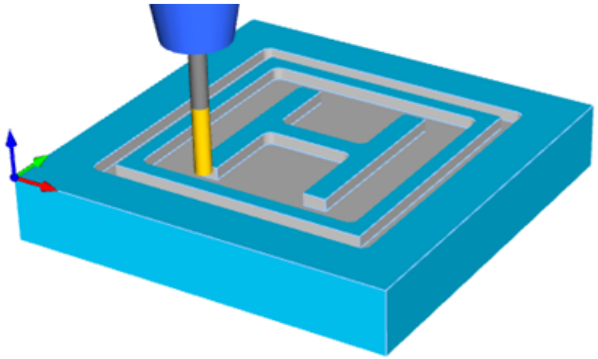
RhinoCAM Teacher/Student Project

with Rhino Education Specialist Pete Sorenson

Pete Sorenson has spent 42 years teaching technology classes to High School students at Lake Washington High School, Kirkland Washington as well as the greater Kirkland Washington area and the Rainier School District in Rainier OR. Pete's curriculum has included AutoCAD & Drafting, Automotive Shop, WoodShop and Metal Shop. Currently, Pete is one of three Education Specialists with McNeel & Associates who actively run technology workshops educating teachers on the use of CAD/CAM technology including the Rhinoceros CAD (Rhino) drawing and modeling program.



Pete's *hands-on* workshops teach educators how to draw in 2D and how to model in 3D using Rhino, how to design for manufacturing, how to setup their CNC machines, how to hold and fixture parts and most of all, how to get projects completed using CNC mills, routers, 3D printers and more.

The RhinoCAM Difference

Pete also performs custom CNC manufacturing for an exclusive set of clients including fixtures and tooling for manufacturing custom cutting tools, hydroplane water racing craft components and automotive street racing applications. Pete also performs custom machining on some of the oldest street clocks in America, many currently in museums! In his home workshop Pete uses RhinoCAM to generate G-Code for his ProLite CNC mill. Also included are 3 manual lathes, 3 milling machines, band saws, drill presses, and a metal-working shaper!

We recently sat down with Pete to discuss his amazing career and to ask him why RhinoCAM is his goto program for generating G-Code and for teaching other educators to use CNC machining technology. Here is just some of what Pete had to say about his RhinoCAM.

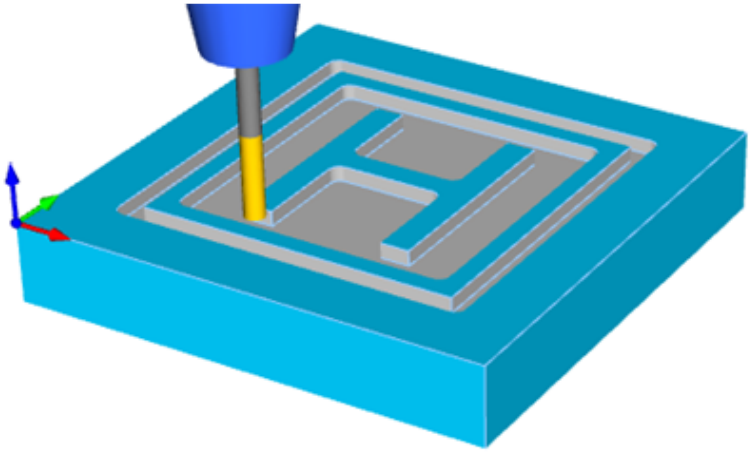
What sets RhinoCAM apart from other CAM systems?

"Well, there is good support #1, good price #2, and once you get the vernacular of what the different menus are asking you to do its relatively easy #3! Also, the fact that you can edit your Rhino drawing and then go directly to RhinoCAM to update your toolpaths makes it very flexible especially with multiple monitors."

