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Modeling Flat Panels

DETAILED METHODS AND ADVANCED TOPICS
PHOTOMODELER TECHNOLOGIES

CONTENTS

This document follows on from the Introductory Guide/Overview of Modeling Flat Panels. For an overview of the benefits and general steps, please refer to that document.

Read on here for more detail and advanced topics on the steps, options and troubleshooting these types of projects. See this page for related information specific to boat decks.

INTRODUCTION

Do you manufacture custom products that require accurate field measurement of flat shapes with complex-shaped outlines? For example, non-slip boat decks, dash panels, countertops, stair/floor/wall panels, glass/glazing, or gaskets/flat machine parts?

Traditionally, getting measurements and diagrams of the shape and its outline has been done by creating a physical template on-site. You cut or draw or trace on paper, plastic, or wood the outline of the existing shape.   This has always been a time consuming and labor-intensive process, and prone to error!

The preparation that traditionally took hours can now be done in minutes digitally, with many of the steps in PhotoModeler fully automated. Get rid of that messy and time-consuming templating step!

A BETTER WORKFLOW – THE PHOTOMODELER WAY

This document provides instructions and shows examples of the workflow using PhotoModeler®, targets, and your camera to accurately trace/outline, and measure a flat shape or pattern.

The process can easily be applied to a model of any flat panel or surface, such as boat decking or a glass table top on a complex shape
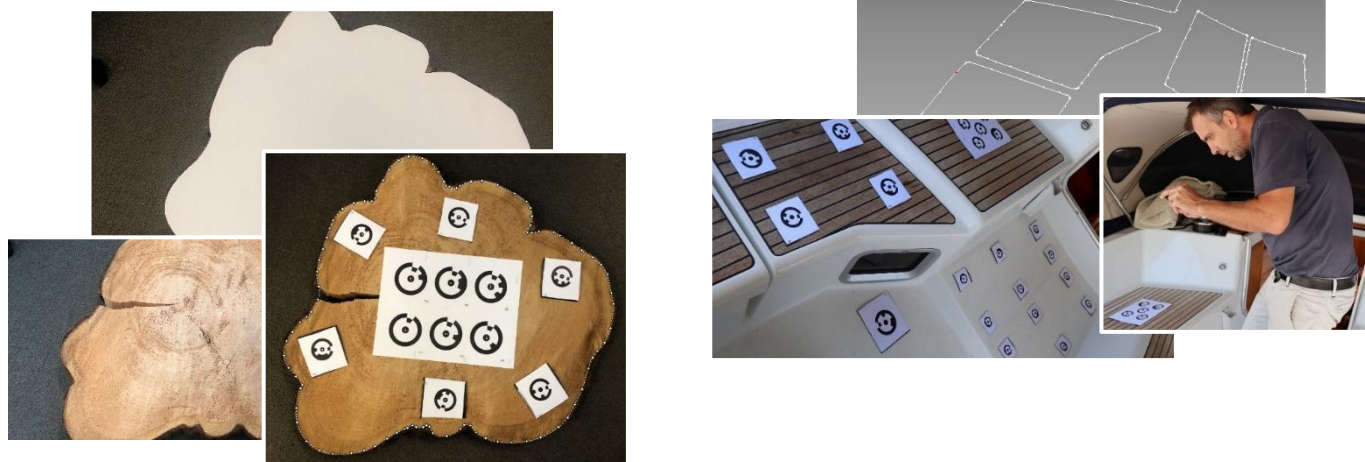
OVERVIEW

The general steps to digitize a flat shape in PhotoModeler are as follows:
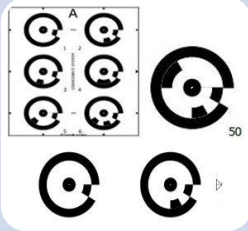
1. Choose a camera – phone camera, compact/point-and-shoot, or digital SLR.

2. Print or purchase targets and target sheets.

3. Place targets - singles throughout the scene, multi-target 'Letter Sheets' on regions of interest.

4. Take photos from a variety of angles with overlap and plenty of crisp targets. Also take birds-eye view photos of areas of interest.

5. Take one or more measurements between targets. Optionally, the project will be scaled automatically based on the Letter Sheet targets. You need to set at least one scale using a known measurement between two targets.

6. Load the photos into PhotoModeler, and launch a project to automatically detect the targets …the cameras are 'oriented' and 3D points generated at target locations.

7. Trace/outline the shapes of interest in PhotoModeler – based on plane surfaces fit to targets.

8. Export the 3D model to send the shape to a CNC machine or other device for manufacture.

Note: When starting out with PhotoModeler and this type of project, it's a good idea to take a few photos for a quick mock-up project (a small or partial project) in conditions similar to the eventual project to check a) the images' light balance and clarity, b) target detectability, and c) camera angles.

Here's what you will need to get the job done:

Camera - almost any camera will do:
- Phone Camera
- Point-and-shoot
- Mirrorless digital
- DSLR

Targets - purchase or print:
- Letter Sheet
- Single
- Paired Offsets

Computer - 64 Bit Windows:
- Desktop
- Laptop

PhotoModeler Software
- The PhotoModeler Standard version works for this application.

If you're new to PhotoModeler, it's a good idea to get familiar with the capabilities of the software. Work through the tutorials and start with simple projects before moving on to more complex tasks.

After working on some simple projects, you'll be better equipped to know how best to set up the project, prepare the site and work through the modeling process for flat panel projects.

