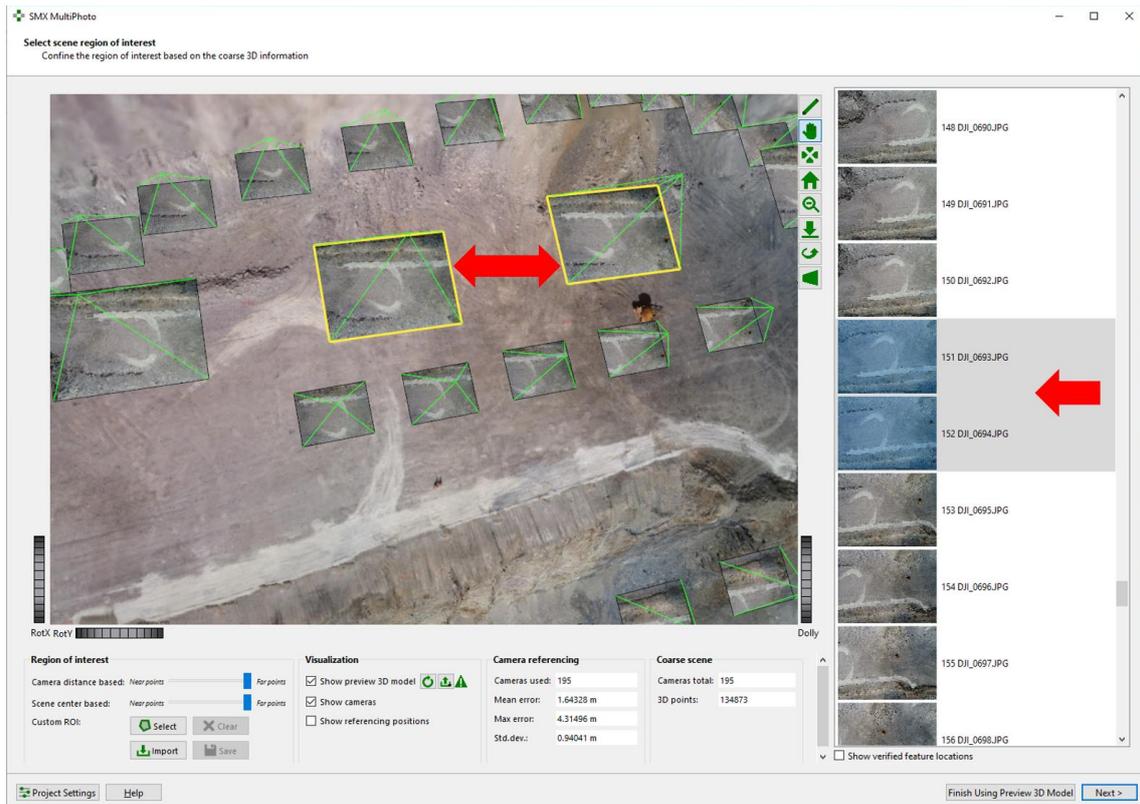


Figure 15: Highlighted camera position of selected images

**5.2.3 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 16). The polygon should define the desired ROI.
    - iii. Relieve the mouse button and the point cloud is reduced to the outlined ROI (Figure 17).
    - 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.

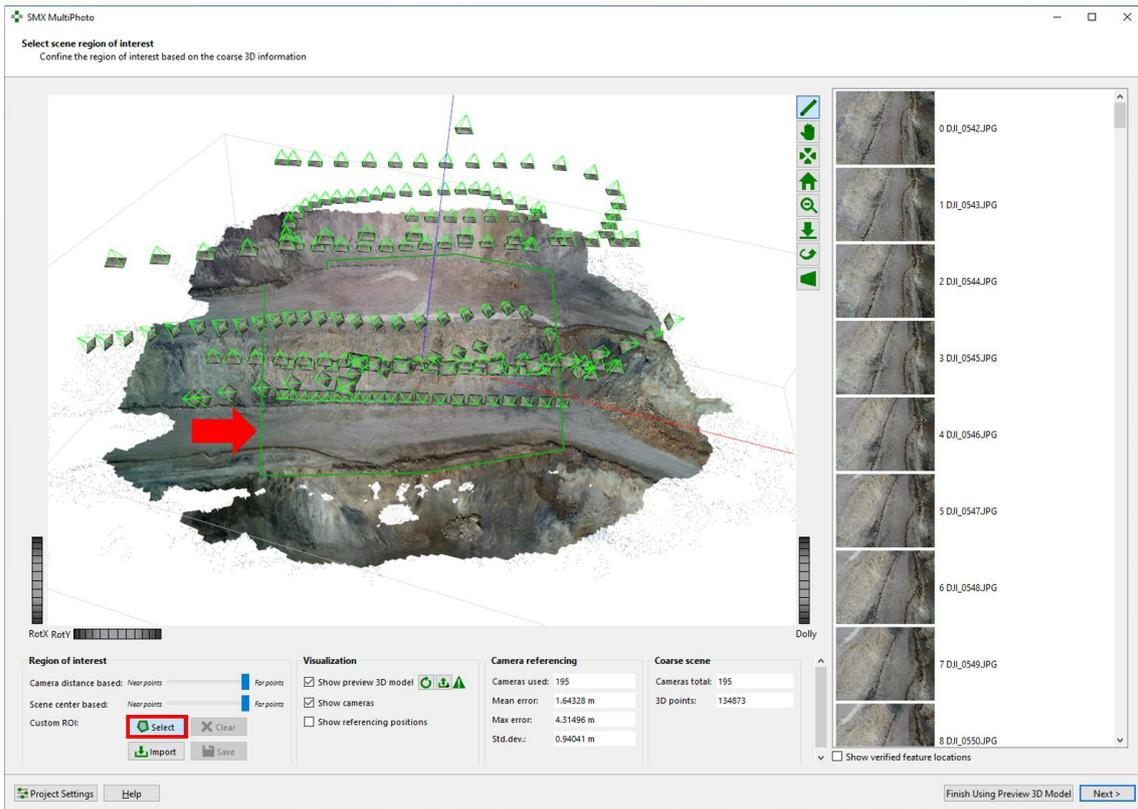
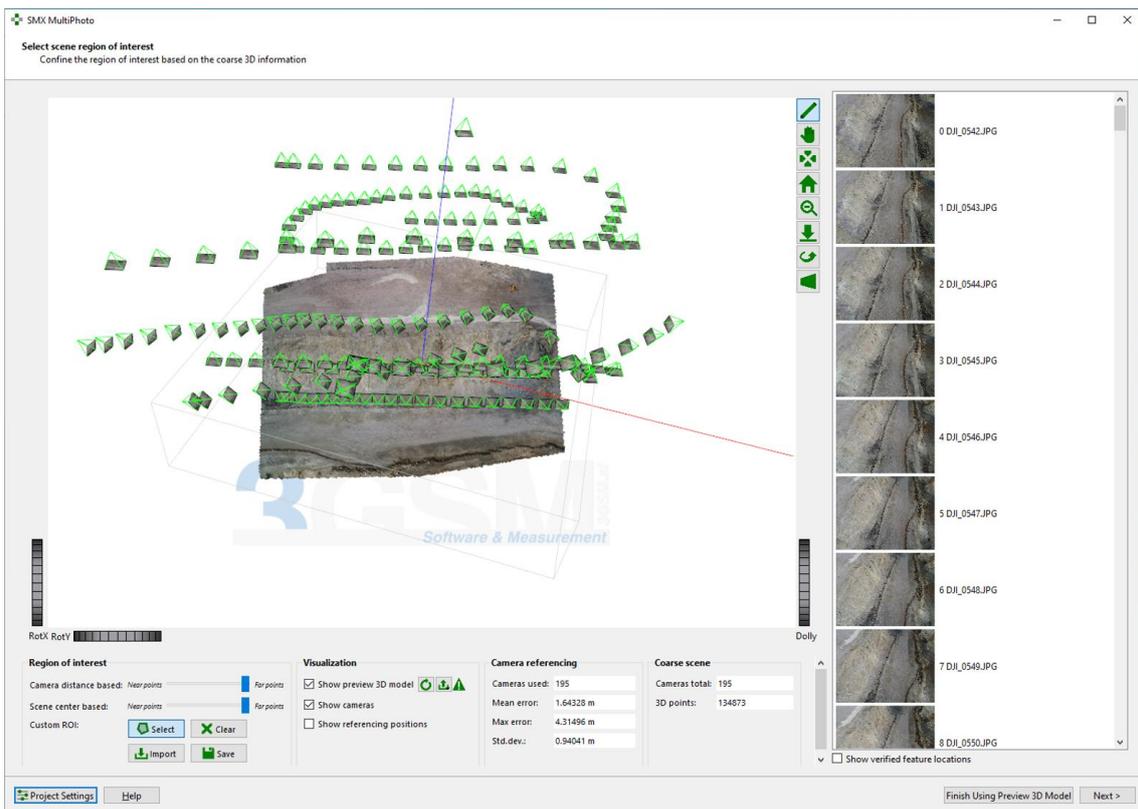


Figure 16: Definition of ROI with a polygon (green solid line)



