Lithophane Tutorial

Lithophanes are images that can be created by limiting the amount of light that passes through a material. By changing the thickness of the material the amount of light passing through creates a contrast.

The material used must be translucent for the effect to work.

Lithophane History

Perhaps one of the most unusual and interesting art forms to emerge from the early 19th century is the lithophane. Generally credited as being the invention of Baron Paul de Bourguignon, of Rubelles, France, in 1827, the earliest forms of lithophanes were actually produced in China many years before other countries produced them. Chinese potters employed the process to trace floral designs in the delicate walls of eggshell thin porcelain vases. There is little historical evidence indicating the exact origins of this technique in China, but it is certain that the knowledge predates the subsequent discovery by the Europeans. However, it was the Europeans that evolved the concept from simple floral pictures into complex, intricately detailed scenes. A wide variety of images appeared on lithophanes. The subject matter included quaint and delightful replicas of rural scenes and children at play, reproductions of famous portraits and popular paintings, dramatic religious scenes, hunting images, and scenic panoramas.

It was the efforts of the Baron de Bourguignon that led to the great popularity of lithophanes during the mid-19th century. His concept was simply this: a sheet of porcelain carved in varying degrees of thickness, when held to a light, would result in a highly detailed picture with the soft image quality of a mezzotint. This simple concept however, was not easy to execute. Sheer artistry of high order was required to make a master carving from which the lithophanes could be moulded.

The very first lithophanes were individually carved entirely by hand. But shortly after their introduction, the artists reasoned that moulds could be made, from which numerous pieces could be cast. To produce these moulds, a sheet of wax was placed on a piece of plate glass. This provided sufficient transparency for the artist's guidance. The full thickness of the wax on the glass stopped all light, and any scratch or gouge produced varying degrees of grey. Therefore, the entire range of shading from dark to bright was available for the skilled artisan to bring to life.

The artist first drew his general design on the surface of the white wax. Then, with modelling knives, burnishers, and other tools, he sculpted the minute details of the subject chosen for reproduction. From the wax carving, when finally approved by the master model maker, a plaster cast was made. This was the original die, which was used in moulding the porcelain bisque. A moist porcelain paste was then skilfully pressed into this cast, picking up all the details in the carving. Close examination of this mould would reveal intricate surface detail. During the porcelain casting process, the friction of the clay would swiftly wear these fine details out. To address this problem, the artists developed master moulds. Master moulds were made out of a harder plaster than the production moulds, and the image was reversed; like a negative. Production moulds were then cast from the master mould, allowing many more lithophanes to be successfully cast.

The seemingly simple process of removing the thin moist panels from the moulds required the highest degree of skill to avoid damaging the intricate details in the image. Since the panels were very thin and delicate, and the kilns extremely hot, many fired pieces were warped, twisted, and cracked. In addition, any slight impurity in the porcelain clay body showed up when the fired pieces were lit from behind. Therefore, the number of acceptable finished pieces to come out of the kilns has always been far less than the number that went in. Sometimes, only about 40 percent of the panels survived this process. Since the earliest days of their production, these issues have challenged the makers of lithophanes. Only the most determined craftsmen could overcome these difficulties, and go on to produce these brilliant art pieces.

During their heyday, lithophanes were produced by many potteries throughout the world. Some of the finest examples, as well as some of largest quantities of lithophanes were produced in Germany by the companies Prensaich Porzellan Manufactur in Plaue (P.P.M.), Berlin Porzellan Manufactur (B.P.M.), and Koniglichen Preussische Manufactur (K.P.M.). About 25 factories in Belgium, France, Denmark, Portugal, England, Italy, and Czechoslovakia produced lithophanes during the last century, with their popularity peaking in the middle of the century. Some of the well-known companies involved in lithophane production were the Wedgwood and Worchester Potteries in England, Phoenix Pottery in Pennsylvania, Beleek in Ireland, and Limoge in France. Surprisingly, no individual lithophane artists have been identified, however, many pieces are marked with the manufacturer's name.

Lithophanes were hung in front of windows, where the sunlight streaming through the panel revealed the designs in the porcelain. Since lithophanes need to be lit from behind be viewed properly, many beautiful types of lamps were made incorporating these porcelain artworks. Because of the era from which they originated, most lithophane lamps were quite fanciful and ornate. Candle screens were quite popular. Typically, they consisted of a decorative frame holding a lithophane, with a built-in candleholder to illuminate it from the rear. Multipaneled lamps were also quite popular. These came in many forms. Some were ornate shades that would hold from four to six flat panels, mounted on a matching lamp base. These panels could be shaped as rectangles or trapezoids. Sometimes, a similarly constructed shade was made to hang from the ceiling instead. Other lamps, instead of utilizing multiple panels, used one-piece hollow castings; cylindrical, conical, or sometimes round, with several images around their circumference. This type of shade is quite rare and highly prized. Lithophanes were made to fit in "hurricane" type lamps, desk lamps, table lamps, ceiling lamps, wall sconces;

virtually any type of lighting fixture. A unique but popular vehicle for displaying lithophanes was the tea warmer. These ornate fixtures had lithophanes surrounding an enclosure, in which a candle was lit. Topping the enclosure was a metal plate on which a teapot could be set, and kept warm from the candle below.

Another popular application for lithophanes was to cast them into the bottom of drinking vessels. As one would finish his drink, a delicate image would appear in the bottom of the cup or mug. In Germany, many beer steins were made with lithophanes in the base; sometimes with images that were quite risqué! From Denmark, and France came beautiful tea and demitasse sets with lovely images in the bottom of the cup. In the early 20th-century, Japanese potteries began to produce lavishly decorated tea sets (called Dragonware) with images of geishas in the bottom. This practice became quite popular in the post-WWII and Occupied Japan era for the GI trade in Japan. Production of these teacups tapered off in the 1950's, and a few are still being made today. By the late 1800s, the bloom was off the rose, and the great popularity enjoyed by lithophanes began to fade. The potteries moved on to other items, and the highly evolved skills and techniques that the master craftsman had developed disappeared with the original artists as they passed away. Since then, knowledgeable collectors, wise to the hidden beauty of this truly remarkable art form, have avidly sought antique lithophanes.

Machined Lithophanes

Using the Denford Quick CAM and a CNC Machine lithophanes can be machined from translucent materials in quite a simple process.

Unlike photographs and paintings the images will remain sharp and not fade.

Several parameters define how the machined part has to be machined. These include: material, colour, cutting tool, machine parameters and time.

Material

The material used to make lithophanes must be translucent, to test this, take an uncut piece of material, hold it to the light and pass your finger across the back of it. If you can see a dark shadow where your finger is the material should be suitable.

We have found that Cast Plexiglas that is 3mm (1/8”) thick is ideal for the process. While Plexiglas is available in both cast and extruded forms the cast version cuts better than the extruded form.