CODED TARGETS

Targets need to be placed in the scene so that PhotoModeler can detect them in multiple photos and solve their 3D positions. Each target needs to be visible in at least 2 photos, ideally 3 or more. The purpose of the target points is twofold – 1) camera orientation, and 2) surface/plane definition. Once you have a 3D model of points and surfaces, the shapes of interest can be traced.

Targets throughout the scene

- Place 'Letter Sheet' targets in areas of interest so that a plane or surface can be defined by them in that specific area. Also place single targets between specific areas of interest, especially if areas aren't adjacent to each other.

Targets must not move

- Once you start taking photos, be careful not to move targets or target sheets.

Targets crisp and clear

- Take photos so that targets (and their code rings) are in focus and not occluded by objects or shadows, and aren't distorted by too much perspective. The smallest targets (those in the background) should have inner dots should be at least 10 pixels in diameter in the photos.

These types of projects can be done with a series of printed targets (printed from within PhotoModeler) or purchased targets. Targets can be used in various forms as shown at right.

When using the Letter Sheet targets, several steps in the process can be automated. Contact PhotoModeler sales about packaged Letter Sheet and single targets and their usage.

Letter Sheet Targets	Single Target	Paired Offsets

You can also do a project like this with a series of spread out single targets. See the Automated Coded Targets tutorial for information on setting up an automated project with your targets.
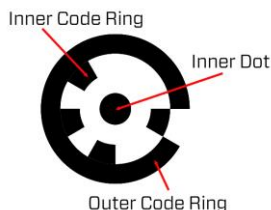
Example Coded Target - PhotoModeler automatically detects the centre of the target to high precision and reads the pattern in the rings to determine the target ID in the photos for automatic matching between photos.

For more information on target detection see this Troubleshooting and Advanced Topics section.

PHOTOGRAPHY

Photography should be focused on the regions of interest where shapes are to be traced/modeled, and these regions need to be connected with overlapping photos.

At right are examples showing the hypothetical camera positions and target locations over a curvy countertop and boat deck.

A systematic approach to photography is best, for example, at each panel/shape location take a series of overlapping photos, then when moving to the next panel/shape location, make sure photos capture enough 'connection' targets so that regions are tied together.
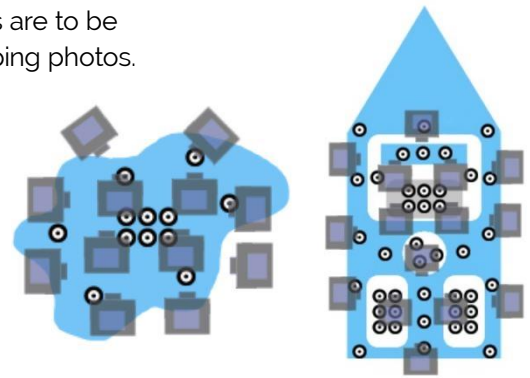
Enough Targets Visible

- Each photo must have **at least 6 crisp targets, ideally 10 or more**. And on each specific panel/region of interest, there are at least 3 non-linear target points.

- Target center dots should appear in the images **at least 10 pixels in diameter**. When printing the targets from within PhotoModeler, target sizes can be calculated based on the camera, and the typical approximate distance from camera to model object.

Camera Angles

- **Take photos from a variety of angles**, such that there is suitable overlap between them. Camera positions can be separated horizontally and vertically. Do not pivot the camera at a position - move around the scene.

- **Take birds-eye/top down photos** also, at each region to facilitate panel/shape tracing in PhotoModeler, as the closer to perpendicular, the more accurate the trace.

- Take photos with **suitable overlap**. If the project is to include multiple connected shapes in one model, these shape regions need to be 'connected'. PhotoModeler uses points to connect part of a model. Photos are 'connected' if they share at least 6 points.

Camera Settings

- Use autofocus to keep targets in focus, but **do not change the zoom between photos!**

Lighting

- **Indoors** – if the scene is indoors, ensure lighting is adequate and targets will be visible and crisp. Determine if flash is required and/or if a tripod is needed to avoid motion blur.

- **Outdoors** – if the scene is outdoors and the sun is shining, ensure that there isn't excessive glare and/or dark shadows that can obscure targets or areas of interest. A dry cloudy day is ideal for photography, but if the sun is out, sometimes the flash can help make lighting more uniform.

For more information on Photography, see this

This section describes the steps to digitize flat 2D shapes in PhotoModeler. The featured examples focus on two projects: 1) a series of boat decking panels, and 2) an irregular shaped tabletop project. Similar steps apply to other applications such as countertops, glazing, etc.

NOTE: If using Letter Sheet targets, and if you want a) the coordinate system to be automatically defined, b) planes to be fit through the letter sheet targets, and c) optionally offset points generated around the perimeter, please see the "Automatic Plane and Coordinate System Setup" section below.

These steps can be applied to any project where a flat shape or panel needs to be modeled and manufactured:

- Start a new project - load the photos into PhotoModeler, assign a camera definition, and launch the automated process to detect the targets, process the project and generate 3D points at target locations.
- Scale the project using known distances between targets. This can be done automatically based on the Letter Sheet target patterns.
- Fit planes or surfaces through groups of 3D points using simple tools in PhotoModeler. This can be done automatically based on the Letter Sheet target patterns.
- Trace/outline the shape(s) of interest in PhotoModeler.
- Export the digitized 2D or 3D model of the shape(s).