Pete Sorenson, Education Specialist
McNeel & Associates, Kirkland, Washington

The RhinoCAM Student Project

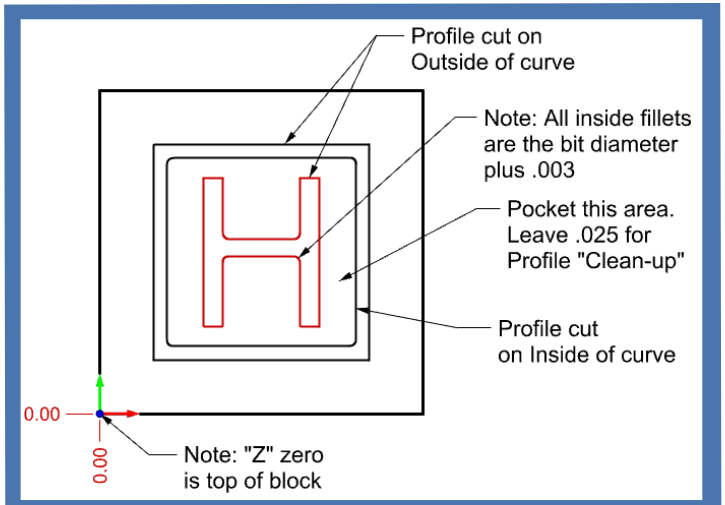
In this project teachers and students learn the basics of RhinoCAM by programming 2½ Axis Pocketing and 2½ Axis Profiling operations to machine the letter tile block shown here on the right. The exercise illustrates the use of simple 2D geometry to define setup and stock parameters as well as the ability to cut pockets for roughing and Profiles for finishing. There are similar tiles for each letter in the alphabet so teachers and students select combinations of tiles to complete a project.



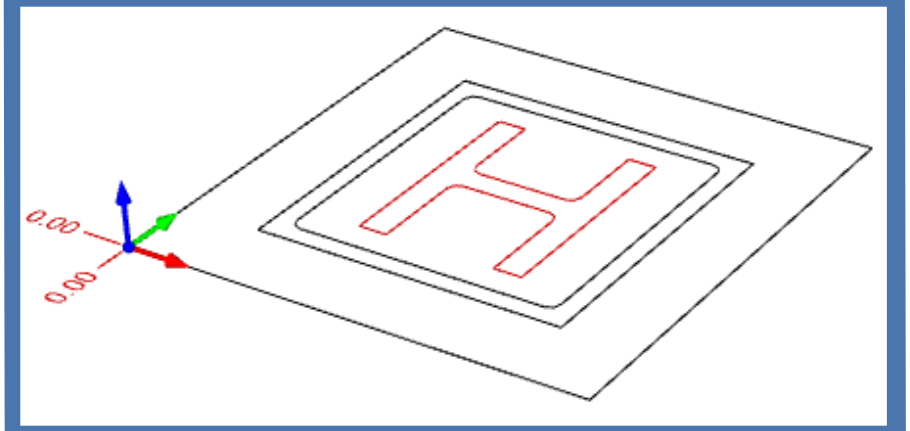
- Get the source files for this project here (available for RhinoCAM 2021 and VisualCADCAM 2021 only).

The CAD Geometry

The CAD geometry for this project is simple planer 2D curves drawn on the default Rhino XY construction plane (from the Top View) as shown in the illustrations below. All of the curves are located on this default XY Plane. The outer rectangle is 3” x 3” square and represents the outer perimeter of the tile. The bottom left corner of this rectangle is located at the WCS (World Coordinate System) 0,0,0 origin. We will refer to this as “XYZ” zero. That is because this default construction plane is located at a Z depth of zero and the bottom left corner of the geometry is located at XY zero.



The illustration above shows the 2D curve geometry that will be used for this project. All dimensions are for reference only and are not used in the CAM project. The curves are located on Rhino’s default XY plane. You can show this plane by selecting the Top View in Rhino.

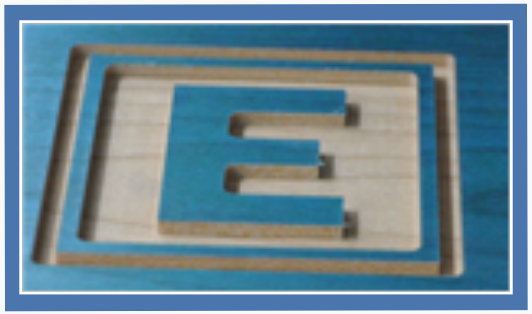


Here we see the default Perspective view in Rhino. It shows that all geometry is located on the default XY construction plane with the bottom left corner located at the WCS (World Coordinate System) 0,0,0 origin.