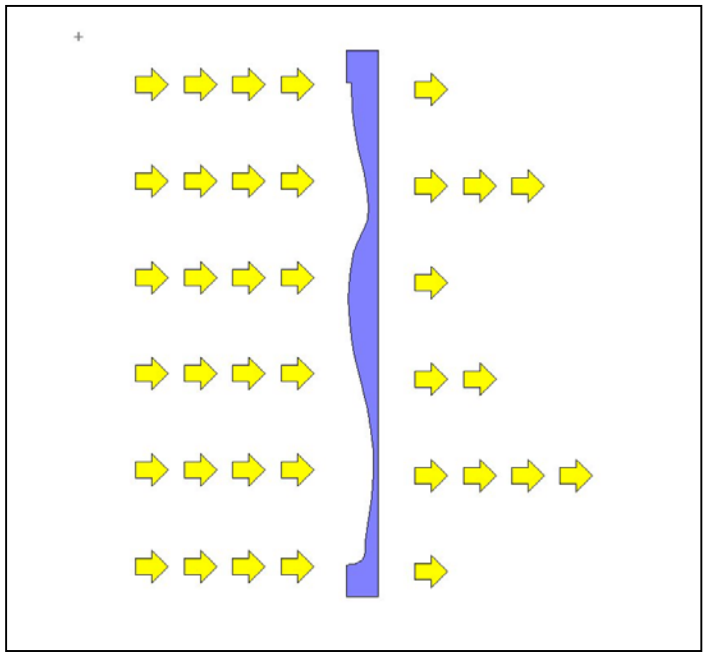
Other materials can also be machined with excellent results including Corien. Provided that the material is translucent and can be machined you can experiment with machining Lithophanes.

Colour

Any colour of material will work provided the material is translucent though the ones we have found to work best are Blue and White.

The darker the material the less light passes through so the thinner the relief required to produce the image.

The light hits the material travelling from Left to Right and is filtered by the material.



The thicker the material the more light is filtered and the image appears to be darker.

Where the material is at its thinnest most of the light passes through and the image appears to be white.

If the material shown was white then more light would pass through the material and the effect is the image would appear brighter.

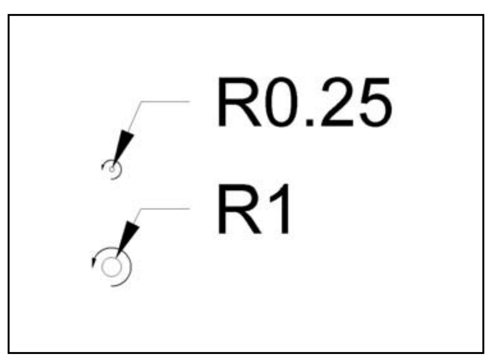
To get more contrast with light coloured materials the relief's have to be thicker.

Cutting Tool

The cutting tool is very important when manufacturing a lithophane. The smaller the tool tip, the finer the detail that can be produced.

If very small diameter tool tips are used. The tool will be more fragile will require higher spindle speeds to cut correctly

For each revolution of the tool you can calculate the distance the tool surface travels.



The distance travelled per revolution is 3.14 X Diameter of the tool.

For the 0.5mm diameter cutter the tool travels 1.57mm while the 2mm diameter cutter travels 6.28mm

If you know the spindle revolves at 23000 RPM (Revolutions Per Minute) and you know the diameter of the cutter you can calculate the distance travelled by the tool diameter in a minute.

This is known as the tool surface speed.

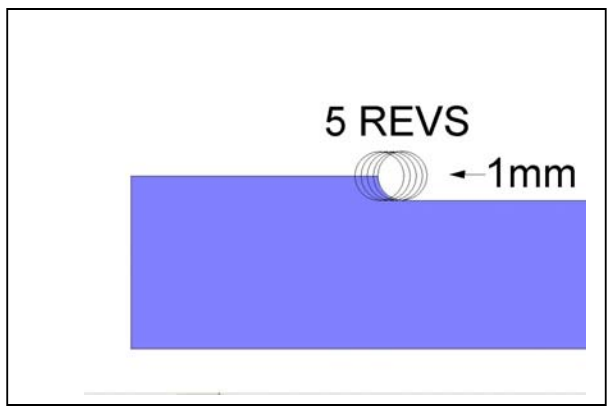
For the 0.5mm Diameter tool the surface speed is:

23000 x 1.57 = 36110mm/Min or 36.11 M/min

For the 2mm diameter tool the surface speed is:

23000 x 6.28 = 144440mm/Min or 144.44 M/min.

When the tool cuts away the material the cut each revolution of the takes limits how fast the tool can be moved without damaging the cutter.



In the example shown the tool is moving 1mm in 5 revolutions. This means that the tool removes 0.2mm of material for every revolution.

The programmed federate for this example would be 23000/5= 4.6M/min

Cutting Plexiglas the maximum feedrate that you would want to use is about 3M/Min with the 0.5mm cutter.

A feedrate of 3M/minute gives the following values

Feedrate = 50mm/second
Spindle = 23000/60 = 383 Revs/second

At this feedrate the tool is revolving 7.6 times/mm so each cut is 0.13mm in depth.

Machine Parameters

The size and speed that lithophanes can be manufactured depends on the type of machine you have.

Routers typically have a high spindle speed, which result in the tool having a high surface speed, which in turn allows higher feedrates to be used.

Milling machines have much lower spindle speed and as a result the feedrates used must be slower than that of a router. Using a larger diameter cutter on a milling machine will increase the surface speed and allow higher feeds to be used but reduces the resolution of the image produced.

The maximum size of lithophane that can be produced depends on the bed size of the machine being used.

The best machines for producing Lithophanes are routers as they have higher feeds and spindle speeds and a larger work area.

Time

The time taken to produce a lithophane is dependent on the size of the image, the speed and feeds used in the program and the tool step over programmed.

When manufacturing a lithophane the Z (vertical) axis makes lots of moves both up and down. Each time the axis reverses the slides must stop then reverse. This prevents the other axes achieving the full-programmed speed.

The larger the image the further the X or Y-axis move before an axis reversal so the faster the actual feedrate.

Images with large areas of one solid colour will be machined faster as there is no z-axis move over this area, so the tool accelerates to the programmed feed then moves to the next direction reversal before decelerating.

The larger the lithophane the longer it will take to manufacture. The relationship of size to time is not however linier. A 100mm x 100mm model will not be 4 times faster than a 200mm x 200mm model. This is because there will be a similar number of Z-axis reversals in each program so the moves in-between are longer and therefore able to achieve a higher feedrate.

Editing a Photograph Prior to Machining

A photograph can be edited prior to manufacture to reduce the manufacture time and to increase the definition and contrast.

While editing is not essential it can improve the finished result.

In the following examples a photograph is edited to give an ideal image to machine.

The photograph to the right was taken at high resolution and includes a complicated background.

While the image can be machined the background is not the part we want to view.

Use any photo editing package to cut the part of the photograph that you want to manufacture and save with another name.

The photograph has been cut down to show the part that will be machined.

Using a package like Photoshop the background can be cut away to leave just the image that you want to machine.