NEW PROJECT

Once the scene has been set up with targets and photos are taken (see previous section for tips on Photography and capturing the targets in the scene), you're ready to launch PhotoModeler and start a new project – choose the Automated Target Project (click File, New >):

Automated Target Project
Automatically mark coded or non-coded targets to build a points-based wireframe project.
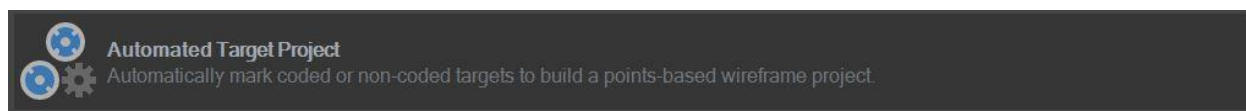
LOAD PHOTOS AND ASSIGN CAMERA

You'll be prompted to load the photos into the project and assign a camera definition. See the Working with Cameras section in the online Help document for more information.

- If you've calibrated your camera and added it to your Camera Library, the camera definition will be found and assigned to the photos in your project automatically. See the Camera Matching section of the online help for more information.
- If your camera is calibrated but not in your library, and if you've used it in a PhotoModeler project before, simply browse to a project containing the right camera – the camera definition will be copied to your new project.
- If your camera hasn't been calibrated, we recommend doing that first (here's a tutorial). If your project is set up optimally (good target count, good spread, good camera positions etc.), PhotoModeler can optionally run Auto-calibration, which 'solves' or defines the camera while processing the project.

TARGET DETECTION

When the new project setup stage completes, automated target detection will begin. All or most of the targets in the scene will be detected and 3D points will be generated at each target location. The camera positions will be solved (i.e. oriented) and the 3D Viewer will show the model.

CHECK PROJECT QUALITY

Once the project is processed, it's important to check the quality of the solution. If the project doesn't solve well (see Troubleshooting and Advanced Topics section), the accuracy will be off, and the resulting panel will not fit well.

There are several metrics for auditing a project, which are described in detail here. The most common metric is the 'Marking Residual', as described here. If your project has multiple scales, use the Check Distances table to verify accuracy of a project. The table shows 'deltas' between a known distance between two points and the distance calculated by PhotoModeler and provides a good indication of model accuracy

If the project is set up well with a good point count, good point spread, proper camera angles and a well solved camera, the project quality will be good right out of the new project wizard, and no troubleshooting will be required.
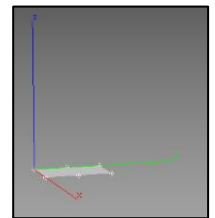
SCALE AND COORDINATE SYSTEMS

To obtain accurate export results, the project scale and coordinate system must be defined.

AUTOMATIC COORDINATE SYSTEM DEFINED

If you've set up coordinate system presets in PhotoModeler Preferences, your project will be automatically scaled, rotated and translated (based on predefined Letter Sheet target ID's and ranges).

 To set up Automated Coordinate System definition see the "Automatic Plane and Coordinate System Setup" section below.

MANUAL COORDINATE SYSTEM DEFINED

If not automatically set up, the coordinate system must be defined so that the model is in a real-world coordinate system. The coordinate system has three components: Scale, Rotation and Translation. Have a look at this tutorial video for complete instructions on how to set up a coordinate system.

