3GSM

TUTORIAL 2

STANDARD AND CONSTRAINED REFERENCING USING GROUND CONTROL POINTS

MultiPhoto is a convenient tool designed for generating 3D models from multiple overlapping images, typically obtained from aerial photography using Unmanned Aerial Vehicle (UAV) systems. After the user sets all the input parameters, the reconstruction process runs automatically. Additionally, MultiPhoto includes **standard** and **constrained referencing** features that references the 3D model to a higher-level coordinate system using externally surveyed **Ground Control Points (GCP)**.

This tutorial help will you become familiar with the process of performing **standard** and **constrained referencing** in **ShapeMetriX's MultiPhoto** tool.

TOPICS COVERED IN THIS TUTORIAL

- Standard Referencing
- Constrained Referencing

FINISHED PRODUCT

The finished products of this tutorial can be found in *Tutorial 2 - Standard and Constrained Referencing Using Ground Control Points* file, located in the downloaded *Tutorial 2 - Standard and Constrained Referencing Using Ground Control Points.zip* folder.

1.0 INTRODUCTION

Standard Referencing is a post-processing step which is performed after Dense Reconstruction of the 3D model (3D model generation is discussed in more detail in *Tutorial 1 – 3D Model Generation*).

MultiPhoto provides three different modes of standard referencing:

- **Full Reference** 3D model is converted into a higher-level coordinate system using the known coordinates of **at least three** externally surveyed GCPs through a similarity transformation.
- **Single Point** 3D model is transferred to a coordinate system using the coordinates of a single externally surveyed point (GCP) through a similarity transformation. This mode is only available if the model is already referenced (EXIF GPS). It allows the 3D model to be transferred to a user-defined coordinate system.
- **Sample Mode** 3D model is scaled in a local coordinate system.

Constrained Referencing optimises the 3D model by using the positions of externally surveyed GCPs to achieve better spatial accuracy. Initial camera positions are readjusted and optimised, and the generated 3D points of the dense point cloud (3D model) are aligned to the GCP coordinates.

Note:

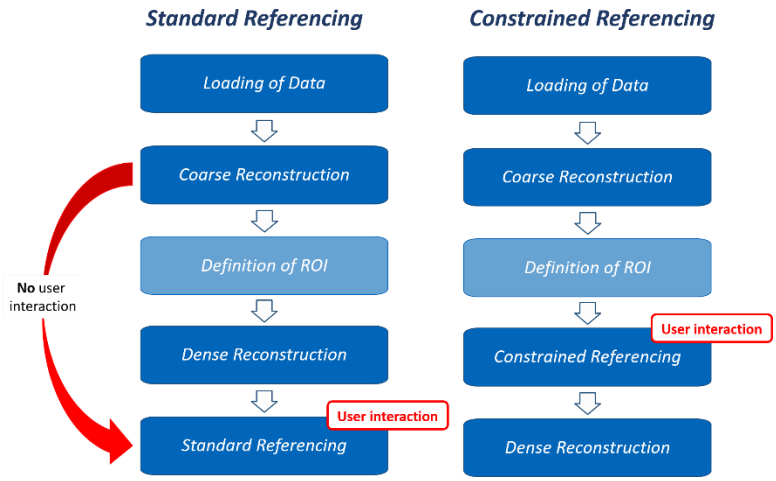
Constrained Referencing strongly depends on the accuracy of the provided geo-locations and their respective image measurements and needs **reliable** and **precise** data for a successful application.

Constrained Referencing requires a step-by-step procedure for generating the 3D model. First, the image data is loaded in the **Configure Project** view and coarse 3D point cloud is created using **Coarse Reconstruction**. Then, in an intermediate step, GCP constrained optimisation of the model (Constrained Referencing) is performed. After this optimisation, the final 3D model (**.jm3x*) is generated using **Dense Reconstruction**.

Note:

GCP constrained optimization is an intermediate operation in 3D model reconstruction procedure and cannot be performed post dense reconstruction.

The workflow of **Standard Referencing** and **Constrained Referencing** is summarised in the chart below. Please note that definition of a **Region of Interest (ROI)** is optional and can be skipped.



