



# 3DFLOW 3DF ZEPHYR

USER MANUAL

LITE / PRO / AERIAL - VERSION 2.6



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## Introduction

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Welcome to 3DF Zephyr

3DF Zephyr allows you to automatically reconstruct 3D models from photos. The process is completely automatic and no coded targets, manual editing or special equipments are needed. 3DF Zephyr is built on top of our proprietary, cutting-edge, reconstruction technology. 3DF Zephyr comes with a user friendly interface, and the possibility to export in many common 3D formats or even to generate lossless video without the need of external tools. Furthermore it is possible to generate true orthophotos, digital elevation models (DTM) and even calculating areas, volumes, angles and contour lines. 3DF Zephyr is the perfect tool for modeling from reality.

Here in 3Dflow we worked really hard to build up both the core technologies and the user interface. The obtained solution is in all probability the most accurate, completely automatic, best engineered multiview-stereo algorithm available on the market.

If you need further help, if you would like to request features or if you simply want to discuss about the product and the technology behind, please remember that our forum (<http://forum.3dflow.net>) is always willing to receive new users.

Before starting, you might want to read some [hints and tips on how to take the 'correct' photos](#) and [the overview of the reconstruction process](#).

If you prefer you also can jump start and directly [Start a new Project](#).

Moreover, please note that there are also free online tutorials available, featuring also demo datasets you can download and more in-depth tips and tricks: our tutorials are available at the url <http://www.3dflow.net/it/technology/documents/3df-zephyr-tutorials/>

## System Requirements

3DF Zephyr is a computationally demanding application. It takes advantage of all available Cpu cores and it makes use of the nvidia CUDA technology where available. Please note that a CUDA enabled Video Card can drastically improve the performances (multi gpu configurations are supported as well in Evaluation, Pro and Education). We also suggest to exit all running applications when performing a reconstruction with 3DF Zephyr.

Minimum System Requirements:

OS: Windows 10/8.1/8/7/Vista (64 bit)

Processor: Dual Core 2.0GHz or equivalent processor

Memory: 4GB System RAM

Hard Disk Space: 4GB free HDD Space

Video Card: Direct X 9.0c compliant video card with 256 MB of RAM

Recommended System Requirements:

OS: Windows 10/8.1/8/7/Vista 64 bit

Processor: Quad-core Intel or AMD CPU

Memory: 8GB System RAM

Hard Disk: 10GB free HDD Space - SSD drive

Video Card: DirectX 9.0c NVIDIA video card with 1GB of RAM (Nvidia GeForce GTX 260 or higher; Nvidia CUDA 2000 or higher)

## Versions

3DF Zephyr comes in three versions: Pro, Aerial and Lite.

**3DF Zephyr Pro** is the standard solution conceived for application fields such as architecture, archaeology, medicine & dentistry and body scanning.

**3DF Zephyr Aerial** is the dedicated version to aerial photogrammetry and it involves topography, urban monitoring, nature hazard, mining and precision agriculture world.

**3DF Zephyr Lite** is a commercial solution aimed to small businesses, artists or in general to those user who just want to obtain a 3D mesh and/or those who don't need all the tools available in the other versions. The most important limitations are the export capabilities (no point clouds can be exported), no Ortophoto/Ortomosaic generation and maximum one GPU will be used when doing computations.

3DF Zephyr Pro, Lite and Education require an online activation.

## Activation

3DF Zephyr Pro, Lite and Aerial editions require an online activation (3DF Zephyr Lite Steam Edition will work through the Steam Application by Valve and does not require a product key)

The product keys are supplied by mail at the moment of purchase. If you lost your product key, please get in touch with our technical support so that we can resolve your issue.

You can activate your software either during installation or on the first run.

The activation process will bind the product key to the computer.

Usually a product key can be activated only on one computer at a time. You can always deactivate the software by using the uninstaller.

If you have problems regarding online activation or deactivation, please write an email to [sales@3dflow.net](mailto:sales@3dflow.net). A manual offline activation process can also be issued in special cases.

## Documentation

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3Dflow pushed a lot of effort to make Zephyr's interface as more user friendly as possible.

However, if you want to get the best results, please spend a few minutes reading the hints and tips you will find in this documentation.

This guide is intended for all the different versions of 3D Zephyr unless stated otherwise.

In the [next section](#), we will quickly review the reconstruction process. It is not mandatory to fully understand the "magic" behind zephyr, but a quick review of the main concepts can be useful.

### A Quick Overview

Here in 3Dflow we are, first of all, Computer Vision researchers. Computer Vision is, generally speaking, the science that studies how to extract (any kind of useful) information starting from images. This is a very rough definition and many subproblem can be delineated and many different meanings for the concept of "information" can be given. Extracting three-dimensional models from a number of images (extracting 3D information from a 2D input) is a well studied problem in Computer Vision. 3DF Zephyr represents an highly refined and well engineered solution for this problem.

There are four main phases in Zephyr:

- [Starting a new project an Aligning the Cameras](#) - this is also referred as 'Structure from Motion'
- [Extracting a Dense Point Cloud](#) - this is also referred as 'Multi-View Stereo'
- [Extracting a Surface](#)
- [Extracting a Textured Mesh](#)

When [starting a new project](#) the software will extract the camera positions and orientations and their internal parameters (i.e. the focal lenght and other camera properties). The first are referred as external parameters, while the latter are called

internal parameters. All the magic of this phase is done by [Samantha](#), our leading Structure from Motion Technology. If you want to input the internal camera parameters manually instead of letting Samantha estimate them, [you can](#).

After the cameras have been aligned, you can proceed and extract a [dense reconstruction](#). The process requires the input cameras to be correct. If you believe a camera is not correctly aligned, you can remove it from the workspace. Before proceeding you can also [restrict or expand the volume of reconstruction](#). The reconstruction process is powered by [Stasia](#), our Multi-View Stereo technology. You can create different dense reconstructions (with varying parameters) and save them into the workspace.

Starting from a dense reconstruction, you can [create a triangular mesh](#). Basing on what you are going to reconstruct you can choose among the generation of a smoothed surface (when dealing with human body or terrains for instance) or the generation of a sharp surface that more fits scene such as buildings or mechanical parts. The latter kind of surfaces are handled by [Sasha](#), the latest algorithm developed by 3Dflow.

Every mesh polygon get textured with pictures zone where it is detected. Within texture generation phase there is a color balance algorithm as well, that allows to select and set-up the best color for each pixel automatically by checking the different lighting changes on the photos.

In the [next section](#) we will give some hints and tips on how to take the right photos.

## Photography Guide



In this section we will list some tips to obtain good reconstructions. 3DF Zephyr is completely automatic but does require some forethought to produce the best results.

### Camera sensors.

What you'd better keep in mind when picking your gear:

- camera performance is not provided by its megapixels resolution;
- high-end cameras do not always lead to better result;

A good camera must allow a full light management in order to control each exposition value. That's why DSLR cameras (reflex) are usually recommended even if both mirrorless and bridge camera can fit that need.

Camera sensor is the real highlight of the matter and the following hints could be quite helpful:

- Pixels size must be higher than  $2 \mu\text{m}$ ; therefore it is strongly recommended to exploit camera sensor bigger than 1/2.3" even if smaller sensors may be used depending on the accuracy you want to reach;
- You'd better draw your attention to pixels size rather than pixels mount for each picture. For instance, if a 36 megapixel full-frame reflex (35.9 x 24 mm) is being employed it is worthwhile to shoot at a lower resolution than the maximum provided. That is the way to get bigger pixels in the images even though less;

### Lenses.

Every survey has its own features and conditions so choosing the most suitable lens for that depends on both environment status (light, obstacles on field, user movement capability) and features of the survey subject/scene. Following a few tips are provided so as to pick the proper photographic gear:

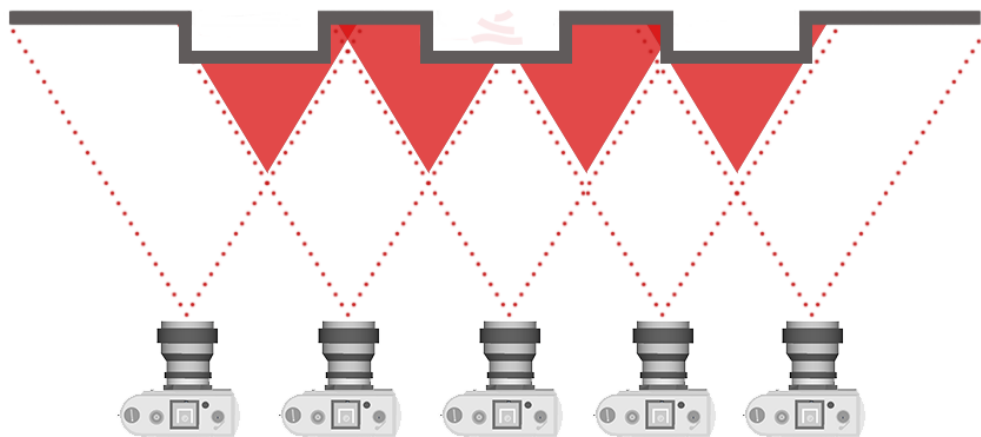
- Full-frame cameras: use lenses with focal length value between 25 and 50 mm;
- Aps-c cameras or lower sensor size: use lenses with focal length value between 18 and 35 mm considering a crop factor value between 1.5 e 1.6;

It is strongly recommended to shoot keeping the same focal length for all the pictures you take. Even if Zephyr can handle several kind of cameras and lenses at the same time and in the same project, you can get better and faster results if working with an equivalent set-up;

### Shooting techniques.

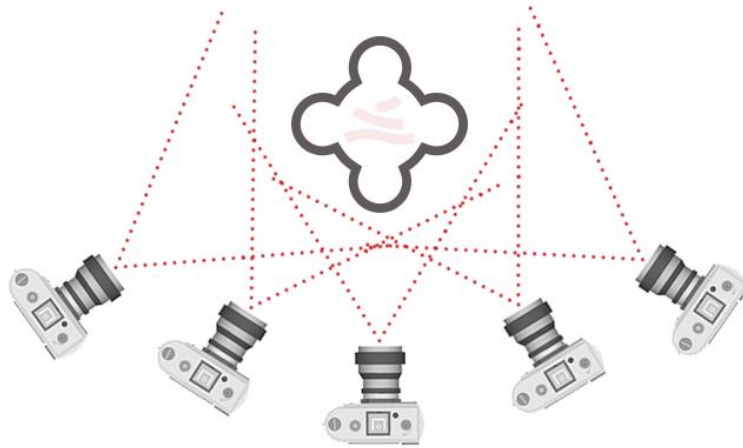
Following some proposals for standard photographic acquisition are featured. At any rate survey modalities are different and need to be adapted on a case by case basis.

#### ***Parallel axis capture***



*That is exploited with planar or regular surface in application fields such as architecture and aerial photogrammetry. Red fills show the overlap area among the pictures taken.*

### **Convergent axis capture**



*That is exploited when it is allowed to move around the subject/scene.*

If a small or medium size object is needed to be fully reconstructed it is possible to keep the camera in a fixed position (on a tripod for instance) and to put the object on a turntable. Then [3DF Masquerade](#) will allow to hide the background in the pictures.

#### **General rules.**

- Keep the subject on the center of the framing;
- Avoid direct light sources that may cast shadows and hide surface areas;
- Avoid high ISO value since the noise may set back the Structure from Motion phase in Zephyr;
- Keep a high aperture value (f/8 - F/16) when possible as it helps get a deep depth of field on pictures;
- Avoid blurry photos. Using good quality cameras and having a good illumination can help. Consider also using a tripod if necessary.
- Have a lots of overlap on each photo (70-80%). This is probably the most important tip. Shoot as many photos you can. Each part of the scene you're shooting should appear in at least three separate views taken from different locations. This is a minimum requirement, taking more photos will likely improve the final results.
- Limit the angles between photos. When moving around objects, try to keep the angle between each photo very low.
- Shoot scenes with lots of detail and texture. The visual texture in the photos is what ties them together. 3DF Zephyr does not work well with uniform or highly repetitive texture and does not work at all with specular or transparent objects. You can, however, mask out certain areas using 3DF Masquerade (bundled with 3DF Zephyr)
- Don't try to adjust lens distorsion as that error is quite essential during the first phase of Structure from Motion;

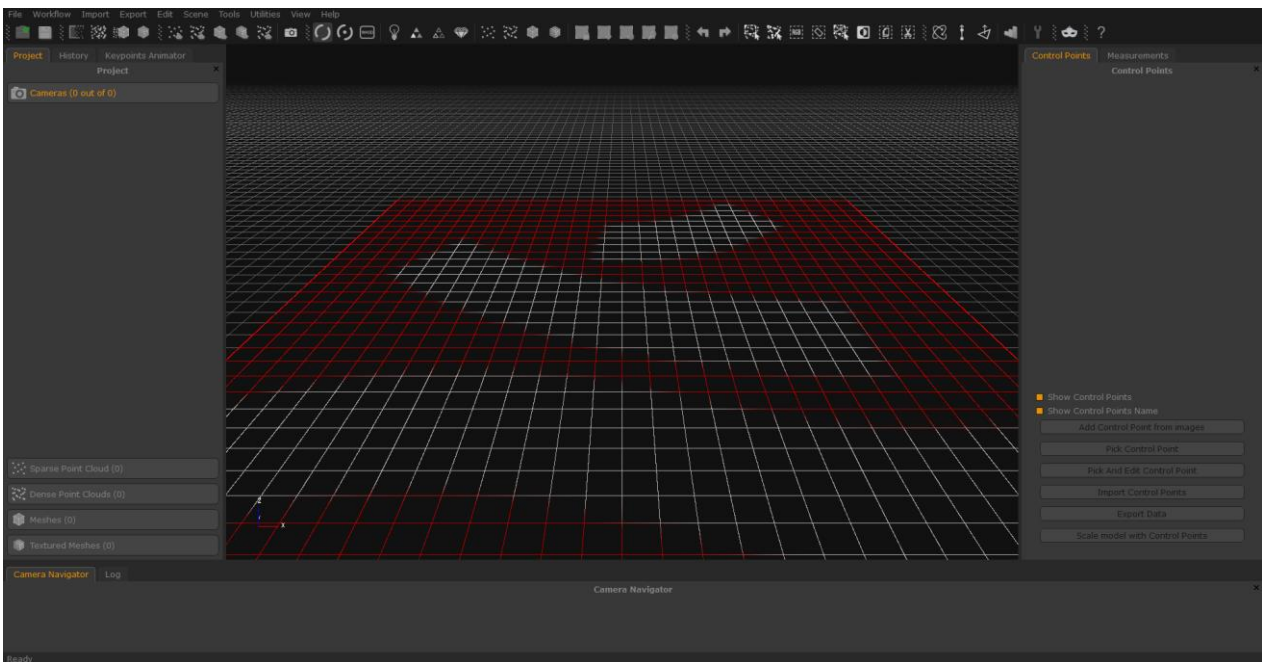


- Even if 3DF Zephyr can deal with different cameras or lenses within the same dataset, you will obtain better results by using the same camera with the same focal length.
- Be redundant: the more photos you take, the better results you will get.

Remember that you can even use the **Image Quality Index** inside Zephyr to check the status of the pictures you are working on.

## The Main Window

When opening Zephyr for the first time, the interface layout will look like this:



On the upper side, the menubar and the toolbar give you access to all the basic actions and functionality of Zephyr.

The Render window at the center let you [navigate through the 3D scene](#). You can also right click on it to open a contextual menu to perform specific actions.

The other windows are completely "dockable"; this means you can move them and dock in any part of the main window. To hide or show a specific dock use the **View** menu. 3DF Zephyr always saves and loads the interface layout of your last run. From **Tools > Options > Application > Restore Settings** you can restore the factory default settings (including the interface layout).

On the left side, in the **Project** tab you can review all the objects currently loaded in the workspace. The Objects are divided into 4 categories: cameras, sparse point cloud, dense point clouds and meshes. You can remove, rename and edit every object by right clicking on them and selecting the specific action.

On the left side you can find even the **Animation** tab, where you are allowed to create and export video animation of your 3D models.

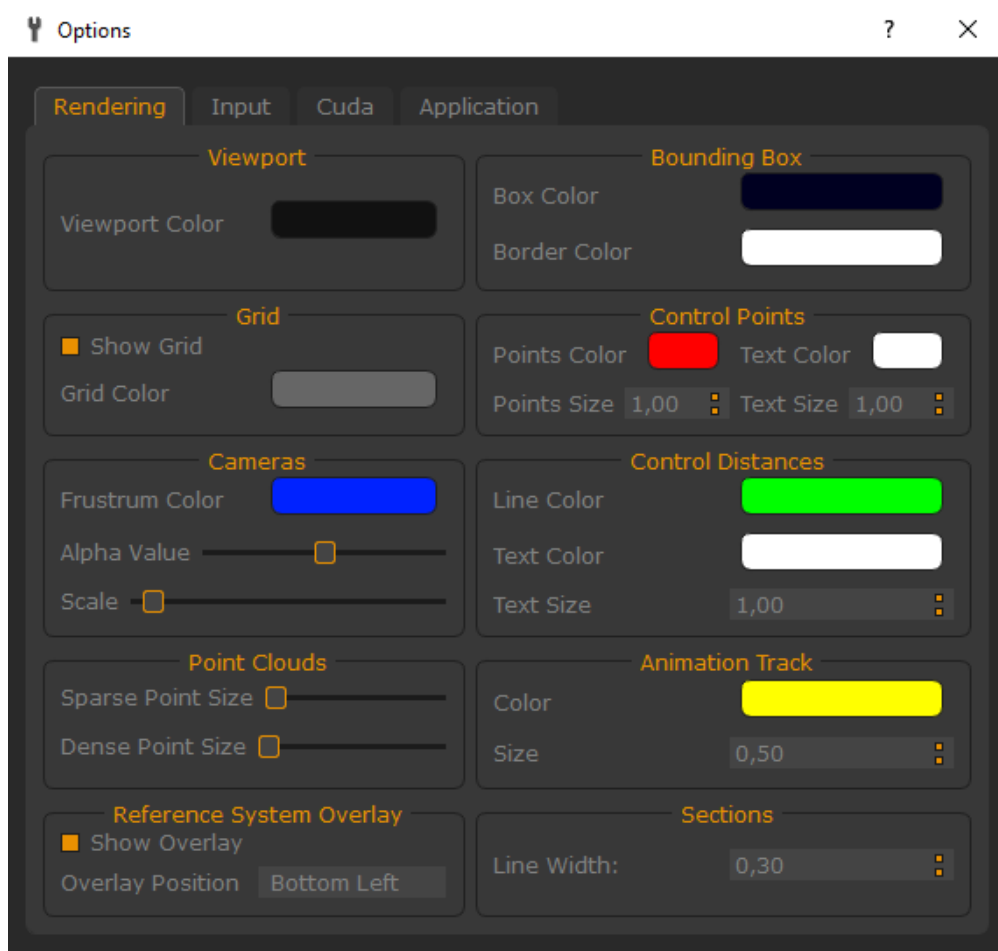
On the right side there are the **Control Points** tab, the **Measurements** tab and the **Drawing** tab as well.

On the same tab, the **History** tab let you review, undo and redo the performed actions.

The **Navigation** bar is located in the bottom side alongside the thumbnails of the photos loaded in Zephyr and the **Log** pane.

## OPTIONS

By clicking the wrench icon in the toolbar or selecting Tools in the menu bar you can enter the **Option** window arranged in four tabs: Rendering, Input, Cuda and Application.



The **Rendering** tab allows you to edit 3DF Zephyr graphic appearance. You can modify the colors of several items ranging from the work space to the grid and control points. As for point clouds generated within 3DF Zephyr you can change the graphic size of individual points. As for the cameras you can edit at any time the alpha channel which is worthwhile to set both the images transparency and the size and color of cones detecting shots in three-dimensional space.

The **Input** tab allows to change parameters related to the visualization and virtual camera control.

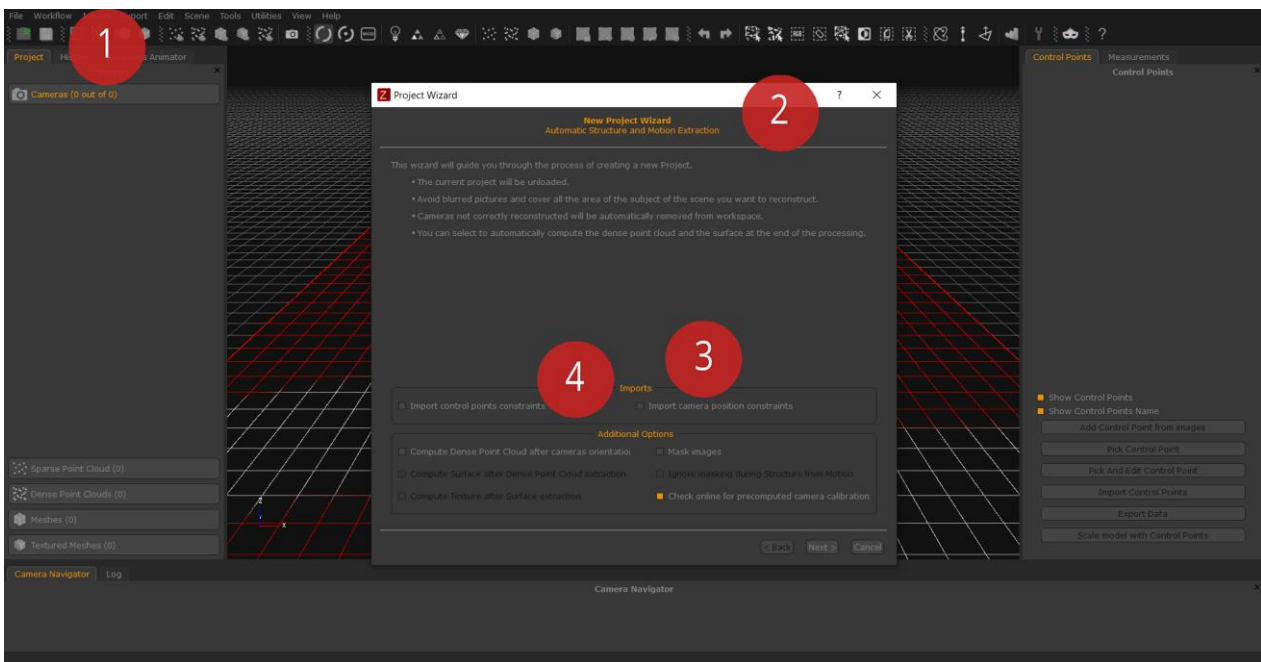
The **Cuda** tab allows you to enable the graphics card with CUDA technology if that is located in the hardware components of your computer.