*Figure 17: Defined ROI after relieving the left mouse button. The point cloud and the coarse 3D model are limited to the ROI. Note the minimized bounding box.*

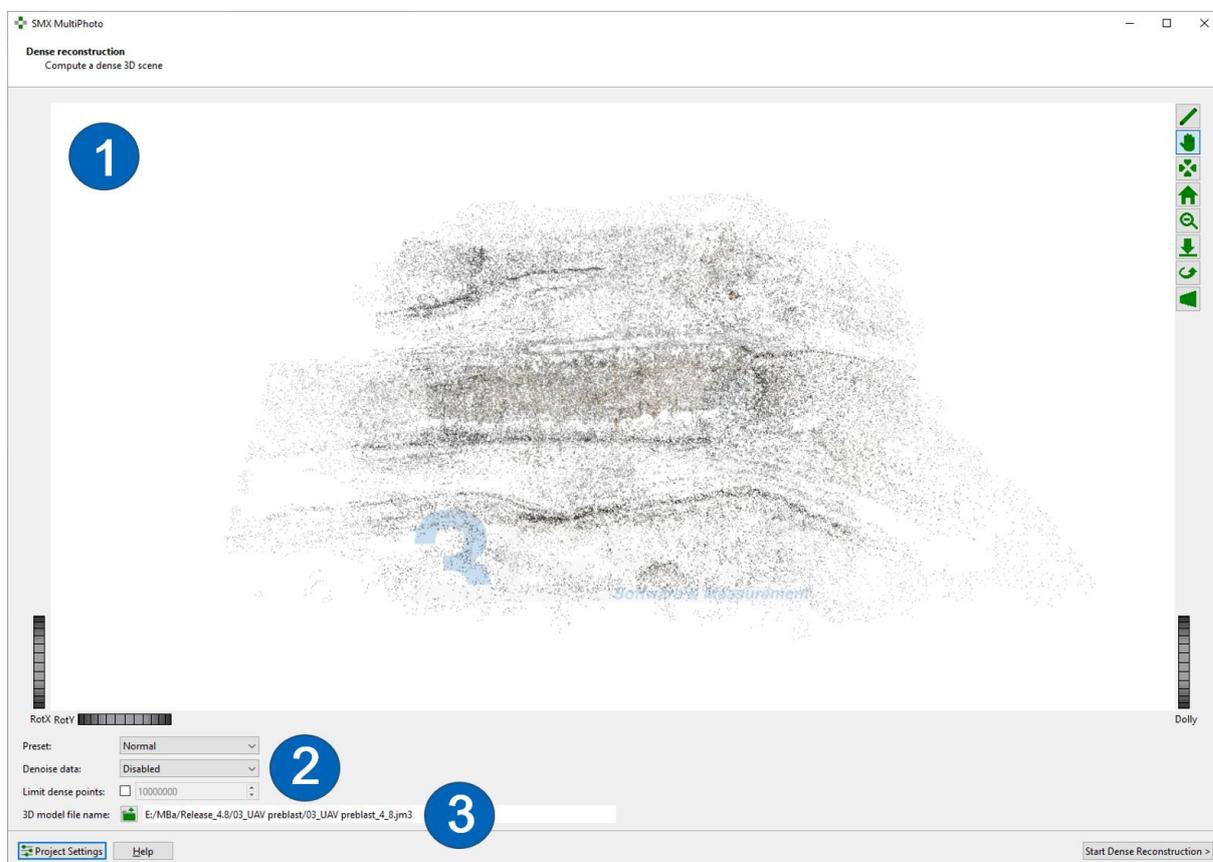
**Note:**  
 The update of the preview 3D model by using the “Update Preview 3D Model”  button is not mandatory. It should be performed only if the coarse 3D model shows distorted or unwanted surface measurements (e.g. sky or floor at border regions). No update is required for the *Dense Reconstruction*, the ROI is considered even without updating the preview 3D model.

### 5.3 Dense Reconstruction

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

#### 5.3.1 User interface

The user interface *Dense Reconstruction* of the *SMX MultiPhoto* comprises the 3D viewer with the navigation bar displaying the coarse 3D point cloud and the settings for *Dense Reconstruction* (Figure 18).



- 1 3D viewer with coarse 3D point cloud
- 2 *Dense Reconstruction* settings
- 3 Output file (“.jm3”)

Figure 18: User interface *Dense Reconstruction*

### 5.3.2 Features

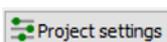
The following section describes the available functions of *the Dense Reconstruction* interface.

#### 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 (".jm3" file)

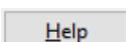
#### General

##### *Project Settings*



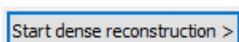
Allows to adapt the export settings of the current project (generation of the reconstruction report, ortho-photo, GeoTIFF and ".obj" export). See Chapter 8.

##### *Help*



Opens the user manual

##### *Start Dense Reconstruction*



Starts the reconstruction process and continues to the next step

### 5.3.3 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 (“.jm3”) 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 19).
7. Inspect the 3D model in the 3D viewer

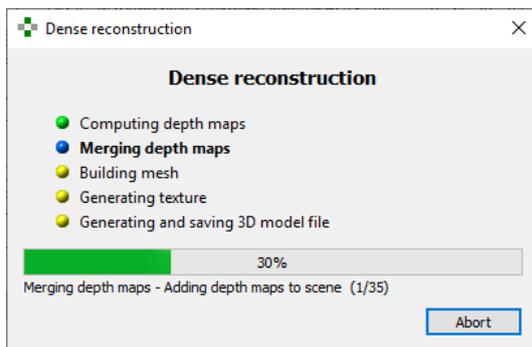


Figure 19: Progress window: Dense Reconstruction

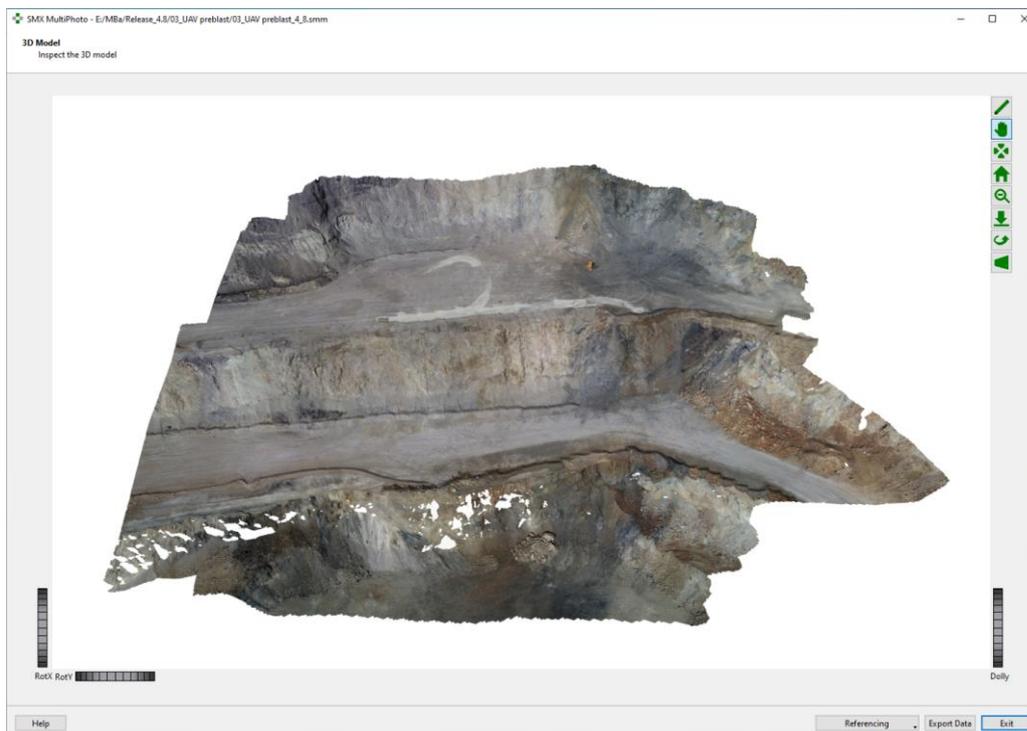


Figure 20: Final 3D model

### 5.4 Standard Referencing

SMX MultiPhoto provides three 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.
- *Sample Mode*  
Scaling in a local co-ordinate system

To enter the referencing interface the button Referencing “Referencing” and “Control Points” from the pull down menu (Figure 21) has to be selected.