2.0 STANDARD REFERENCING

Standard referencing can be performed in two ways:

1. As the last step during a standard 3D model generation procedure (3D model generation is discussed in more detail in *Tutorial 1 – 3D Model Generation*).
2. By selecting **Perform Referencing** in the **MultiPhoto Workflow Selection** page and loading an existing project file (**.smm* file; coarse reconstruction) and corresponding 3D model file (**.jm3x* file; dense construction).

2.1 Project Import

1. Run the ShapeMetriX (SMX) program by double-clicking the **SMX** icon in your installation folder or by selecting **Programs > ShapeMetriX > ShapeMetriX** in the Windows Start menu.

ShapeMetriX comes with several example images and files installed with the program. For this tutorial though, we will use the *Bench Example.smm*, *Bench Example.jm3x* and *GCP.csv* files included in the downloaded *Tutorial 2 - Standard and Constrained Referencing Using Ground Control Points.zip* folder to demonstrate the standard referencing features of ShapeMetriX.

2. Select the  **MultiPhoto** tool
3. Select **Perform Referencing**.
4. Open the *Bench Example.smm* project file and *Bench Example.jm3x* 3D model file.

This will open the dense reconstructed 3D model file.

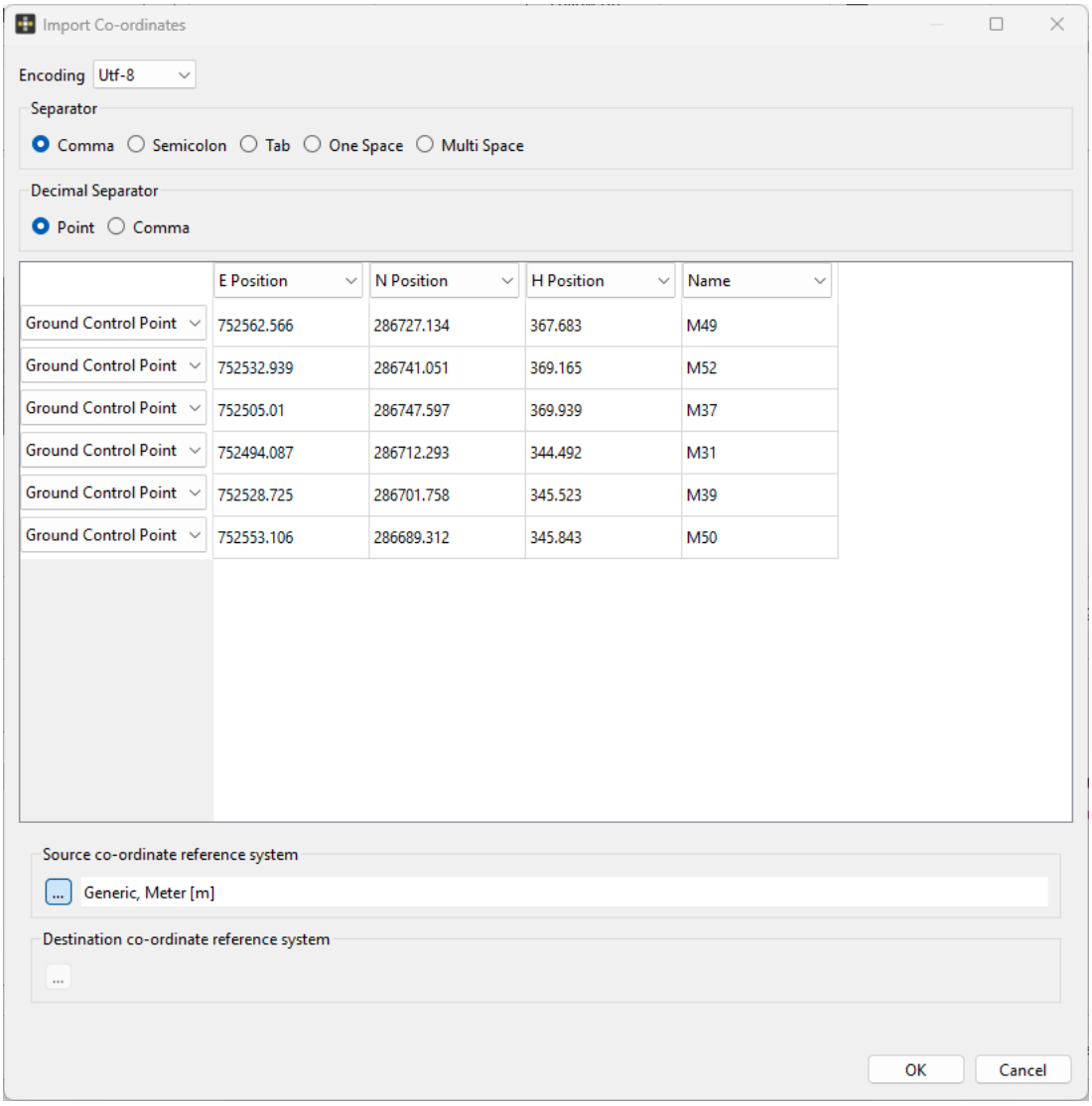
5. Select **Referencing > Control Points** to perform Standard Referencing using Ground Control Points (GCP).