Using the known/measured distances between the targets, enter a series of scale measurements using the Imports and Coordinate Systems panel:
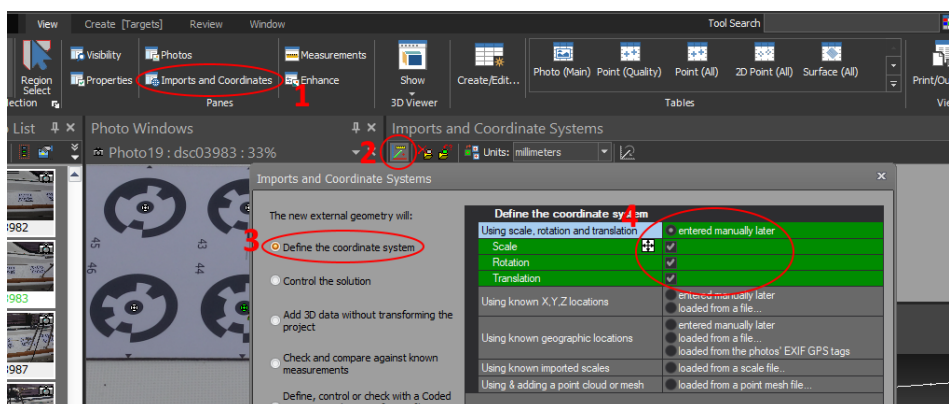
Define the scale distances. Multiple scales are recommended, and ideally the points used to define the scales have good spread. In this example the 5 known distances between 6 targets points were used:
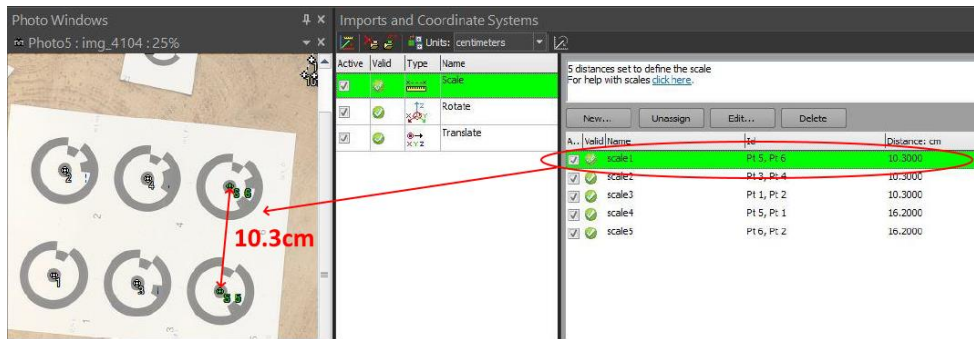
While the Rotation (XYZ axes) is defined using 3 target points that define the X and Y axes:
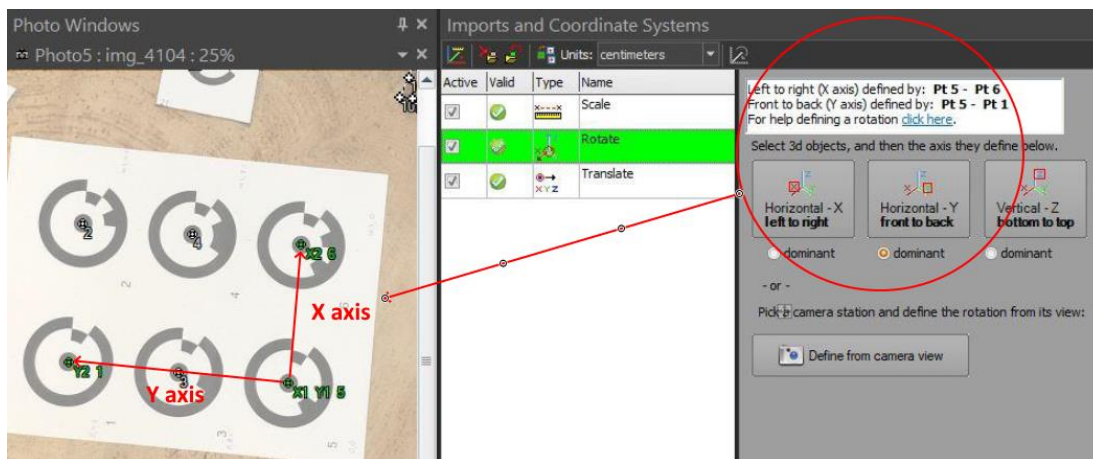
It is often best to use the plane in your model (e.g. one defined by a Letter Sheet or series of planar target points) to define the rotation. This ensures that when the model is exported as a 2D shape the traced panel will be flat on that defined XY plane. To set the XY plane (where Z is up) select a plane and click the 'Vertical – Z' button.

PLANE AND SURFACE DEFINITION

Planes and/or surfaces must be defined before the panel shape can be traced.

AUTOMATIC PLANES

If you've set up coordinate system and plane presets in PhotoModeler Preferences, your project will be automatically scaled, and plane surfaces will be fit through certain points (based on predefined Letter Sheet target ID's and ranges).
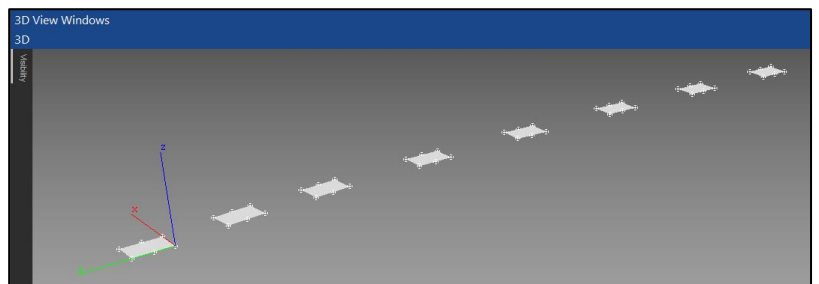
To set up Automated Coordinate System definition see the "Automatic Plane and Coordinate System Setup" section below.

## MANUAL PLANES AND SURFACES

If not automatically generated, planes or surfaces must be defined in the regions where the shape(s) will be traced. For example, in the images below, a plane needs to be defined using the points on the grippy panel at left, the inlaid panel shown in middle, or the wood edge at right:

The surface on which the Surface Draw points/lines/curves are drawn on can be manually defined as any Surface type in PhotoModeler:

- Planes (Fit-through-points) See this tip video.
- Regular Surfaces: path, triangle, loft, sweep, revolution, boundary, or cone
- Triangulated Meshes generated from SmartPoints or DSM point clouds
- Note we recommend Plane surfaces for work like this.
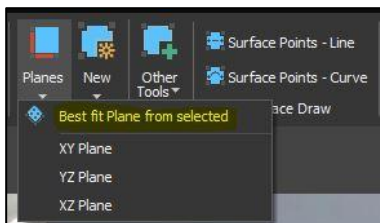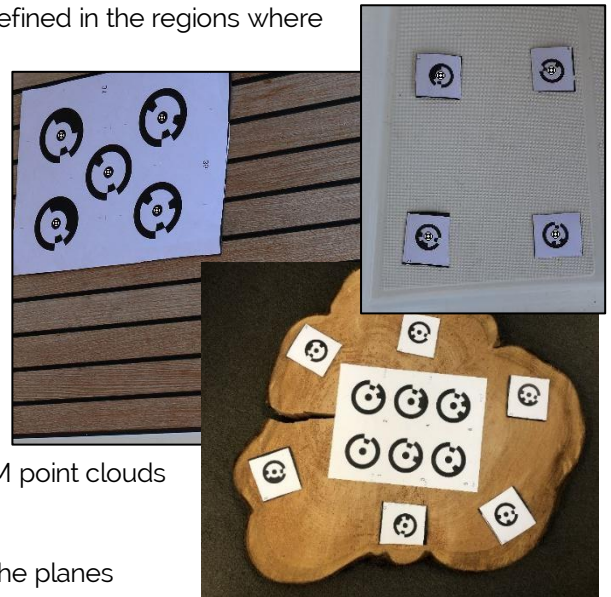
Ensure the target points used for the planes have 3D positions, have appropriate spread and are in fact planar. If targets are too linear, a plane surface may not match the real surface which can lead to inaccuracies. To define a plane surface, select the 3 or more points that are in fact planar and click the "Planes" drop down menu ("Create [Targets]" ribbon tab, Surface group), then "Best fit Plane from selected" tool.