**Note:**  
The actions *Control Points* and *Stereo Setups* marked with asterisk pointing out unsaved data.

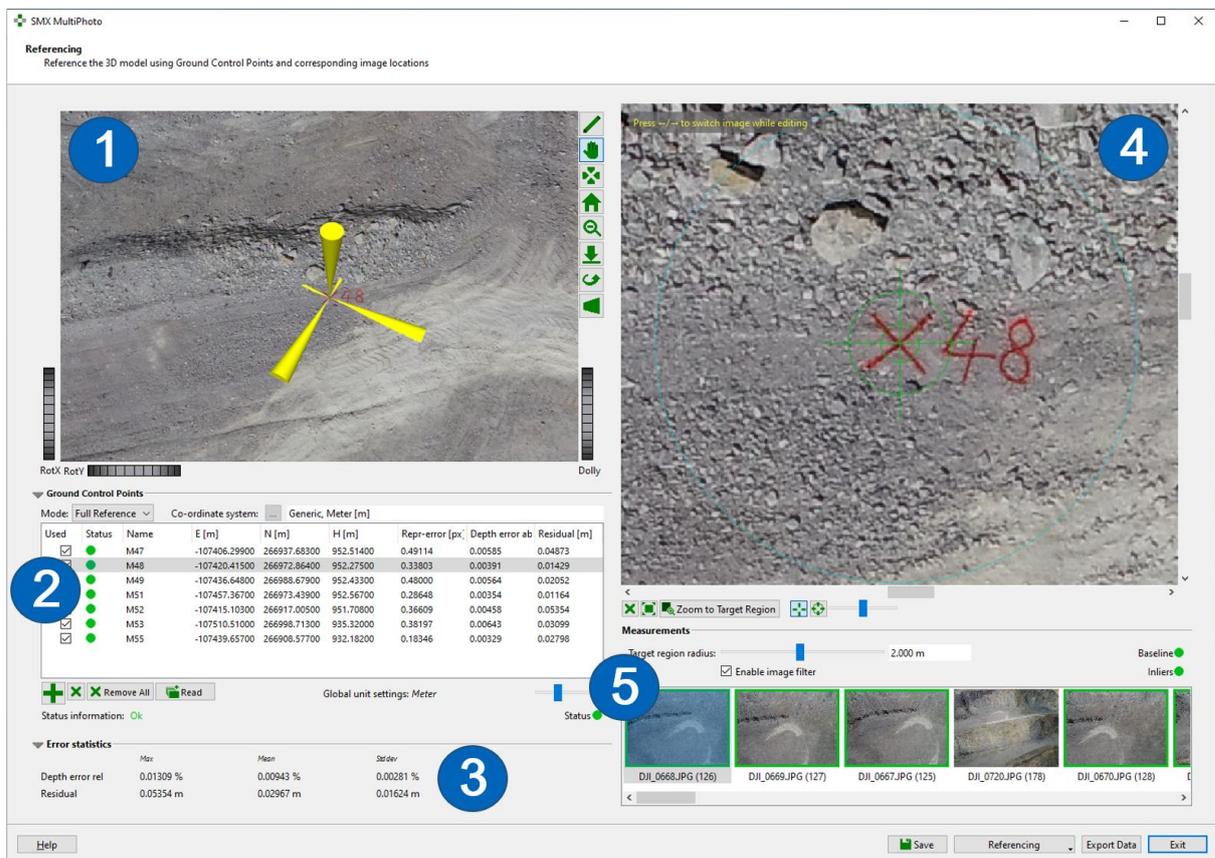


Figure 21: Action Control Points from the pull-down menu to transfer the model into a superior co-ordinate system

### 5.4.1 User interface

The user interface *Referencing* of the *SMX 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 Statistics
- 4 View of the selected image
- 5 Partner images

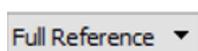
Figure 22: User interface Referencing

### 5.4.2 Features

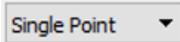
The following section describes the available functions of the *Referencing* window.

#### Ground Control Points

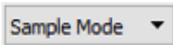
*Full Reference*



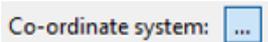
Mode for referencing the 3D model using three or more *GCP*

*Single Point*

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

*Sample Mode*

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

*Co-ordinate system*

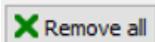
Browse a specific co-ordinate system (Figure 8) or choose *Generic*

*Add GCP*

Adds a new *GCP*

*Remove selected GCP*

Removes the selected *GCP*

*Remove all GCP*

Removes all *GCP*

*Read GCP from text file*

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

*Slider Target Size*

Changes the size of the target in the 3D viewer

**Image preview and measurements***Remove Current Image Measurement*

Removes the current measurement

*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

*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*



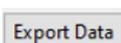
References and saves the 3D model (".jm3")

*Referencing*



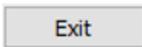
Choose another action: *Inspect 3D Model* or *Stereo Setups*

*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 8.

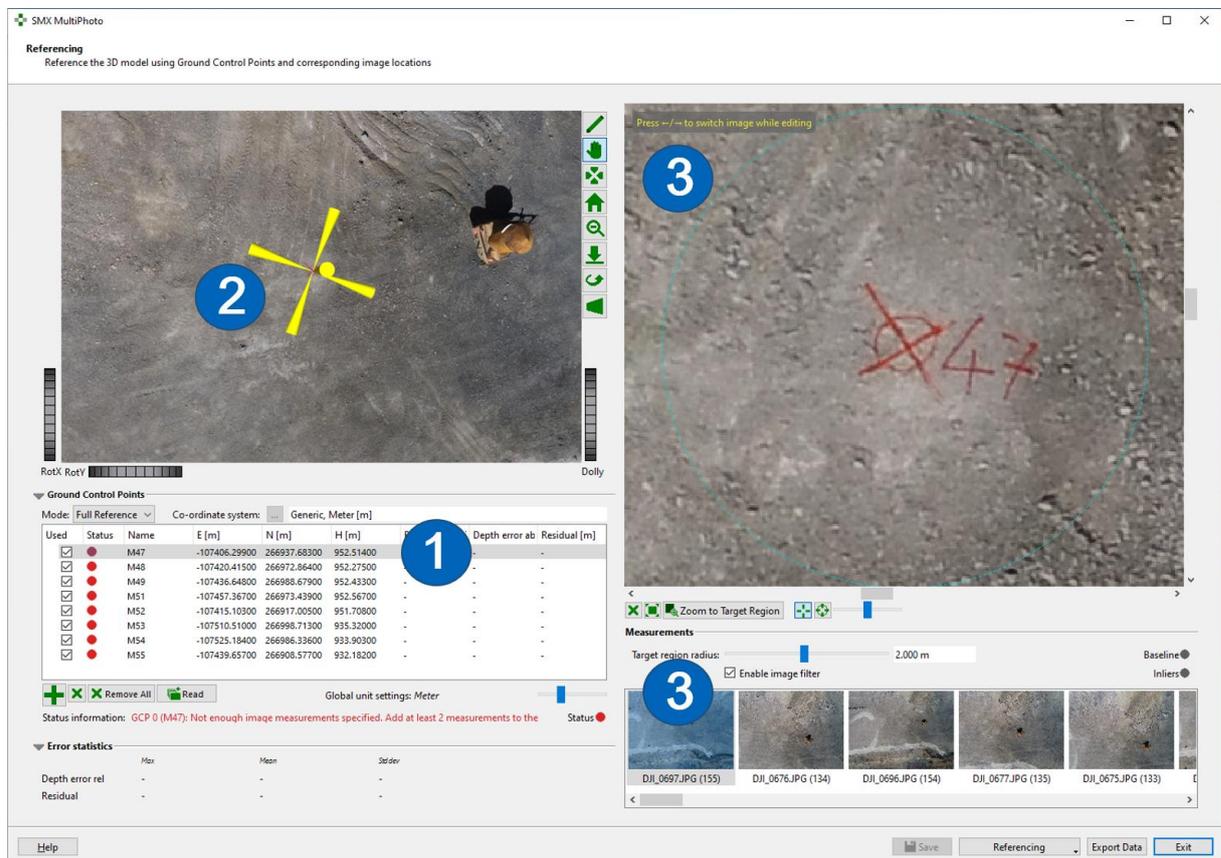
Exit



Closes the SMX MultiPhoto

5.4.3 Procedure - Full Reference

1. Choose the mode "Full Reference" from the pull down menu.
2. 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 file (".csv", ".txt", ".dat", ".prt"). See Chapter 5.4.6 for further details.
3. 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 23.



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

Figure 23: Localizing GCP in the 3D viewer

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 24).

- Choose at least 2 images (more than 3 are recommended) showing the same GCP and centre the target position in the viewer. 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 25.

**Hint:**

Switch between the individual images in the list by using the arrow keys left and right.

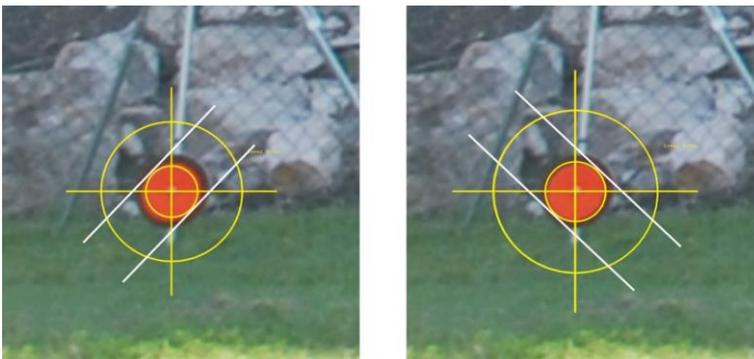


Figure 24: Check of the target center

Used	Status	Name	E (m)	N (m)	H (m)	Repr. error (m)	Depth error (m)	Residual (m)
<input checked="" type="checkbox"/>	●	M47	-107406.29900	266937.88300	952.51400	0.24644	0.00318	-
<input checked="" type="checkbox"/>	●	M48	-107420.41500	266972.86400	952.27500	-	-	-
<input checked="" type="checkbox"/>	●	M49	-107436.64900	266988.67900	952.43300	-	-	-
<input checked="" type="checkbox"/>	●	M51	-107457.38700	266973.43900	952.56700	-	-	-
<input checked="" type="checkbox"/>	●	M52	-107415.10300	266917.00500	951.70800	-	-	-
<input checked="" type="checkbox"/>	●	M53	-107510.51000	266998.71300	935.32000	-	-	-
<input checked="" type="checkbox"/>	●	M54	-107525.18400	266998.33600	933.90300	-	-	-
<input checked="" type="checkbox"/>	●	M55	-107439.65700	266908.57700	932.18200	-	-	-

Figure 25: 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 26.
8. Choose an action form the pull down menu “Referencing” or close the *SMX MultiPhoto* by clicking the “Exit” button.