2.2 Referencing

In this example, we will use six externally surveyed GCPs for Standard Referencing to convert the 3D model into a higher-level coordinate system. Hence, we will proceed with **Full Reference mode**.

To add a GCP:

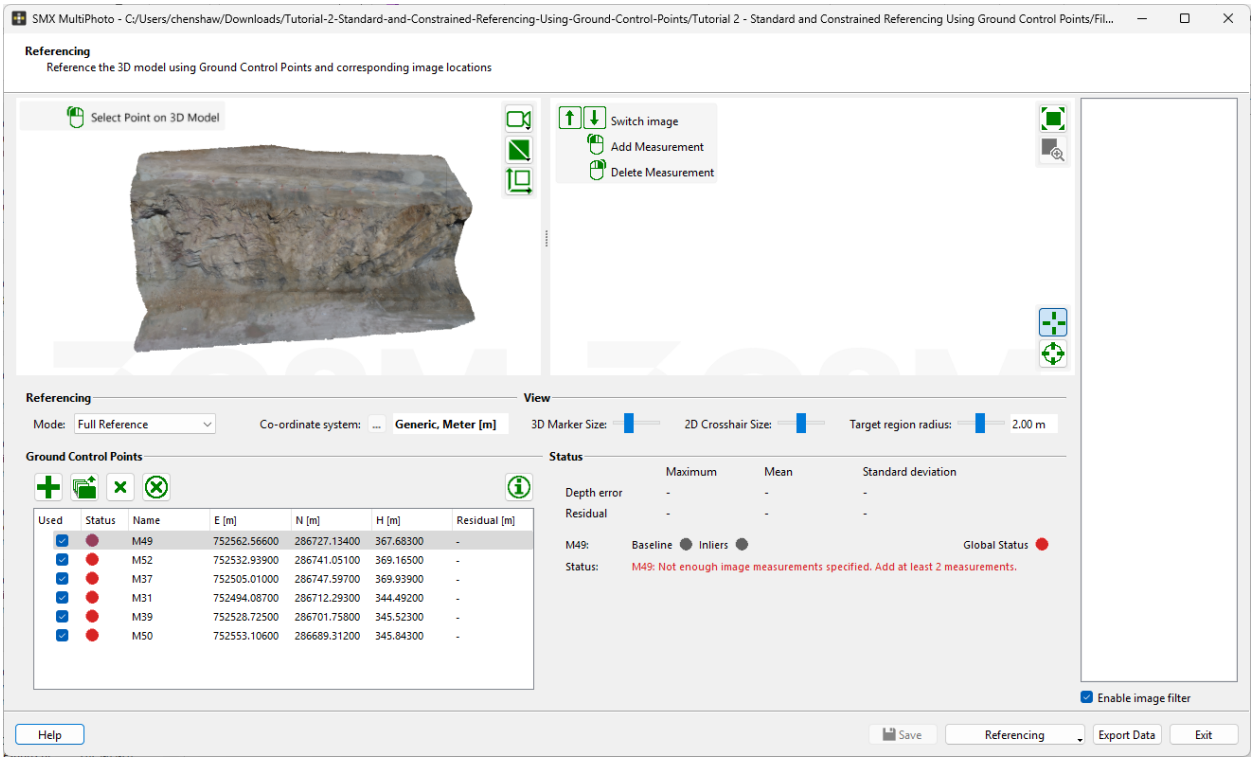
1. Click the **Load GCP from Text File** button and open the *GCP.csv* file.
2. Click the drop down and set row one as **E Position (Easting)**, row two as **N Position (Northing)**, row three as **H Position (Elevation)**, and row four as **Name**.
3. For **Source Co-ordinate Reference System**, click ... and select **Generic, Meter [m].**
4. Click **OK**