The background can be filled and if required a border added as shown.

The manufacturing time for this edited image will be reduced substantially and the resultant lithophane will have more detail because the subject has been enlarged.

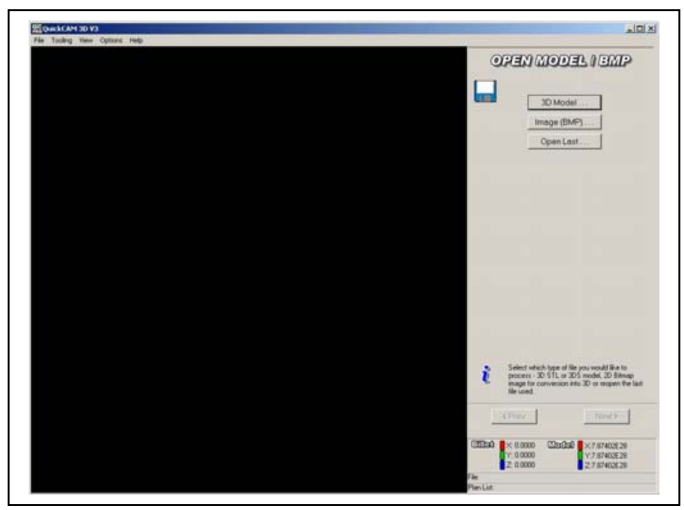
Using Quick CAM 3D to produce a Lithophane

Open Quick CAM 3D from the start Menu or Desktop Icon.

Quick CAM 3D is a simple to use "Wizard Program". The opening screen is shown.

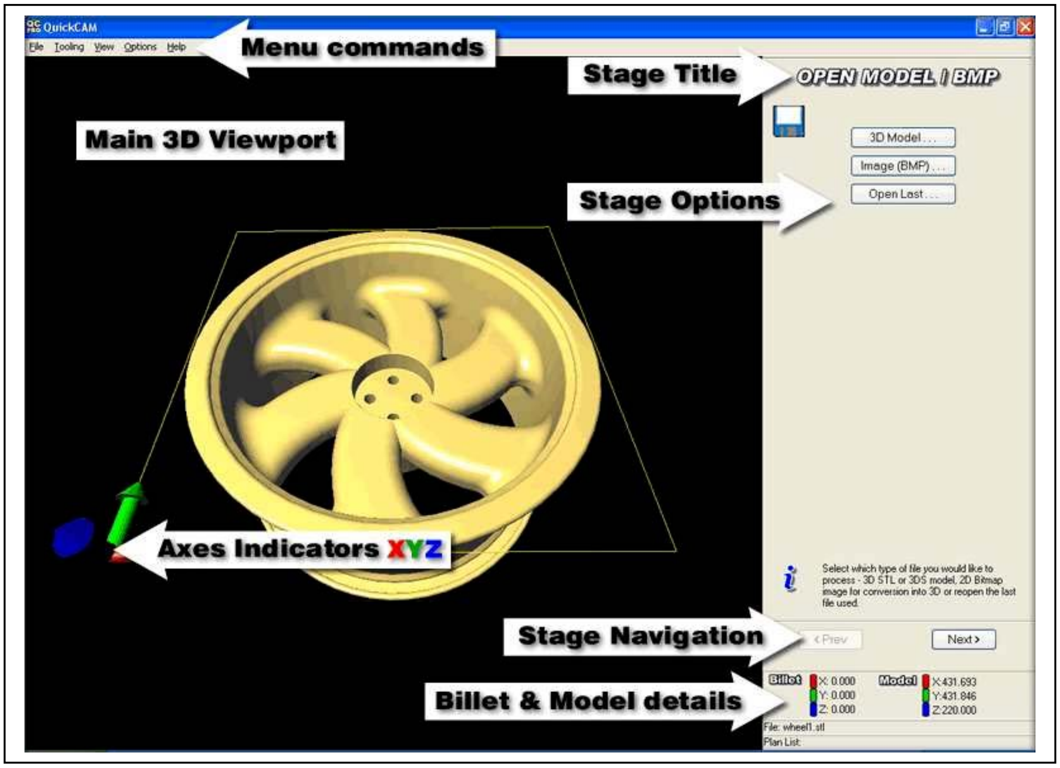
This tutorial will take you through producing a Lithophane from importing a photo to machining the part.

In addition to this tutorial there is a comprehensive help library, which can be accessed by clicking the Help Menu command or pressing the F1 Key.



Identifying the parts of the Quick CAM 3D Wizard

The picture below identifies the key areas of the wizard screen.



Useful tips are displayed in each menu page above the stage navigation section by the “i “symbol.

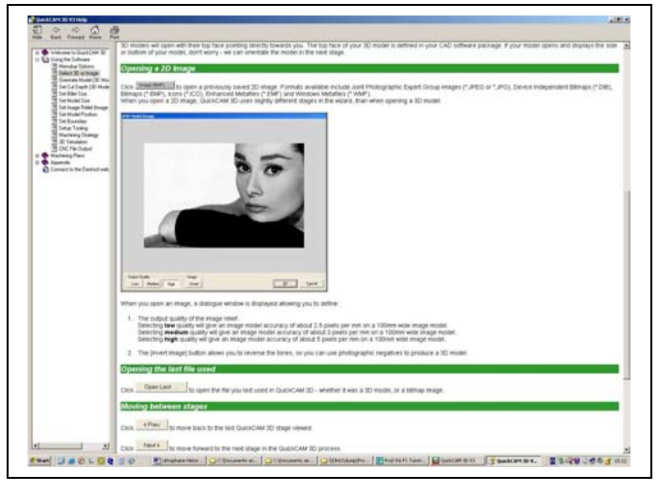
Using the Help

While it is possible to open the help from the Help Menu on the top toolbar it is better to use the “F1” key.

When you press the “F1” key you get context sensitive help. This means that if you are on the opening screen of the software and you press F1 the Help will open on the page relating to opening 3D Models or an Image file.

If you scroll down the right hand side of the help you will find the section on importing a 2D image.

At the bottom of the section there is information that explains how to manipulate the image file.



Close the Help by clicking on the X in the top right hand corner of the help window.

OPEN MODEL / BMP

To import an image file click on the 

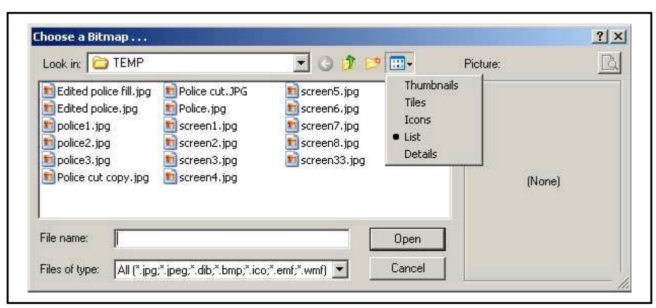
button.

A brows window opens and gives a preview if an image file is selected.

Browse for the desired image then click on the image to see the preview.