The **Application** tab allows to change some features of the software such as the operating language, the text size and enable the autosave that could be quite important when running 3D reconstructions in [batch processing](#).

## Starting a new project

Got the Photos? Then you are ready to begin the reconstruction process!

To create a new project, just click on **Workflow > New Project (1)** . The **Project Wizard (3)** screen will appear which will guide you through the process of importing your pictures.



For standard workflow you simply click on the **Next** button and going on adding your photographs within the software.

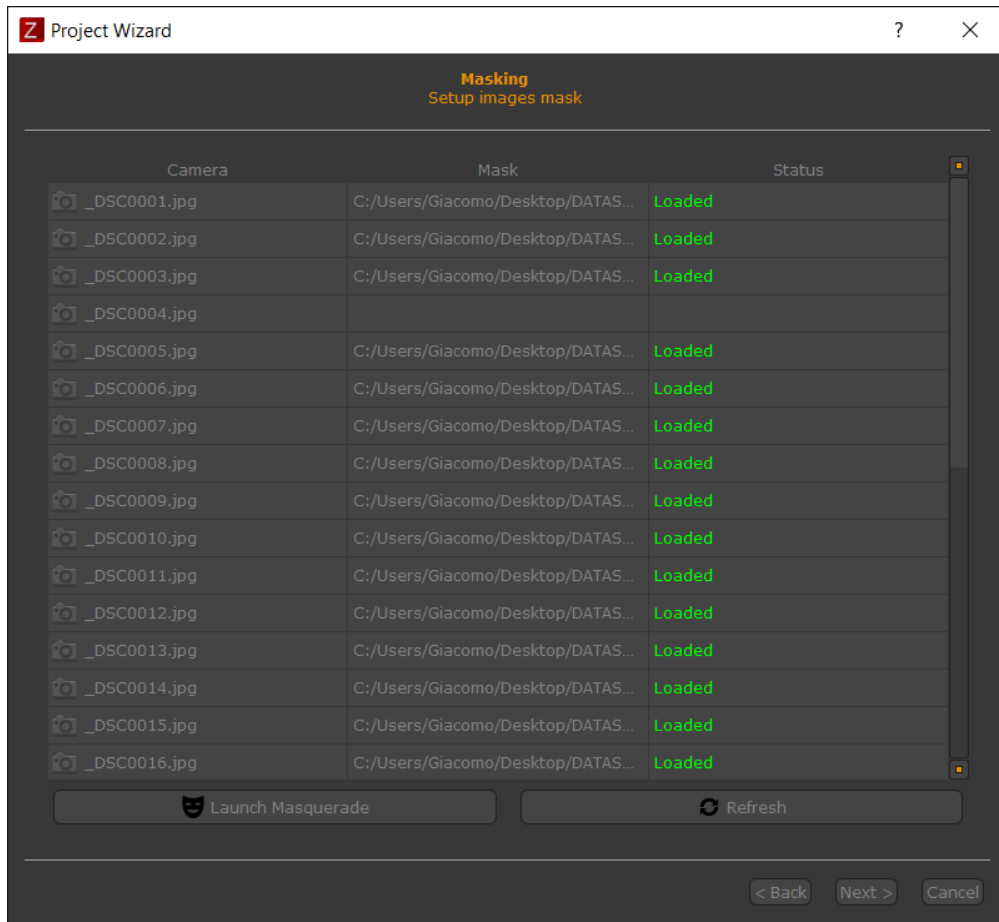
However, in that wizard there are two submenus called **Imports (3)** and **Additional options (4)**.

Inside the **Imports** menu you have two options:

- **Import control points constraints:** 3DF Zephyr does not need any pre-calibration file; anyway, if you have a calibration file created with your own equipment, you can load the calibration file by selecting this option. By clicking on the **Next** button you will find a further submenu where you can choose whether:
  - manually enter each internal and external parameter (for each image);
  - specify the position and the Euler angles;
  - import internal and external parameters using a text file;
- **Import camera position constraints:** as the previous option, this one allows you to import camera position (by loading a txt file) in 3DF Zephyr and to use them to

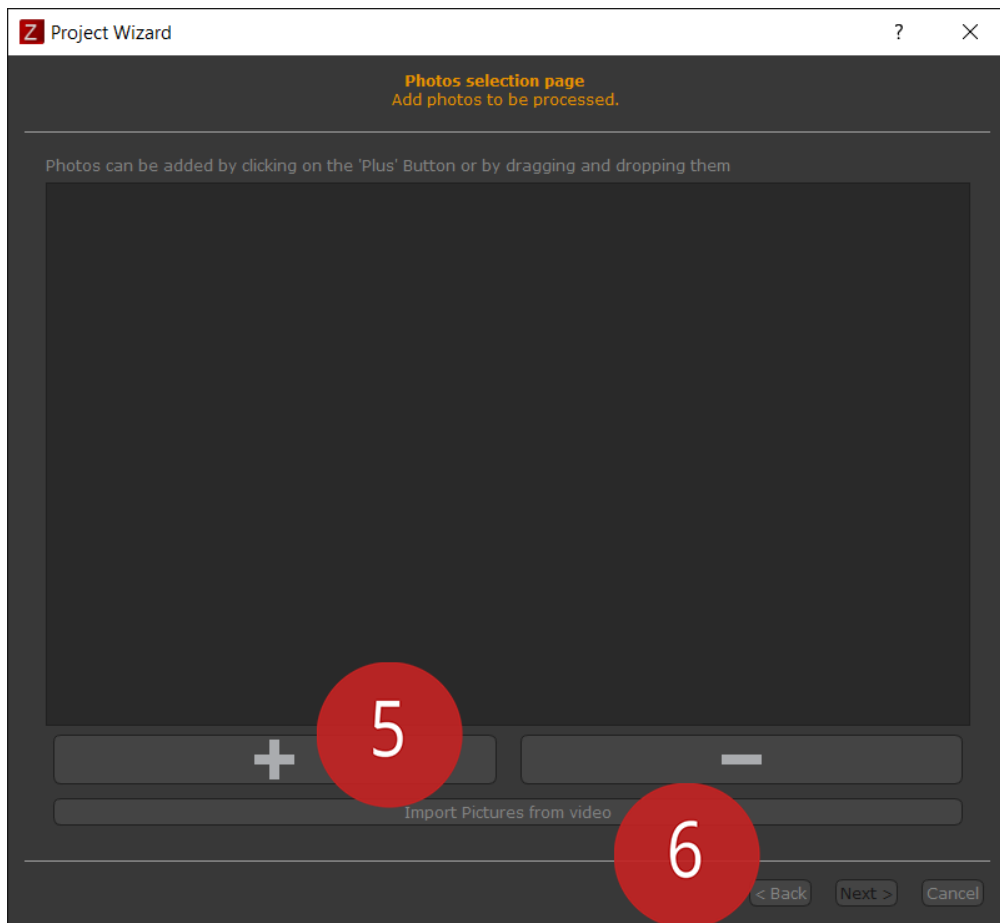
constrain the 3D reconstruction; a standard example of practical usage of this entry is represented by the pictures taken by drone or UAV system record recording GPS coordinates of the shots into the Exif data.

In the **Additional options** submenu (4) you can specify the software to perform each of the four 3D reconstruction phases without stopping between a phase and the other one; this tool can be very helpful when you don't have enough time to set your 3D reconstruction in details . This technique is called **batch processing** and is only recommended for advanced users, as it represents the highest level of automation in 3DF Zephyr.



In **Additional options (4)** the **Check online for precomputed camera calibration** option allows to save camera calibration parameters on a 3DF Zephyr online database so that the software will be able to automatically get that providing the exact calibration parameters and reducing the timing of Structure from Motion phase, when that camera will be exploited again.

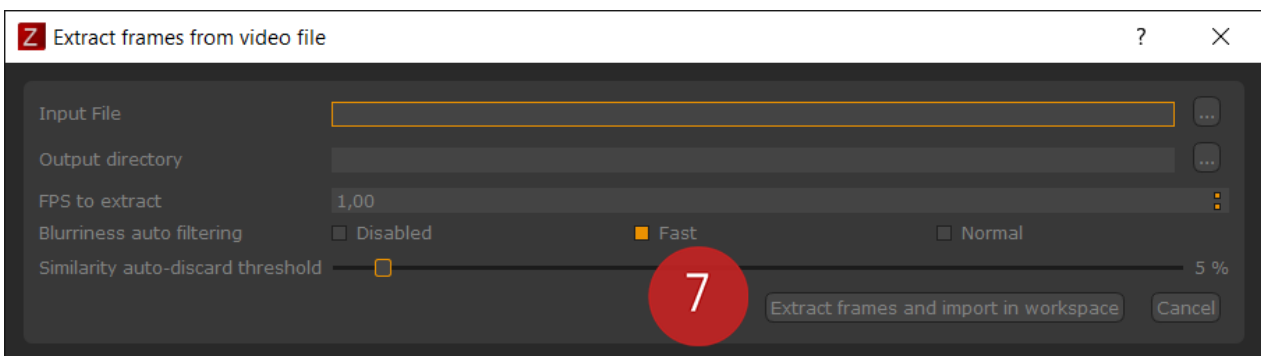
In the previous submenu, you can also load the masks related to photographs, if these have been previously generated with the [3DF Masquerade](#) tool. After clicking **Next** the Masking page will appear(see image above) and it will specify whether the masks have been properly loaded into 3DF Zephyr (a green ok should appear close to the picture's name, for each imported mask) or not.



By selecting the **Ignore masking during orientation** option 3DF Zephyr will exploit the masks only when generating the dense point cloud; this tool is useful if the image background is well textured and can therefore help the first phase of cameras orientation.

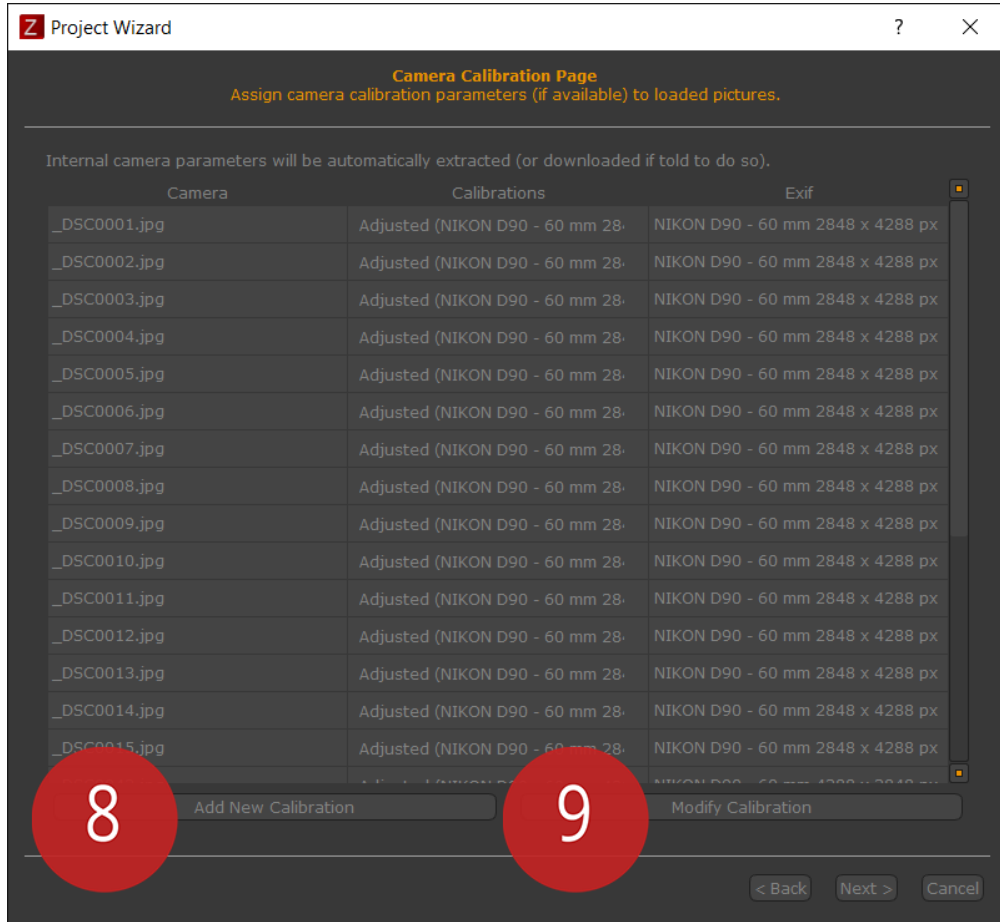
The next window is the **Photos selection page**, where user is asked to load the pictures. It is possible to drag 'n' drop the files into the window or to click on **Add** (5) to select a photos directory.

3DF Zephyr allows you to import both images and videos through the **Import from video images** button (6); this tool can divide videos in frames which are treated as photographs in the end.



In the loading window it is possible to select the desired file and then to specify the destination folder where it will save the set of extracted frames. In the options below you can set the frame rate to be extracted (FPS), the blur analysis on each frame and the threshold of identification, and rejection, of similar frames.

To start the extraction, simply click on **Extract frames and import in the workspace (7)**.



After loading the images or video files and clicking on **Next** button, you will see the **Camera calibration page** where you can notice a list of every single imported image as well as the calibration that 3DF Zephyr will use for each camera and its Exif data.

By clicking with the right button of the mouse you can select or deselect all the images, and clone calibrations.

From this page, you can [Add a New Calibration](#) (8), or **Modify the Calibration** (9) that 3DF Zephyr has automatically identified through the Exif data of the photographs.

In the **Modify Calibration** page, you can select the focal length you want to change (if loaded pictures have been taken with different focal lengths) and then define the calibration parameters.

By the **Import parameters from file** button you can load a calibration files already created with an external application (see Lapyx 3DF).

**TIP:** If you have imported pictures taken with wide-angle or fish-eye lenses it is recommended to activate the **Adjust tangential distortion parameters** option (10)

Once the calibration step has been completed you have to set-up the first phase of the 3D reconstruction by means of the **Camera orientation settings** page, which will generate a sparse point cloud as initial 3D result.

There are three settings way for the first three phases of 3D reconstruction (only in Zephyr Pro and Aerial):

- **Categories and Presets:** is the fastest way to set the parameters of the reconstruction;
- **Advanced Mode:** allows you to define every detail of the 3D reconstruction phases;
- **XML File Import:** allows you to load an XML file where the user has already defined the most suitable parameters for its own reconstruction (recommended for professional users);

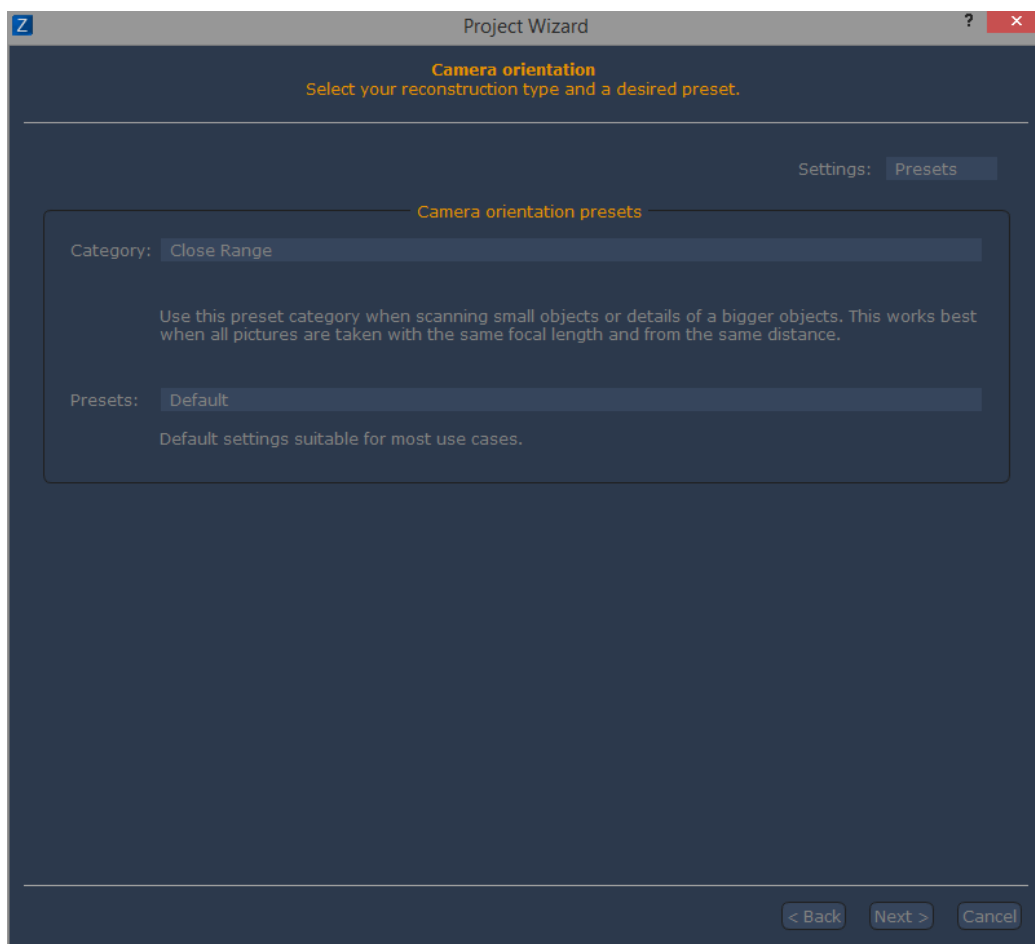
	Zephyr Lite	Zephyr Pro	Zephyr Aerial
Close range	Yes	Yes	Yes
Aerial	Yes	Yes	Yes
Human Body	Yes	Yes	No
Urban	Yes	Yes	Yes
Advanced parameters	No	Yes	Yes
XML import	No	Yes	Yes

Versions presets

It is possible to use categories and presets, advanced mode and import XML files **in every stage of the 3D reconstruction** whether what has been exploited in the previous phases or not.

## Cameras orientation

The first phase of 3D reconstruction is called Structure from Motion and it is in charge of defining the position and orientation of each photo that has been loaded in Zephyr. That step yields a sparse point cloud as initial 3D product.



Depending on the selected category it is possible to choose among four quality values (fast - default - deep - exhaustive) that gradually increase the capabilities of Samantha algorithm managing this first phase.



You can switch **to advanced mode** to define each parameter of Structure from Motion phase in detail. To do so, simply select "**Advanced**" from the "**settings**" dropdown menu.



**Keypoints Density:** keypoints represent the matched pixels in the pictures. This parameter allows to set the amount of keypoints that 3DF Zephyr will have to extract for each photo; nevertheless **a substantial amount of keypoints does not lead to a better result**, since the more the elements involved the higher the ambiguity during correspondences detection between the keypoints themselves.

- Very low: extracts up to 2,500 keypoints per image
- Low: extracts up to 5,000 keypoints per image
- Medium: extracts up to 7,500 keypoints per image
- High: extracts up to 10,000 keypoints per image
- Very High: extracts up to 15,000 keypoints per image

It is recommended to decrease keypoints density when:

- it is required a high computing speed;
- the distance between cameras and subject/scene on survey does not change;
- pictures get a high percentage of overlap (70% - 80%);

It is recommended to increase keypoints density when:

- Cameras are not correctly oriented;
- There are some pictures too close and too far from the subject/scene;
- The dataset counts a few photos that have a low percentage of overlap;
- The subject/scene has a uniform surface and no texture (a white wall for instance);

**Matching Type:** allows to select different kinds of matches between the keypoints in the images. The accurate option requires more time to be completed;

**Matching Stage Depth:** set-up how many matches are performed on the images between the keypoints. By setting this parameter to the higher value, the capability to align multiple images at the same time is going to increase just like computation time.

It is recommended to decrease the depth value of the matching stage when:

- it is required a high computing speed;
- The distance between the camera and subject is not high;
- The overlap percentage between different shots is high (70% - 80%);

It is recommended to increase the depth value of the matching phase when:

- Cameras are not correctly oriented;
- There are some pictures too close and too far from the subject/scene;
- The dataset counts a few photos that have a low percentage of overlap;
- The subject/scene has a uniform surface and no texture (a white wall for instance);

**Reprojection Error Tolerance:** it checks the maximum reprojection error allowed (in pixels) for each point during geometrical reconstruction step and the minimum number of points required to merge two clusters of images together. By selecting **strict** option it is possible to get a more accurate reconstruction while **wide** option increases the chance to orient the cameras which would otherwise be discarded.