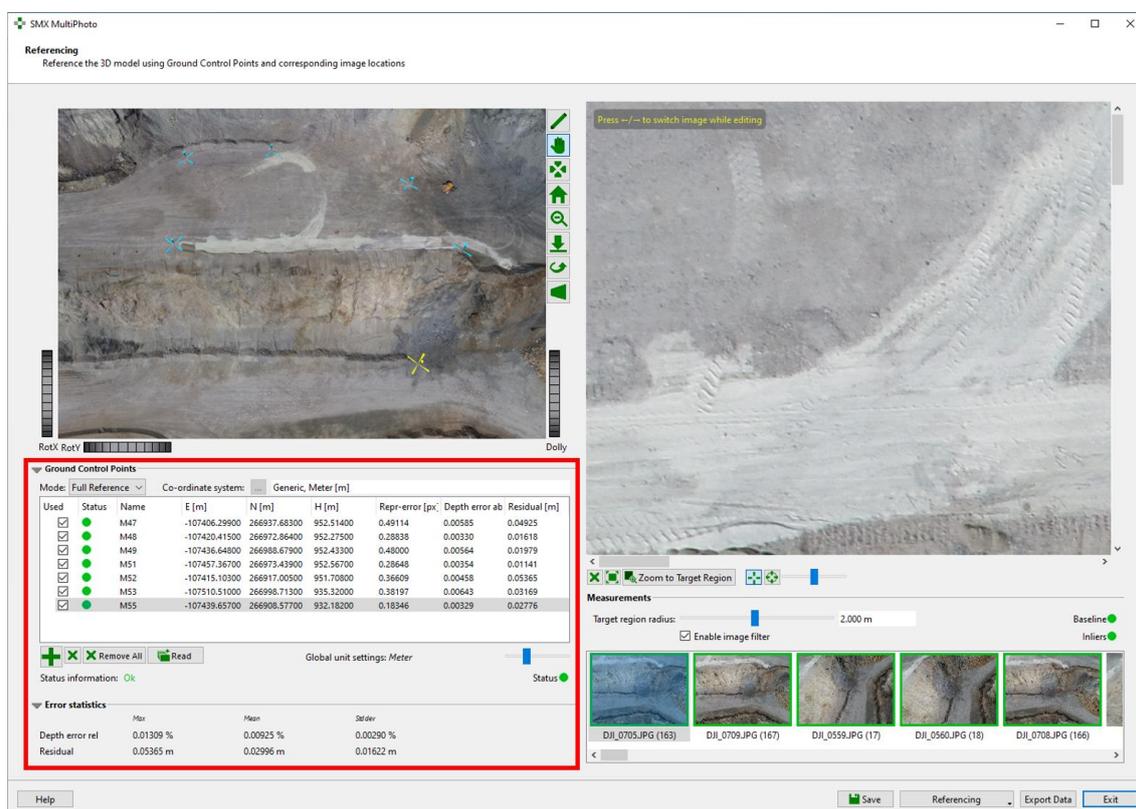


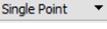
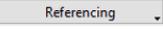
Figure 26: Valid GCP and error statistics

**Note:**  
A defined *ROI* (Chapter 5.2) does not limit the localization of *GCP*. *GCP* may be located 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:**

A *GCP* is excluded by clicking the corresponding checkbox in front of its name in the *GCP* list.

**5.4.4 Procedure – Single Point**

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 5.4.6 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 23.
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 24).
5. Choose at least 2 images (3 or more are recommended) showing the same *GCP* and centre the target position in the viewer. 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 25.
6. Check the *Status Information* (green status signals) and enable referencing by clicking the “*Save*”  button. See Figure 27.
7. Choose an action from the pull down menu “*Referencing*”  or close the *SMX 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.

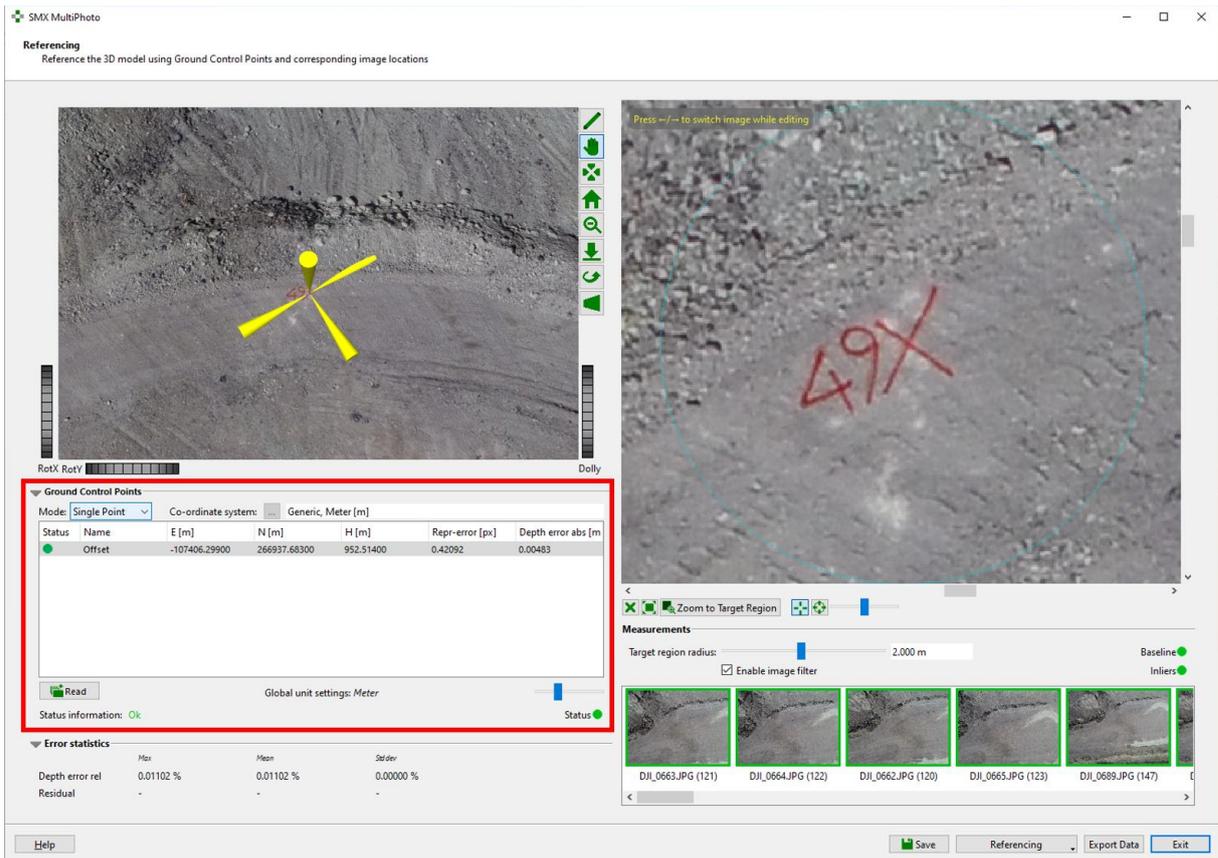


Figure 27: Single Point mode

### 5.4.5 Procedure – Sample Mode

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 23.
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 24).
4. Choose at least 2 images (3 or more are recommended) showing the same *GCP* and centre the target position in the viewer. 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 25.
5. Activate *Second Point* and Plane Point in the list and repeat steps 2 – 4.
6. Check the error statistics and the Status Information (green status signals) and enable referencing by clicking the “Save”  button. See Figure 28Figure 28.
7. Enter the distance between the *First* and the *Second Point* in the “Enter Point Distance” dialog. See Figure 29.
8. Choose an action form the pull down menu “Choose action”  or close the *SMX 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.