Note: The display of the files may not show thumbnails unless this option has been selected.

Click on the dropdown menu shown to select the file view you require.



Thumbnail view may not be available on some operating systems.

Once you have the file you want to manufacture selected click 

The image opens by default in greyscale and at low resolution.

The quality of the image required depends on the size you wish to manufacture at.

The larger the required part the higher the required image quality.

Using the High setting will work for all sizes but will result in larger programs that take longer to produce than is required.

Typically you should set the resolution as follows:

Low

For parts that are less than 100mm in size or are very high resolution pictures to begin with.

Medium

For parts that are less than 150mm in size or pictures with a lower resolution.

High

For any part over 200mm in size or for pictures of low quality.

Note:

Selecting **low** quality will give an image model accuracy of about 2.5 pixels per mm on a 100mm wide image model.

Selecting **medium** quality will give an image model accuracy of about 3 pixels per mm on a 100mm wide image model.

Selecting **high** quality will give an image model accuracy of about 5 pixels per mm on a 100mm wide image model.

Select the file “High” Quality output.

You will have to wait while the image is resized.

Once the file has resized at high quality select OK.

The image will then be opened in the Main 3D Viewport.

The picture will be positioned in the Main 3D Viewport with the zoom level set to whatever the image size is.

Click the View Reset from the Menu Command bar and the image will return to a default view.

Note:
The View Reset command is a useful tool and can be used throughout the wizard.

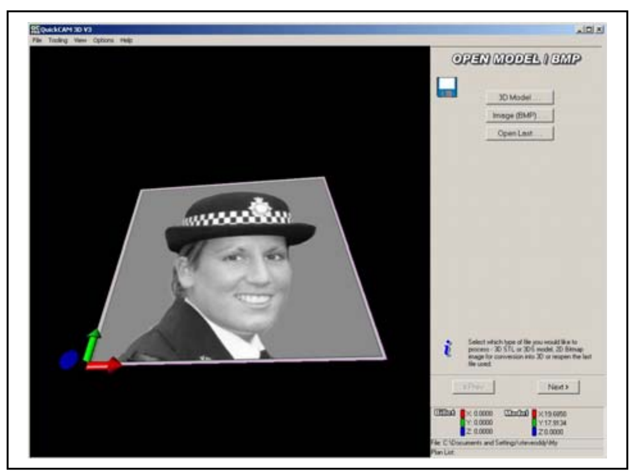
The view can be changed using the commands below:

Clicking anywhere in the **Main 3D Viewport** with the mouse, will manipulate the current 3D display.

Click and hold the **left** mouse button while moving the mouse to rotate the object.

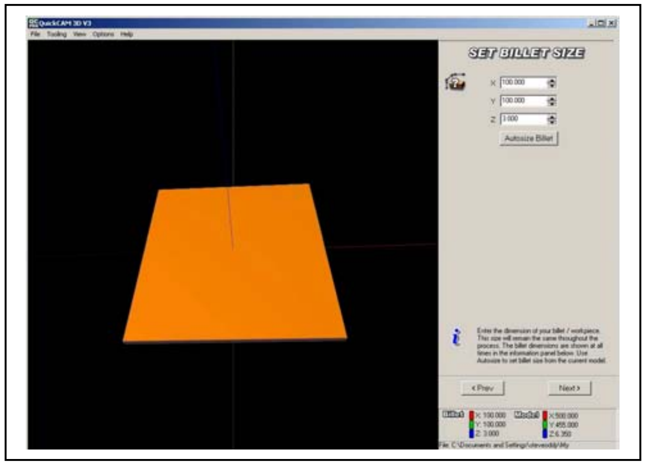
Click and hold the **right** mouse button while moving the mouse to zoom, making the object closer or further away.

Click and hold **both left** and **right** mouse buttons while moving the mouse, to shift the object up-down or left-right.



Click "Next" once you have rotated your view to look like the one above.

Set Billet Size



In this window you will define the size of the material used to machine the part in.

The thickness will default to 3mm the X and Y values should be set to match the billet (work piece) size.

View Reset will auto size the Billet and give a plan view.

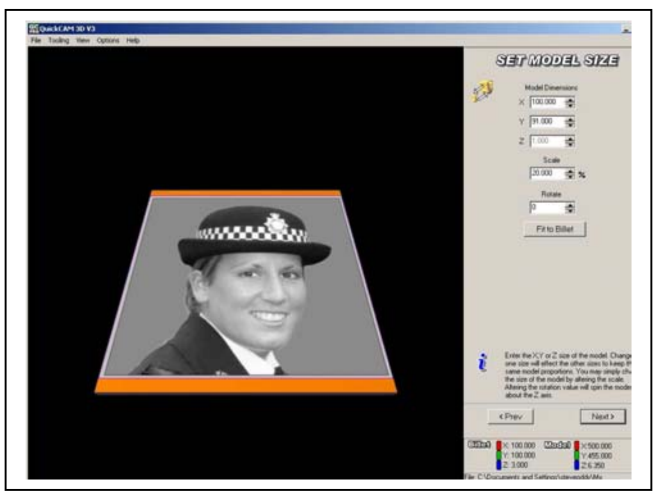
You can pan zoom and rotate using the mouse in the same way as before.

Set the billet size to:

X100
Y100
Z3

Once the Billet has been defined click next.

Set Model Size



In this window the size of the photograph is scaled onto the Billet and the finished relief will be made the size of the image shown.

The image is automatically scaled as large as possible without exceeding the bounds of the billet as it is imported.

The scale that the image has been imported at is a good indication as to if the quality setting was set correctly.

In this case the scale is 20% indicating that the image is of a high quality. If the image imports at 100% then it is the optimum for machining. If the value is over 100% then it may be worth going back through the wizard and increasing the quality.

If you are unable to increase the quality any further then you must accept the finished part resolution may be reduced as a result of a poor quality input image.

If the Scale is less than 100% then you will have enough data to produce a good image.

The smaller the value the more data that is used and the longer the processing and cutting time will be but the better the finished part.

When you produce the finished part you want there to be a border around the model.

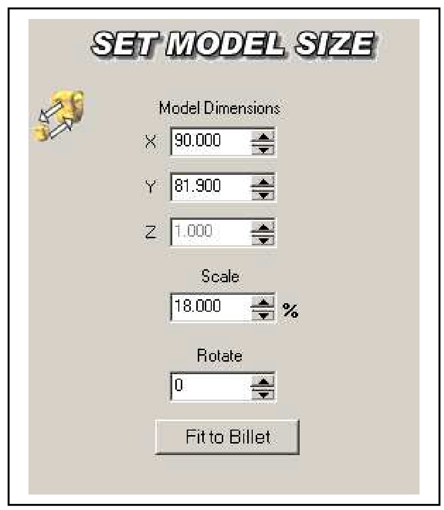
All the dimensions are linked so changing any of the X, Y or Scale values will change the linked values.

In this case the X value is set to 100mm or the width of the block, so you will change this value.