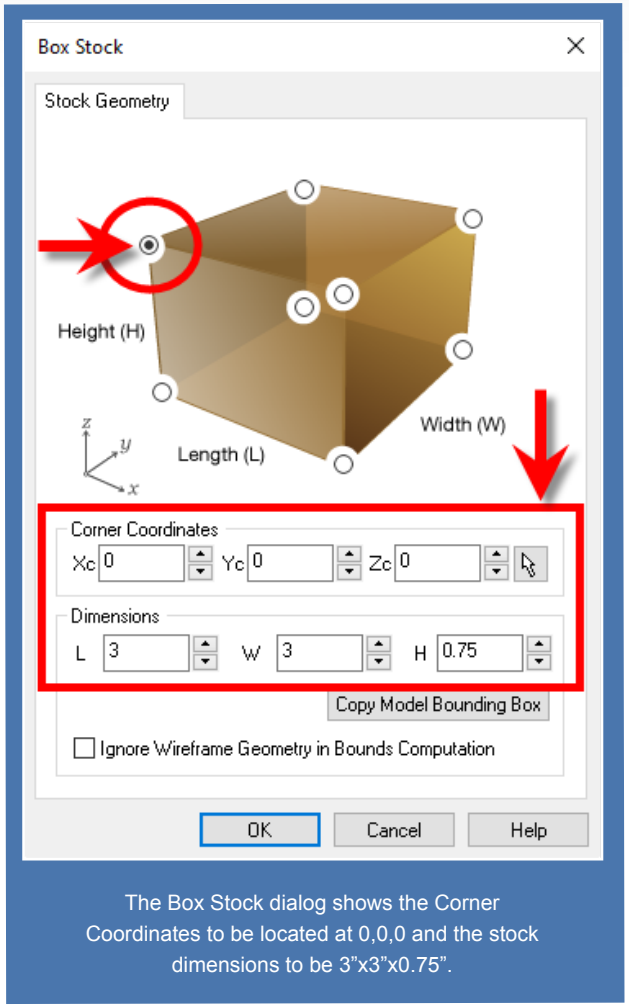
The Stock & Setup

The stock definition in RhinoCAM for this project is a Box Stock with Length (L) equal to 3.00”, Width (W) equal to 3.00” and Height (H) equal to 0.75”. Notice that the top right corner of the stock in the dialog below is selected. This means that the dimensions entered into the dialog are measured from this corner of the box stock. Also, under Corner Coordinates you see that Xc, Yc and Zc each equal zero. That corresponds with the lower left corner of our control geometry which by default is the WCS (World Coordinate System) origin. The setup or workpiece origin is located at this 0,0,0 position.

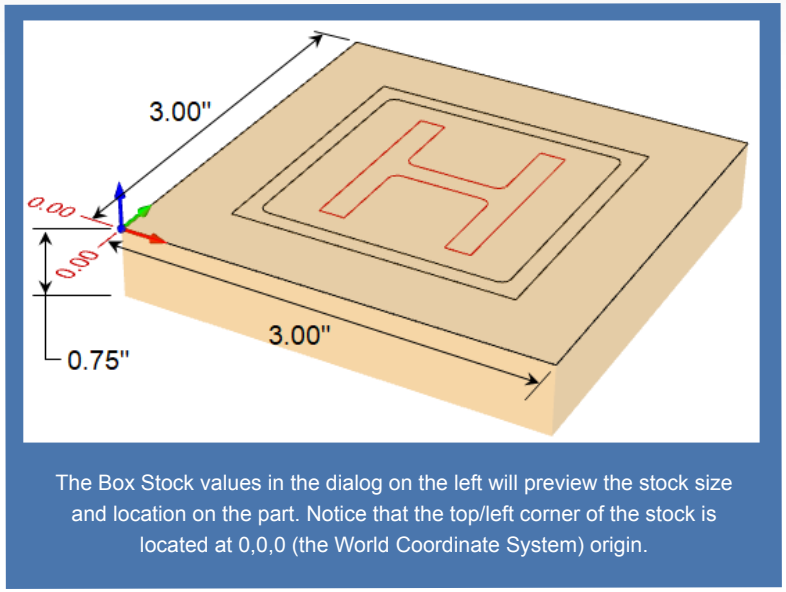
For the project’s limited piece runs, Pete uses blue tape and super glue to hold the blocks to the fixture on the milling table. Pete also uses ORACAL Oramask 813 Stencil Film to mask the top of the stock prior to machining.



Pete recommends using a 2-flute down cut ⅛” diameter flat end Mill (from 2Linc.com) at a cut feed rate of 10 in/min for each of the 2½ Axis Pockets and Profiles. This tool in combination with the ORACAL Oramask 813 Stencil Film provides very clear and sharp edges that shear the Oramask eliminating "paint bleed" under the masking. See more finished letter tile block images below!



The Box Stock dialog shows the Corner Coordinates to be located at 0,0,0 and the stock dimensions to be 3”x3”x0.75”.