It is recommended to reduce the reprojection error tolerance when:

- Reconstruction is not able to converge;

It is recommended to increase the reprojection error tolerance when:

- Not all cameras are properly oriented;

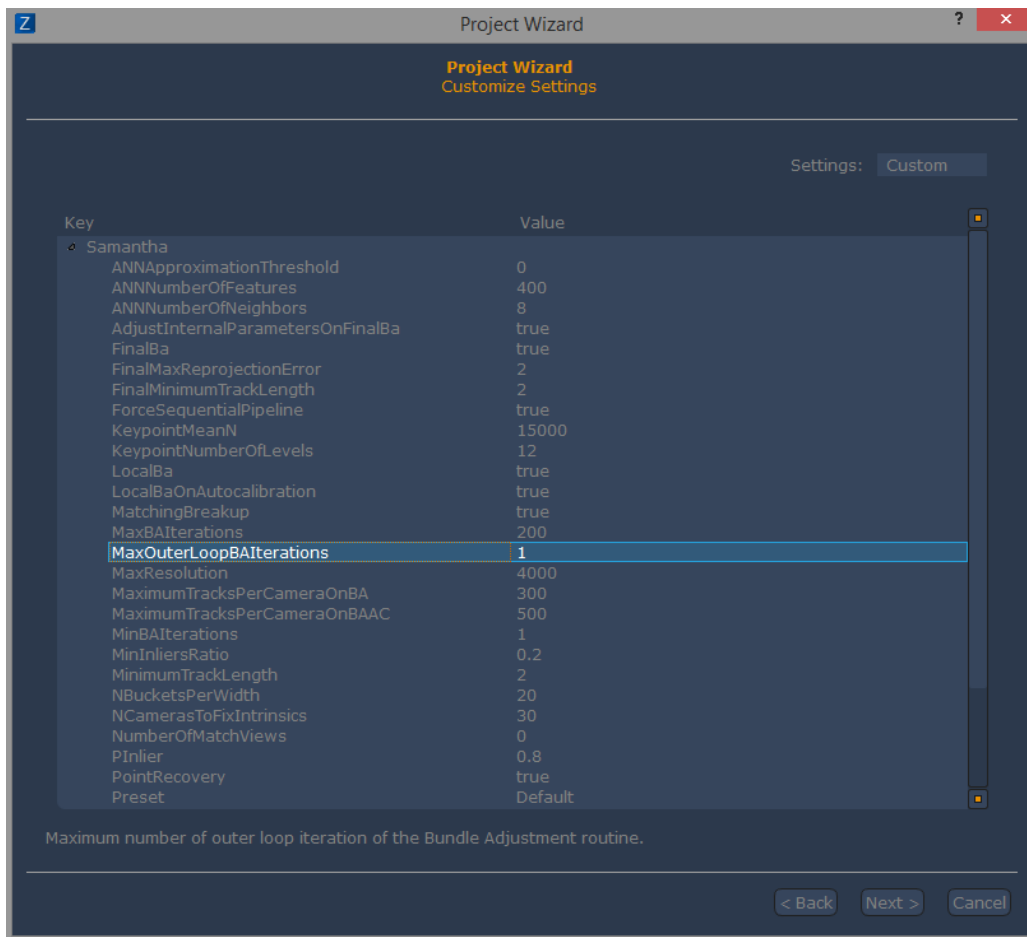
**Bundle Adjustment:** it is a nonlinear minimization procedure that corrects points and cameras positions while minimizing the reprojection error of each point: it is performed at the end of each merge and a further Bundle Adjustment run at the end the procedure. If you are working with huge datasets you'd better choose **local and restrained** option.

**Photo Ordering:** this parameter suggests the software which was the photographic capture applied on field and therefore the sequence of the pictures taken . That way can speed up the near images detection process. By using **sequential** option the photos

have been taken following a numerical order (photo 1 near photo 2 - photo 2 near photo 3 and so on), while **circular** option indicates a loop sequence. If you are aware that the photos have been taken with a specific order, you can streamline the process by choosing among those two options, otherwise you can consider the **sparse** option. The last option is called **approximate grid** and it was designed for data acquisition collected from drones or UAV systems, and it is exploited when capture is sequential and has a high percentage of overlap between the pictures (70% - 80%).

A further description of those parameters is available here: <http://www.3dflow.net/3df-zephyr-parameters-tuning-guide/>

You may also switch to the "**Custom**" mode by selecting "**Custom**" from the "**settings**" dropdown menu. This mode allows to fine tune in detail every single reconstruction parameter. Remember that you can load an XML file or reset to default by right-clicking and selecting the desired option. Please also note that a hint regarding the selected parameter is shown at the bottom of the window.

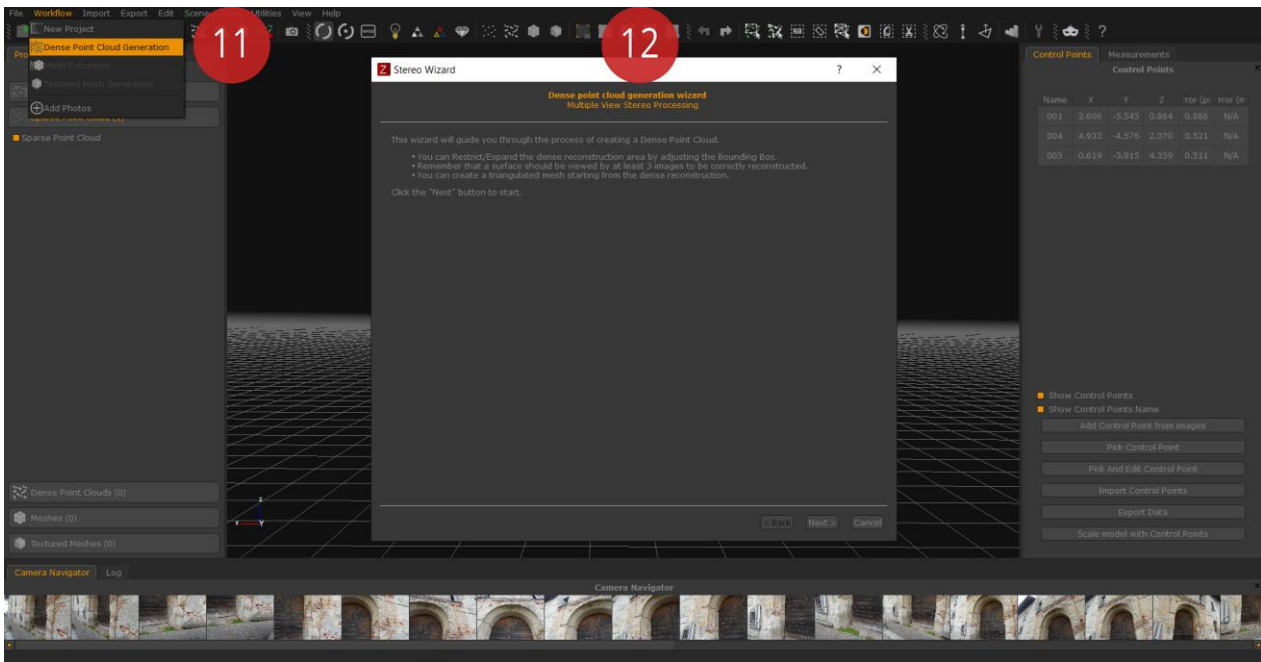


At the end of the first phase of cameras orientation you will see both the sparse point cloud and the pictures sequence around the point cloud.

Photographs in the render window are identified by blue stylized cones whose graphics are editable in Zephyr **Options**.

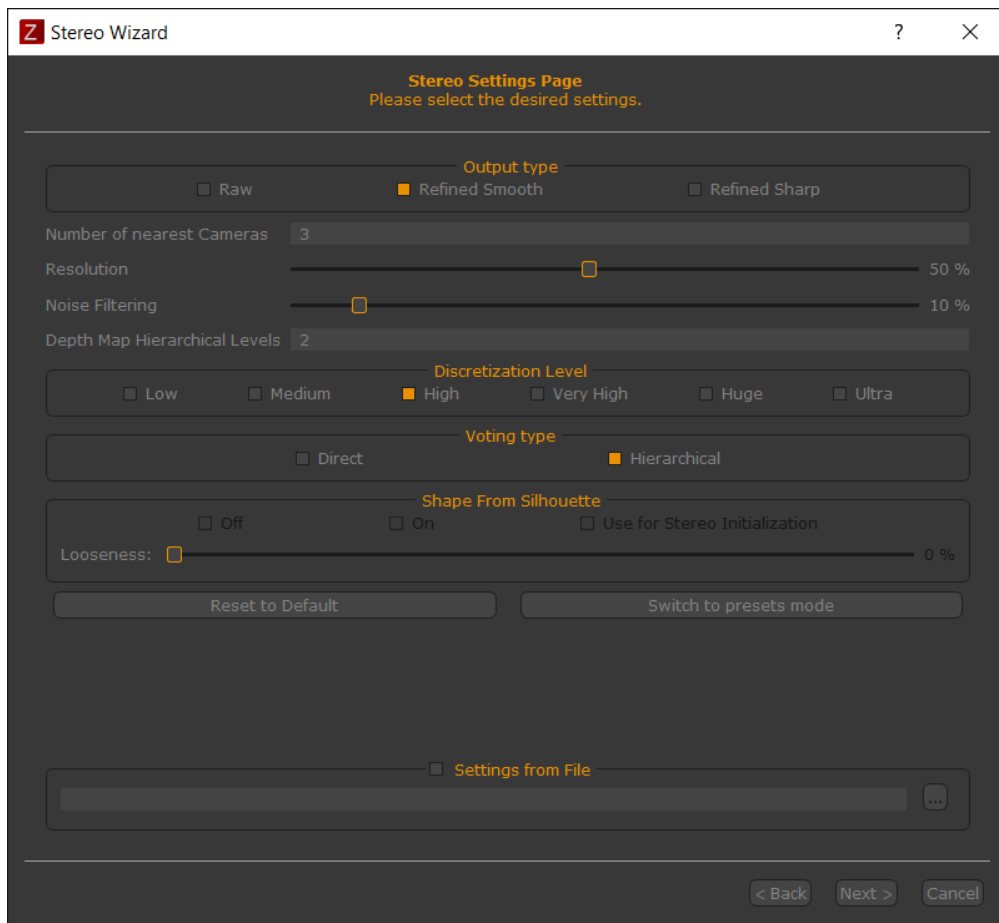
## Extracting a dense point cloud

To start the process simply click on **Workflow > Dense Point Cloud Generation (11)** or click on the corresponding icon in the toolbar.



**Tip:** Before starting the generation, it is possible to restrict or vary the reconstruction area by [changing the Bounding Box \(12\)](#). This step is an optional one as the Bounding Box is automatically generated. Anyway by restricting the reconstruction area to the your 3D object you can improve the results and speed up the computation time.

Just like the first phase of cameras orientation this second phase of the 3D reconstruction can be set-up by using categories and presets, or switching to the advanced mode. The items are explained below:



- **Output Type:** raw method returns only 3D points with real 2D matches in the images, while the other two optimizations exploit some filters in post-production to make the point cloud cleaner and denser. These filters are designed to keep sharp edges (that is quite helpful when you have to deal with buildings or interiors for instance) or smooth edges (terrains, human bodies, etc.)
- **Number of nearest cameras:** the amount of cameras used to create depth maps that is also linked to the amount of pictures taken. You'd better increase that value if you guess that there are N photos, for each camera, those are aiming at the same point of the scene. Increase the number of cameras may increase the processing time.
- **Resolution:** it defines the resolution used for the pictures. A higher resolution keeps more details, but it may produce noisy results if the photos quality is low. The time required for the dense point cloud generation is strictly related to this parameter.
- **Noise filtering:** low values will produce much denser clouds with noisy areas though, whereas high values will produce cleaner clouds with less endpoints.
- **Depth maps hierarchical Levels:** it calculates depth maps at gradually increasing resolutions. It is recommended to keep this value at default.
- **Discretization Level:** allows to Control the level of discretization of the bounding volume. A low value will produce a less dense point cloud even if it will make the process tougher to noise, whereas a higher value will keep the detail although the point cloud will be more exposed to reconstruction noises (if there are low-quality

photos for instance). Notice that using high value settings will affect your hardware memory.

- **Voting type:** calculate a hierarchy for the dense point cloud when noise reduction is applied. It is recommended to select the **hierarchical** option.
- **Shape from Silhouette:** it is an image-based modeling technique that uses the profile, or silhouette, of the subject to create a virtual hull containing the subject. You must create the masks for all the pictures before running that. This technique can be quite worthwhile when you need to deal with transparent or reflective surfaces which can not be removed with 3DF Masquerade.

Once the parameters are chosen you can start the process by clicking on **Run** button.

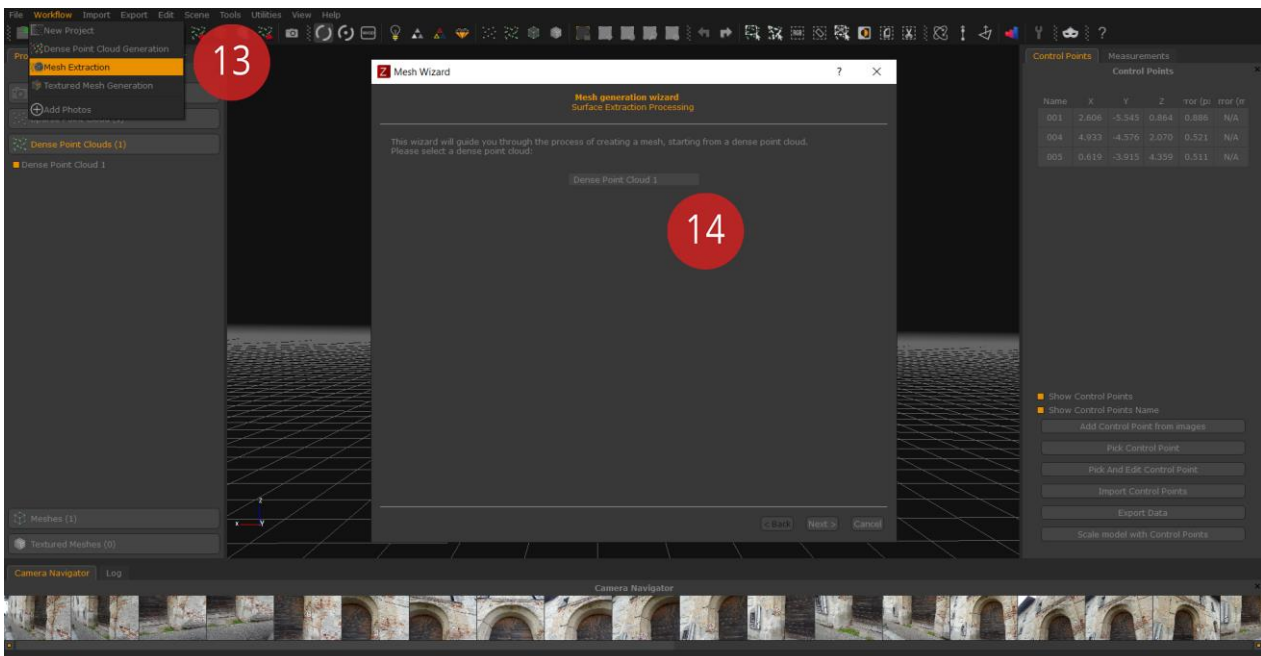
The dense point cloud generation requires the most of hardware capabilities along with the cameras orientation phase.

Don't forget that you can reconstruct and add more dense point clouds in the same Zephyr project even exploiting different parameters or reconstruction volumes.

A further description of the parameters above is available here:  
<http://www.3dflow.net/3df-zephyr-parameters-tuning-guide/>

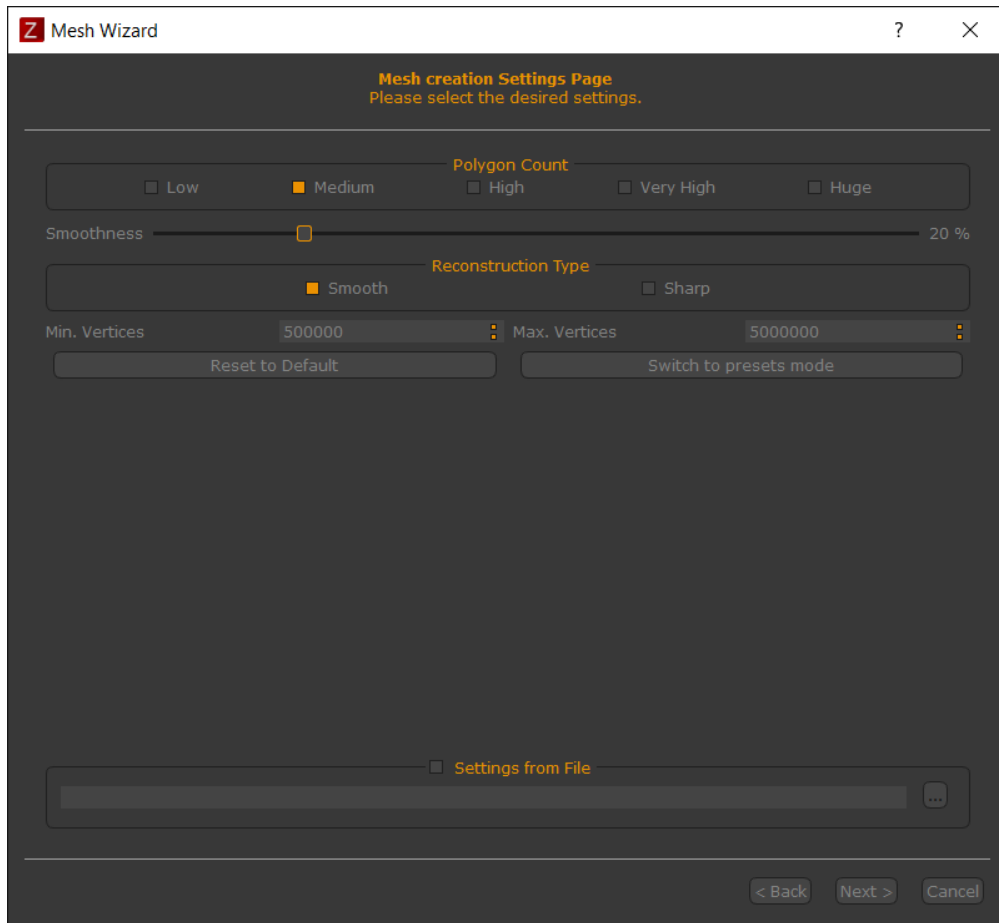
## Extracting a surface

Click on **Workflow > Mesh Extraction (13)** to start the **mesh generation phase**.



In the new window you need to select the dense point cloud you want to exploit to start the mesh generation (14). That is because you can create more dense point clouds in Zephyr.

In the following page you can see the reconstruction settings. You can choose if select categories and presets or enter the advanced setup mode (for Zephyr Pro and Aerial users) as in previous phases of reconstruction.



- **Polygon count** (only for smooth reconstruction type): it checks the discretization parameter during the surface reconstruction. You should increase this value when you want to keep a high mesh detail. Decreasing this value can be helpful when:
  - You do not have enough memory on your pc;
  - You get noisy results;
  - You need a low-poly surface;
- **Smoothness**: allows to define the smoothness of a mesh. You'd better increase this value when you get noisy results and decrease it to preserve higher details.
- **Reconstruction Type**: it is in charge of edges management and you can pick the final output (smooth or sharp shape) of surfaces edges.
- **Number of minimum / maximum vertices**: this step starts after the mesh generation algorithm and **it does not add detail to the output mesh**: when the option is activated a simplification (or densification) is performed so as to get the desired number of vertices.

You can start the mesh reconstruction by clicking on **Next** and then on **Run** button.

Timing may vary depending on the total amount of polygons you have previously selected.

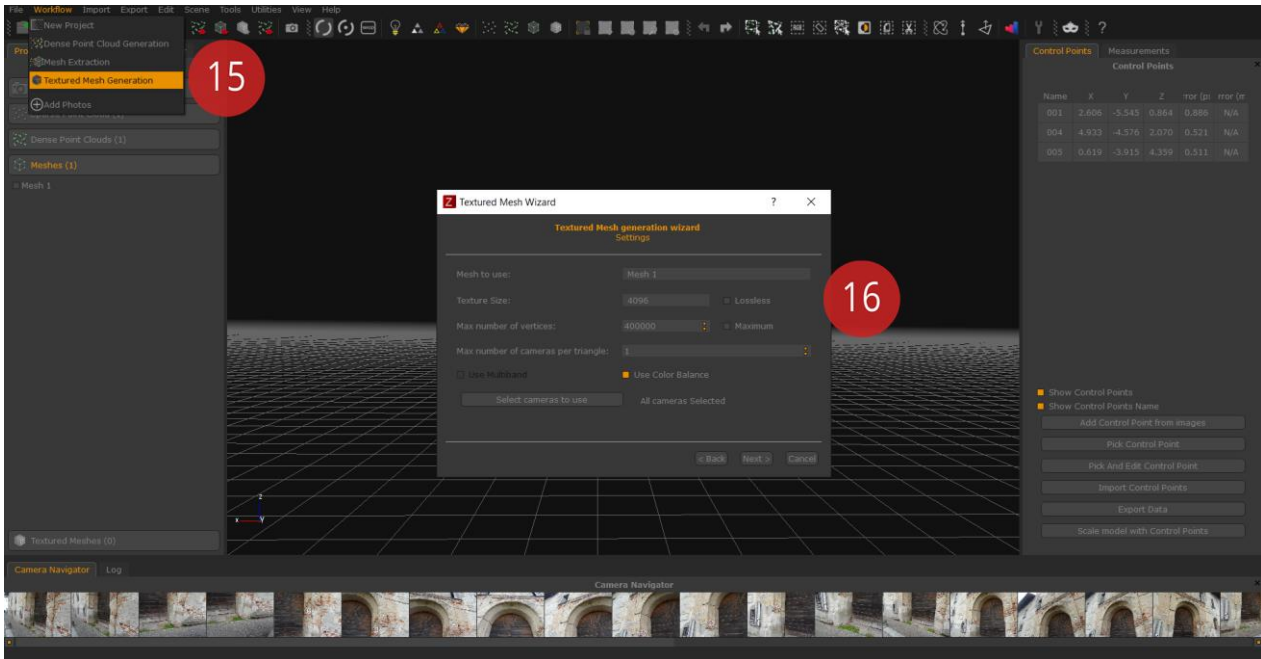
You can create several surfaces in the same Zephyr project using different parameters.