If the plane is defined by targets that have a significant thickness (i.e. the targets sit above the surface), you'll want to set the plane offset property to a negative value of the thickness so that the surface draw lines/curves drawn on that surface lay flat on the actual surface.

In the example project to the right, a plane was fit through the 12 targets on the wood shape.

In example below, one plane at top left was defined through the 4 target points, another plane was defined top right through 5 target points, and a curved loft surface was defined through curves defined by the target points at bottom right. For a non-flat surface, special consideration is need for 'flattening' – see the Troubleshooting and Advanced Topics section on this topic.

Notice how the plane or surface does not need to extend out to the edges of the regions of interest. Surface Draw (see next section) will snap to the surface when starting the trace (if click is not over a surface, you will be prompted to select the 'nearest' surface).

Note: If using the Plane Surface (the most common surface to use in this application), it is important to consider that the points being used are indeed planar. Maybe the surface has a very slight curve to it. You can fit a plane to this, but the fit may not be good (there is feedback on the Measure pane for the fit quality, or a warning or an alert popup will appear at bottom right). The worse the plane fit is, the worse accuracy your exported surface drawings will be. See the Troubleshooting and Advanced Topics section for more on curved surfaces.

SURFACE DRAW

Once planes are defined in the areas of interest, the Surface Draw tools are used to trace the shapes. Here's a tip video showing the Surface Draw tools in use.
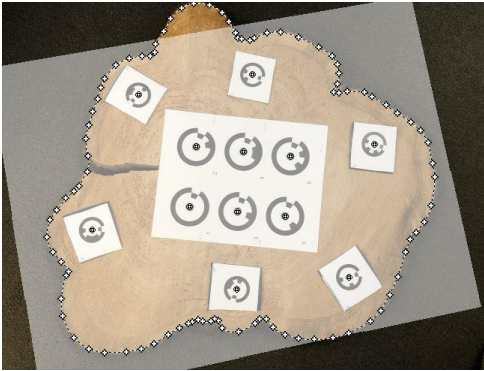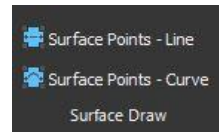
It is the digitized model of these Surface Draw shapes that will be exported and sent to the manufacturer (or your CNC machine/cutter) for production.
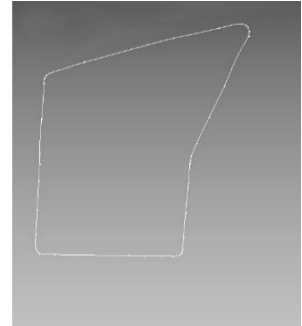
Surface Draw points, lines and curves obtain their 3D position from the plane or surface on which they're marked.

Use the Surface Draw tools to trace the panels or shapes:

- Use the Surface Draw *Curve* tool for curved edges and the Surface Draw *Line* tool for straight edges but do note that you can use both tools on the same shape where appropriate – just continue the new section by clicking on the last Surface Draw point.
- It's a good idea to open a 3D Viewer in PhotoModeler while tracing the shape to confirm the surface draw shape as you draw.
- Zoom in on a photo to make sure you can follow the edge of the shape precisely and click on or near the plane/surface to start the Surface Draw. Use the mouse scroll wheel to zoom in and out, and click and hold the scroll wheel to pan the photo so you can follow the edge or boundary while zoomed in.
- Click a series of surface draw points to define the edge of the shape. If your first click is not on a surface, a confirmation will display to use the nearest surface (which will highlight in the 3D Viewer) to the click. Continue to click along the boundary.
- When you get to a sharp corner while using the Surface Draw Curve tool, in a curved boundary, right click and use the Create Corner Point to ensure the curve follows that corner tightly.
- If the extents of the shape to be traced span across more than one photo, and if you're using Surface Draw Line mode, you can switch to another photo and continue tracing without having to restart the process, just continue clicking along the edge in the new photo. If using the Surface Draw Curve tool across more than one photo, 3D curves need to be visible in the photos, and to continue on a new photo, click the end of the projection on the new photo.
- At the end of the trace, right click and click 'End Curve Draw' (for curves) or 'End Draw' (for lines).

See this instructional video (from about 3:00 to 4:30) showing the use of Surface Draw on a boat deck project.

In some specialized cases, where the edge boundary of a shape is very clear, the Auto-trace tool can be used. This type of project uses the 2D Template and Pattern Capture method and is described on this page with links to several instructional videos.