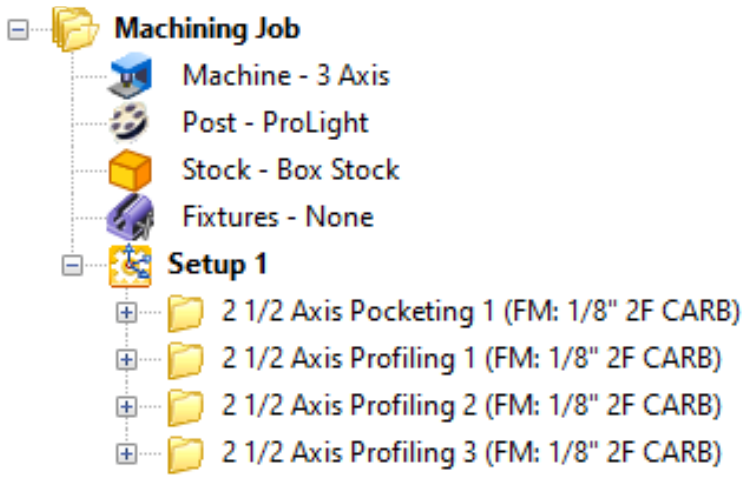


The Box Stock values in the dialog on the left will preview the stock size and location on the part. Notice that the top/left corner of the stock is located at 0,0,0 (the World Coordinate System) origin.

Sequence of Operations

The Machining Job and Setup 1 shown here on the right includes one 2½ Axis Pocketing operation followed by three 2½ Axis Profiling operations. All four operations use the same tool which is a down spiral ⅛” diameter Carbide 2 Flute Flat End Mill.

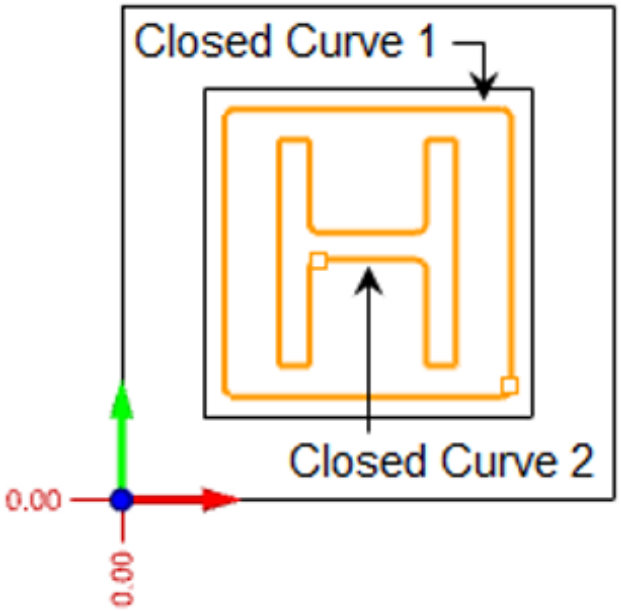
Setup 1 shown in the Machining Job is located at the WCS origin (0,0,0). You can locate this position in the illustrations above. When you post Setup 1, each machining operation is then posted in the order that they appear under Setup 1. See Posting G-Code below for more information on posting options.

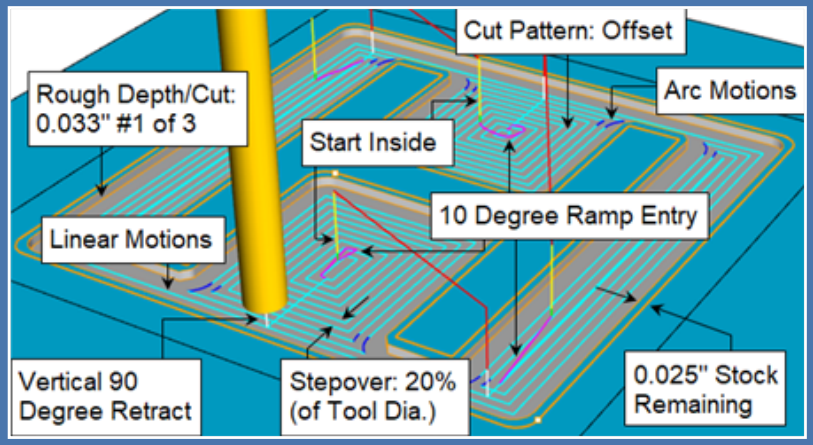


2 1/2 Axis Pocketing 1 (FM: 1/8" 2F CARB)

The first machining operation that appears under Setup 1 is *2 1/2 Axis Pocketing 1 (FM: 1/8" 2F CARB)*. It performs a pocketing operation to clear stock material out between the two closed curve regions shown here on the right. The resulting toolpath and many of its Cut Parameters are shown in the illustrations below.

For Cut Parameters the Global Tolerance for the operation is 0.001”, a Stock value of 0.025” and cutter compensation is disabled. This means that there will be a thickness of 0.025” left between the cutter diameter and the curve regions. The tool path employs an Offset cut pattern, a Climb cut direction, an Inside start point, and a Stepover of 25% of the tool diameter.