A further description of the parameters above is available here:

<http://www.3dflow.net/3df-zephyr-parameters-tuning-guide/>

## Texture generation

In the last fourth phase of 3D reconstruction of Zephyr it is possible to start the **texture generation** on a 3D model by clicking **Workflow > Textured mesh generation (15)**.



In the settings window (16) the user can set-up the following parameters:

- **Texture Size:** sets the pixels size of photographic textures.
- **Maximum number of vertices:** defines how many vertices of the mesh are involved in the texturing generation.
- **Maximum number of cameras per triangle:** manages color calculation of each pixel of the texture. It is recommended to keep one camera per triangle activating color balance as well (we will get back on this conversation when we will talk about orthophoto generation).
- **Select the cameras to use:** allows the user to establish how many cameras should be exploited in the texture generation. All the photos are selected by default.

Since Zephyr 2.0 there is the new automatic color balance algorithm that allows you to select and set automagically the best color for each pixel even on different light conditions.

## Project Panel

The Project panel is located in the left sidebar of the main Zephyr interface. This panel gathers the most important parts of the .zep file.



In the "Camera" section you can find thumbnails of the images imported in Zephyr, both those that were successfully oriented and those who failed the orientation step. By double clicking with the left mouse button on a thumbnail the properties window will appear with:

- information about the resolution and the position in the Zephyr coordinates system
- internal calibration parameters
- statistics about the keypoints that Zephyr managed to find during the SfM phase and the mean reprojection error, e l'errore medio di riproiezione della fotografia;

By right clicking one or more pictures it is possible to:

- try again to re-orientate the cameras that have not been orientated
- see the picture as an overlay, by changing the point of view
- see the picture thumbnail at a bigger resolution
- rotate and rename the camera thumbnail
- change the camera picture file
- change the mask linked to the camera
- open the properties window
- export external and internal parameters of the cameras
- export the undistorted images

**The Sparse Point Cloud, Dense Point Cloud, Meshes and Textured Meshes** sections all allow to access the properties of the reconstructed 3D object (double click with the left mouse button) which will show:

- statistics about the point cloud/mesh with the total number of points/polygons
- information about the generation process of the cloud/mesh (settings, running time, Zephyr version, generation date and time)
- detailed data about the reconstruction settings as they can be used in .xml files
- the log file about the reconstruction phase

**Tip:** in the sparse point cloud properties you can find the **Mean Square Error**, which shows the quality of the reprojection in the orientation phase. As a rule of thumb, when this value is lower than 1 then the orientation can be considered valid and you can proceed with further steps. With values higher than 1, you may want to execute again the orientation phase by:

- excluding pictures with a very high reprojection error (you can find that value in the properties of each single camera)
- adding control points on the images, exporting them, and then using them as constraints in the first phase.

By right clicking the generated **sparse point cloud** it is possible to:

- rename the sparse point cloud
- reset the bounding box volume
- export the sparse point cloud
- view the sparse point cloud properties

By right clicking the generated **dense point cloud** it is possible to:

- rename the dense point cloud, clone it or delete it
- export the dense point cloud
- see confidence information (3DF Zephyr Pro and 3DF Zephyr Aerial only)
- view the dense point cloud properties

By right clicking the generated **mesh** it is possible to:

- rename the mesh, clone it or delete it
- export the mesh
- compute the mesh volume (3DF Zephyr Pro and 3DF Zephyr Aerial only - the value will be saved in the mesh properties)
- view the mesh properties

By right clicking the generated **textured mesh** it is possible to:

- rename the textured mesh, clone it or delete it
- export the textured mesh
- view the textured mesh properties

3DF Zephyr Aerial also features the **Drawing Elements** subsection, which will contain sections, contour lines or vector graphics.

By right clicking a generated **drawing element** it is possible to:

- rename the drawing element
- change the color of the drawing element
- export all the drawing elements or those visible/selected
- access the drawing element properties

## Keypoints animator panel

The Animation panel is located in the left sidebar of the main Zephyr interface. This function allows to easily create demonstration videos of your own models directly from the Zephyr interface, allowing you to export the video in the most common file formats (avi, wmv) or by uploading them directly to YouTube.

In order to create an animation simply reveal the "Keypoints animator panel" and click the "**Add Current Position**" button, while simultaneously moving the workspace camera to the desired position. By enabling the "**show keyframes**" option, every keypoint set will be shown in the workspace with a yellow cone shape.

When all the keyframes have been placed you may click the "**Play Animation**" button to see the animation preview, or you may edit the duration of each movement between the keyframes by right clicking and editing every keyframe or of the whole animation by clicking the "**Set Animation Time**" button.

By clicking the "Start Video Recording" Button a new window will appear (as soon as at least two keyframes have been defined) which will allow you to edit the movie generation settings: the parameters that can be edited are the video resolution, the framerate, the target bitrate and the final type of the output (on hard drive, youtube, or both)

## Control Points panel

These functions are available only in 3DF Zephyr Pro e 3DF Zephyr Aerial.

Please note that every reconstruction is generated with an arbitrary scale, translation and rotation. This chapter will focus on defining a global scale in order to take measurements and align the world position, rotate and translate according to user defined control points.

Control points, alignment and world scaling with known control points (or known distances) can be managed from the panel on the right labeled "Control Points".

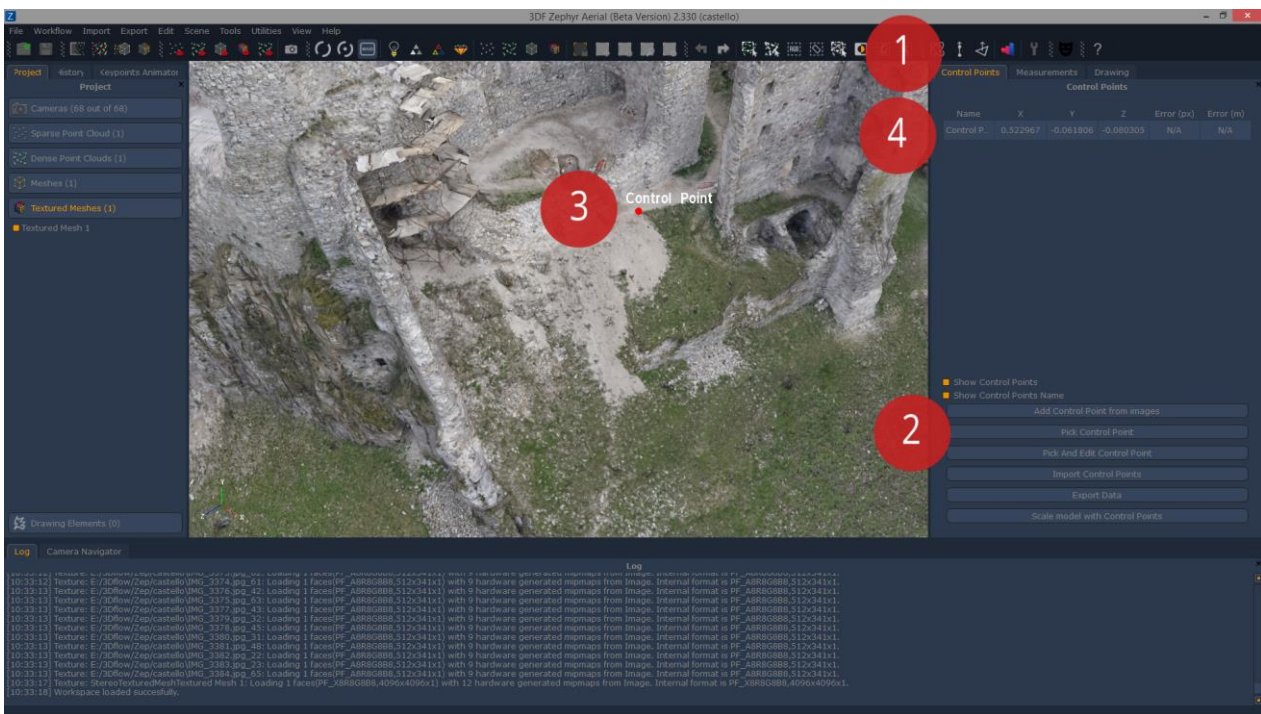
### Picking a control point on the scene

The easiest way (albeit the less accurate) to insert a new control point is to directly pick it from the 3D reconstruction.

From the "Control point" panel (1) click the "Pick control point" button (2). The mouse cursor will show a crosshair: move in on the scene (3) and left click the desired control point position. A new control point will be added to the control points list (4) and will be automatically shown in the scene. until di controllo (4) e sarà automaticamente visualizzato nella scena.

This control point selection mode can not be done on a textured mesh.

That's it! That's all you need to do to directly pick a control point!



### Picking a control point from images

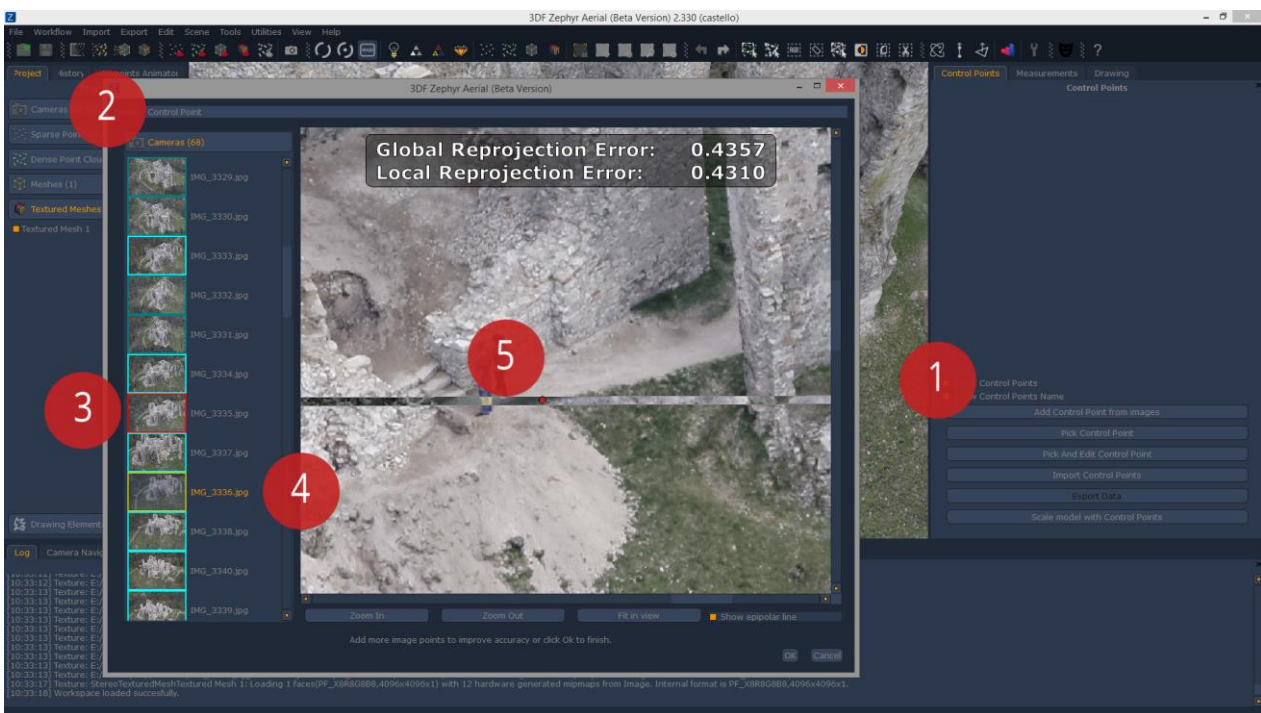
A much more accurate way to add control point is to pick them directly from the photos. You need to pick the same coordinate on at least two pictures in order to triangulate and make zephyr calculate the control points.

Lets clear the previously created control points by right clicking on the Point List and left clicking on "remove all". Click Yes to confirm.

Now, from the "Control Point and distances Dock menu" click "Add Control Point From images" (1): the "Control Point Picker window" will appear. From the "Camera List" (2) left click a picture to view it in the "Control Point Picker Selector". The first selected image will be highlighted by a red border (3). Left click where you want the control point to appear and a red dot (5) will appear. The "Ok button" won't be clickable yet: remember, we need at least two images to define a control point in the 3D world.

Click on another image in the "camera list" (2): this time also the epipolar line will appear (highlighted by the color inversion in the picture) which will help positioning the second coordinate by left clicking. The current image will be highlighted by a yellow border (4). The "Ok" button will now be clickable - it is possible to add as many coordinates as wanted (usually, the more coordinates the better the accuracy) and click OK to complete the control point selection. When changing the 2D position, you can see in real time the global reprojection error and the local reprojection error.

The light blue border will highlight the camera with a direct view on the selected control point while the dark blue border will highlight cameras that may show the control point as occluded.



## The "Pick and edit control point" function

From the same menu where "Add control points from images" and "pick control point" it is possible to find also the "Pick and edit control point" button: this function allows to select a control point by directly picking it on the scene (exactly like the "Pick control point" function) and then modify the position of the control point by editing its position with the "add control point from images" interface, with the control point already in place in all the possible cameras.

## The "Import control points" function

Importing control points from text files allows to automatically add control points exported from other applications: in order to do that, simply click on the "import control point" button, pick the desired text file and then click "Open".

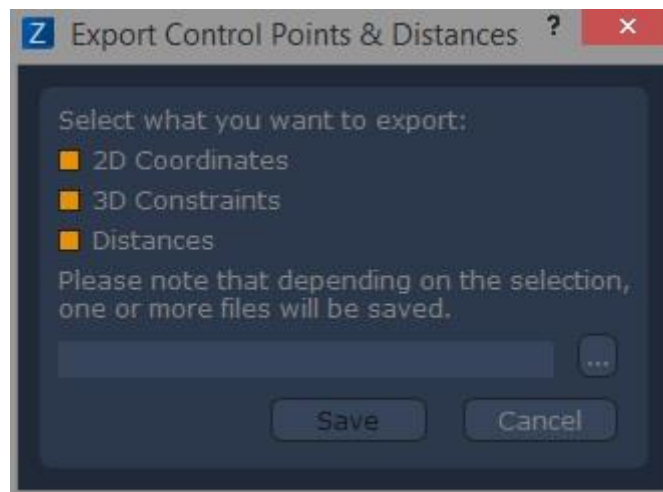
A window will appear to confirm that the import phase has been completed successfully: click OK.

Note: for each imported control point it is necessary to define at least two 2D images coordinates. For example, to import a control point named "point1" seen by the camera "PictureA.jpg" at the (x,y) coordinates 100,600 and from a second camera "PictureB.jpg" with coordinates (x,y) 200,660 the file has to be formatted in the following way: il file dovrà essere formattato nella maniera seguente

```
Point1 PictureA.JPG 100 600
Point1 PictureB.JPG 200 660
```

## The "Export Data" function

Just below the "pick and edit control point" button it is possible to access the control point (and distances, defined in the "measurements" etab) export function.



From this window it is possible to export:

- 2D coordinates

Will create a \*ControlPoitns2D.txt file - defines the control points as 2D images coordinates, as

```
"controlPoint1"    "IMG_3319.jpg"    4.33473658e+03    2.24061730e+03
"controlPoint1"    "IMG_3320.jpg"    3.30352087e+03    2.42468881e+03
"controlPoint2"    "IMG_3319.jpg"    3.01642756e+03    3.16114630e+03
"controlPoint2"    "IMG_3320.jpg"    1.68567672e+03    2.14786953e+03
```

- 3D Coordinates

Will create a \*ControlPoints3D.txt file - defines the control points as 3D coordinates, as

```
"ControlPoint"      8.18880729e-01  -5.14516149e-01  4.54143586e-01
"Control Point #2" -5.64690812e-01  -5.65085273e-01  1.09244112e+00
```

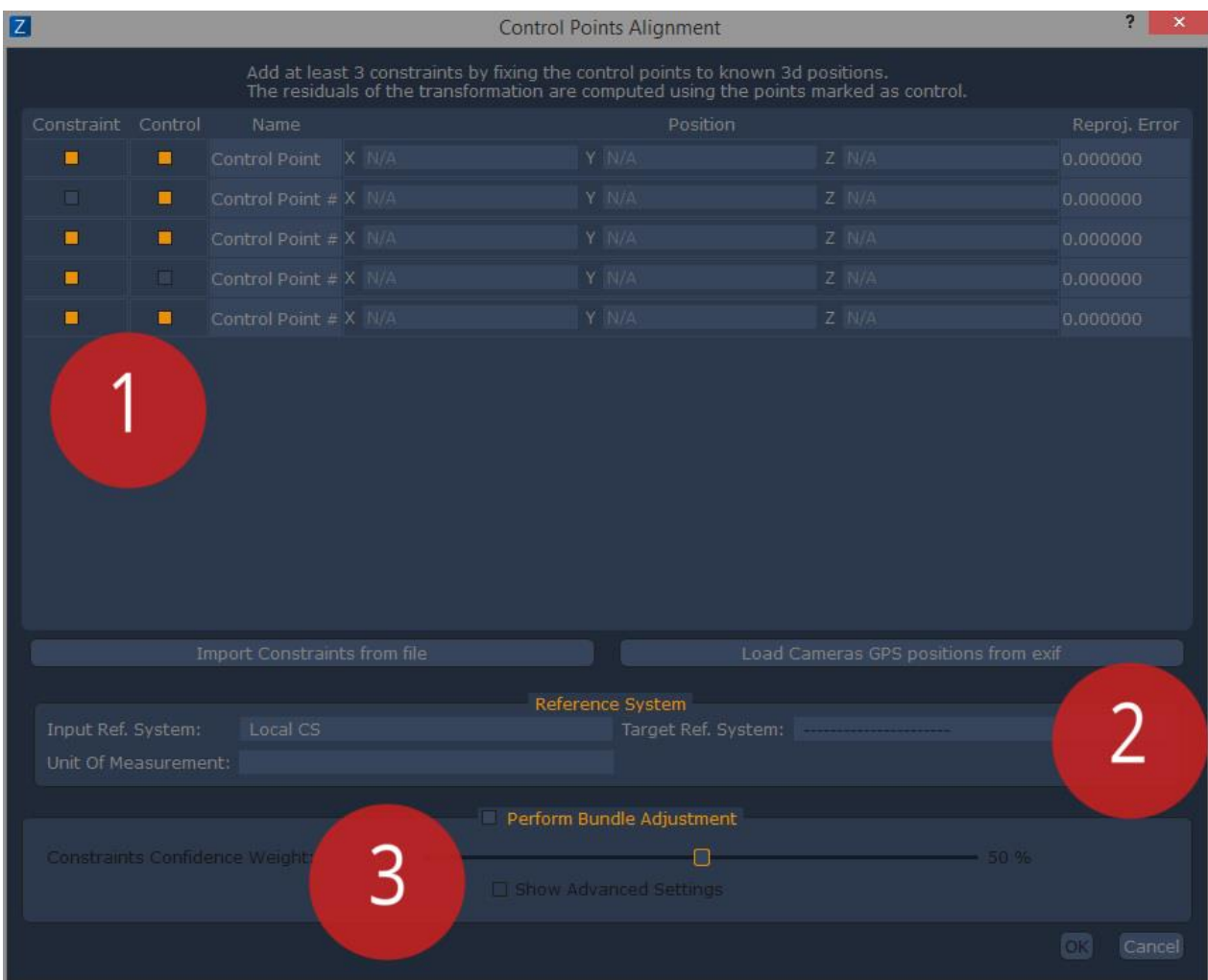
- Distances

Will create a \*ControlPoints3D.txt file - defines the distances as seen in the measurements tab, as

```
"Control Point #2" "Control Point"      2.33824531e+01
```

### The "scale model with control point" function

Just below the "Export data" button it is possible to find the "scale model with control points" function.



By defining at least three constraints (1) it is possible to scale the model using the mentioned control points.

**It is possible to either directly set constraints from text file via the "Import constraints from file" button or manually. Please note how each control point can be set as Control point, Constraint, or both by using the checkboxes on the left of each point.**

It's always a good idea to include some control points that are not set as constraints .

3DF Zephyr Aerial also shows another option, which is the ability to directly change the reference system (2).

You may also perform a bundle adjustment by checking the "perform bundle adjustment checkbox" (3). This can be done by using a slider that will assign a confidence weight in the defined constraints, as well as an advanced mode option.

Click OK to proceed.