Note:

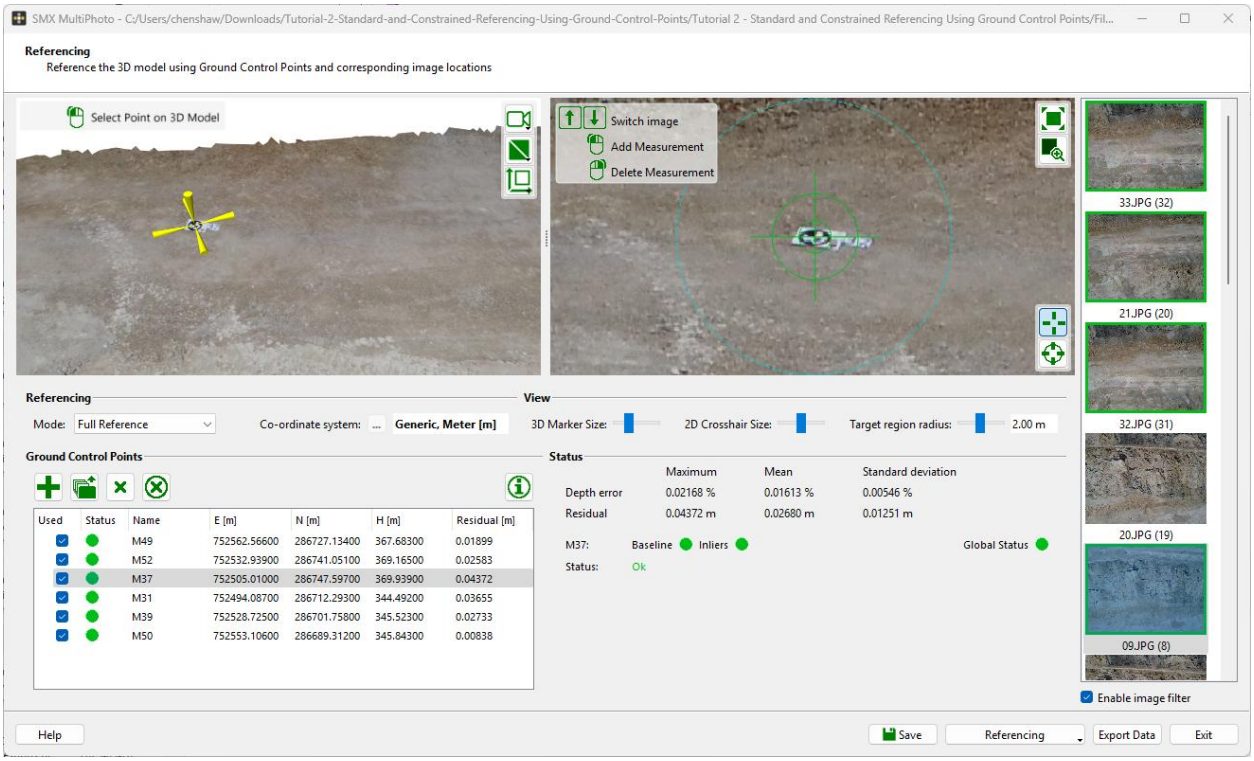
GCP points can be imported from (*.csv*, *.txt*, *.dat*, *.prt*) file formats or by clicking the *"Add GCP"* icon ✚ and entering the name and co-ordinates in the *GCP* list.