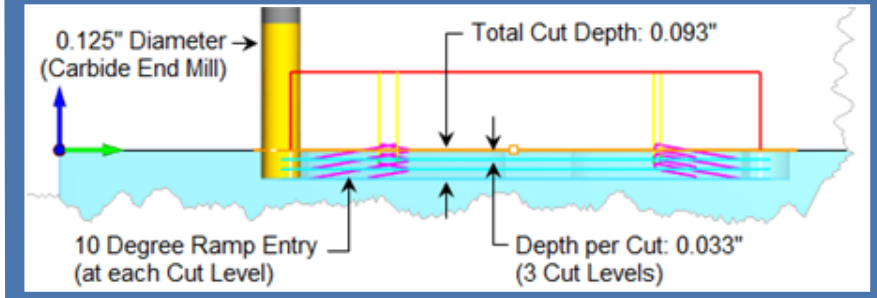




In this illustration we see the cut material simulation and tool paths for the first cut level of the 2½ Axis Pocketing operation.

Many of the Cut Parameters are labeled as well as the entry and exit motions.

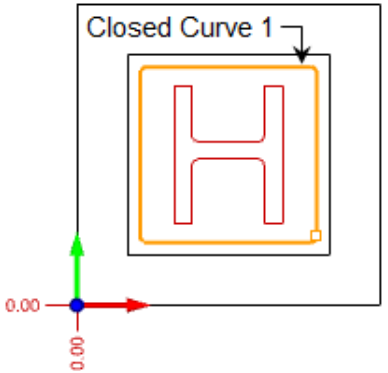
This Pocketing toolpath contains three cut levels. The Total Cut Depth is set to 0.093” with the Depth per Cut set to 0.033”. Each cut level has a 10 degree ramp entry. The elevation view of the cut material simulation is shown in the image below. The control geometry (2D closed curves) are located at Z zero as indicated by the WCS triad on the left. The area below Z zero is the stock geometry.



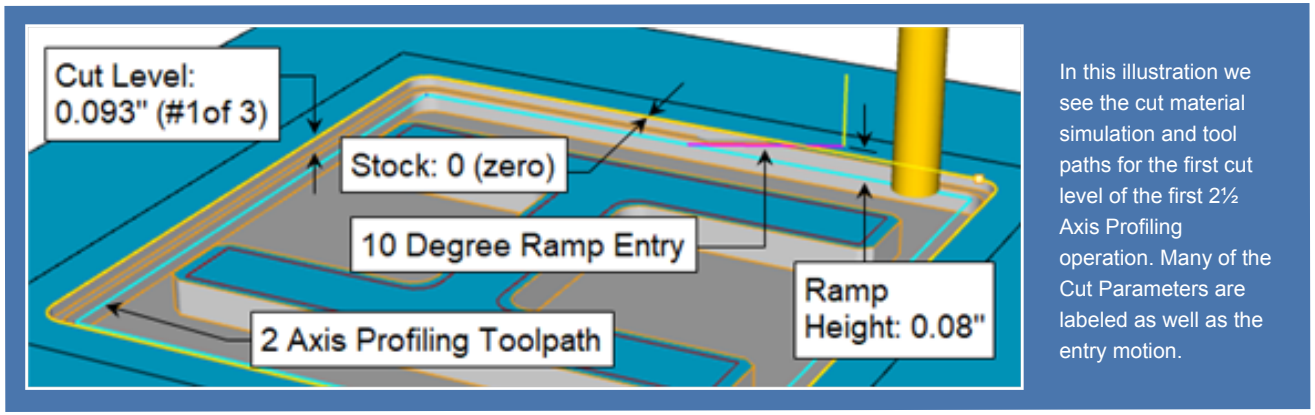
In this elevation view we see the results of the cut material simulation of the 2½ Axis Pocketing toolpath operation. The 10 degree ramp entries are clearly shown as well as each cut level.

2 1/2 Axis Profiling 1 (FM: 1/8" 2F CARB)

The second operation in the Machining Job tree is *2 1/2 Axis Profiling 1 (FM: 1/8" 2F CARB)*. This is a Profiling operation used as a finishing cut around the inner side of the closed curve perimeter of the pocket. The control geometry selected for this operation is shown in the illustration on the right.