## Measurements panel

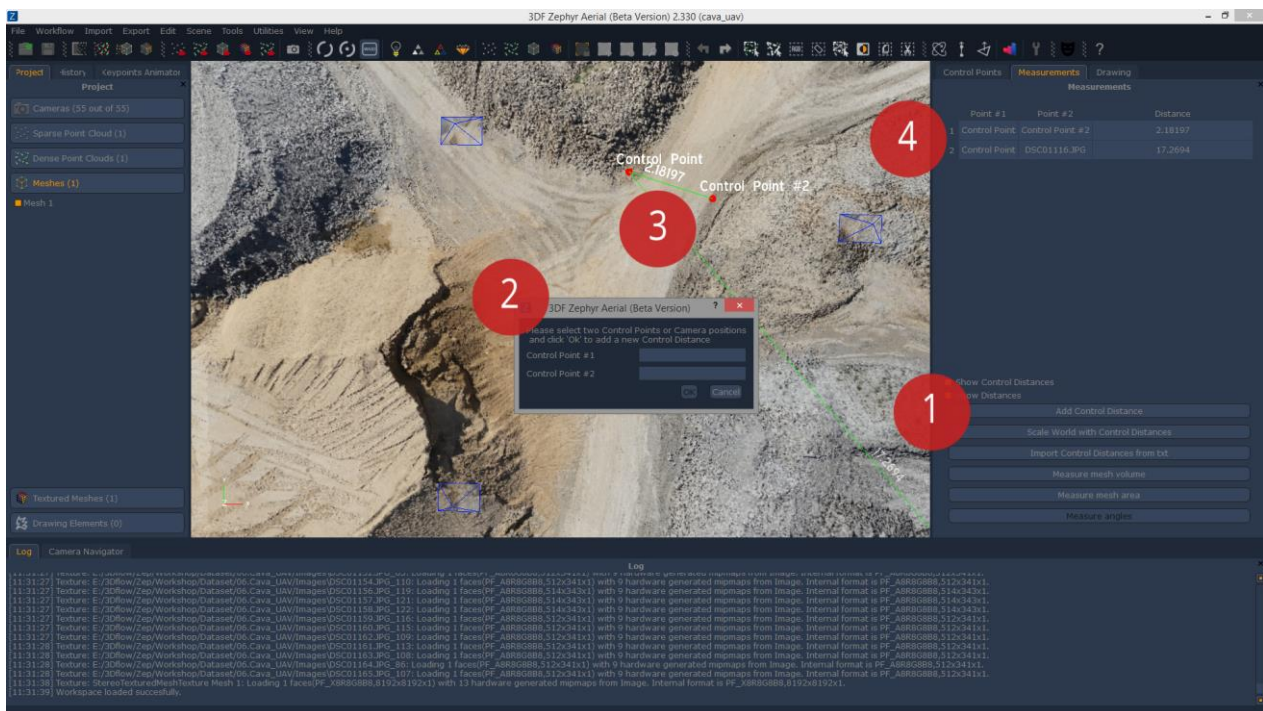
These functions are available only in 3DF Zephyr Pro e 3DF Zephyr Aerial.

Control distances can be defined as the distance between two control points, the distance between a control point and a camera, or the distance between two cameras. With 3DF Zephyr you can easily define control distances and even scale the world with control distances.

### The "Add control distance" function

To add a new control distance, click on the "Add Control Distance" Button (1). The "control point selection window" (2) will pop up. From this window, pick the two control points needed from the Control Point #1 selection menu and the Control Point #2 selection menu. Once you click "OK", the distance will be drawn as a green line (3) and rendered onto the screen (in this case, 2.18197).

The control distance (and the relative used control points) will also appear as a list on the rightside panel (4).



### The "Scale world with control distances" function

It is possible to scale the model using control distances: in order to do so, simply click on the "Scale world with control distances" button: in the window that will popup, simply set the wanted distances as constraints. When completed, the residue error will be shown.

### **The "import control distances from txt" function**

It is possible to import control distances directly from text file: every line of the text file must be formatted as

```
"Control Point #2" "Control Point" 2.18197
```

### **The "measure mesh volume" function**

It is possible to compute the mesh volume using the dedicated button. If the mesh is not completely closed, all holes will be automatically filled and later shown with a red color - it is possible to save that mesh as a separate workspace object.

If you decide to use a point cloud as a source, it will be computed the corresponding mesh anyways.

Once you have selected the reference mesh from the menu, simply click the "Compute" button.

### **La "measure mesh area" function**

Similarly to the "measure mesh" function, clicking this button will compute the area of a given mesh. Just select the mesh and click the "Compute" button.

### **The "Angle measurements" function**

When at least three control points have been selected, you can compute the angle between control points. The interface of the window that will appear will allow you to set control points as A,B and C and then compute the angles between the vectors BA and BC. A checkbox will allow to change the output to radians or degrees.

## **Drawing panel**

These functions are available only in 3DF Zephyr Aerial.

From the "Drawing" tab it is possible to create drawing elements directly on the 3D model, which then can be exported into .DXF or .SHP.

To create a new drawing element, simply click the "Create new" (1) button - the new element will be automatically added to the "Drawing elements" section in the Project tab (2).

Once an element has been created, the dropdown menu to select the current drawing element will be enabled (in this case, showing the only available drawing element, "Drawing Element 0", just below the "Create new" button). This allows to select and edit previously created drawing elements.

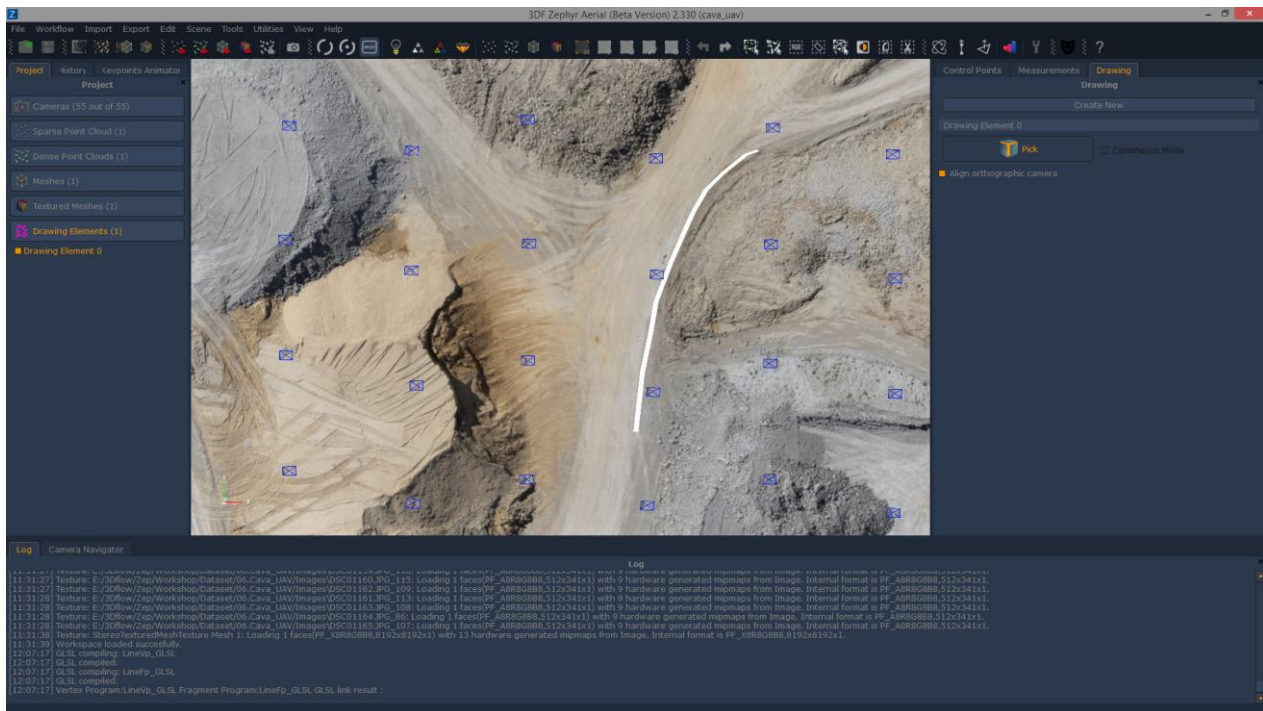
When the drawing element has been selected, it is possible to navigate the scene to the desired position (eventually by making use of the "align orthographic camera" checkbox).



When ready, it is possible to select the middle points that will define the shape of the drawn element, by picking them directly on the mesh using the "Select" button (3). You may also use the "continuous mode" checkbox that won't ask for many clicks (each for every middle point) but instead it will draw the line as long as the left click is kept pressed and the cursor is on top of the mesh.

Press "ESC" to exit the drawing mode.

It is possible to change the color of one (or more) drawing elements by selecting the desired elements from the "drawing elements" section in project tab (2) by right clicking on the selection and then selecting "Change color selected"



## The "Workflow" menu

The workflow menu allows to undertake major actions within the 3D reconstruction workflow, such as starting a new project, completing a reconstruction step or adding photos.

## The "New Project" function

By clicking "New project" the current workspace will be cleaned and the new project wizard will appear, as shown earlier in the "Starting a new project" chapter.

## The "Dense Point Cloud generation" function

Starts a new dense point cloud generation wizard. See the "Extracting a dense point cloud" chapter as reference. More than one dense point cloud can co-exist in the same workspace.

## The "Mesh extraction" function

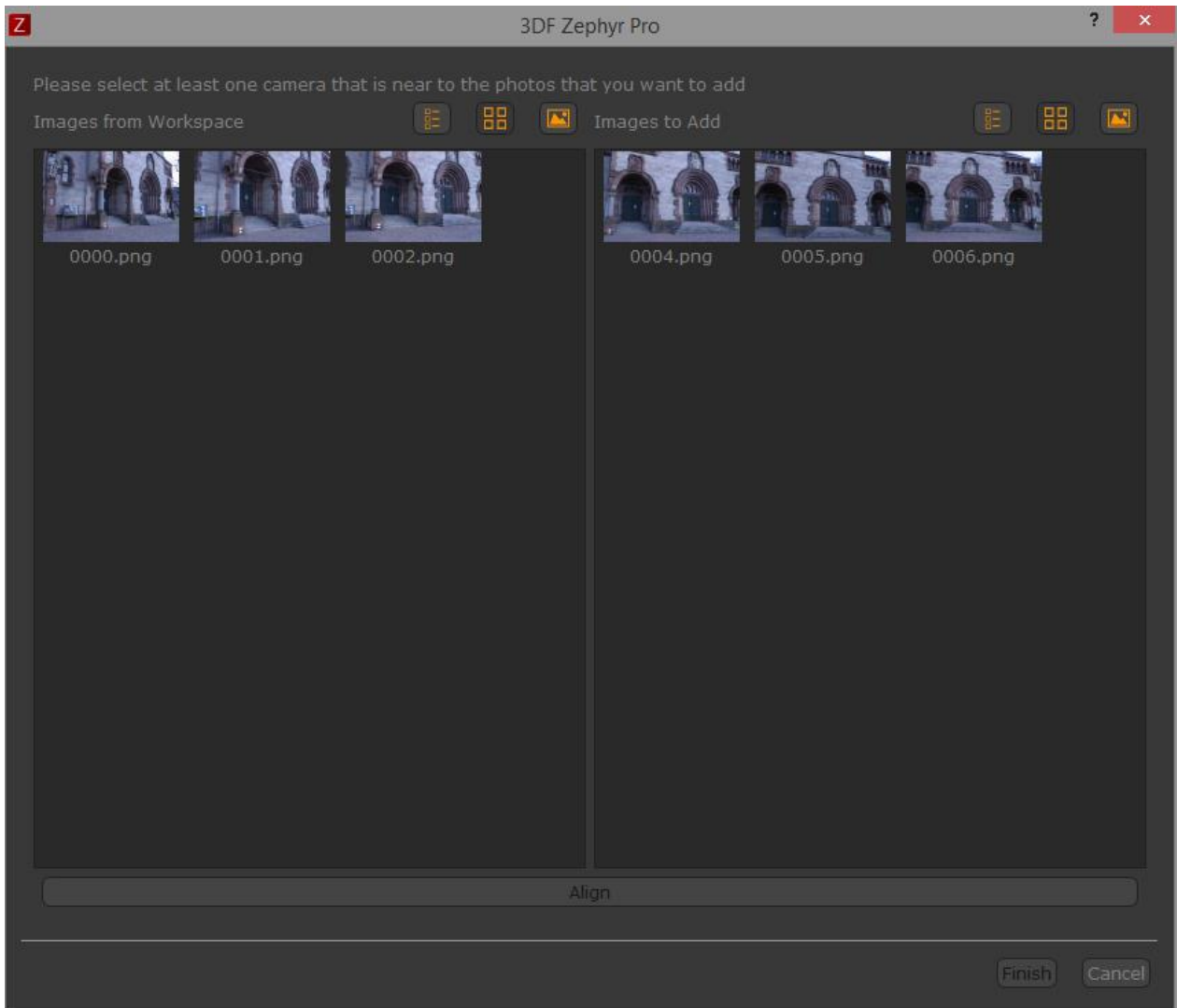
Starts a new mesh extraction wizard. See the "Extracting a surface" chapter as reference. More than one mesh can co-exist in the same workspace.

## The "Textured mesh extraction" function

Starts a new texture mesh extraction wizard. See the "Extracting a surface" chapter as reference. More than one textured mesh can co-exist in the same workspace.

## The "Add photos" function

This process allows to add photos to the current workspace. The photos has to be taken with one of the cameras already used in the original workspace. The "Add photos" dialog is similar to the "New project" wizard, so you simply have to add photos by browsing or by drag and dropping them. After the new photos have been selected, the following dialog will appear:



All that is required to do, is to simply select at least one camera on the left panel (by left clicking it) which is near to the photos that you want to add. If the photos can be added to the workspace correctly, you will see them in the "Cameras" section and the "Sparse point cloud" will be replaced with the new one, computed using the new cameras in the workspace. Any other workspace element (such as dense point clouds and meshes) won't be affected automatically by this action.

## The "Export" menu

The export menu allows to export different elements from the workspace as standalone files (for example, an obj file) or to other services (for example, the direct upload to Youtube).

### The "Export cameras and points" function

This function is available only in 3DF Zephyr Pro e 3DF Zephyr Aerial.

This function allow to export cameras (internal and external parameters for each camera - one text file for the externals and one text file for the internals) giving different options to the advanced user, such as the option to export the projection matrices for OpenGL, the points visibility and the option to export the sparse point cloud (in PLY format) and to generate the undistorted images.

### La "export dense point cloud"

This function is available only in 3DF Zephyr Pro e 3DF Zephyr Aerial.

This function allows to export the generated dense point clouds into different file formats.

The first option in the export dialog allows to select the desired dense point cloud, since more dense point cloud can coexist in the same workspace.

The "Export format" option allows to select the desired export format - it is possible to export directly into .ply, .pts, .ptx, .xyz, .txt, .las, .e57 and to the 3D visualization web service Sketchfab. By selecting certain formats, some advanced options may or may not be enabled

The "Export colors" option (if selected and for the supported formatas) allows to export the point colors.

The "Export normals" option (if selected and for the supported formatas) allows to export the normals

The "Use binary encoding" option (if selected and for the supported formatas) allows to export in binary mode (or in text mode if not selected)

The "Decimate" option (if selected) allows to automatically decimate the dense point cloud point number up to the desired value (as defined by the Max point cloud option)

The "Local rendering reference system" option (if selected and for the supported formatas) allows to export by using the local rendering reference system

### The "Export mesh" function

This function allwos to export the generated meshes into different file formats.

The first option in the export dialog allows to select the desired mesh, since more meshes can coexist in the same workspace.

3DF Zephyr Lite allows to export to .ply, .stl, .obj/mtl and and to the 3D visualization web service Sketchfab. By selecting certain formats, some advanced options may or may not be enabled.

3DF Zephyr Pro and 3DF Zephyr Aerial allow to export (in addition to the format exported by 3DF Zephyr lite) also to the .fbx, pdf3df, Universal3D and Collada file formats. Please note that the fbx format also allows to export the camera positions.

The "Export normals" option (if selected and for the supported formats) allows to export the normals

The "Use binary encoding" option (if selected and for the supported formats) allows to export in binary mode (or in text mode if not selected)

The "Export cameras" option (only for Zephyr Pro and Zephyr Aerial, if selected and for the supported formats) allows to save the camera positions.

The "remesh before exporting" option (if selected) allows to execute a remeshing algorithm, which will generate a new mesh with a vertices count as higher as the number defined by the user.

Eventually, it is possible to already create the mesh at this point. However it is usually a good idea (for a more manageable workflow) to extract also the textured mesh in the workspace. Please see the "Extracting the textured mesh" chapter for more information about the available options.

The "Add comment" option (if selected and for the supported formats) allows to add a text comment as file metadata.

### **The "Export textured mesh" function**

This function allows to export the generated textured meshes into different file formats.

The first option in the export dialog allows to select the desired textured mesh, since more textured meshes can coexist in the same workspace.

3DF Zephyr Lite allows to export to .ply, .obj/mtl and to the 3D visualization web service Sketchfab. By selecting certain formats, some advanced options may or may not be enabled.

3DF Zephyr Pro and 3DF Zephyr Aerial allow to export (in addition to the format exported by 3DF Zephyr lite) also to the .fbx, pdf3df, Universal3D and Collada file formats. Please note that the fbx format also allows to export the camera positions.

The "Export normals" option (if selected and for the supported formats) allows to export the normals

The "Use binary encoding" option (if selected and for the supported formats) allows to export in binary mode (or in text mode if not selected)

The "Export cameras" option (only for Zephyr Pro and Zephyr Aerial, if selected and for the supported formats) allows to save the camera positions.

The "Add comment" option (if selected and for the supported formats) allows to add a text comment as file metadata.

### **The "Export control points" function**

This function is available only in 3DF Zephyr Pro e 3DF Zephyr Aerial.

This button opens the same dialog that the "Export data" button exposes from the "Control point" panel.

### The "Export workspace" function

This function is available only in 3DF Zephyr Pro e 3DF Zephyr Aerial.

This function allows to export the workspace to .ply/text files.

### The "Export processing report" function

This function is available only in 3DF Zephyr Pro e 3DF Zephyr Aerial.

This function will create a pdf report about the current workspace - the report will contain information about the workspace, from the sparse point cloud to the textured mesh, with a technical summary and statistics.

### The "Export current view as PDF"

This function allows to create a screenshot of the workspace current view, as PDF file.

### The "Take screenshot" function

Like the "Export current view as PDF" function, this function allows to create a screenshot of the vurrent view, as an image file. Few additional options are available, such as the possibility to have a transparent background.

## The "Edit" menu

From the "Edit" menu it is possible to quickly access the classic "**Undo**" (CTRL+Z) and "**Redo**" (CTRL+Y) actions.

Not all actions in Zephyr support undo/redo.

The command history can be seen from the "History" panel.

Another submenu labeled "Select" allows to apply certain functions on the workspace elements - most of these commands have a direct quick button on the main toolbar.

**Select all:** selects all the currently active subject in the workspace - triangles for meshes, points for clouds. The selected part will be highlighted by a red color.

**Invert selection:** invert the previously done selection. The selected part will be highlighted by a red color.

**Enable/Disable point selection mode:** allows to select a part of the currently active object in the workspace - the selection is made by considering all the points contained by dragged rectangle in the workspace (keeping the left-click button pressed) - when the click is released, the selection will be done. The selected part will be highlighted with a red color.

**Enable/Disable polygon selection mode:** allows to select a part of the currently active object in the workspace - the selection is made by considering all the points contained by

a polygon defined by clicking and connecting the polygon points in the workspace - when the polygon is closed, the selected part will be highlighted by a red color.

**Delete selected items:** deletes the currently selected (those element which are highlighted in red) from the currently active object.

**Select by color:** selects (on dense point clouds) all the points of a given color (within a given threshold)

**Select by plane:** selects a part of the currently active subject - the selection is done by placing a plane that will "cut" the subject - all points above that plane will be selected. The selected part will be highlighted with a red color.

**New object via copy:** creates a new object in the workspace, by making a copy of the current selection.

**New object via cut:** creates a new object in the workspace, by cutting the selected object. The inverse of the selection will become the origin object.

## The "Scene" menu

This menu allows to manage how the subject is rendered and how the bounding box is defined in the scene.

Most of these functions have a quick access button on the main toolbar.

### Camera management via the "Camera" menu

Zephyr allows to navigate the scene in three different ways:

- Orbit: in order to navigate the scene in "orbit" mode the mouse cursor has to be on scene: keep the left mouse button pressed and move the mouse to orbit around the subject. To zoom in or out, keep pressed the left shift button and move the mouse forward/backwards. The pivot is centered as the center of the bounding box.
- Orbit with pivot: like orbit, however the pivot will be moved where the mouse cursor is at the time of the left click button press.
- Free look: "first person shooter" view where the movement is applied via the WASD buttons (W forward, S backwards, A left, D right) and Q/E (up,down).

The "Orthographic projection" camera mode can be toggled via the dedicated checkbox.

Finally, there are few buttons that allow to move quickly into predefined position with respect to the subject (move left, move up, etc.) and a reset camera button.

### Rendering management

Zephyr allows to change the rendering settings as follows:

Turn light on/off: toggles the lighting applied to the scene

Show only sparse point cloud: changes the current active workspace object to the sparse point cloud.

Show only dense point cloud: changes the current active workspace object to the dense point cloud.

Show only mesh: changes the current active workspace object to the mesh.

Show only textured mesh: changes the current active workspace object to the textured mesh.

Enable/Disable wireframe: toggles the wireframe visualization

Enable/Disable colors : if the lighting is enabled, this can be used to disable the mesh color for an easier mesh inspection. Obviously, if the lighting is turned off this option won't be enabled as well.

Enable/Disable culling: toggles triangle culling

Enable/Disable volume: shows the computed mesh volume

### **Bounding box management**

When a 3D model is reconstructed by Zephyr, the corresponding bounding box will be computed as well. A bounding box is defined as the volume in which all points that do not fall into said volume will be discarded.