Changing the X value to 90mm leaves a 5mm border at the left and right of the image.

A larger gap is left top to bottom.

It is also possible to rotate the image at this point but you must be careful to keep the model within the limits of the billet otherwise you will be unable to proceed.



Once you have set the model size within the Billet click Next.

Set Image Relief

In this page of the wizard you will set the depth of the machined relief.

The relief depth is what gives the image its contrast and makes the image visible. The darker the image the thicker it needs to be to block more light. The thinnest parts will be white.

The information section of the screen gives details of typical settings.

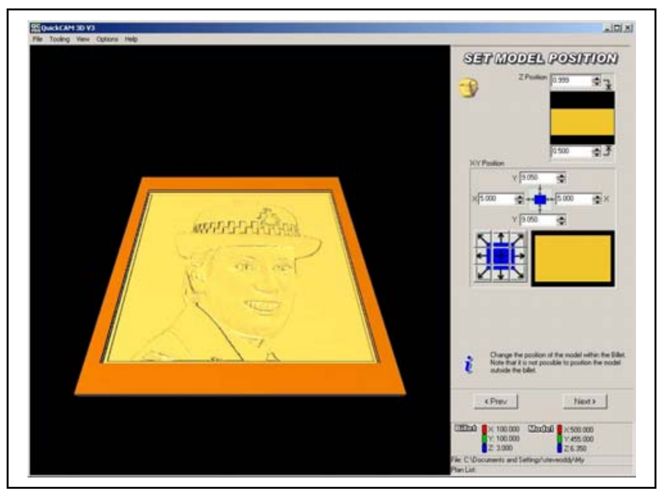
For white material set the contrast or Image Depth (Z) to 1.8mm

For Blue Material set the contrast or Image Depth (Z) to 1.5mm

For Red Material set the contrast or Image Depth (Z) to 1.2mm

Click Next.

Set Model Position



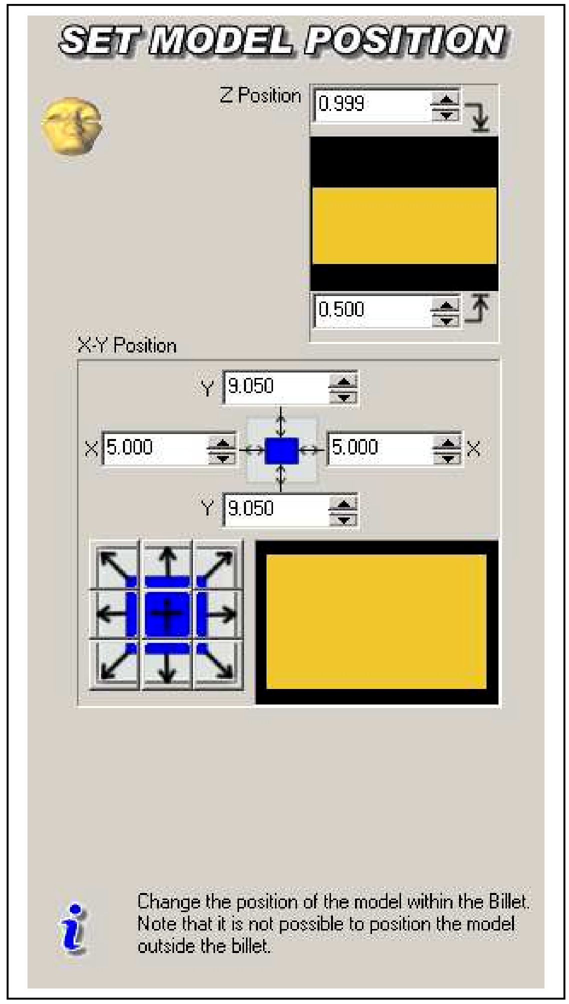
In this page of the wizard you will position the relief within the limits of the Billet.

As the window opens the photograph is converted into a 3D relief with the depth of the relief being what you set in the last section of the wizard.

The black area is the thickest and the white the thinnest.

The model can be positioned left to right, top to bottom and also within the block up and down

The left to right and top to bottom allow you to position the part anywhere you want in the sheet. This could be used to leave a different border size at the top or the bottom of the image to allow a mounting to be fitted.



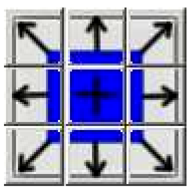
The Z Position is used to set the distance from the bottom of the material to the bottom of the relief.

As shown here the Lower z value is 0.5mm, this means that the white parts of the image are 0.5mm from the bottom of the billet.

The X - Y position can be changed in several ways: grabbing the orange block and dragging it, editing the values in the X, Y windows or by clicking in any of the 9 blue windows with arrows in.

Set the Z Position as shown 0.5mm from the bottom of the block

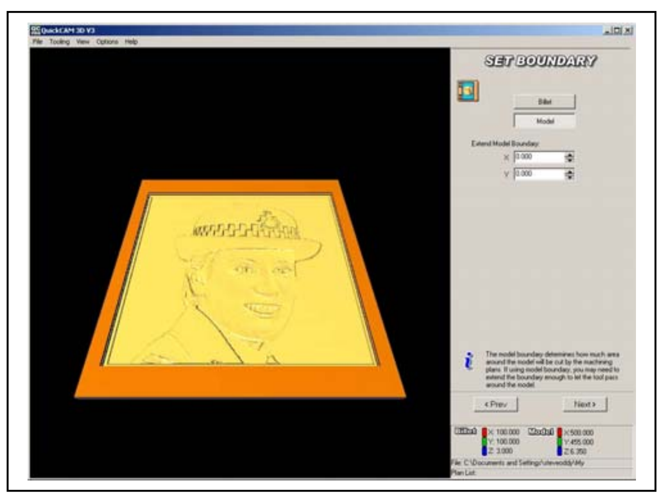
Set the X and Y to the centre of the block by clicking on the Centre blue button as shown



Click Next.

Set Boundary

This window is used to select the area around the model that you may want to machine. In most cases you just want to machine the model itself so the default values are used.



Set the values as shown.

Click Next

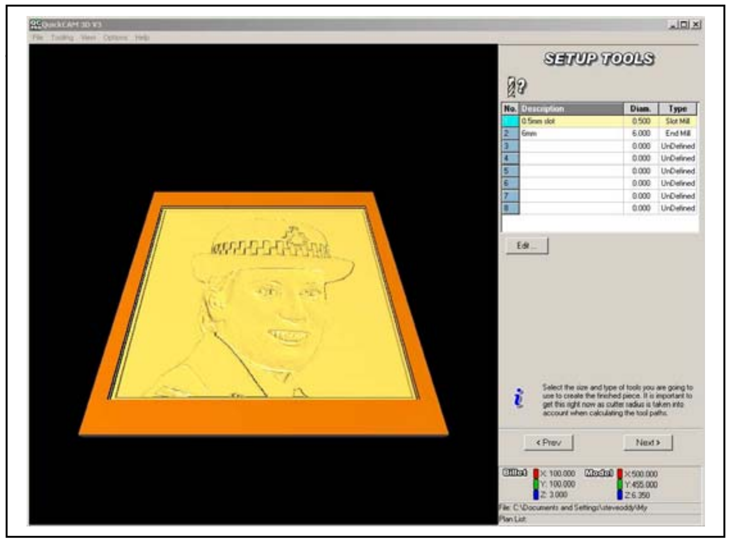
Setup Tools

To cut lithophanes and get a high-resolution finish the best tool to use would have a small diameter. For machines with a slower spindle speeds using a small diameter cutter is not possible as the tool does not have sufficient surface speed and in this case a slightly larger diameter ball end cutter will give the best results.