Once the GCPs are imported:



5. Select one GCP in the list and localise its position in the 3D viewer by clicking the left mouse button. To help locate the ground control points, scroll the mouse wheel to **zoom in** and **out**, and click/hold the mouse wheel to pan the image. When you left-click in the 3D viewer and select the point, the list of reference images will be updated, and the active images including selected GCP will be shown in the viewer.
6. 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.
7. Choose at least **2 images** (more than 3 are recommended) showing the same GCP and centre the target position in the viewer (Tip: you can switch between the individual images in the list by using the left and right arrow keys). The status signals Baseline and the Inliers turn into green, and the error of re-projection and depth is displayed in the GCP list.
8. Activate the next GCP in the list and repeat the steps 1 – 3 until all GCP positions are localised.

Your GCP list should look like this.



Note:

Since the exact points clicked would not be the same while centering each target position, the re-projection error, depth error and error statistics should not necessarily be identical for each referencing.

After all the GCP positions are localised the **Status Information** should be **OK**, and the **Status Signal** should be **Green**. Once you check the status information click **Save** to save the referenced 3D model.

Inspect the 3D model in 3D Model view and click **Exit** to leave MultiPhoto.

Additional files according to the **Project Settings** are also generated at this stage. In this example a pdf report about the reconstruction process and an ortho-photo of the 3D model (jpg) are generated.

3.0 CONSTRAINED REFERENCING

Constrained referencing can be performed in two ways:

1. As an intermediate step during a standard 3D model generation procedure (3D model generation is discussed in more detail in *Tutorial 1 – 3D Model Generation*) by enabling **Constrained Referencing** in **Dense Reconstruction** settings.
2. By selecting **Perform Constrained Referencing** in the **MultiPhoto Workflow Selection** page and loading an existing project file (.*smm* file; coarse reconstruction).

3.1 Project Import

If you have not already done so, run the **ShapeMetriX (SMX)** program by double-clicking the **SMX** icon in your installation folder or by selecting **Programs > ShapeMetriX > ShapeMetriX** in the Windows Start menu.

ShapeMetriX comes with several example images and files installed with the program. For this section of the tutorial though, we will use the *Bench Example.smm* and *GCP.csv* files included in the downloaded *Tutorial 2 - Standard and Constrained Referencing Using Ground Control Points.zip* folder to demonstrate the **constrained referencing** features of ShapeMetriX.