You can then change how Zephyr behaves by changing the bounding box settings (not just for "what" is being reconstructed, but also the discretization level changes when the volume changes too)

Show/Hide bounding box: toggles the bounding box rendering in the scene

Translate Bounding box : click and drag the desired gizmo to move the bounding box over the selected axis.

Rotate Bounding box: click and drag the desired gizmo to rotate the bounding box over the selected axis.

Scale Bounding box: click and the desired face of the bounding box to scale the bounding box.

### **The "Utilities" menu**

From this menu you can launch utilities:

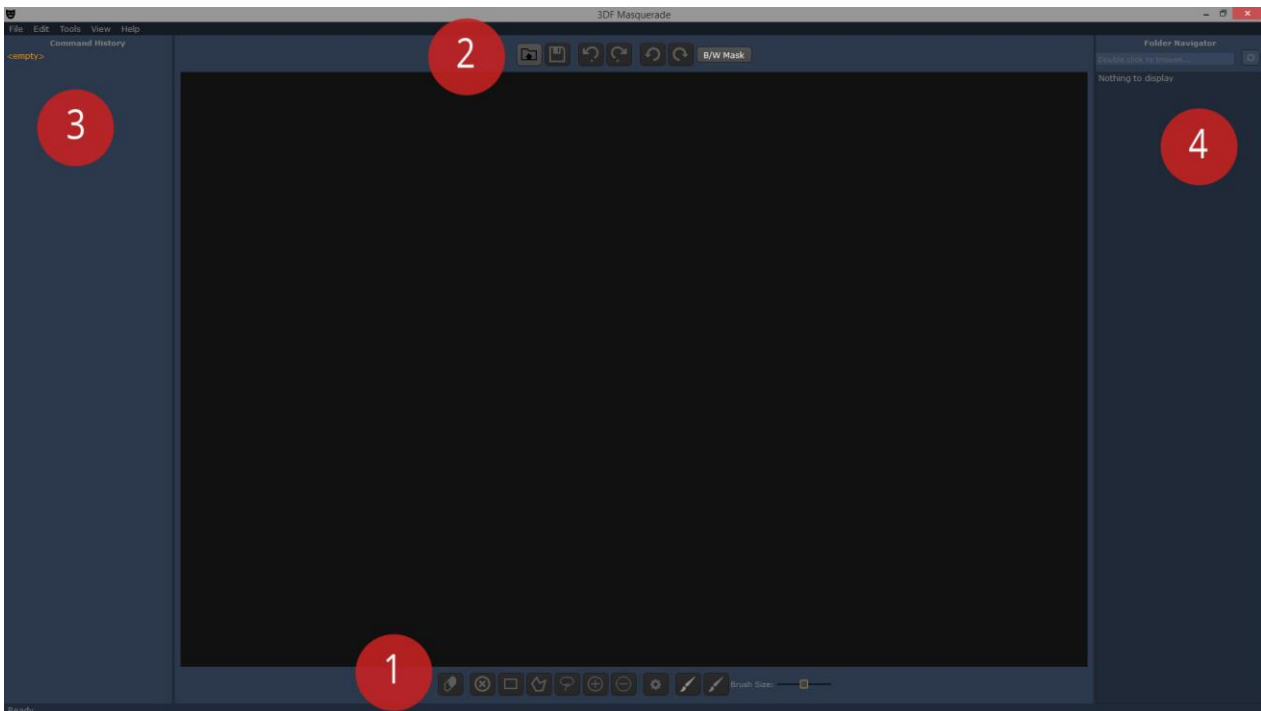
**3DF Masquerade:** standalone external tool (included in all 3DF Zephyr versions) to create masks to pair with the images to be processed in 3DF Zephyr. A mask is defined as a specific selection of one (or more) images that allows to force zephyr to ignore the corresponding part in a picture. The first time you run Masquerade useful tooltips will appear on the screen that will teach you the interface basics.

You can find a complete tutorial (and videotutorial) about 3DF Masquerade at the URL <http://www.3dflow.net/en/technology/documents/3df-zephyr-tutorials/tutorial-use-masking-tool/>

The 3DF Masquerade interface is split in four parts:

- (1) toolbar - select the tool and mask the image
- (2) top toolbar - rotate images / show mask as black and white

- (3) command history - used to undo / redo commands inside 3DF Masquerade
- (4) images list - quickly browse the images



The Rectangle, Polygon and lasso tools are very similar and most users should be already familiar with them: to mask a certain area (the area you want to process) you can:

- drag a rectangle and click the "mask" button to mask the selected area
- use the left click button to add nodes to the polygon path (doubleclick to automatically close the polygon) and click the "mask" button to mask the selected area
- drag the lasso and click the "mask" button to mask the selected area.

When the selection has been made, you should see a blue overlay, while when the mask is being applied, you should see a red overlay.

You may also remove a mask subsection using the "remove mask" button.

Using these tools you can add and subtract different areas by keeping the left control/left shift keyboard button pressed when doing an action. You may also undo actions using the CTRL+Z shortcut or by using the command history.

You may also change the zoom value by using the scroll up/down mousewheel; you may also translate the current view by moving the mouse while the mousewheel is kept pressed down.

The silhouette tools can be also used to automatically compute the silhouette of the subject by tracing the foreground element (red, which will be masked) and the background element (blue, which won't be masked). You may also quickly swap the foreground/background by using left shift + left click.



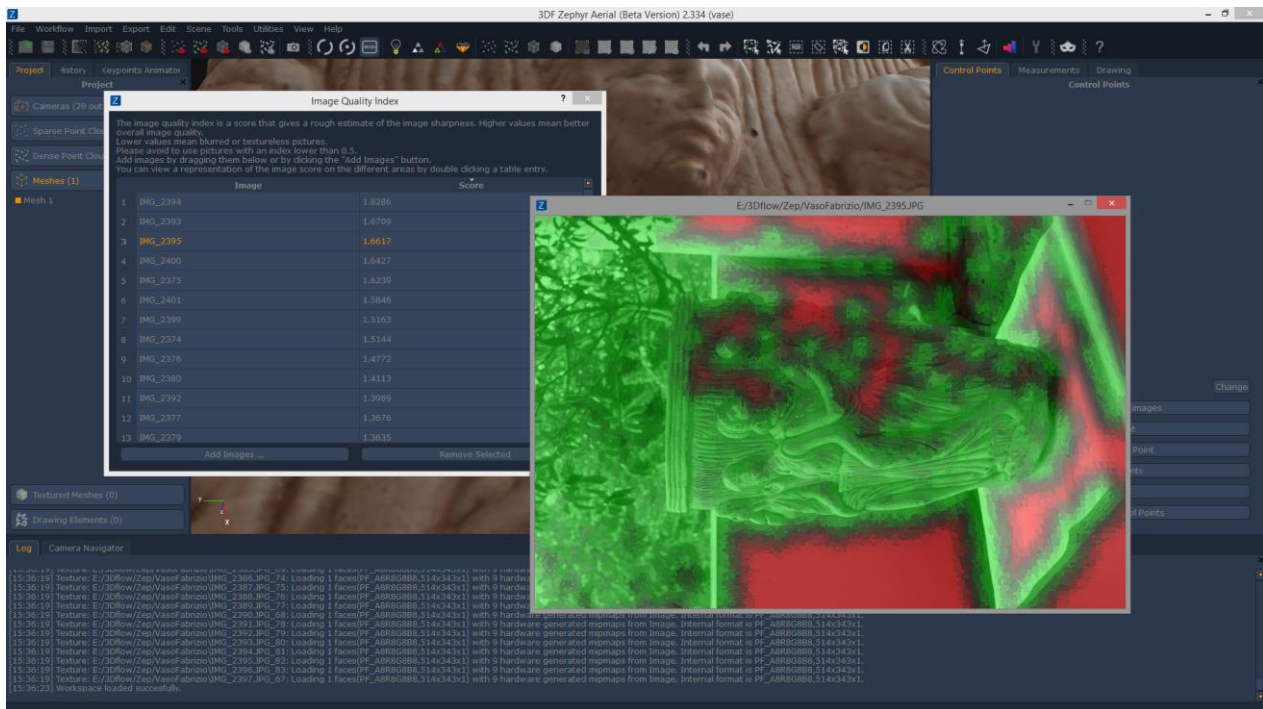
You can also delete strokes by dragging the cursor over it and right clicking while dragging.

This tool is very useful especially when the background has a very high contrast with respect to the subject that you want to reconstruct.

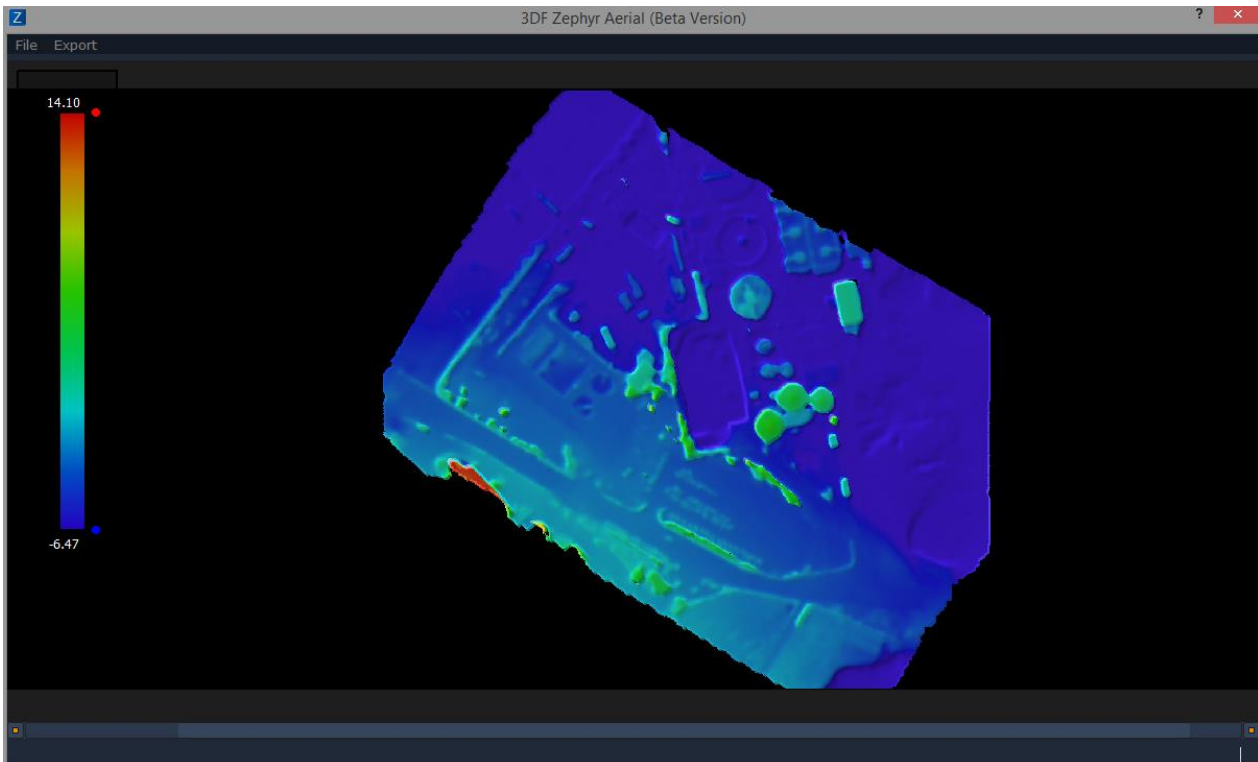
Finally, a gear shaped function allows you to automatically compute the next silhouette, very useful especially when dealing with turntables.

**Open Sunny:** opens 3DF Sunny, 3Dflow's cloud computing service (in beta)

**Image Quality Index:** shows a numeric value (and visually in Pro and Aerial) the quality of the input pictures. You can simply drag and drop the pictures into the quality index window, and the score will be automatically computed. Higher score means higher quality. Please note that this score is computed per picture: it does not use any 3D information or of workspace information - this will simply compute which areas of the picture are well in focus and potentially with a high density of keypoints. A high-score picture does not automatically means that a picture has been shot correctly, however a low-score picture should be discarded (in green are shown the better areas). Double click each line to open the visual mode.

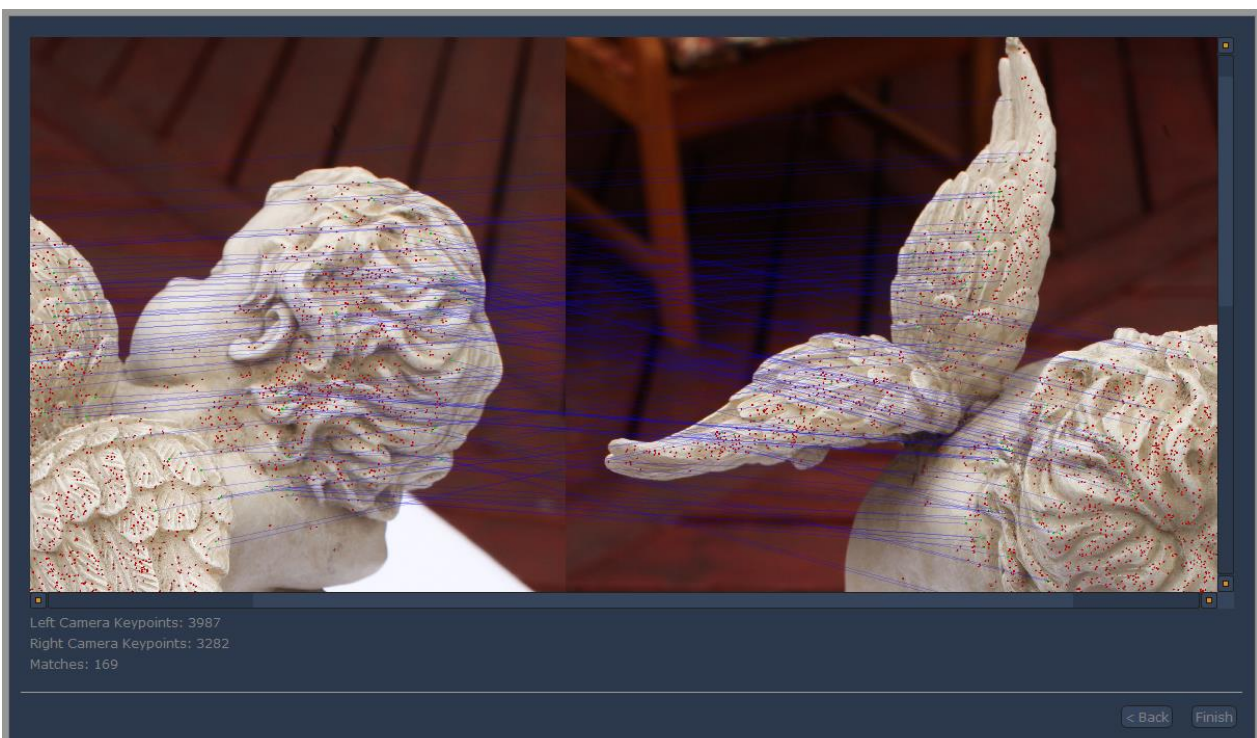


**DEM viewer utility:** allows to view .DEM files directly from the Zephyr UI. Please refer to the "DEM file and profile generation" chapter for more information.



**Launch camera calibration:** opens 3DF Lapyx, with an easy to use wizard to compute the camera calibration. Follow the onscreen instruction if you wish to precalibrate your camera. You won't need to print anything: the pattern will be shown on the screen and that is what you need to photograph.

**Matches viewer:** opens the match viewer interface. Simply select an image on the left panel by left clicking it and similarly an image on the right panel. After clicking "next", keypoints and matches will be shown with a line. between the two images. Simply click "back" and repeat the process to see matches from different images.

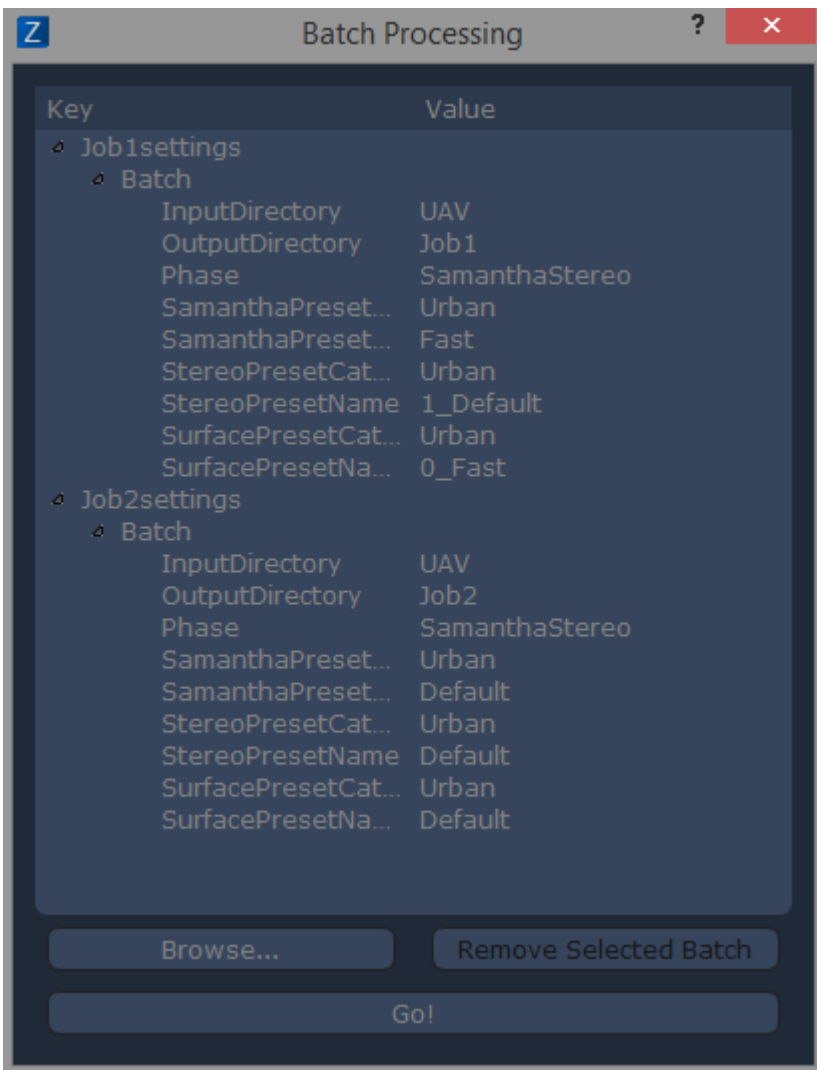


**Batch:** available only in 3DF Zephyr Pro and 3DF Zephyr Aerial, the batch processing window allows to schedule certain reconstruction jobs. Jobs must be defined via XML files, and they must follow the pipeline workflow, at least partially (this means that you can setup a job from the sparse point cloud generation to the texture mesh generation, eventually stopping at any of the intermediate step, but you can not define a job that starts after a camera orientation).

The xml files must be defined in this format:

```
<?xml version="1.0"?>
<Settings>
  <Category name="Batch">
    <Entry key="InputDirectory" value="ImagesInputPath">
    <Entry key="OutputDirectory" value="OutputPath"/>
    <Entry key="Phase" value="SamanthaStereo"/>
    <Entry key="SamanthaPresetCategory" value="Urban"/>
    <Entry key="SamanthaPresetName" value="Fast"/>
    <Entry key="StereoPresetCategory" value="Urban"/>
    <Entry key="StereoPresetName" value="1_Default"/>
    <Entry key="SurfacePresetCategory" value="Urban"/>
    <Entry key="SurfacePresetName" value="0_Fast"/>
  </Category>
</Settings>
```

It is also possible to use the custom parameters directly in the XML. A description of the categories and the parameters is available when selecting "Custom" during the reconstruction wizards or by selecting the properties (with the right click) of an element reconstructed within the workspace. After scheduling one or more job, they will be listed in the interface, from where you'll be able to start the batch operations.



### DEM file and profile generation

These tools are available for 3DF Zephyr Pro and Aerial versions only.

You are supposed to generate an orthophoto before running DEM generation, so click on Tools > Orthophoto and orthomosaic > Generate orthophoto.