If using a Router the spindle speeds are in excess of 20,000RPM so a 0.5mm engraving tool is ideal.

For milling machines with spindle speeds less than 3,500RPM then you are better using a 2mm Ball End Cutter.

In this page of the wizard you will ensure that there is a suitable tool produce the part in the tool list.

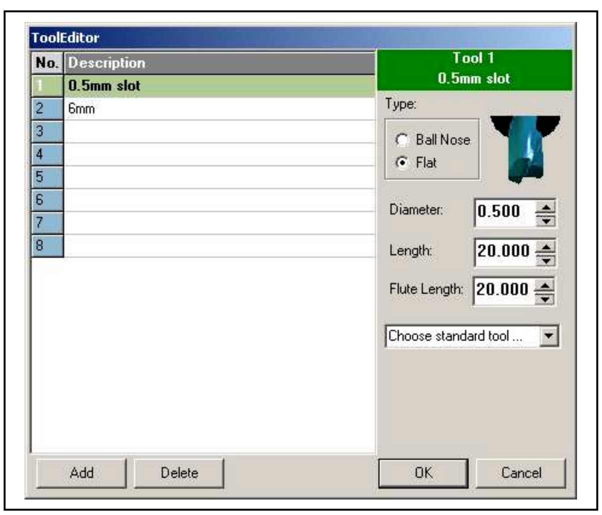


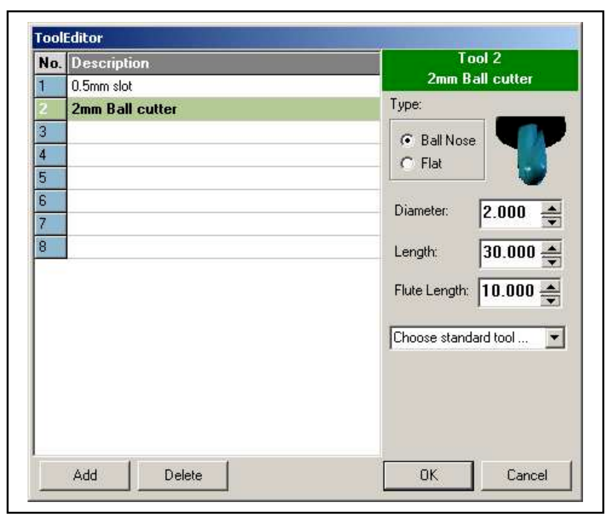
If you have a router ensure there is a 0.5mm Slot drill defined in the list.

If you have a Milling machine ensure that you have a 2mm ball cutter in the list.

If the tool is not shown, select an empty line in the list and click “Edit”.

The tool edit windows are shown below.





Settings for the 0.5mm engraver or 2mm Ball nose cutter. Click OK to apply changes.

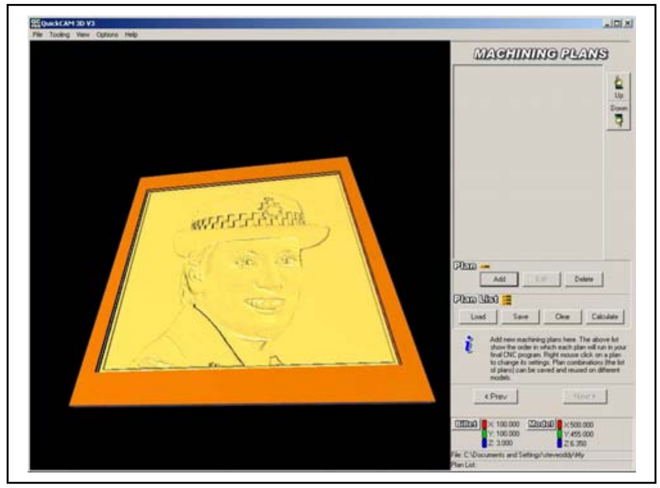
When the tool is shown in the list click “Next”.

Machining Plans

In this page of the wizard you will generate the machining plan or cutter path that will be used to machine the lithophane.

Quick CAM 3D has only two types of machining plan available but others can be found in Quick CAM PRO.

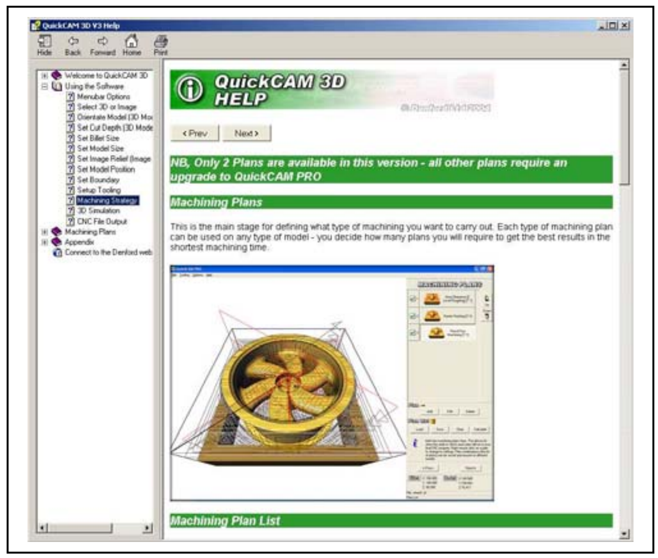
Press the “F1” key to display the help.



The Help file will explain how to define the cutting plans available.

For cutting Lithophanes in 3mm material there is no need to make a roughing pass.

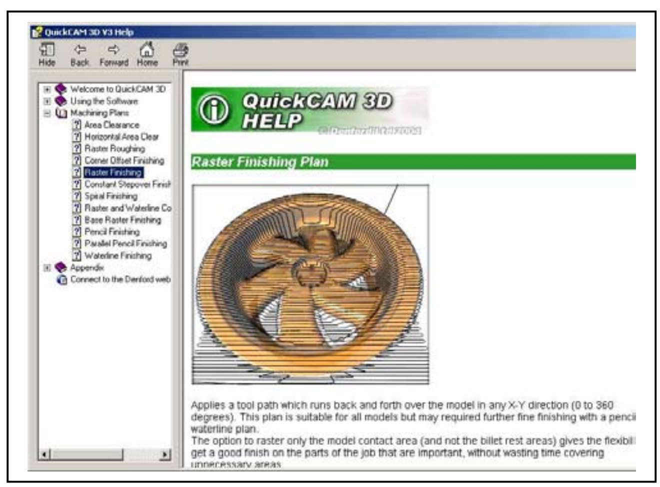
The raster-finishing plan is ideal for cutting lithophanes.