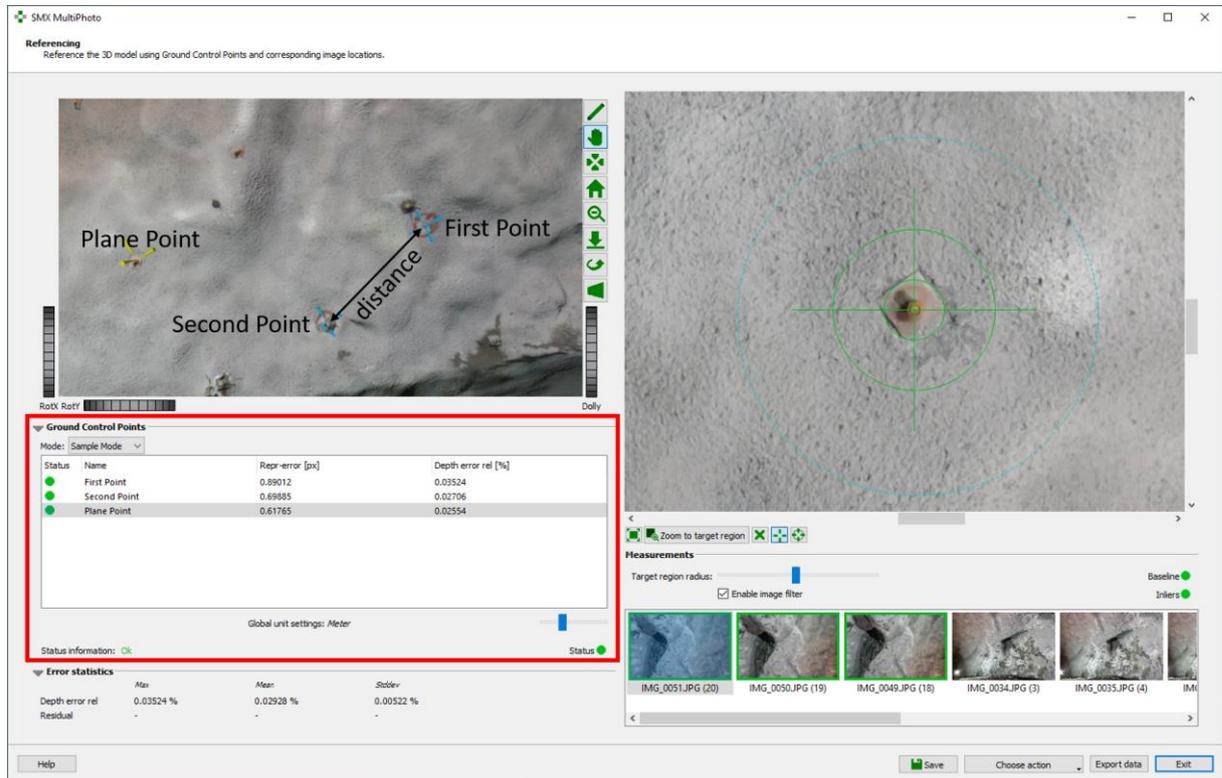


Figure 28: Standard Referencing – Sample Mode

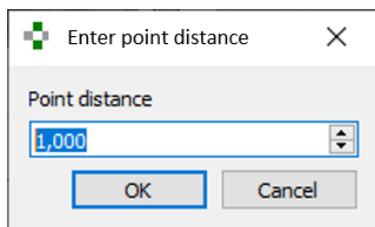


Figure 29: Enter point distance

#### 5.4.6 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 30).

##### 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**

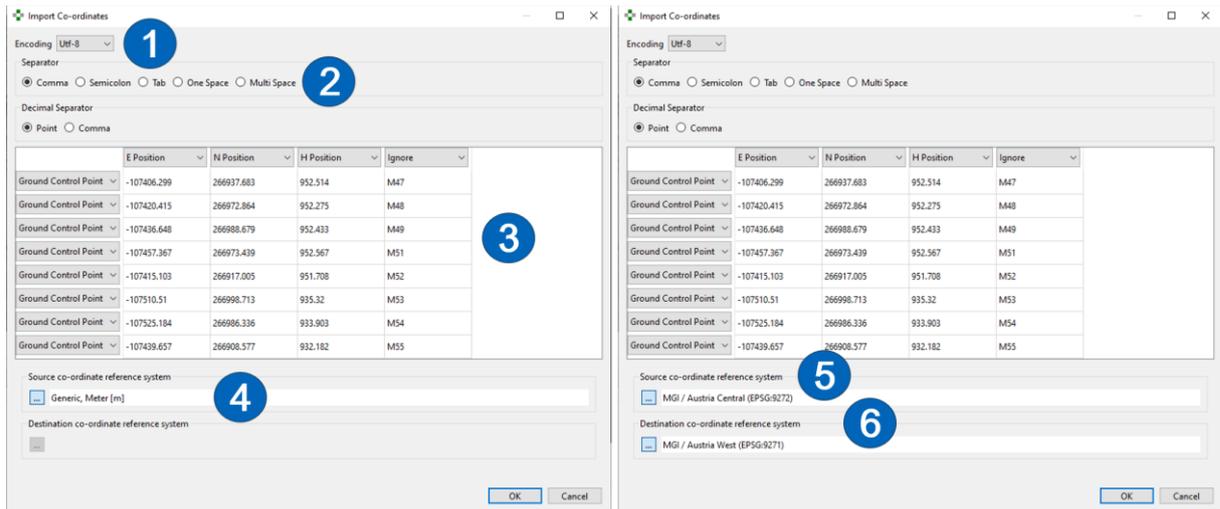
<i>9453674.75</i>	<i>456235.21</i>	<i>248.45</i>
<i>9452978.18</i>	<i>456576.89</i>	<i>223.15</i>
<i>9458763.65</i>	<i>456832.76</i>	<i>287.83</i>

**Point name and co-ordinates:****GCP\_Name / Easting / Northing / Elevation**

<i>GCP1</i>	<i>9453674.75</i>	<i>456235.21</i>	<i>248.45</i>
<i>GCP2</i>	<i>9452978.18</i>	<i>456576.89</i>	<i>223.15</i>
<i>GCP3</i>	<i>9458763.65</i>	<i>456832.76</i>	<i>287.83</i>

**Procedure:**

1. Click on the “Read GCP from text file” button.
2. A dialog window (Figure 30) 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 30):
    - 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



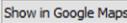
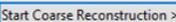
- 1 Character encoding
- 2 Separators
- 3 Data
- 4 Generic import in units (undefined source co-ordinate reference system)
- 5 Custom source co-ordinate reference system
- 6 Custom destination co-ordinate reference system

Figure 30: Import of co-ordinates. Left: generic data import. Right: customized co-ordinate system

## 6 Constrained Referencing

For the description of user interfaces and corresponding features of the individual steps refer to Chapters 5.1 (Data input and *Coarse Reconstruction*), 5.2 (*Select scene Region of Interest*) and 5.3 (*Dense Reconstruction*).

### 6.1 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. A
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 8). The export start automatically when leaving the *SMX MultiPhoto* after 3D model generation.
7. Choose *Coarse Reconstruction* settings “Normal” (default).
8. Rename the *Project File* (“.smm”) and select the directory to save by clicking the “Project file name”  icon in *General Settings*.
9. Enable the reference mode *Constrained Referencing* (Figure 31)
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.

**Note:**

The *Automatically Continue Reconstruction* does not feature the use of *Constrained Referencing* (see Chapter 3).