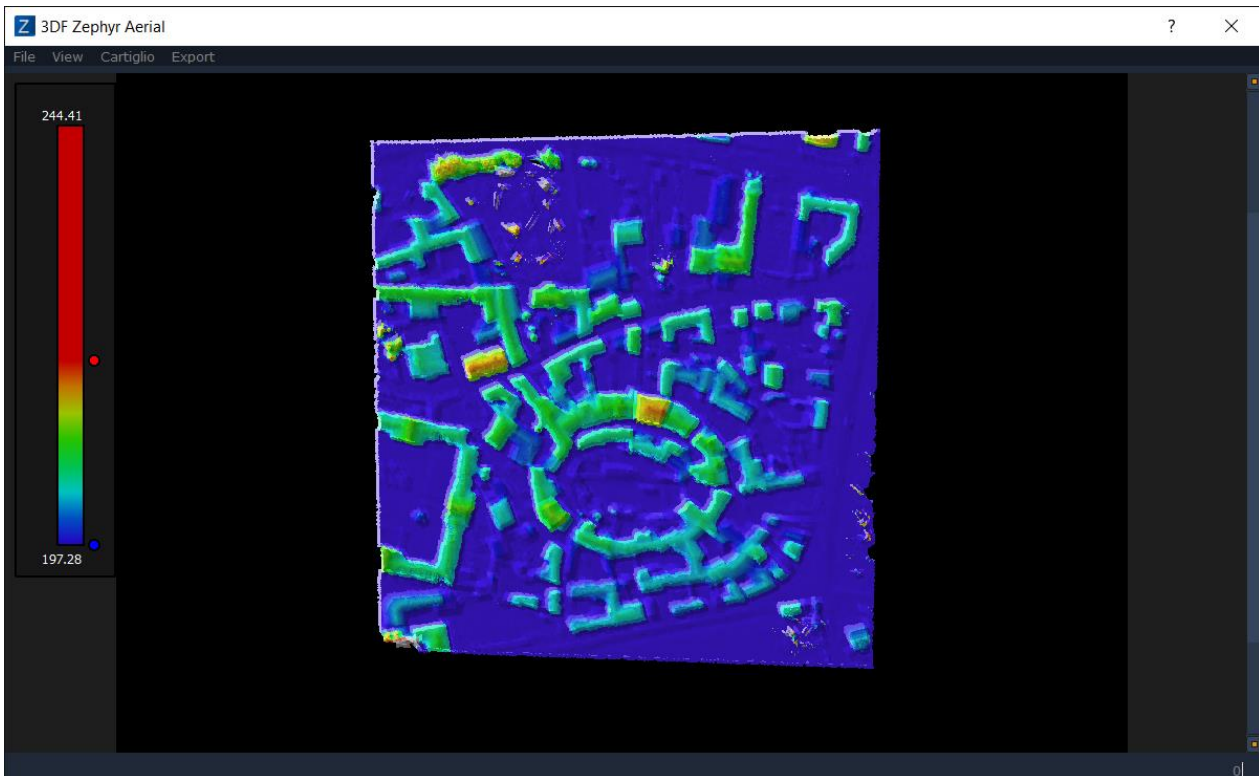
You are allowed to choose if either exploiting control points or axis method, then just click on Next button.



Check the Export section into the orthophoto settings window and activate the Export DEM file option (image)

After clicking on Generate orthophoto button simply choose a file name and format as well as the file destination.

As soon as the computation is completed the DEM viewer will appear automatically. It allows to see the DEM you have just created directly inside 3DF Zephyr. (image)



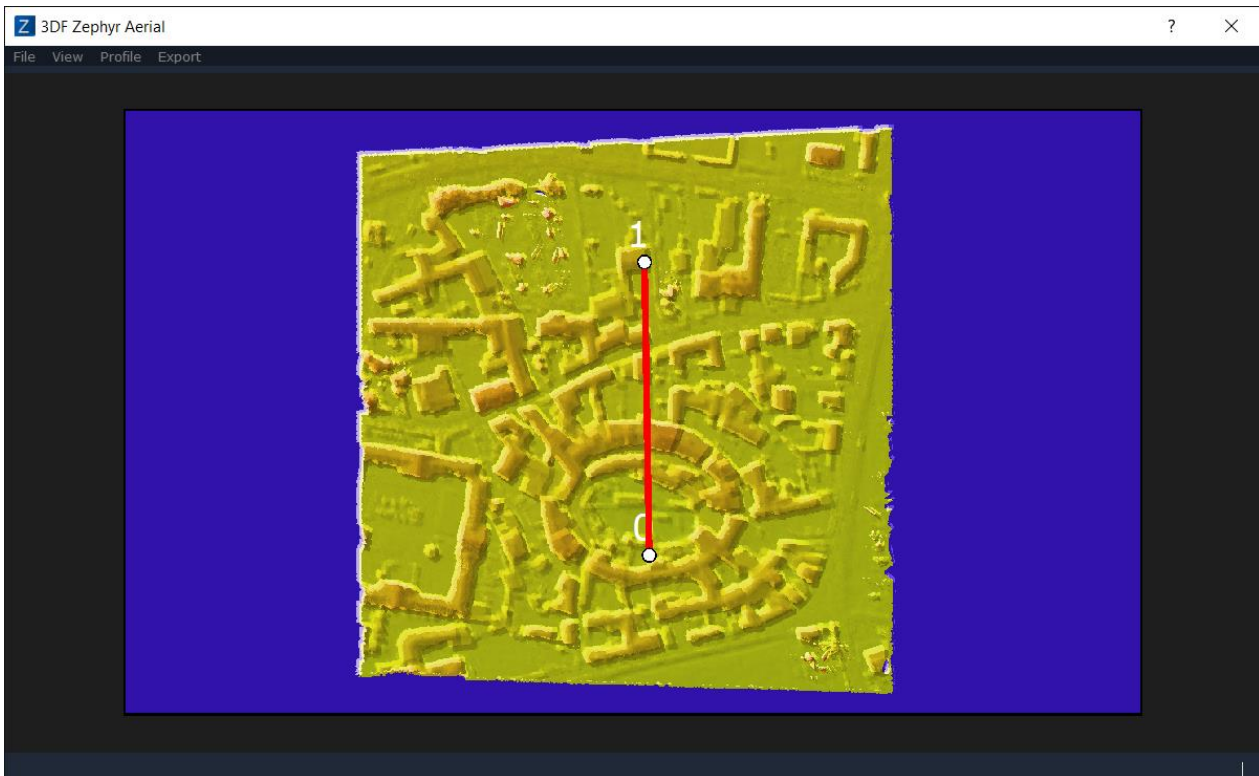
DEM viewer can be run whenever by clicking on Utilities > DEM viewer in the menu bar of 3DF Zephyr, and it can be exploited to:

- load DEM files (even those not related to the project you are working on) by clicking on File > Open;
- place contour lines on DEM if they have been previously generated in 3DF Zephyr, by clicking on View > Show Contour Lines;
- export DEM as a image format (.png, .jpg, .bmp);

## PROFILE GENERATION

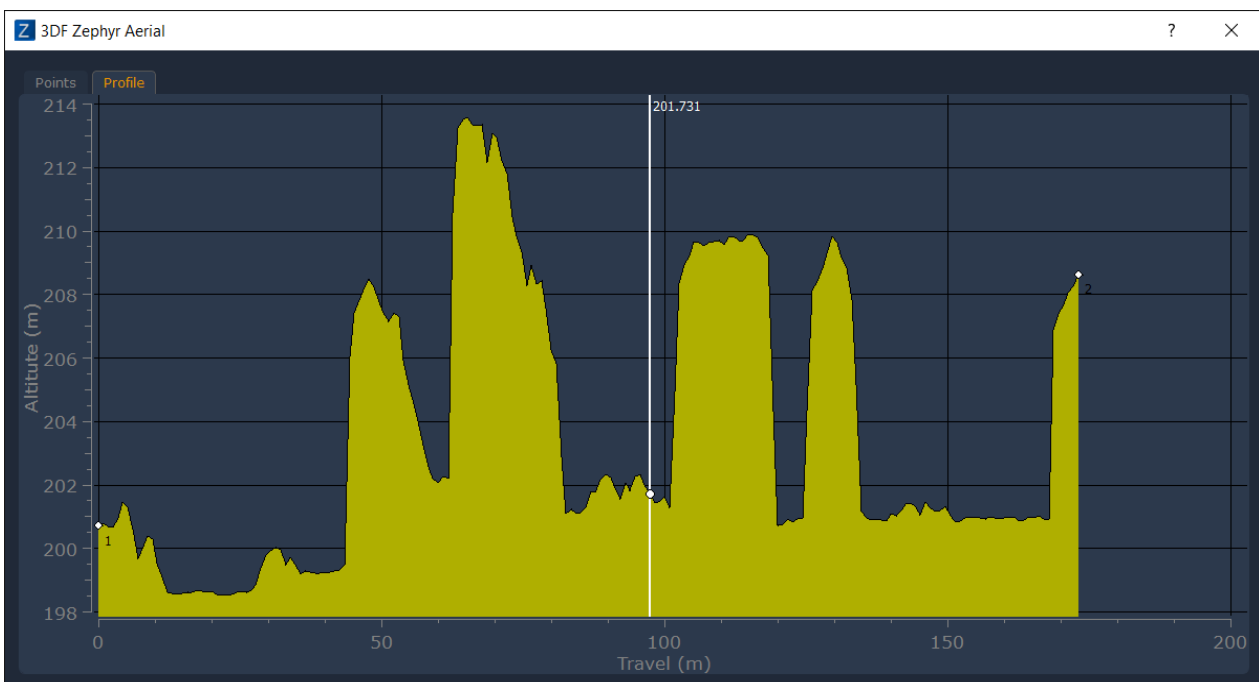
In the DEM Viewer it is also possible to run a Profile generation in order to draw one or more polylines directly on DEM and getting then their altimetric profile.

To to draw a polyline on DEM you simply click on **Profile > Enable Picking** in the DEM viewer window. By drawing one or more polylines on DEM you will notice that each vertex will be identified by a number (see image below).



Once all polyline vertices are placed you can click on **Profile > Show info** and you can check the tab **Points**, where each vertex of the polyline is listed, and the tab **Profile** as well, where you can see the altimetric profile of the polyline (see image below).

Moreover, by moving the cursor you can see the quote of every single profile point in detail.



You can also export a profile (pdf format) by clicking on **Export > Profile Report**.

## Tools - Workspace

The Workspace menu allows to run tools dedicated to the management of the 3D objects and to the pictures used in the 3D reconstruction:

- **Scale - Rotate - Translate world:** allows to scale/rotate/translate the 3D models (clouds and meshes)
- **Define the up vector by selecting two points:** allows to draw a segment directly on the 3D model to be aligned with the Z axis (basically, the drawing must be done on an element of the 3D model that is actually on the up vector in the real world, such as a wall in a building)
- **Define the up vector by selecting the ground plane:** allows to draw a triangle (a plane) from which the Z axis will be computed (the plane must be done on an element of the 3D model that is actually on the horizontal axis in the real world, such as the ground). After picking the second point in the plane, two arrows will be rendered on the screen, one that will show the Z axis (blue arrow) and the normal direction of the plane (Red arrow). In order to correctly align the z axis, the two arrows must match.
- **Define the plane vectors by selecting two axes:** allows to select the plane vectors by selecting the two corresponding axes. Simply left click the origin point and then the second point that will define the first axis. After that, select the second point (from the selected origin) that will define the second axis.
- **Change workspace images:** this tool is very useful when working with thermal or nir images: after the 3D reconstruction has been completed using classic RGB images from anormal camera, you can swap the corresponding NIR/thermal image and everything will behave exactly as the sparse point cloud was made with those images.
- **Change Masks:** allows to change the maks used for the current dataset
- **Camera Stats:** shows information about the mean reprojection error and the number of points viewed by each camera in the sparse point cloud.
- **Camera GPS Coordinates:** shows a preview of the GPS coordinates via OpenStreetMap
- **Enable/Disable confidence:** allows to see/hide information about the dense point cloud confidence
- **Optimize camera parameters:** this tools allows to run a further *bundle adjustment*, in order to improve the accuracy of the Structure from Motion algorithm. It's advised to run this tool before running the Multi View Stero phase (dense point cloud extraction).

**Tip:** a typical case in which the bundle adjustment step is requiried is when the first camera orientation step has completed with a mean reprojection error value above 1: after placing at least three control points from the images it is possible to run the "optimize camera parameters" step, giving much more weight to the defined constraints.

## Tools - Mesh Filters

From this menu it's possible to applied the selected mesh filter to a mesh in the workspace.

**Decimation:** select the desired mesh with the dropdown menu and the number of desired vertices. The mesh will be regenerated decimating the vertex count to the maximum specified value once.



**Densification:** select the desired mesh with the dropdown menu and the number of desired vertices. The mesh will be regenerated using the vertex count to the maximum specified value once.

**Laplacian smoother:** will smooth the surface of the selected mesh. Reduces noise and won't keep sharp edges.

**Bilateral smoother:** will smooth the surface of the selected mesh. Reduces noise while trying to keep sharp edges where possible.

**Fill holes:** will fill the mesh holes. From the selection window it is possible to select a specific hole (in the workspace scene the hole border will be highlighted with a border) or all holes of a certain size (or all holes). The color of the triangles that will close the hole will most likely wrong when the missing visibility of the point from the camera will behave in a degenerate way (and, obviously, it is impossible to identify the color of something that is not seen by any picture). Two algorithms are available, watertight and selective. While the selective one can close the selected hole in a fast way, it might not work for complex cases, in which case we suggest to you the watertight algorithm.

## Tools - Control points and Distances

These functions are available only in 3DF Zephyr Pro e 3DF Zephyr Aerial.

This menu allows to access certain control points tools.

**Scale model with control points:** same functionality exposed in the "Control points" tab.

**Scale with control distances:** same functionality exposed in the "Measurements" tab.

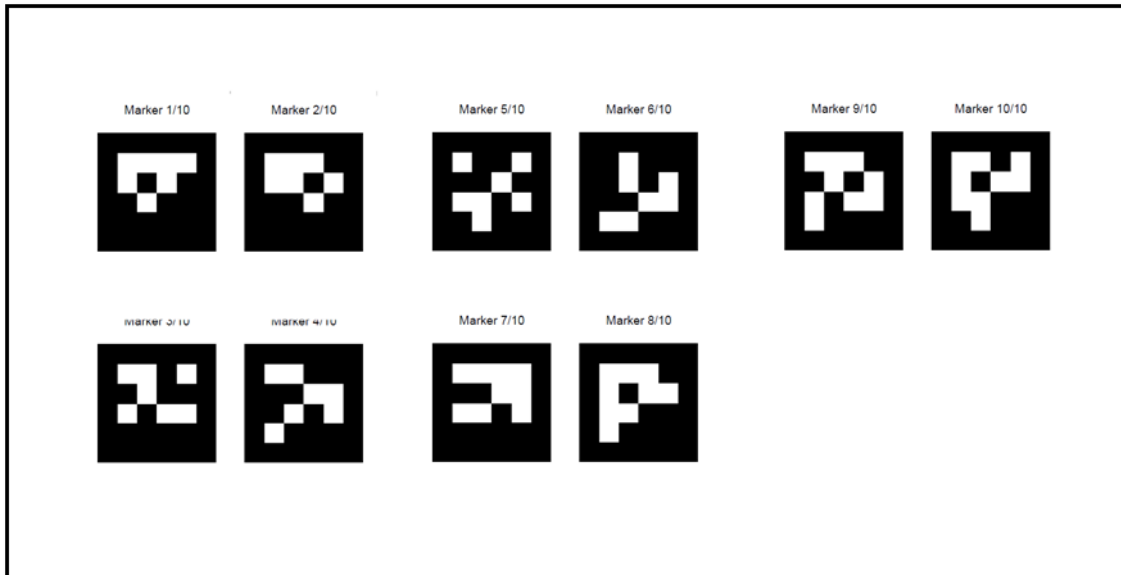
**Show last alignment information:** shows information about the latest "scale model with control points" operation.

**Change current coordinate reference system:** allows to change the reference system of the project (only 3DF Zephyr Aerial). You must have already defined the reference system with control points before you can change the reference system

## Print Markers and markers use

The following chapter will explain learn how to exploit coded targets in 3DF Zephyr in order to further improve the cameras orientation phase.

3DF Zephyr's coded targets are square-shaped (see image below).



In order to print coded targets just click on **Tools** in Zephyr's menu bar and then on **Control points and Distances > Print Markers**. You can print up to 24 different targets.

3DF Zephyr supports 16 bit coded target: their size strictly depends on the kind of 3D reconstruction and the related photographic survey as well.

Recommended settings are as follows:

- Close Range and Human Body      4 targets per sheet (A4 size)
- Urban                                      2 targets per sheet (A4 size)
- Aerial                                        1 target per sheet (A4 or A3 size)
- 

You can define the amount of targets per sheet by editing the printing menu settings on Windows ( the term "page" implies a target inside that menu).

It is recommended NOT to use coded targets randomly; instead it is highly recommended to use them in their own numerical sequence (1, 2, 3, 4, etc. and not 4, 13, 22, etc.)

When photographic survey is completed and after the cameras orientation phase is done you can start the automatic detection of coded targets by clicking on Tools > Control Points and Distances > Detect Markers.

In the new windows you have to specify:

- Which is the context where coded targets have been exploited (Urban, Close Range, Aerial);
- Which preset (detection quality) you want to run;
- The amount of coded targets within the scene;

After clicking the confirmation button, 3DF Zephyr will start the automatic target recognition and will set the control points based on the detected targets.

Please note that the automatic target recognition has to be started AFTER having completed the camera orientation phase in Zephyr.

## Tools - Sections and Contour Lines

Sections and contour lines generation tool is only available in **Zephyr Aerial**.

By clicking on **Tools > Sections and Contour Lines** you can select the drawing element you want to create choosing among:

- **single section:** this tool generates only one plane that you can move, rotate and resize; the position of the plane can also be modified using the control points, if they have been previously placed on the 3D model;
- **Track Sections:** this tool generates several planes (user can fix the amount of those) on each positions of the control points so it is worthwhile when it is necessary to draw sections on an irregular path (for example, a river bed);
- **Contour Lines:** allows to generate one or more contour lines on the 3D model and user can choose the reference axis for contour lines direction;

Each one of the tools above leads to a window after the planes have been placed (see image below).



In this window you can draw sections and contour lines previously identified by the planes both automatically or manually. In the upper bar of the window there are editing and drawing icons as follows (from left to right):

- Create: manual method that allows you to draw a polyline;
- Remove: removes the vertex of a polyline;
- Move: moves the vertex of a polyline;
- Split: adds vertex to a polyline;
- Clear: deletes all polylines;
- Close Polylines: closes a polyline;
- Smooth Polylines: allows you to smooth all the polylines drawn;
- Autocompute Current: generates a polyline only on the section shown in the window;

- Autocompute All: generates a polyline for each section previously created using the planes;
- Export: allows you to export drawings in dxf and shp format;
- Import to Workspace: allows to import drawing elements in Zephyr workspace;

Previous and Next icon allow to scroll among the sections created.

## **Tools - Orthophoto and orthomosaic**

These functions are available only in 3DF Zephyr Pro e 3DF Zephyr Aerial.

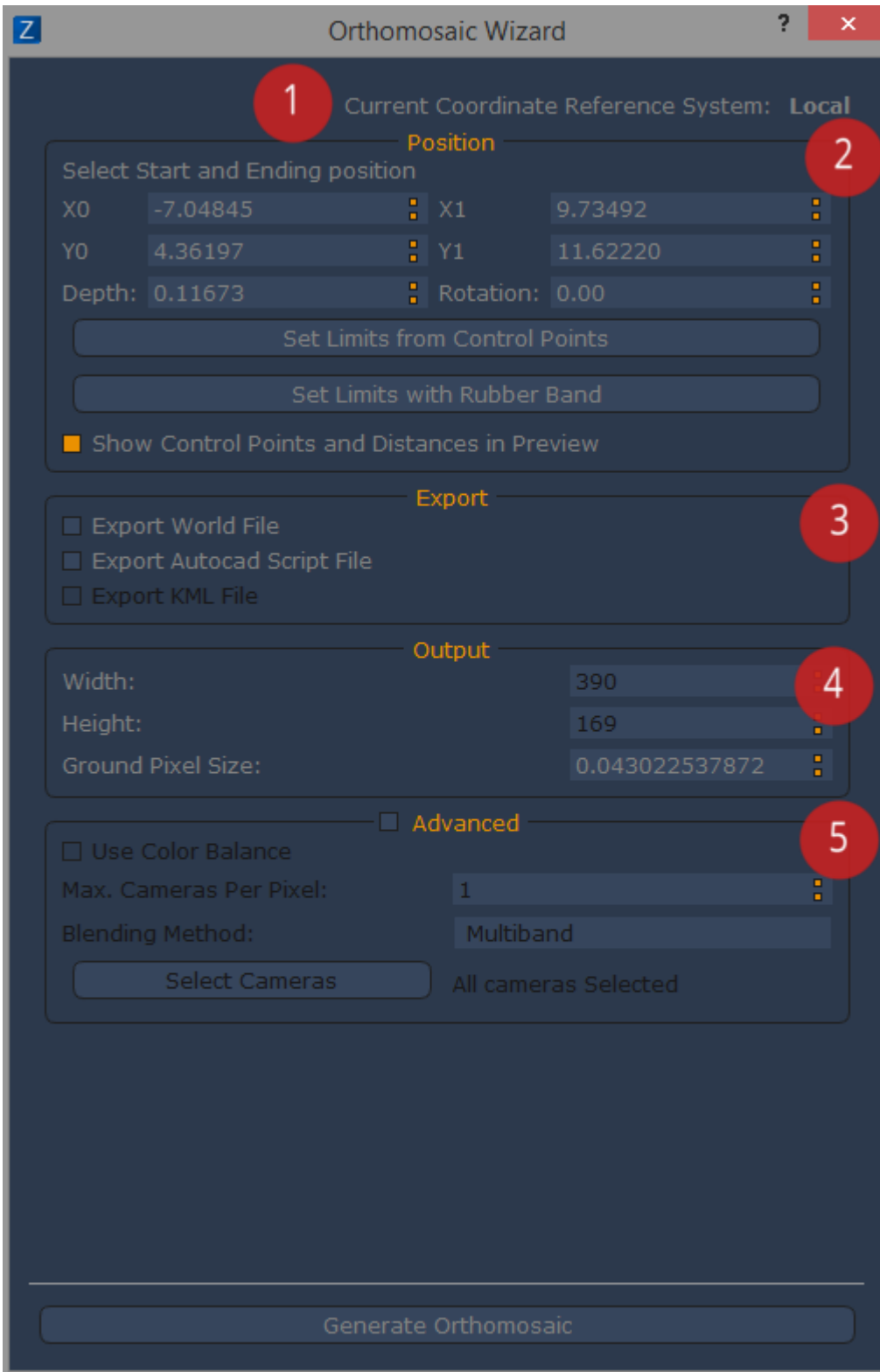
From this menu it's possible to access the Orthophoto and Orthomosaic generation functions. These functions are available in 3DF Zephyr Pro and 3DF Zephyr Aerial only.