See this Troubleshooting and Advanced Topics section for a method to determine the surface draw is accurate.
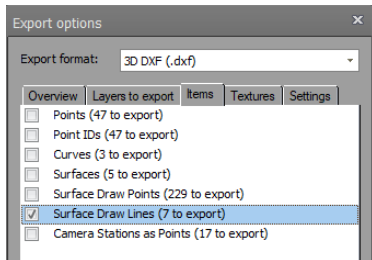
EXPORT

Once the shapes are traced and the model is scaled, it's time to export. PhotoModeler exports in a variety of file formats. The file format you select will depend on the format expected by your CAD package and/or your cutter/CNC machine.


When the panel or panels are flat, the 2D DXF format is appropriate (click File, Export >, Export Model..), However, in some cases where the traced shape is curved or the series of model shapes do not all lie on the same plane, a 3D DXF export is more appropriate, which is further explained in this Troubleshooting and Advanced Topics section.
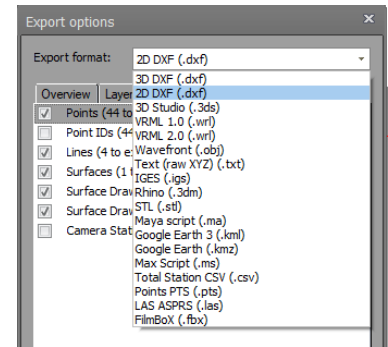
You can limit the items to be exported to just the Surface Draw lines.

When exporting the surface draw lines, you may want to use the 'Merge connected polylines' setting so the connected lines/curves will be a single polyline in the output .dxf file. In PhotoModeler the Surface Draw segments are drawn as separate curves and lines but using the merge option during export means the final .dxf file will have just a single entity for the whole outline.
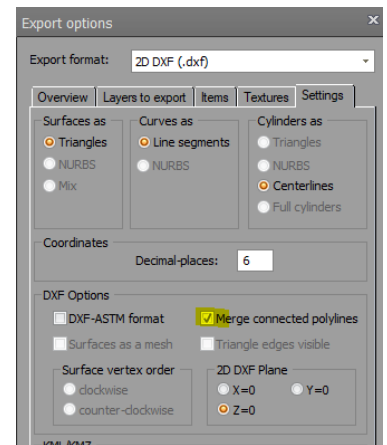
For example, the process below shows the tabletop shape exported as a dxf file, and brought into in a CAD package for touch up. The model is then sent to a cutter for an optional paper test cut, and then once fit is confirmed, sent to the cutter for final production:

Exported Model	Test Paper Cut
The model in CAD for touch-up (optional).	Test the paper cut shape for fit (optional).

Acrylic Cut	Finished Product
The model is sent to the acrylic cutter.	Placed for a perfect fit!
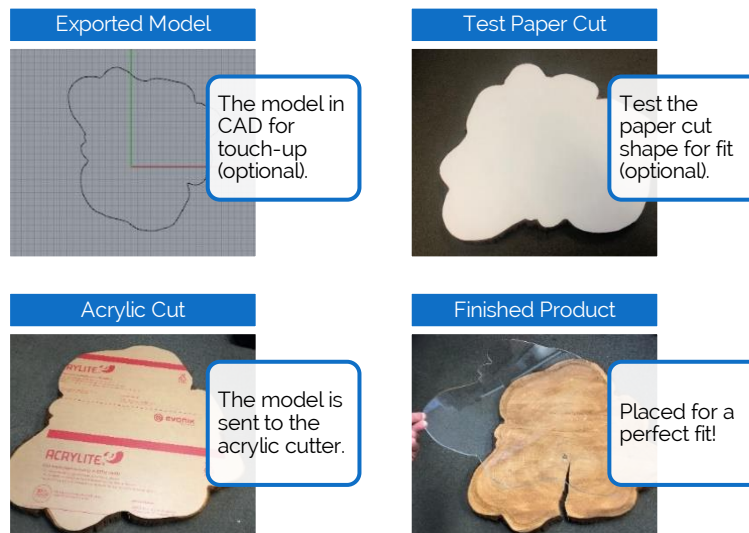
>> MODEL INACCURACIES

There are a number of things that contribute to model accuracy. Camera calibration, camera positions, marking accuracy, and surface fit are all factors. An inaccurate or mis-measured scale can also be a factor.

See this page on the PhotoModeler website for information on the factors affecting project accuracy, and this page on checking accuracy of a project.

A key benefit of having multiple scales in a project is the ability to use the Check Distances table to verify accuracy of a project. The table shows 'deltas' between a known distance between two points and the distance calculated by PhotoModeler and provides a good indication of model accuracy.

On top of the basic project accuracy, through calibration and orientation, the fit of the surface used for Surface Draw can also be a big factor. See the PANEL OR SURFACE ISN'T FLAT section below.

>> SOME OR ALL OF MY PHOTOS ARE NOT ORIENTED

The four most common reasons for an incomplete solution, where photos don't orient are:

- Point Count – make sure there are at least 6 target points marked in each photo.
- Point Spread – make sure the target points have spread in the photos. Target points that fall in a straight line, do not provide suitable geometry to orient the photos.
- Camera Angles – when taking photos, make sure you get photos from a variety of angles. Do not stand in one position and pivot the camera around. Separate the camera positions horizontally and vertically. While getting a variety of angles, include birds eye view photos of panels of interest for optimal tracing.
- Lack of Tie – If a model spans multiple panels make sure to place sufficient targets between the panels so that these points can 'tie' the scene together.
- Poor Camera Calibration – a project set up with a poorly or non-calibrated camera may not solve well or at all. Either calibrate the camera, or if the project is set up well, use the auto-calibration setting when setting up the project, or when reprocessing.
- Moving targets – if the targets are inadvertently moved during photography, this can confuse the orientation system.