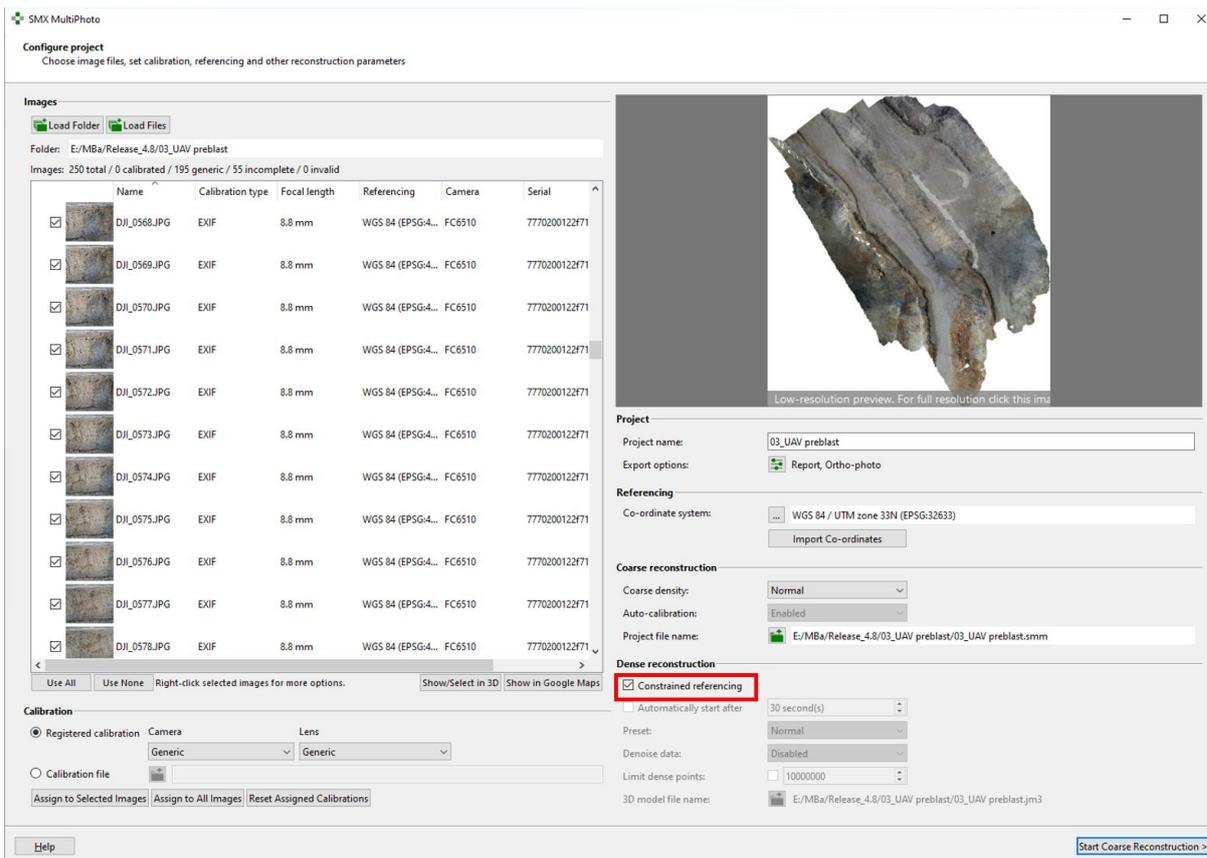


Figure 31: Enabling of the Constrained Referencing Mode

## 6.2 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 5.2 for detailed description.

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*”
    - ii. Click with the left mouse held down in the 3D viewer and draw a polygon. 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*”
3. Click on the “Next” button to continue to the next step

### 6.3 Constrained Referencing

The interface of *Constrained Referencing* (Figure 32) is similar to the *Referencing* interface (see Figure 22) whereby two additional feature are provided:

Run



Runs GCP optimization

Reset



Resets GCP optimization

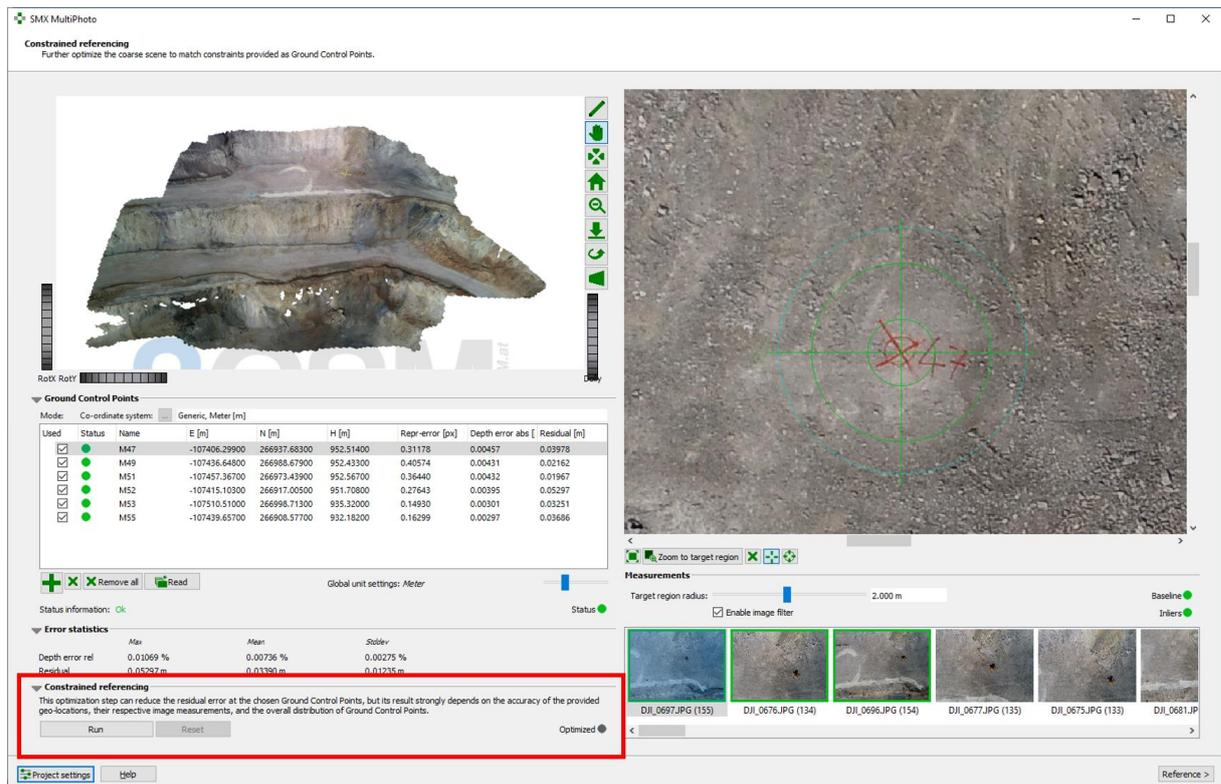
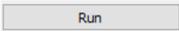
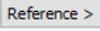


Figure 32: Interface of Constrained Optimization

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 file (“.csv”, “.txt”, “.dat”, “.prt”). See Chapter 5.4.6 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.
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.
4. Choose at least 2 images (more than 3 are recommended) showing the same *GCP* and centre the target position in the viewer. The status signals *Baseline* and the *Inliers* turn into green and the error of re-projection and depth is displayed in the *GCP* list.
5. Activate the next *GCP* in the list and repeat steps 2 – 4. Continue until all *GCP* positions are localized.
6. Check the *Status Information* (green status signals) and enable referencing by clicking the “*Run*”  button. The *Optimized* signal turn into green.
7. Check the error statistics and enable referencing by clicking the “*Reference*”  button (Figure 33)

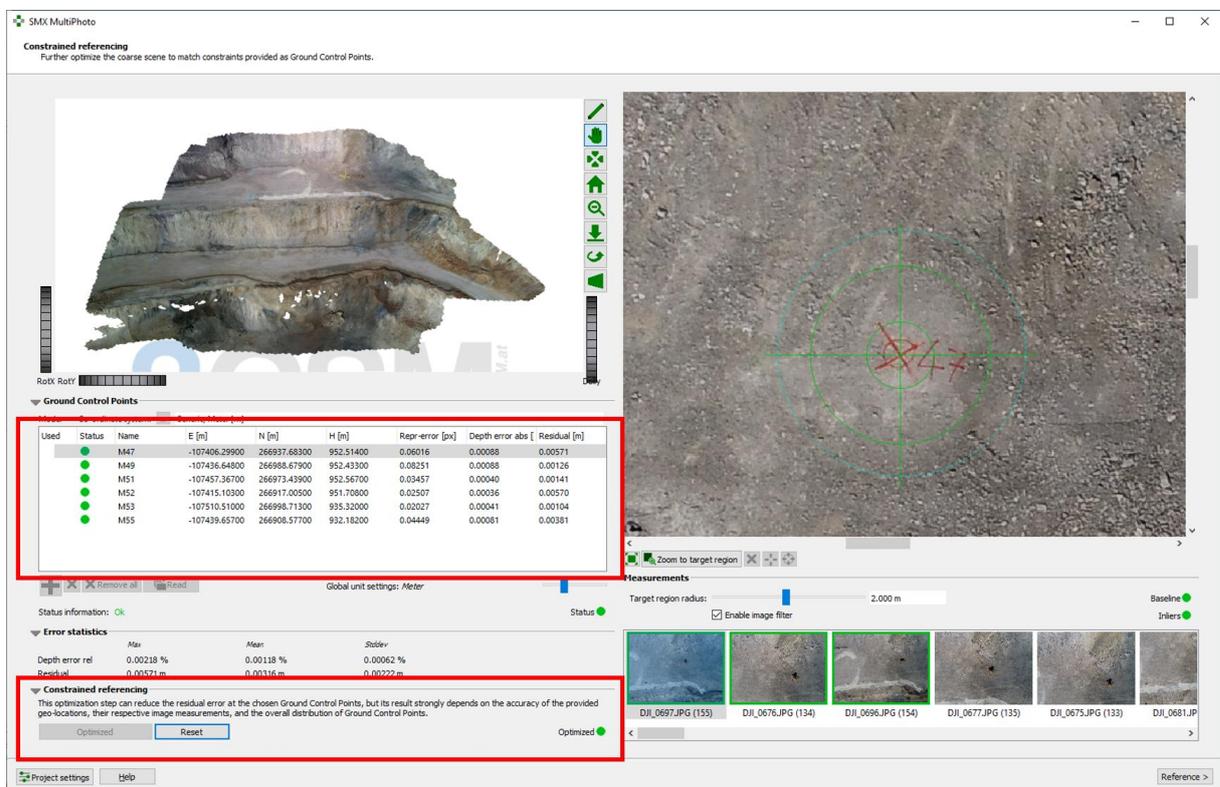
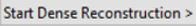


Figure 33: Valid GCP positions and optimized error statistics

## 6.4 Dense Reconstruction

See Chapter 5.3 for detailed description.

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 (“.jm3”) 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 19).
7. Inspect the 3D model in the 3D viewer
8. Close the *SMX MultiPhoto* by clicking the “*Exit*”  button.