Both this functions allow to select the generation method either via control points (having previously defined at least three control points) or via a reference axis. If you pick the axis mode, you will later be granted the possibility to select the desired area via a dedicated UI or via control points.

Both these functions expose a preview of the orthophoto/orthomosaic directly in the scene.

### **Generate Orthomosaic**

The orthomosaic generation requires a dense point cloud in the workspace. After selecting the generation mode in the first wizard page (by control points or by axis) the orthophoto generation wizard will appear:



3DF Zephyr Aerial will show the current coordinate system (1).

The "Position" subsection (2) (in this example the axis mode has been selected) will define the initial and final position of the orthomosaic. You may set the limits via control points or by dragging a rectangle with the rubber band tool

You may control the appearance of control points and control distances using the "show control points and distances in preview" checkbox.

The "Export" (3) subsection allows to export:

- World file (3DF Zephyr Pro and 3DF Zephyr Aerial)
- Autocad script (3DF Zephyr Aerial) - exports a scr file that will automatically load the orthomosaic within autocad, with the correct scale settings set in Zephyr
- .KML file (3DF Zephyr Aerial)

The Output subsection (4) allows to define the width and height of the output file (thus controlling the ground sample distance)

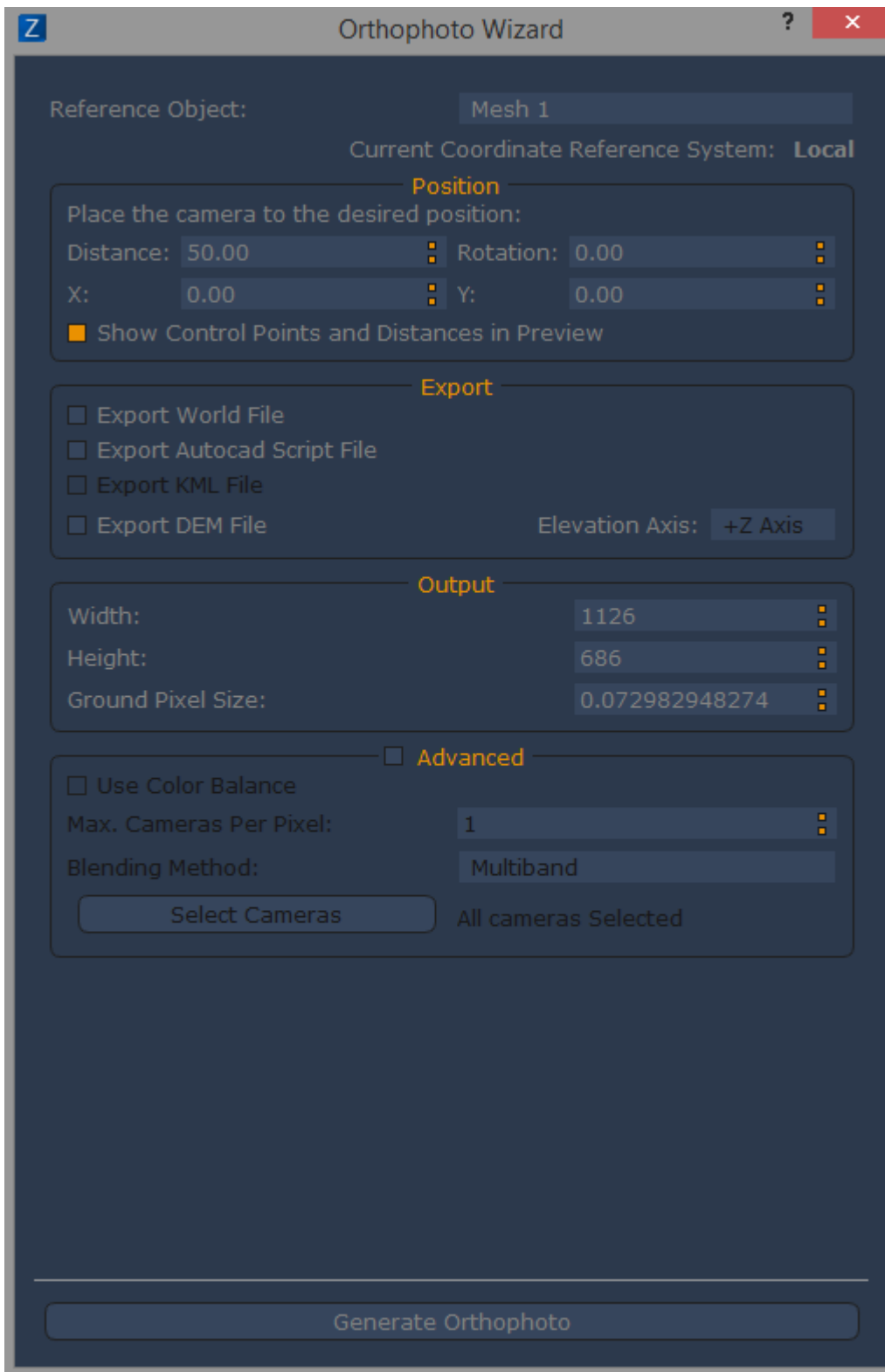
The Advanced subsection (5) allows to control the color generation mode for each single pixel. This system is very similar to the texture generation system. We advise to leave the color balance on with 1 camera per pixel. If you wish, you may however use more cameras for a different color weight. If this happen, you may choose between a fusion algorithm:

blending - will weight the color source depending on the view angle and the distance. Although it's robust to lighting changes, the mean won't keep high frequencies.

multiband - will use the mean to to compute low frequencies and the best images to compute the high frequencies. This is usually a better choice than blending because while it is still robust to lighting changes (usuually just a little worse than blending) by preserving the high frequencies the resulting image will be more in focus and sharp.

### **Generate Orthophoto:**

To proceed with the orhtophoto generation you must have generated a mesh first.



Every option in this wizard has the same explanation as the orthomosaic. Please note how in this screenshot the control point mode has been selected to define the orthophoto plane, and thus the "Position" subsection is slightly different, offering parameters such as distance, rotation and X,Y positions.

As a last note, it is possible to export the .DEM file in the Export subsection (by specifying the elevation axis)

## Open, Save and Load a project

Each project created with Zephyr is saved as .zep format.

Each project file also includes the photographs used for the 3D reconstruction, therefore it is possible to open, send and edit the path of zep files which have not to be followed by the images. Nevertheless it will not be possible to start one of the four phases of 3D reconstruction or make changes involving photographs usage.

Click on **File > Open or Open Recent** to open a .zep project, or click on **Save or Save As** to save your work.

If you have a command-line reconstruction made with 3DF Samantha, the Structure from Motion algorithm, you can import that by selecting **File > Load from 3DF Samantha**.

## Load a file .psz

This function is available in 3DF Zephyr Pro and 3DF Zephyr Aerial only.

Within Zephyr you can be load psz project by clicking on **File > Load from .psz file**.

Cameras, sparse point cloud and mesh of psz project are imported In Zephyr and you can now start some 3D reconstruction phases such as the dense point cloud or texture generation.

## Load pictures with the known camera parameters

This function is available in 3DF Zephyr Pro and 3DF Zephyr Aerial only.

In Zephyr you can manually import all the parameters of a camera before starting the cameras orientation phase; cameras will be calibrated without being adjusted by Structure from Motion algorithm.

To load the parameters just click on **File> Load images with known camera parameters**.

## Merge projects

In Zephyr you can merge two or more .zep projects related to the same scene or subject.

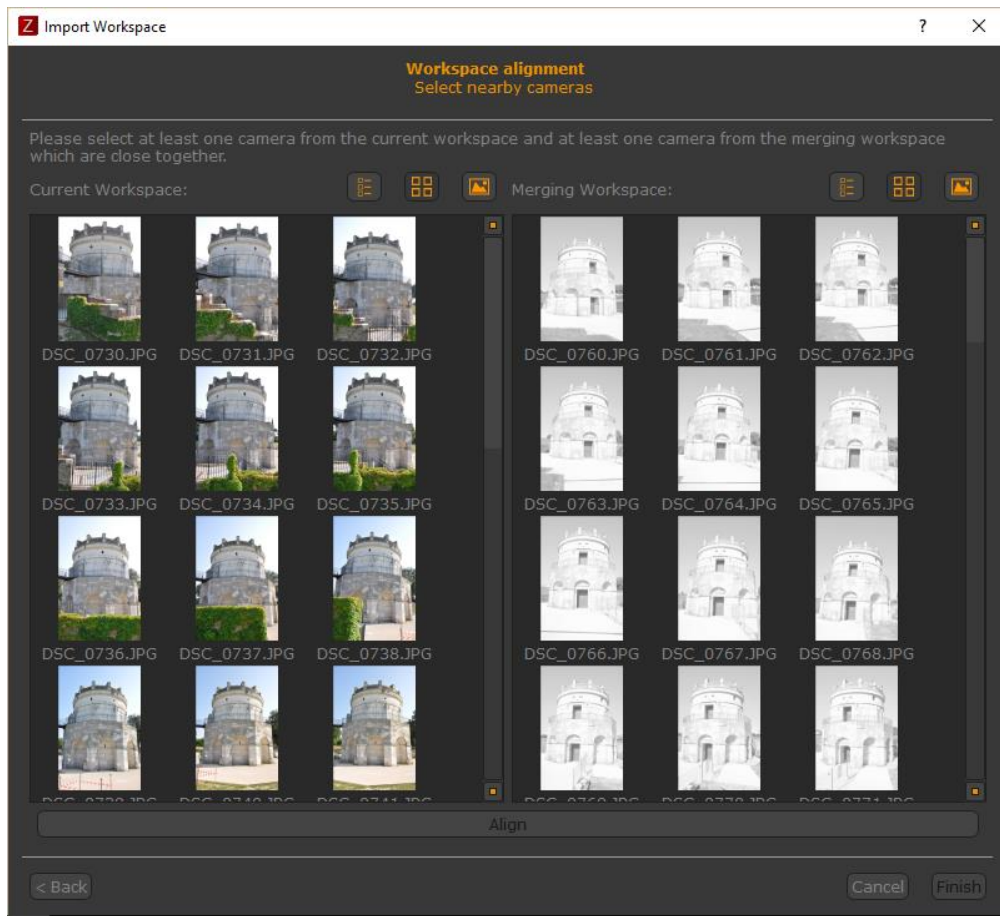
To optimize the procedure it is recommended **to generate just the sparse point cloud** into the projects involved before proceeding with the merge. Once you completed that it will be possible to start the following steps of 3D reconstruction.

The photographs of the projects have to share a common area so you can proceed to the merge by means of:

- **Control points:** after clicking on **Import > Import and merge another workspace** you will see the Import window. It is necessary to place at least three control points on each point cloud of the projects before running this procedure. Control points must have the same position and the same name to allow Zephyr to find matches between them and proceed to the merge. It is recommended to keep the **Compute Bundle Adjustment** option active so as to further optimize the merge process.
- **Nearby cameras (only in Zephyr Aerial):** click on **Import > Import and merge another workspace** to open the Import window where you just select the project you



want to merge and click the **Import** button. If no control points are placed in the projects Zephyr will automatically select **Use the nearby cameras** option.



In the image above you can see the pictures of current project work on the left side while the images to be merged are showed on the right side of the window. Note that the thumbnails of images on the right side are displayed in black and white as long as the user selects at least one photograph of the group on the left.

First of all you need to select at least one picture in the list on the left, then you have to select at least one picture in the list on the right. **The most proper pictures to be selected focus on a common area of the captured subject or scene.**

### Handle laser scanner point clouds

These functions are available only in 3DF Zephyr Pro e 3DF Zephyr Aerial.

It is possible to import point clouds generated by means of laser scanner equipment, orienting them to the clouds generated through Zephyr.

**Tip:** before using that tool it is necessary accomplish at least the camera orientation phase. However it is recommended to perform even the second phase of 3D reconstruction and get the dense point cloud.

Once the dense point cloud is generated simply click on **Import** on menu bar and select **Import and align point cloud**. In the new window you can choose between two different alignment methods: control points or SRT alignment. Make sure to follow only one of the proposed methods.

This procedure is also available at <http://www.3dflow.net/technology/documents/3df-zephyr-tutorials/point-cloud-coloring-using-3df-zephyr/>

## Control points alignment

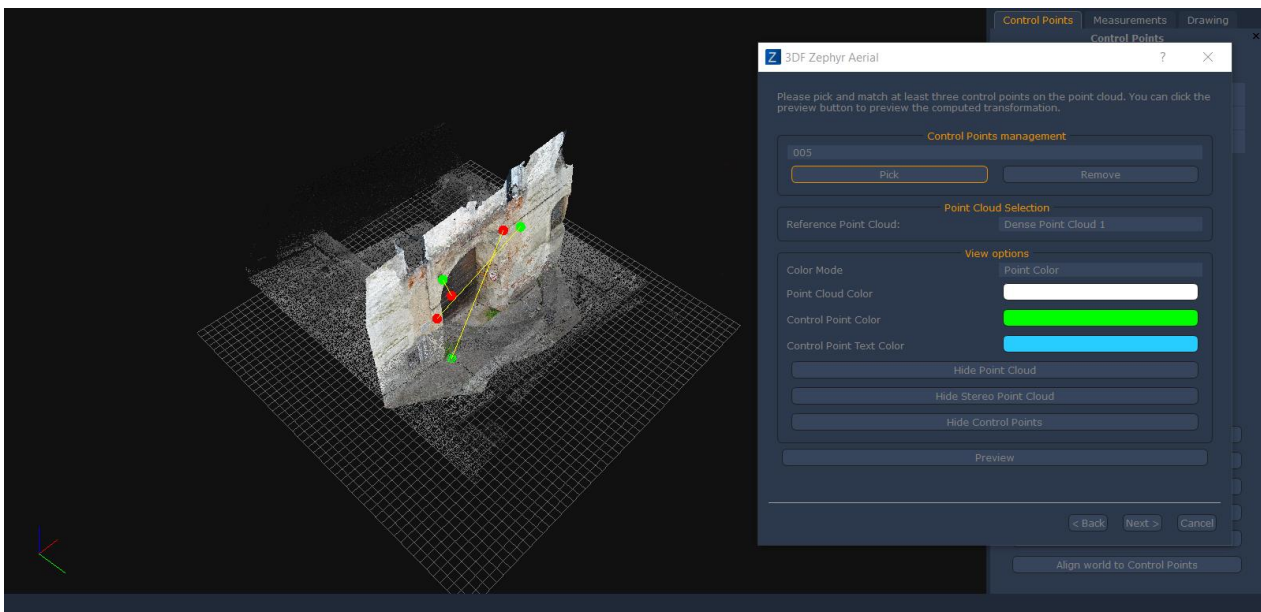
Before starting you need to place at least three control points on the point cloud exploiting them for the clouds alignment.

After clicking on **Import point cloud** button and choosing your data simply select **Align with Control points** and click on **Next** button.

File formats available are the following:

- ply
- txt
- xyz
- ptx
- pts
- las

Note that the imported cloud is immediately shown into Zephyr workspace.



In the next window you can activate the decimation tool if the imported cloud contains a considerable amount of (million) points. This tool is disabled by default. Click on the **Next** button to continue.

When checking the following window in the image above you will notice that it is arranged in three sections:

- **Control points Management** section allows you to place the corresponding control points one by one on laser scanner cloud and to link them to the points previously identified on the dense cloud generated with Zephyr.

- **Point cloud selection** section allows to identify the reference cloud to place the control points.
- **View Options** section allows you to define how to see the cloud you are importing (with RGB color or reflectivity info).

The buttons below allow to hide or show the two point clouds so as to simplify the identification of control points.

Once the process is finished just click the **Next** button to move forward to the last window. **Recompute Colors** option is enabled by default and it can add color information to the laser scanner cloud.

The **ICP algorithm** - Iterative Closest Point - improves alignment accuracy even if you should not use it when you are dealing with flat surfaces.

In the **Import to workspace** section you can choose which cloud will be the reference for the alignment and which one will be moved so as to be aligned.

Click now on **Import point cloud** button to complete the procedure. You will notice that the laser scanner cloud will be included into the list of dense clouds in the Project panel and below the point cloud generated with Zephyr.

You can even merge the two point clouds and go on with the mesh generation.

## SRT transformation alignment

Before starting you need to place at least three control points on the point cloud exploiting them for the clouds alignment.

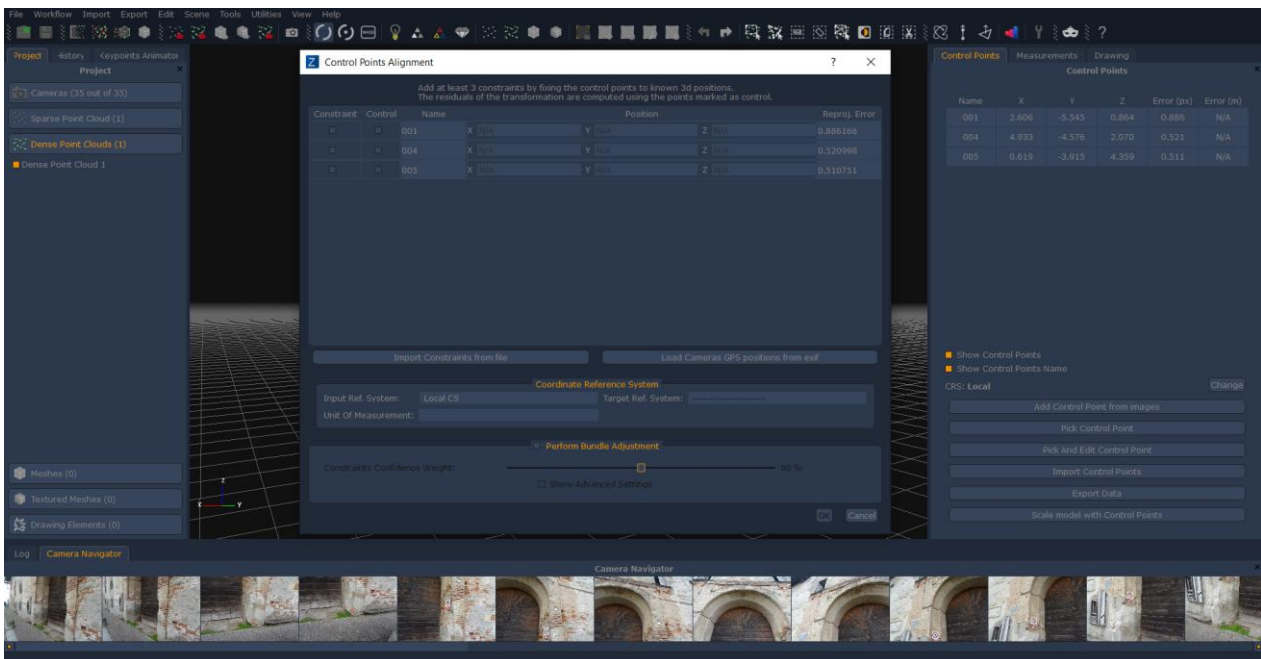
In this procedure you can use an external software that allows the processing of point clouds, such as **CloudCompare**, rather than the application that comes with the laser scanner equipment.

After importing the laser scanner cloud in CloudCompare it is necessary to identify as many control points as those that have been placed in Zephyr. Each point must have the same position and the same name of the corresponding point in Zephyr. Once the identification of points is done simply save the list as a .txt file.

The purpose of this first operation is to copy the reference system of the laser scanner cloud identifying at least three points on it and importing it inside Zephyr so as to assign the same reference system to the photogrammetric cloud as well.

Getting back to Zephyr and looking at the **Control Points** tab on the right side of main interface you have to click on **Scale model with Control points** button and clicking then on **Import constraints from file** button in the new window in order to load the txt file where you previously save the point picked on laser scanner cloud.

Now click on Ok to complete that step and close the window.



Simply click on **Import > Import and align a cloud of points** choosing the laser scanner cloud and selecting then the **SRT transformation alignment** procedure. Note that the imported cloud is immediately shown into Zephyr workspace.

Now click on **Next** button to move forward.

In the next window you can activate the decimation tool if the imported cloud contains a considerable amount of (million) points. This tool is disabled by default. Click on **Next** button to continue.

Notice that the imported cloud is already aligned to the Zephyr cloud. Now click on **Next** button to continue.

**Recompute Colors** option is enabled by default and it can add color information to the laser scanner cloud.

The **ICP algorithm** - Iterative Closest Point - improves alignment accuracy even if you should not use it when you are dealing with flat surfaces.

In the **Import to workspace** section you can choose which cloud will be the reference for the alignment and which one will be moved so as to be aligned.

Click now on **Import point cloud** button to complete the procedure. You will notice that the laser scanner cloud will be included into the list of dense clouds in the Project panel and below the point cloud generated with Zephyr.

You can even merge the two point clouds and go on with the mesh generation.

## Import a mesh

These functions are available only in 3DF Zephyr Pro e 3DF Zephyr Aerial.

It is possible to import an external mesh in Zephyr and the file formats available are the following:

- obj
- ply
- dae

Before using this tool you need to make a 3D reconstruction completing at least the mesh generation phase. In this way you can add the color information to the mesh you want to import.

**Tip:** the mesh you are importing and the one generated with Zephyr must have the same reference system. In a nutshell you have to make the same procedure as in SRT transformation alignment tool related to point cloud import.

To start the tool just click on **Import > Import mesh** in the menu bar. Now click on **Import mesh from file** button. Timing to import depends on the size of the mesh file.

Once the file is loaded you can click on **Import in the workspace** button.