>> SOME OR ALL OF MY CODED TARGETS AREN'T DETECTED

Make sure that the smallest target in the photo has an inner dot diameter of at least 10pixels (zoom in on a photo to confirm). Targets smaller than that can still be detected, but reliability is reduced.
Avoid photography where the targets are blurred, occluded or obscured, over-exposed, or too much perspective:

Distorted by motion blur

Obscured by shadows

Code ring obscured by other objects

Over-exposed

Perspective distortion

>> SURFACE DRAW POINTS/LINES/CURVES DO NOT LINE UP WITH FEATURES IN ALL PHOTOS

A good way to confirm the solution is to check whether the surface draw projection lines/curves align well with the features on various photos in the PhotoModeler. A 'projection' is the 3D object (a curve in this case) displayed, rendered, or projected on the photo using the photo's position in 3d space. It is a 3D view, but from the direction of the original photo. To enable Surface draw projections (e.g. the red curve shown in the images below), enable the setting on the Visibility on Photos Pane (highlighted yellow below):
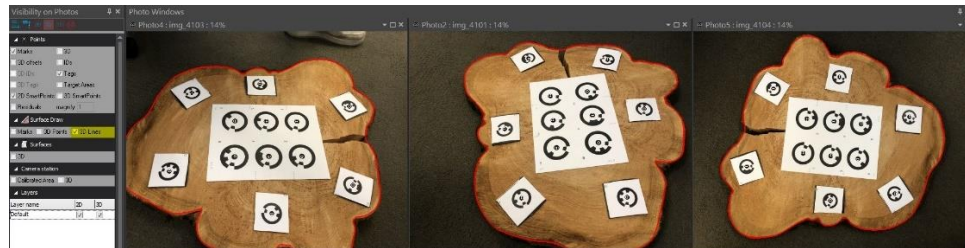
- One of the more common problems with surface draw is when the wrong surface or plane, or an improperly defined surface or plane, is used as the base surface for the Surface Draw. This can happen because there are multiple surfaces or planes defined in an area of interest. Be sure to keep the surface draw marked on the appropriate surface, especially if there are multiple surfaces defined in a small area.

- If the surface or plane is defined by target points that lie above or below that panel or shape, the trace may not be accurate, especially when there is perspective in the image.

- Try to use photos for Surface Draw that are taken perpendicular to the surface, as from a bird's eye view. In the example at right, the shape was traced using surface draw on an image with too much perspective. Although the shape can be traced, it will not be optimal, and the negative effects will be more pronounced if the points used to define that plane aren't on that same surface.

Bird's eye view, top down camera position, good for tracing.
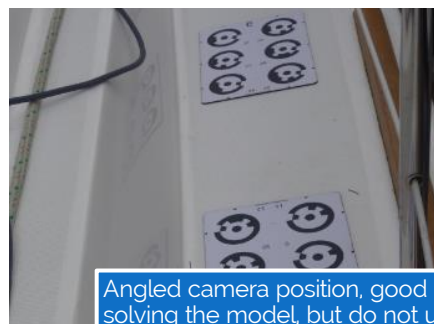
Angled camera position, good for solving the model, but do not use for tracing.

>> PANEL OR SURFACE ISN'T FLAT

When the output of a PhotoModeler project is sent to a CNC machine or cutter, the shape is cut from a flat material. If however, the shape to be modeled is not flat, the defined surface won't be flat, and therefore the Surface Draw outline will not be flat.

For example, the bench surface shown below is curved, and the red outline shows the traced panel boundary:
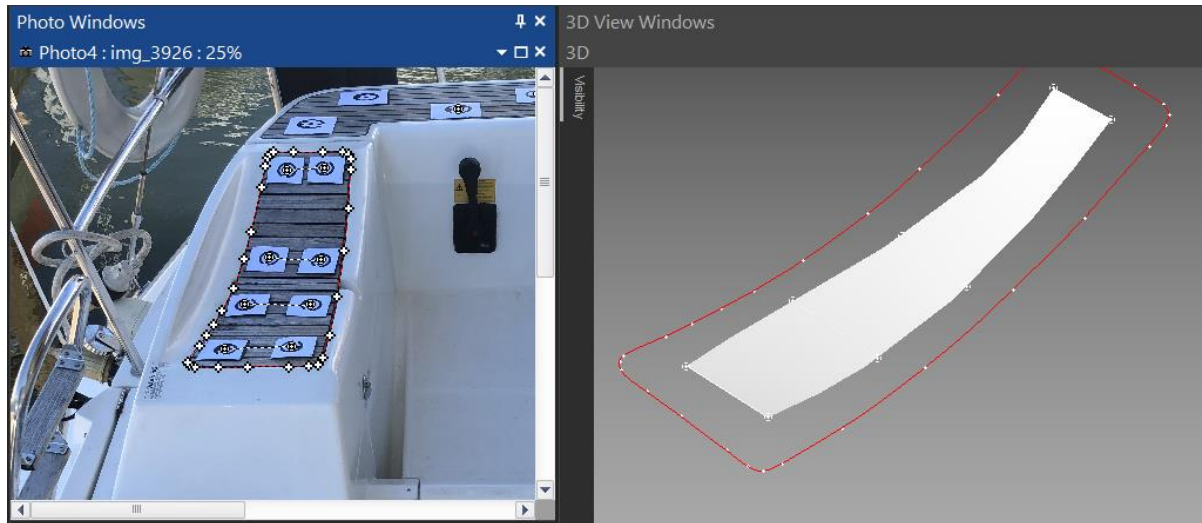
When exporting this type of model as a 2D shape, the 3D traced shape is projected onto the flat XY plane by removing the height or Z axis component. This distorts the shape and if produced it will not align well on the boat. Note this can happen even with slightly curved shapes especially if they are large.