## 7 Selection of Stereo Setups

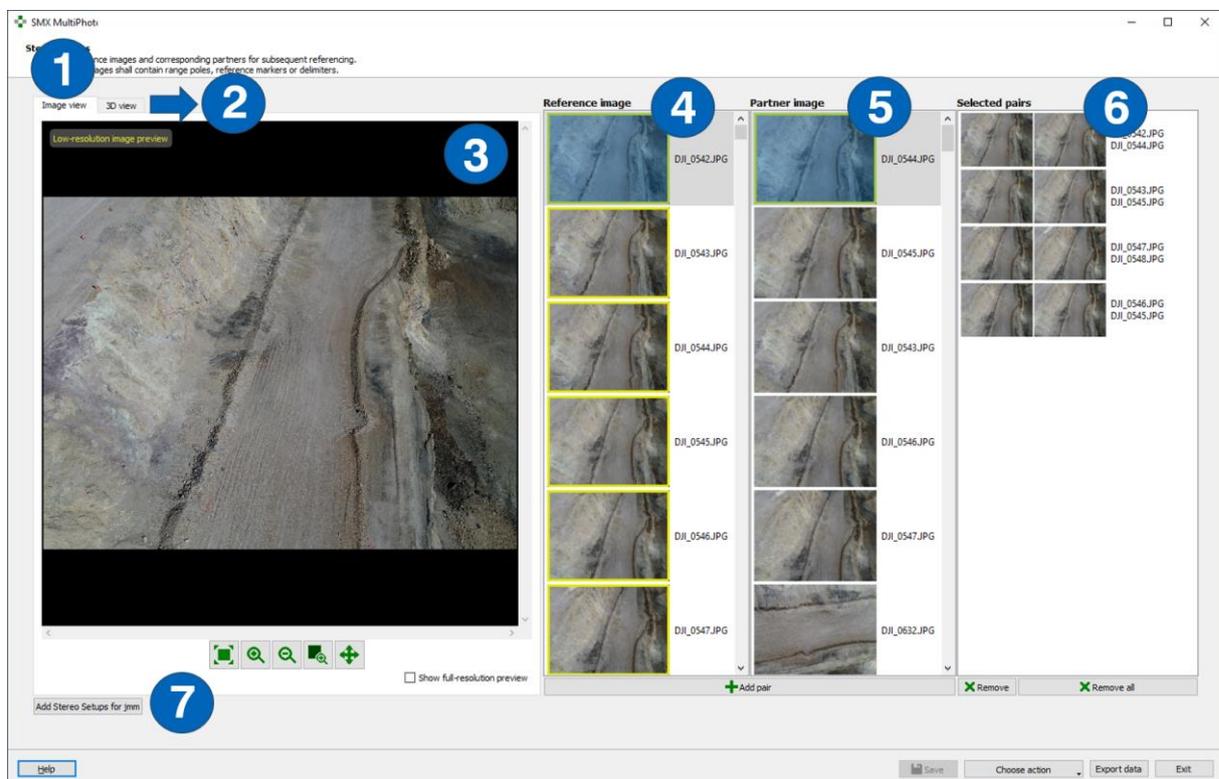
Image pairs, so called *Stereo Setups*, are used for:

- scaling a generic 3D model in a local co-ordinate system with the *SMX Normalizer*
- transforming a *2D Map* onto a *3D model* with the *SMX Mapper*
- scaling/referencing a 3D model by the use of *Range Poles* with the *BMX BlastSiteGenerator*

*Stereo Setups* can be added to the *3D Model* only manually by the user. Refer to the corresponding user manuals for further information.

### 7.1 User interface

The user interface *Stereo Setup* (Figure 34) of the *SMX MultiPhoto* allows the selection of image pairs, so called *Stereo Setups*. It comprises a preview window (*Image View* tab), a list of *Reference Images* with corresponding *Partner Images* and the list of *Selected Pairs*. The *3D View* tab shows the generated model in the 3D viewer.



- 1 *Image View* tab
- 2 *3D View* tab
- 3 Preview window
- 4 List of *Reference Images*
- 5 List of *Partner Images*
- 6 List of *Selected Pairs*
- 7 *Add Stereo Setups* for“.jmm”

Figure 34: User interface *Stereo Setup* of the *SMX MultiPhoto*

## 7.2 Preview window

The *Preview* window (Figure 35) allows a detailed view of the selected image. By enabling the checkbox “*Show full-resolution preview*”  *Show full-resolution preview* the images are provided in full resolution in the viewer.



Figure 35: Preview window

### Toolbar

The viewer comprises two scroll bars and a toolbar supporting the image display with following features:

#### Window fit



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

#### Zoom in



Zooms into the photo

#### Zoom out



Zooms out of the photo

#### Zoom to region



Enables to zoom in and out by using the computer mouse

Move



Enables mouse navigation

**Hint:**

Zooming can also be done using the mouse wheel. Click on middle mouse button zooms in and centres the photograph to the clicked point. In general clicking with the left mouse button performs an action, for instance definition of points.

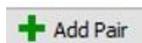
**Hint:**

Panning is performed with the horizontal and vertical scroll bars at the bottom and the right hand side of the viewer window.

### 7.3 Features

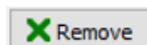
This section describes the available functions *of the selection of Stereo Setups window.*

Add Pair



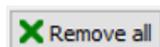
Adds the selected *Reference Image* and *Partner Image* to the list of *Selected Pairs*

Remove



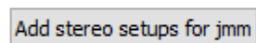
Removes the selected image pair

Remove all



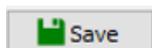
Removes all *Selected Pairs*

Add Stereo Setups for jmm



Adds *Stereo Setups* containing pictures of a *2D Map* (".jmm")

Save



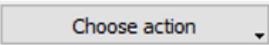
Saves the selected image pairs to the 3D model (".jm3")

#### Export Data



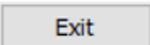
Opens the *Export Options* dialog for the generation of the reconstruction report and ortho-photo

#### Choose Action



Choose another action: *3D Model* or *Referencing*

#### Exit



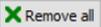
Closes the *SMX MultiPhoto*

## 7.4 Scaling in a local co-ordinate system

A click on the *Reference Image* or the *Partner Image* displays the photo in the *Preview* window. It allows inspecting the photos to identify the marking elements for scaling (refer to the *SMX Normalizer* or *BXM BlastSiteGenerator* user manual for further information). Marking elements located in the *Reference Image* have to be clearly visible in the corresponding *Partner Image* as well. If a *Reference Image* is selected, the related *Partner Image* is also highlighted by grey shading (Figure 34).

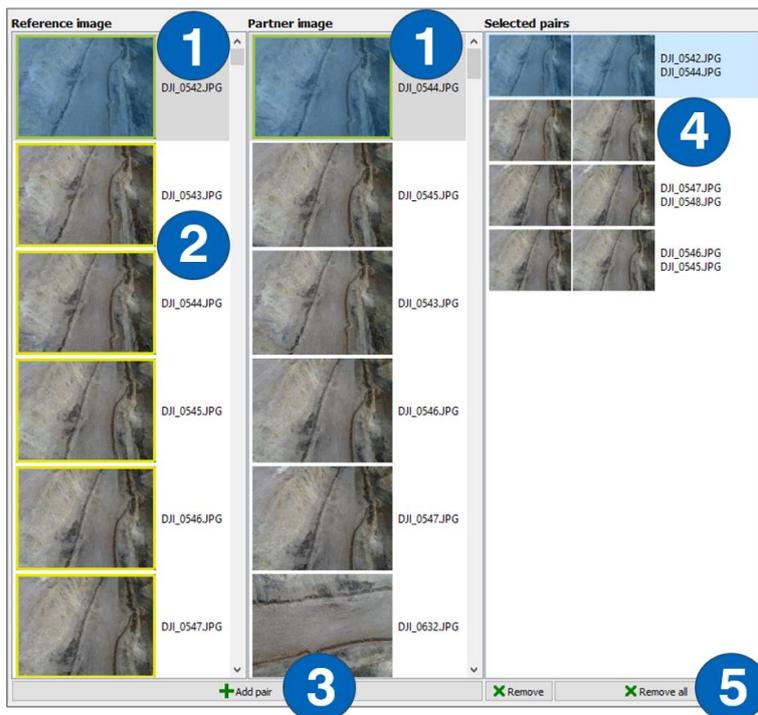
#### Note:

The *Partner Images* are automatically ranked by the software. The first *Partner Image* in the list fits best to the selected *Reference Image*, followed by the second et cetera. Ranking criteria include the number point correspondences, the similarity in image scale and the baseline - distance ratio.

If the automatically selected *Partner Image* does not comply the requirements (e.g. the *Partner Image* does not contain the required marking element), or it shows an unfavourable position, another *Partner Image* shall to be chosen from the list. An image pair consisting of the selected *Reference Image* and *Partner Image* is added to the image pair list by clicking “Add Pair”  button. Images forming *Stereo Setups* are surrounded with a yellow frame in the list (Figure 34). *Selected Pairs* can be removed individually or collectively from the list by a click on “Remove”  or “Remove all”  button respectively.

#### Note:

The defined *ROI* (optional) does not limit the listed *Reference Images*. The list corresponds to the images used for *Coarse Reconstruction*.