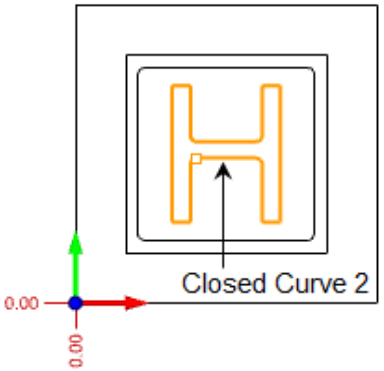
For Cut Parameters the Global Tolerance for the operation is 0.001”, a Stock value of 0 (zero) and cutter compensation is disabled. This means that the diameter of the cutter will touch the perimeter curve and follow it along the inner side of the previous pocketing operation. The Cut Direction is set to Climb and the Cutting Side is set to Inside. The Total Cut Width is set to zero. This means that the cutter will not offset in the XY direction. The cutter will ramp at a 10 degree angle into the stock material at the cut start point and will travel around the curve and then perform a vertical retract when it passes the cut start point by 0.2”. The cut level parameters are similar to the 2½ Axis Pocketing elevation view shown above.



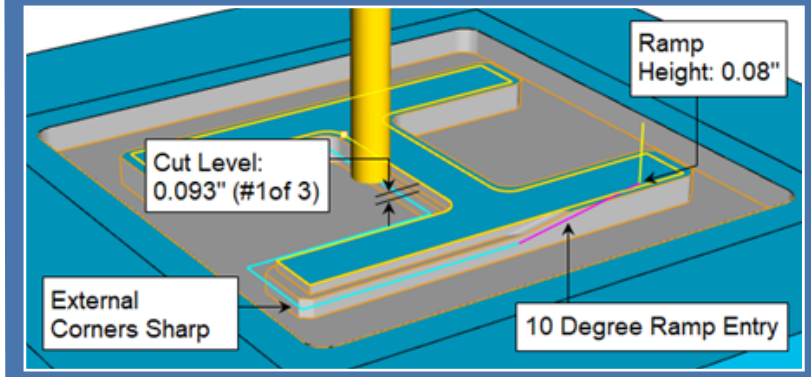
In this illustration we see the cut material simulation and tool paths for the first cut level of the first 2½ Axis Profiling operation. Many of the Cut Parameters are labeled as well as the entry motion.

2 1/2 Axis Profiling 2 (FM: 1/8" 2F CARB)

The third operation in the Machining Job tree is *2 1/2 Axis Profiling 2 (FM: 1/8" 2F CARB)*. This is the second Profiling operation used as a finishing cut around the outer side of the closed curve perimeter of the letter “H”. The control geometry selected for this operation is shown in the illustration on the right.



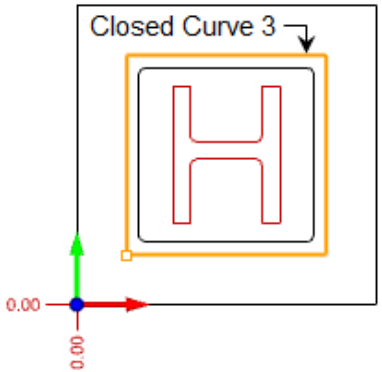
The Cut Parameters are nearly identical to the previous Profiling operation. One difference is that the Cutting Side is set to Outside. Another difference is that on the Cornering Parameters tab, the External Corner Type is set to Sharp. This means the cutter will not *roll around* the 90-degree corners but will travel past the corner and then make a 90-degree turn. These sharp corners are labeled in the illustration below. This method results in a precise sharp corner where needed. The Cut Direction, Cutting Side, Ramp Entry, Vertical Retract and Cut Levels are all identical to the previous Profiling operation. The cut material simulation for the first of three cut levels in this operation is shown below.



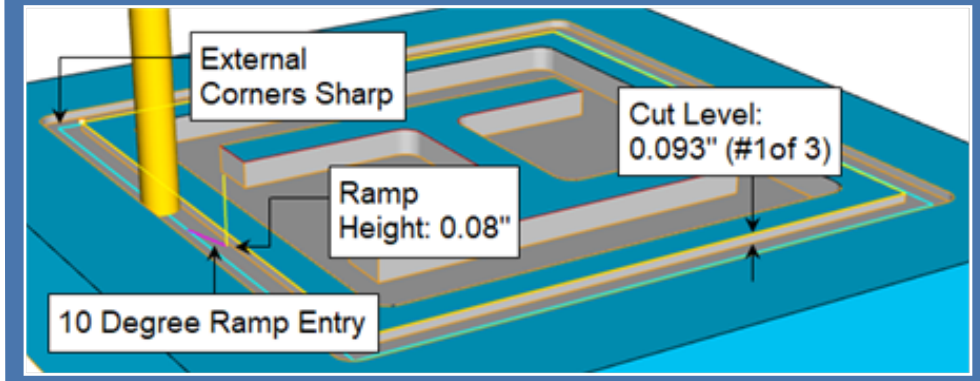
In this illustration we see the cut material simulation and tool paths for the first of three cut levels in the second 2½ Axis Profiling operation. The 10-degree Ramp Entry can be clearly seen as well as the External Sharp Corner option.