1. Select the **MultiPhoto** tool 
2. Select **Perform Constrained Referencing**
3. Open *Bench Example.smm* file

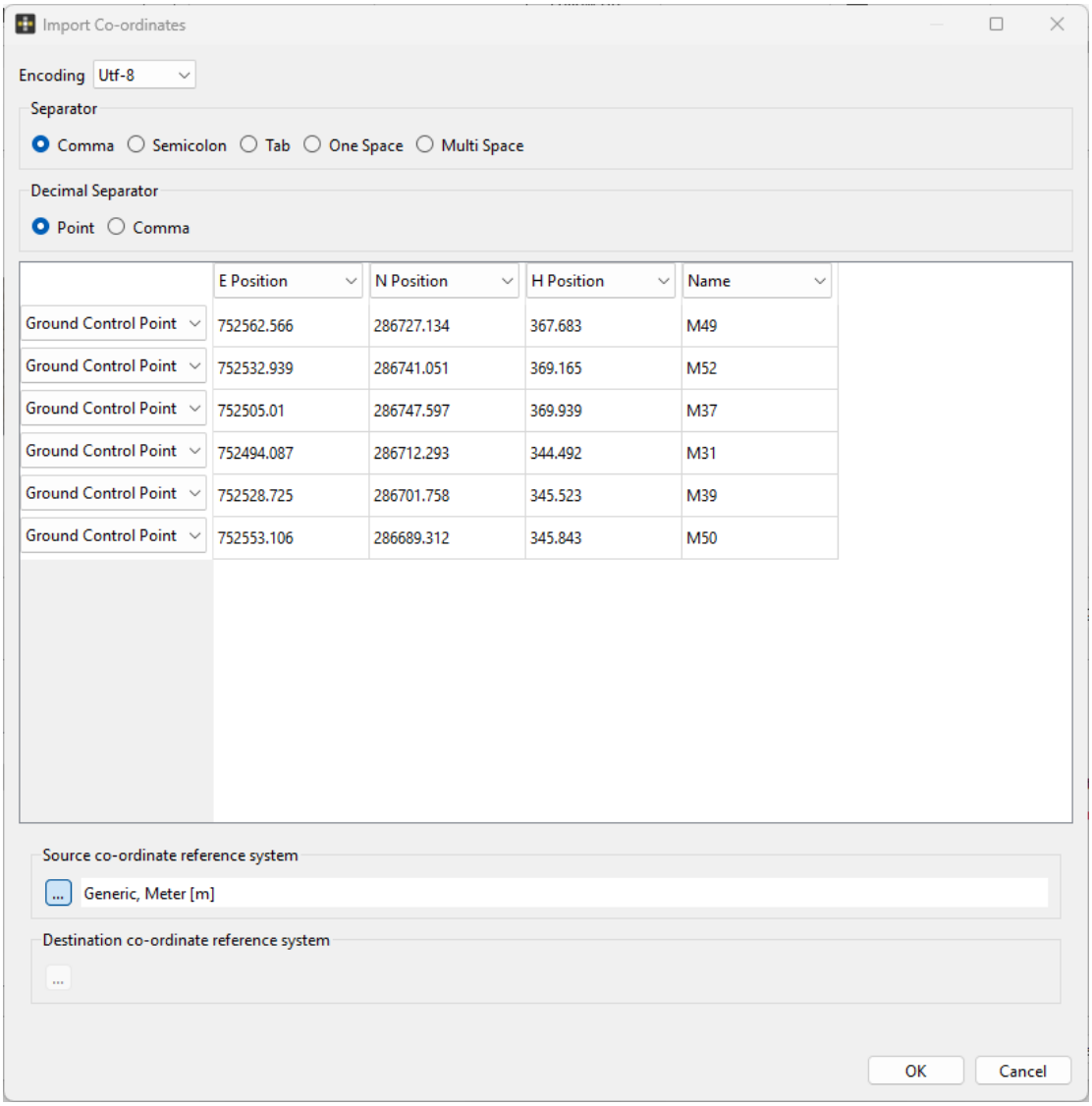
This will open the coarse reconstructed project file. A **Region of Interest (ROI)** can be defined in this step by clicking **Select** to activate drawing mode in **Custom ROI** and drawing a polygon. The definition of the Region of Interest is optional, and it is skipped by clicking the **Next >** button. If no ROI is defined, the entire 3D point cloud of the Coarse Reconstruction is used for Dense Reconstruction. (Selection of a ROI is discussed in more detail in *Tutorial 1 – 3D Model Generation*)

4. Click **Next** > to proceed to **Constrained Referencing**.

3.2 Referencing

To add a GCP:

1. Click **Load GCP from Text File** and open the *GCP.csv* file.
2. Select row one as **E Position (Easting)**, row two as **N Position (Northing)**, row three as **H Position (Elevation)**, and row four as **Name.**
3. Select **Source Coordinate Reference System** as **Generic, Meter [m]**.
4. Click **OK.**