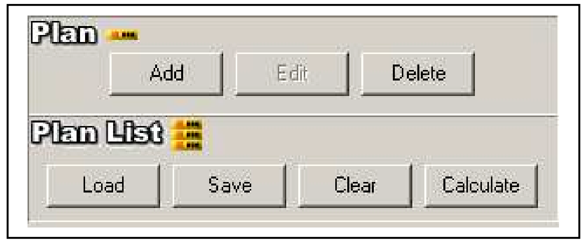
Expand the Machining plans help menu by clicking the + symbol to the left of the option.

The help menu explains what all the cutting plans do and why you would use them.

Read the information relating to Raster Finishing.



Select the Add option from the Plan List.



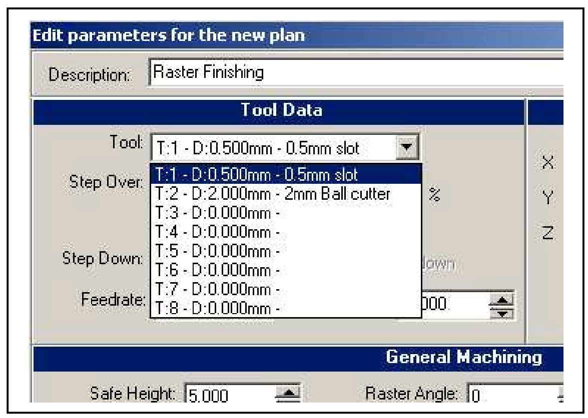
You will now select the Raster finishing Plan from the Menu.

This will open up a window that allows you to edit the parameters that will be used to create the tool path.

Depending upon which type of machine and tooling you have will define the parameters to use.

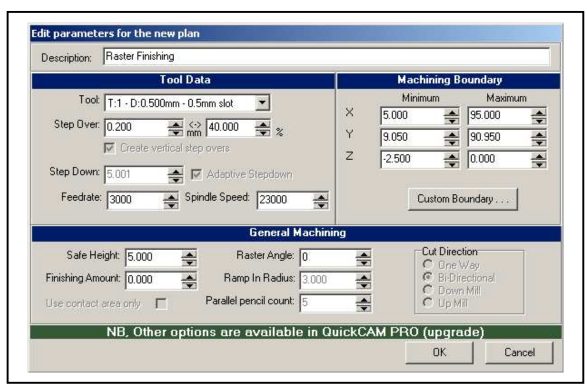
If you have the 0.5mm Slot drill defined select it from the tool data dropdown. This is ideal for routers or machines with a high spindle speed.

If you have a milling machine select the 2mm Ball end Cutter from the list.



0.5mm Engraving Cutter Settings

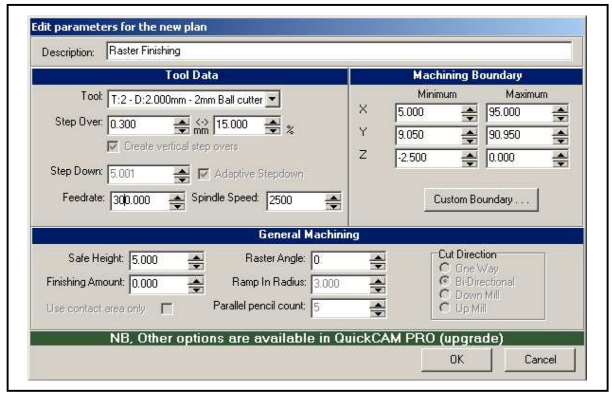
Step Over	40%
Feedrate	3000
Spindle Speed	23000
Safe Height	5.00
Raster Angle	0



These are typical values for cutting a lithophane with this type of tool. A Step Over of 30% will improve the finish but take longer to machine. A Step Over of 60% will reduce the manufacture time but the finished part will not be as well defined.

2mm Ball End Cutter

Step Over	15%
Feedrate	300
Spindle Speed	2500
Safe Height	5.00
Raster Angle	0



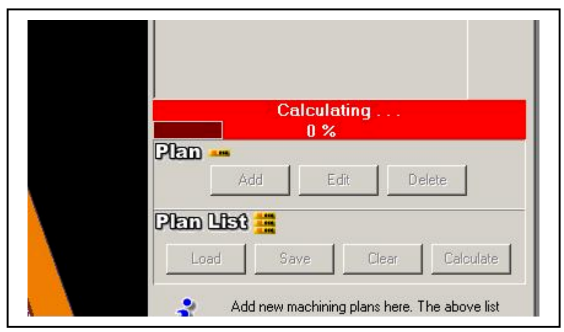
These are typical values for cutting a lithophane with this type of tool. A Step Over of 10% will improve the finish but take longer to machine. A Step Over of 30% will reduce the manufacture time but the finished part will not be as well defined.

You should program the maximum spindle speed your machine is capable of doing as the spindle speed value.

Once you have defined the cutter parameters for the plan click “OK”.

A calculating bar will appear as the tool path is generated

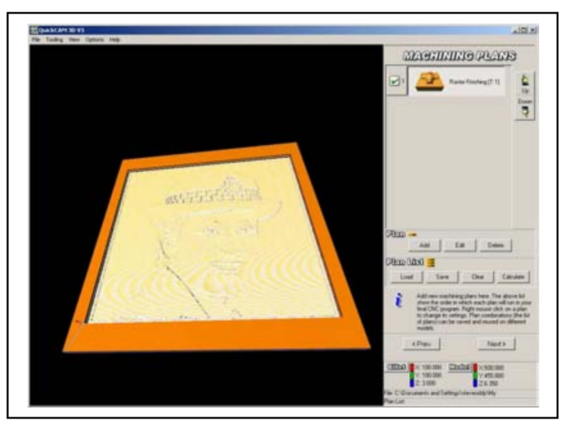
Once the tool path is complete it will be displayed over the model



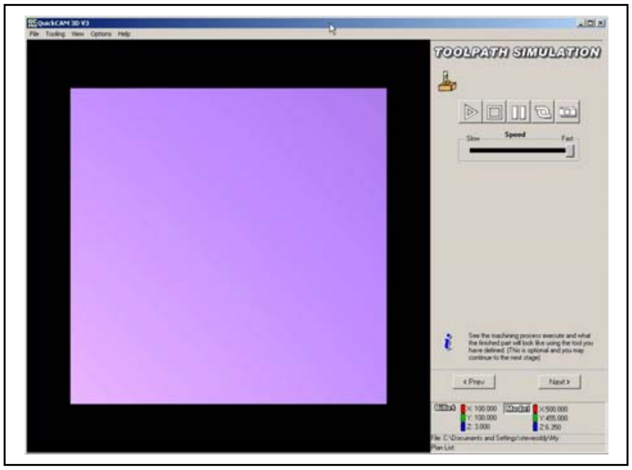
The tool path is can be seen over the model. If you zoom in you will see this clearly.