2 1/2 Axis Profiling 3 (FM: 1/8" 2F CARB)

The final operation in the Machining Job tree is *2 1/2 Axis Profiling 3 (FM: 1/8" 2F CARB)*. This is the third Profiling operation used as a finishing cut around the outer side of the closed curve boundary surrounding the letter “H”. The control geometry selected for this operation is shown in the illustration on the right.



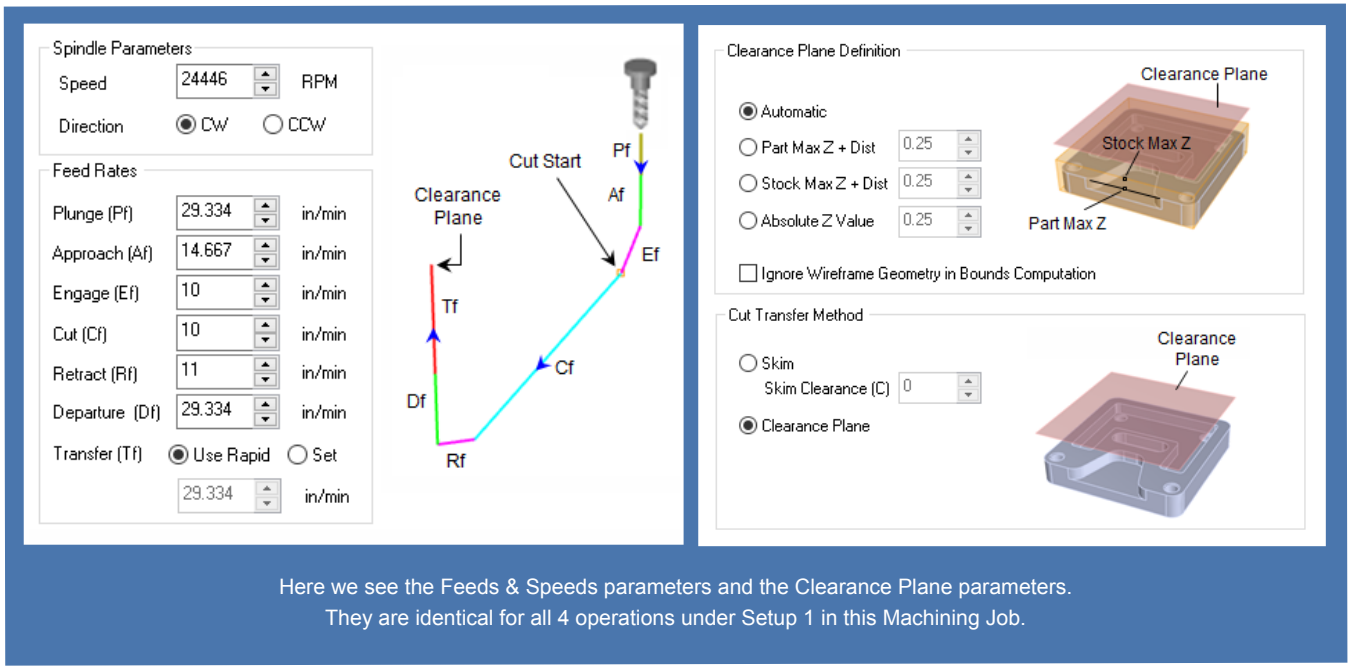
The Cut Parameters, Cornering Parameters, Cut Levels and Entry/Exit parameters are identical to the previous Profiling operation shown above. The Cut Direction, Cutting Side, Ramp Entry, Vertical Retract and Cut Levels are shown in the cut material simulation illustration below.



In this illustration we see the cut material simulation and tool paths for the first of three cut levels in the third 2½ Axis Profiling operation. The 10-degree Ramp Entry and the External Sharp Corners are clearly visible.

Other Operation Parameters

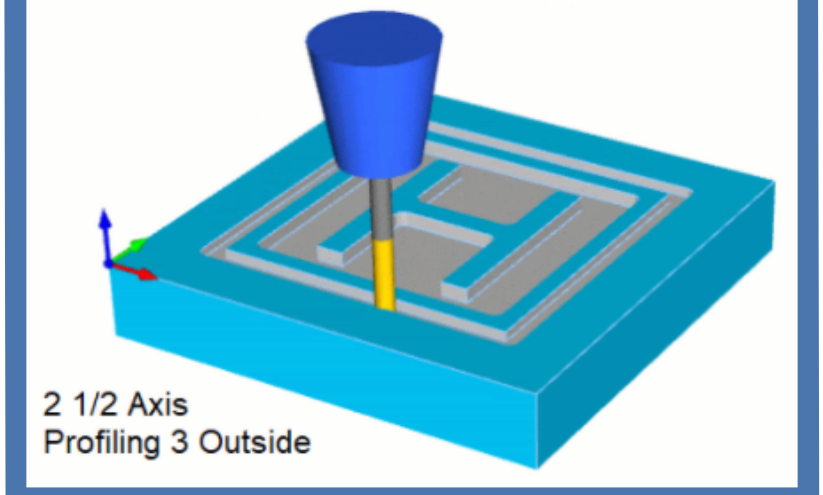
The dialogs below shows the Feeds & Speeds parameters as well as the Clearance Plane parameters.
These are identical for all of the operations in this setup.