- 1 Reference Images and Partner Images
- 2 Selected Pairs
- 3 Add pairs
- 4 List of Selected Pairs
- 5 Edit list of Selected Pairs

Figure 36: List of images, the corresponding Partner Images and the Selected Pairs

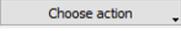
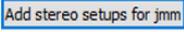
Procedure:

1. Choose the action *Stereo Setups* from the pull down menu “Choose Action” .
2. Choose a *Reference Image* with a click in the corresponding list. The *Partner Image* is automatically selected by the software and displayed in the corresponding list (first entry).
3. If the *Partner Image* does not comply the expectations, check the next image from the list until a suitable is found.
4. Add the selected images to the list of *Selected Pairs* by a click on “Add Pair”  button.
5. If necessary, remove *Selected Pairs* by a click on “Remove”  or “Remove all”  button.
6. After selecting all required pairs click on “Save”  button to save the *Stereo Setups* selection.

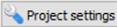
## 7.5 Transformation of Maps – SMX Mapper

2D Maps are generated with the software component *SMX Mapper*. In order to use the 2D Map with the 3D models it is necessary to transform the 2D Map onto the 3D model. For this reason, the photos used for generating the 2D Maps must be used for the 3D model generation and be part of the camera setup of the *Coarse Reconstruction*. For 3D models generated with *SMX MultiPhoto* it is necessary that all photos corresponding to a 2D Map are also part of *Stereo Setups*. In order to ease the identification of the correct photos one can use the feature “Add Stereo Setups for jmm” (Figure 34). The user selects a 2D Map (“.jmm” file) and suitable *Stereo Setups* corresponding to the 2D Maps are chosen in the list of *Selected Pairs*.

Procedure:

1. Choose the action *Stereo Setups* from the pull down menu “Choose Action” .
2. Click on the “Add Stereo Setup for jmm”  button and load the image used for mapping.
3. After selecting the required image click on “Save”  button.

## 8 Export options

The export of data is enabled in the “Export Options” dialog (Figure 37) opened by clicking the “Export Data”  button or “Project Setting”  button (see Chapter 5.1.2, 5.2.2 and 5.3.2) in the individual interfaces of the *SMX MultiPhoto*. Selected exports are generated and saved automatically by the software after closing the *SMX MultiPhoto*.

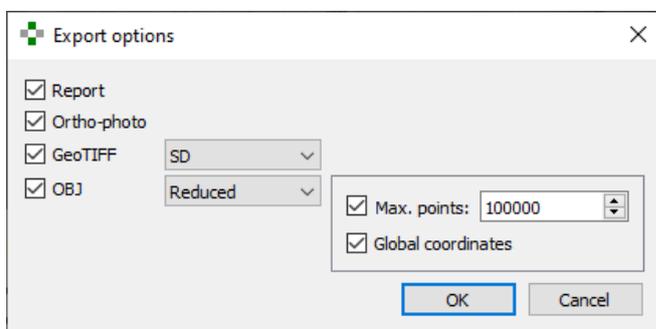


Figure 37: Export options

The *SMX 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 38).
- Ortho-Photo (“.png”; Figure 39)
- 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.

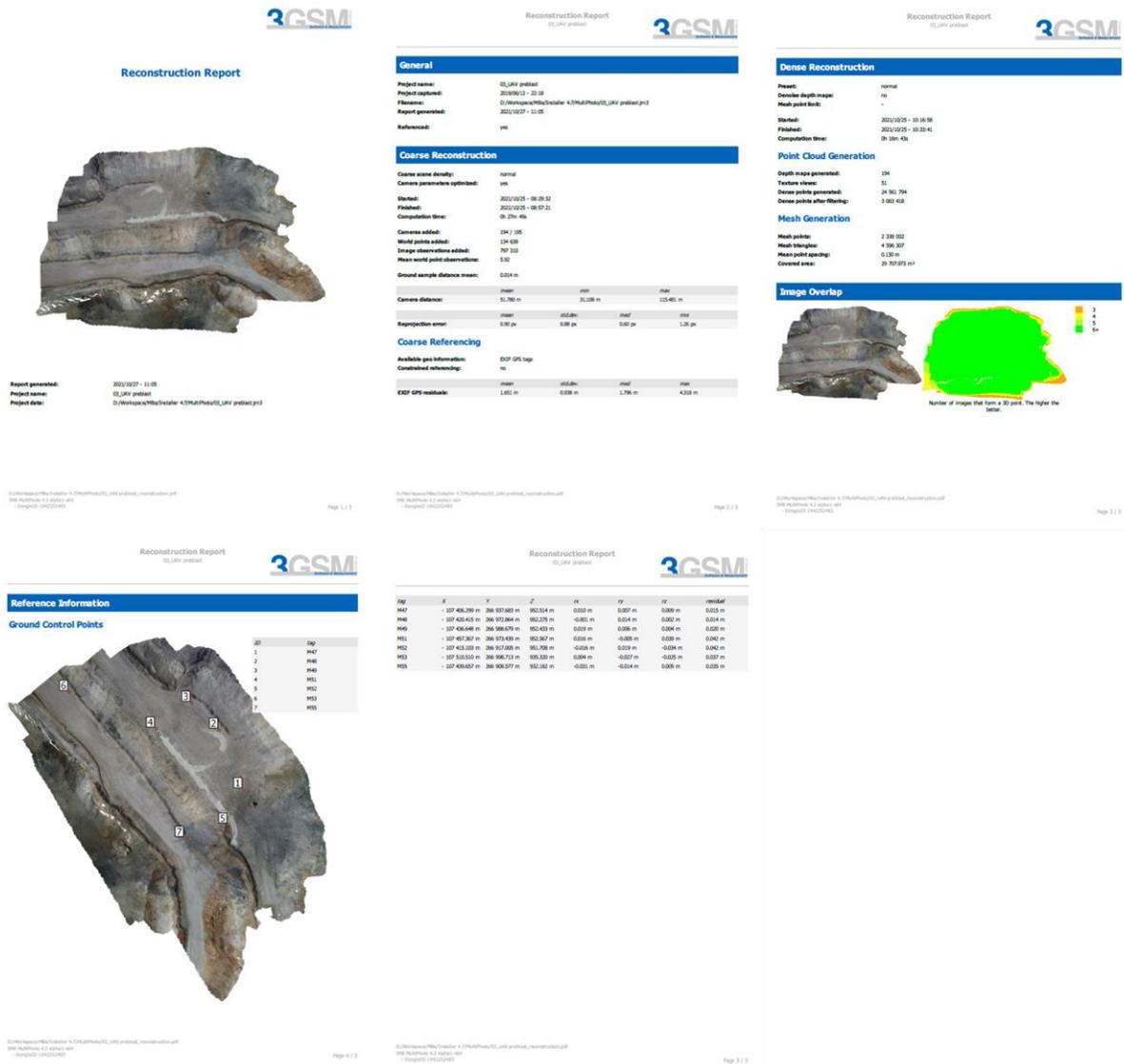
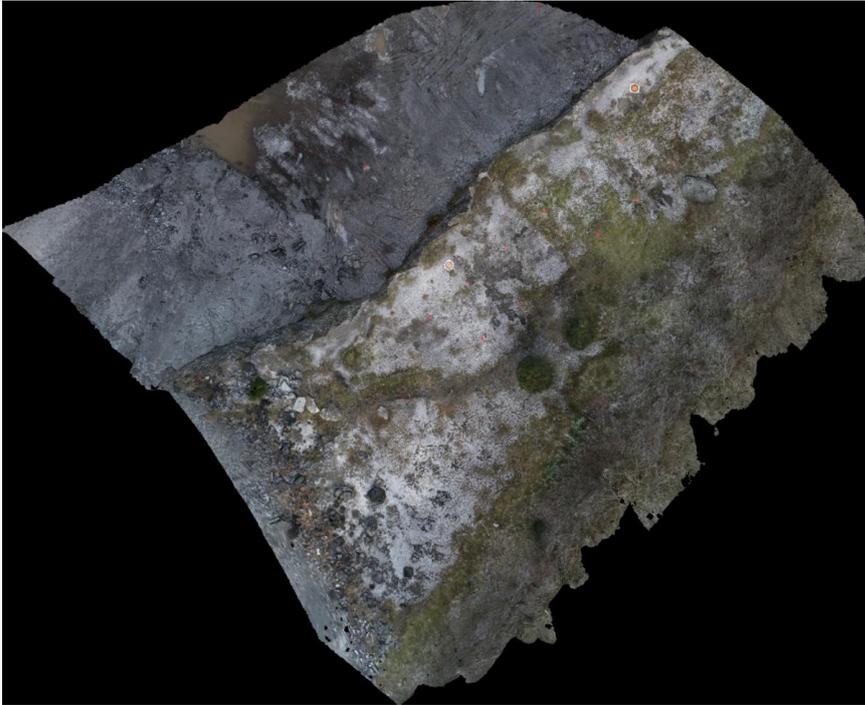


Figure 38: Reconstruction report of the SMX MultiPhoto



*Figure 39: Ortho-photo generated by the SMX MultiPhoto*