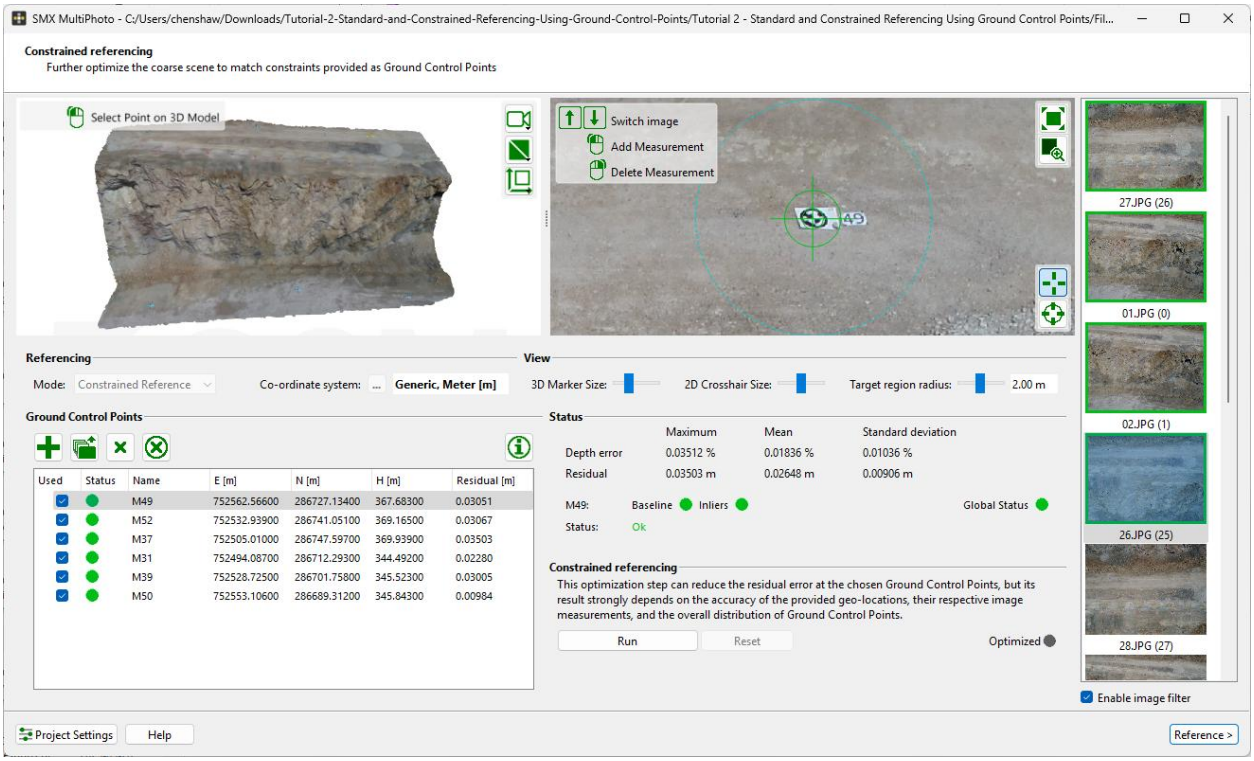
Note:

GCP points can be imported from (*.csv*, *.txt*, *.dat*, *.prt*) file formats or by clicking the ***Add GCP*** icon and entering the name and co-ordinates in the *GCP* list

Once the GCPs are imported:

5. Select one GCP in the list and localise its position in the 3D viewer by clicking the left mouse button. The list of reference images will be updated, and the active images including selected GCP will be shown in the viewer.
6. 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.
7. Choose at least 2 images (more than 3 are recommended) showing the same GCP and centre the target position in the viewer (Tip: you can switch between the individual images in the list by using the left and right arrow keys). The status signals Baseline and the Inliers turn into green, and the error of re-projection and depth is displayed in the GCP list.
8. Activate the next GCP in the list and repeat the steps 1 – 3 until all GCP positions are localised.

Your GCP list should look like this:



Note:

Since the exact points clicked would not be the same while centering each target position, the re-projection error, depth error and error statistics should not necessarily be identical for each referencing.

After all the GCP positions are localised the **Status Information** should be **OK**, and the **Status Signal** should be **Green**. Once you check the status information:

9. Start **Constrained Referencing** by clicking the **Run** button.
10. The **Optimised** signal should turn **green** once the optimisation is completed.
11. Check the error statistics. Click the **Reference >** button to finalise **Constrained Referencing** and perform **Dense Reconstruction**.

Once the Dense Construction process is completed, a 3D model with texture is generated and an output file (**.jm3x*) is automatically saved.

Additional files according to the **Project Settings** are also generated at this stage. In this example a pdf report about the reconstruction process and an ortho-photo of the 3D model (jpg) are generated

Notice that **Standard Referencing** option is disabled in **Referencing > Control Points** after Dense Reconstruction is completed, since we already performed a Constrained Referencing.

12. Inspect the 3D model in 3D Model view and click **Exit** to leave MultiPhoto.

This concludes the tutorial for Standard and Constrained Referencing Using Ground Control Points in MultiPhoto.