The completed plan is show in the plan list.

Click “Next”.



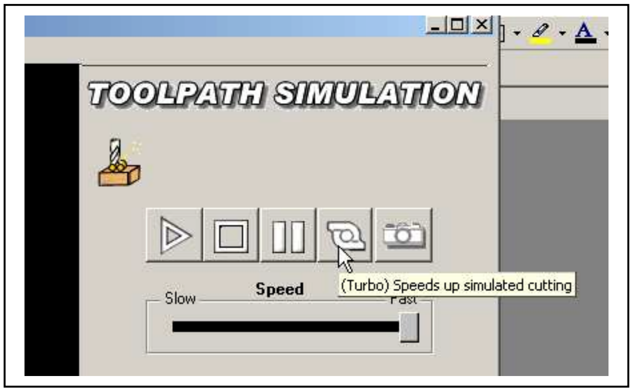
Tool path Simulation



Use the View Reset command from the Menu Command toolbar.

Zoom the display as shown.

Clicking play on the simulation tool bar will simulate the tool path.



Hover over each of the tool path simulation keys and a hint as to the function is displayed.

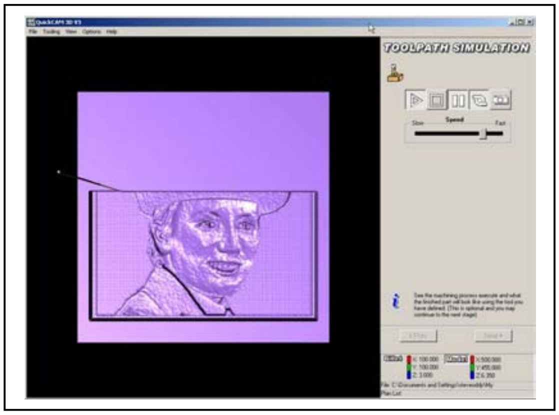
The Turbo button is on by default. Click this button and switch Turbo off.

When the simulation is playing and turbo is off every line of the simulation is displayed.
If turbo is on the graphics are updated less frequently to speed up the simulation.

Press stop and the simulation stops and the display is shown at full resolution.

If you press play now the program will re-simulate from the beginning.

Press pause and the program stops. Pressing play will resume the simulation from the point where it was paused.



The Camera button allows a picture of the simulation to be saved and is a snapshot of the onscreen simulation.

The speed slider will allow the simulation to run faster by displaying the simulation at a lower resolution.

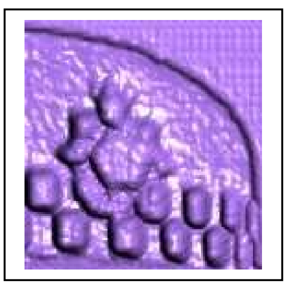
When the simulation finishes the final part is displayed, as it will be machined.

The finished part will look like this if cut with the 0.5mm slot drill.

In this case because the tool diameter is smaller the definition of the Lithophane is very good.

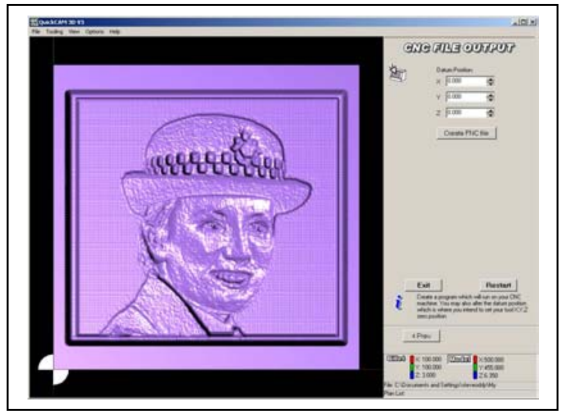
The finished part cut with the 2mm Ball End Cutter will be as shown.

While the image is not as sharp as the one cut with the smaller tool it will still be clear.



Once the simulation is complete Click "Next"

CNC File Output

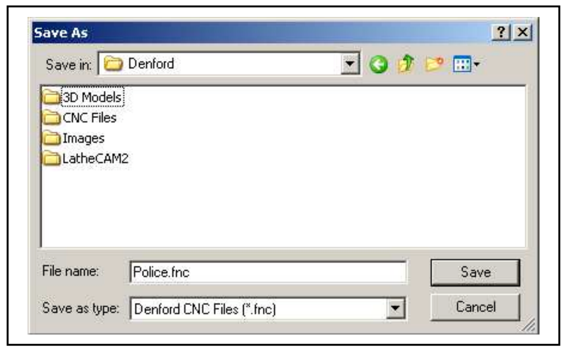


In this page of the wizard you will define the Datum position the machine will use and then save the CNC file.

The origin will default to X0 Y0 Z0 and for nearly all instances this will be the required value.

If you wish to use another Datum position press “F1” for help.

Click the “Create CNC File” button to save the file.



Browse to the place where you want to save your file.

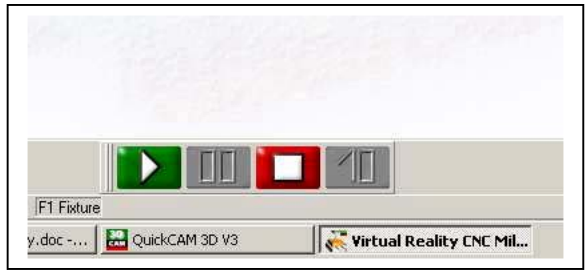
Name the file then click “Save”

Depending on the configuration of your installation the VR Milling may automatically load in which case the file will appear as the current program in the editor.

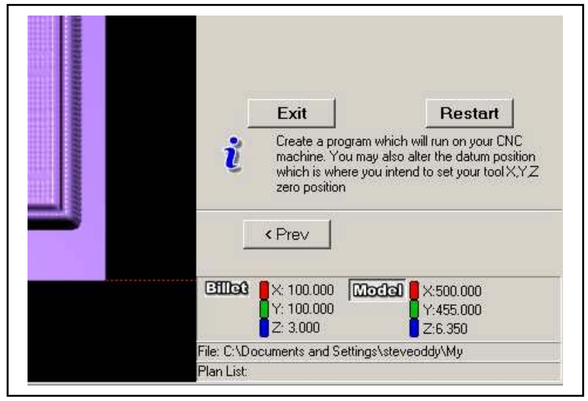
If VR Milling is not installed or not configured to auto run then you will need to start the VR milling software and open the FNC file in the normal way.

VR Milling shown with the program loaded to the editor.

Quick Cam 3D will still be open and can be selected from the taskbar at the bottom of your screen.



You can either “Exit” or “Restart” the software at this stage.



Manufacture

Once the FNC file has been opened in the machine editor manufacture is carried out in the same way as normal.

It is important that the material thickness is the correct thickness as any variation will effect the quality of the image created.