To do this correctly, the model must be 'flattened' (as opposed to projected onto a plane). PhotoModeler does not have flattening tools, so this flattening would need to be done in other CAD software after the export. For example, Rhino3D has tools and there are various CAD plugins available for this.

Please contact PhotoModeler Technologies Support if you have questions about 2D vs 3D and how to approach this type of project.

>> POOR FIT OF A SERIES OF PANELS MODELED ON A NON-FLAT SURFACE

Closely related to the issue above on non-flat panels, is the issue of a series of modeled panels in one project, that all lie on a larger surface that isn't flat. An example would be the floor panels on an open deck of a boat that is convex or bowed for drainage.

If the overall deck or surface is not flat, it is usually easiest and best to model the panels in a series of small individual PhotoModeler projects. Otherwise, as described above, the series of modeled shapes in 3D space can be warped or have inaccuracies due to the projection of the shapes onto a flat plane when exporting.

If all panels need to be modeled in one project, flattening software may be required for best fit.

If the panels can be modeled individually on flat, 'local' surfaces, there will be no need for flattening.

>> EDGE OR BOUNDARIES OF TRACE PANEL AREN'T CLEAR

If the boundary of the panel isn't clear, PhotoModeler's Enhance Image tool can adjust the photo display settings to help make features more obvious:
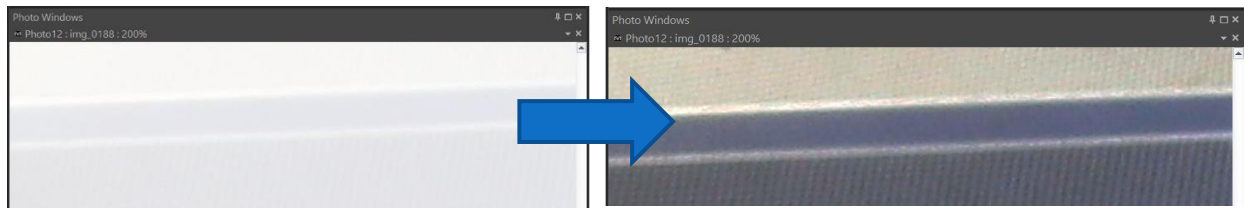
*Before Enhance*   *After Enhance*

A crisp boundary helps when marking or tracing the shape with Surface Draw.

AUTOMATIC PLANE AND COORDINATE SYSTEM SETUP

When using Letter Sheet targets, the project coordinate system and plane surfaces can be automatically set up when launching a new project. Once this profile has been set up, these settings will apply to all new projects of this type.

The coordinate system, including the project units, the Translate point, the Rotation and up to eight scales can be set up on Preferences:

- Open the Preferences dialog (click File, Options >, Preferences)
- Scroll down the left pane to the "Automated Target Projects" section, and select the "Coordinate System and Planes", then on the right, click the "Load Coded Target Preset Values" button to populate the fields with preset values corresponding to the target pattern on Letter Sheets.
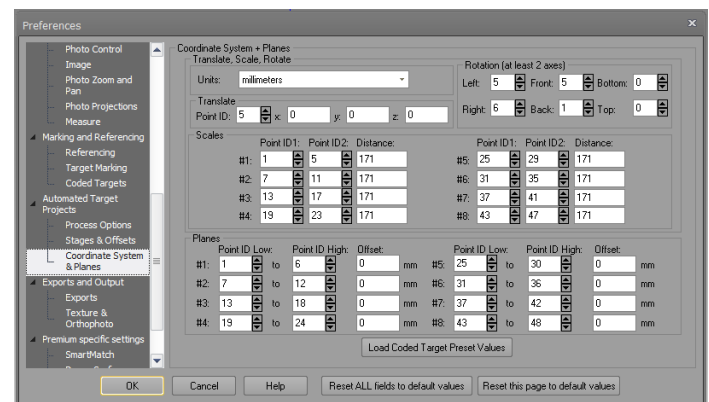
You can also use these settings to setup your own presets associated with your target sheets or patterns. Set the Point ID corresponding to each of the components of the coordinate system so it can be set up during the automated project processing.

Predefined planes based on certain target ID ranges can also be set. If using Letter Sheets, enter the low and high target IDs for each plane to be defined. Up to 8 planes can be predefined here.

If planes are defined by targets that have a significant thickness (i.e. the targets sit above the actual surface), you'll want to set the Offset Value to a negative value of the thickness of the target backing so that the surface draw lines/curves drawn on that surface lay flat on the actual surface.

Contact PhotoModeler Technical Support for more information on Letter Sheet targets and their availability and usage, or for other ways to further customize your project setup.

USEFUL LINKS

[The Other Photogrammetry Automation – Coded Targets](#)

[PhotoModeler Coded Targets and Automation - How to automate some measurement tasks](#)

[Using PhotoModeler's Surface Draw Tools to Outline Shapes](#)

[How to Measure Boat Decks without Physical Templates](#)

[How and When to use PhotoModeler's Automated Coded Target Method](#)

[Targeted Projects Resources](#)

[Digitize 2D Patterns and Templates with a Camera](#)

[Using PhotoModeler's Surface Draw Tools to Outline Shapes](#)