Here we see the Feeds & Speeds parameters and the Clearance Plane parameters.
They are identical for all 4 operations under Setup 1 in this Machining Job.

Cut Material Simulation

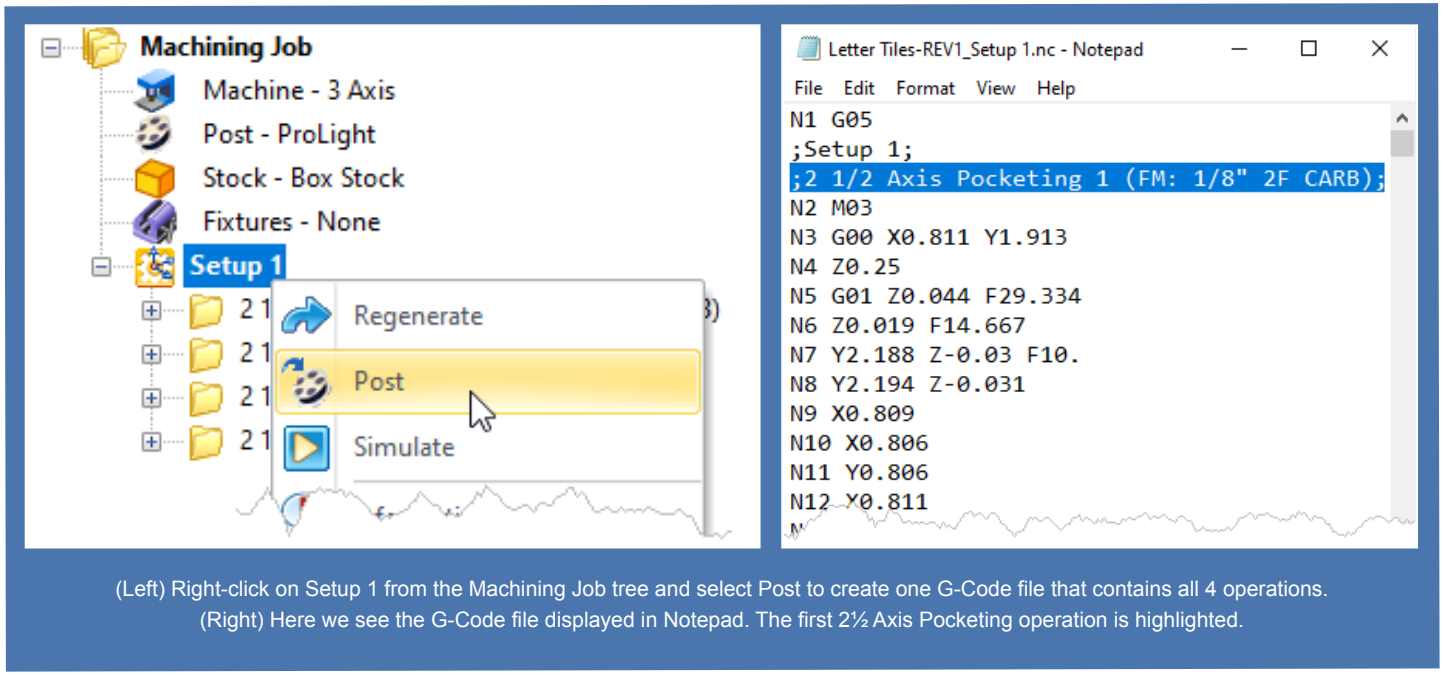
The illustration below illustrates the complete cut material simulation for all 4 operations under Setup 1 in the Machining Job. It begins with the 2D drawing, and then shows the stock model overlay and then proceeds to simulate each operation starting with 2½ Axis Pocketing followed by each of the three 2½ Axis Profiling operations.



Here is the cut material simulation for all 4 toolpath operations under Setup 1. It begins with the 2D drawing, and then shows the stock model overlay and then proceeds to simulate each operation starting with 2½ Axis Pocketing followed by each of the three 2½ Axis Profiling operations.

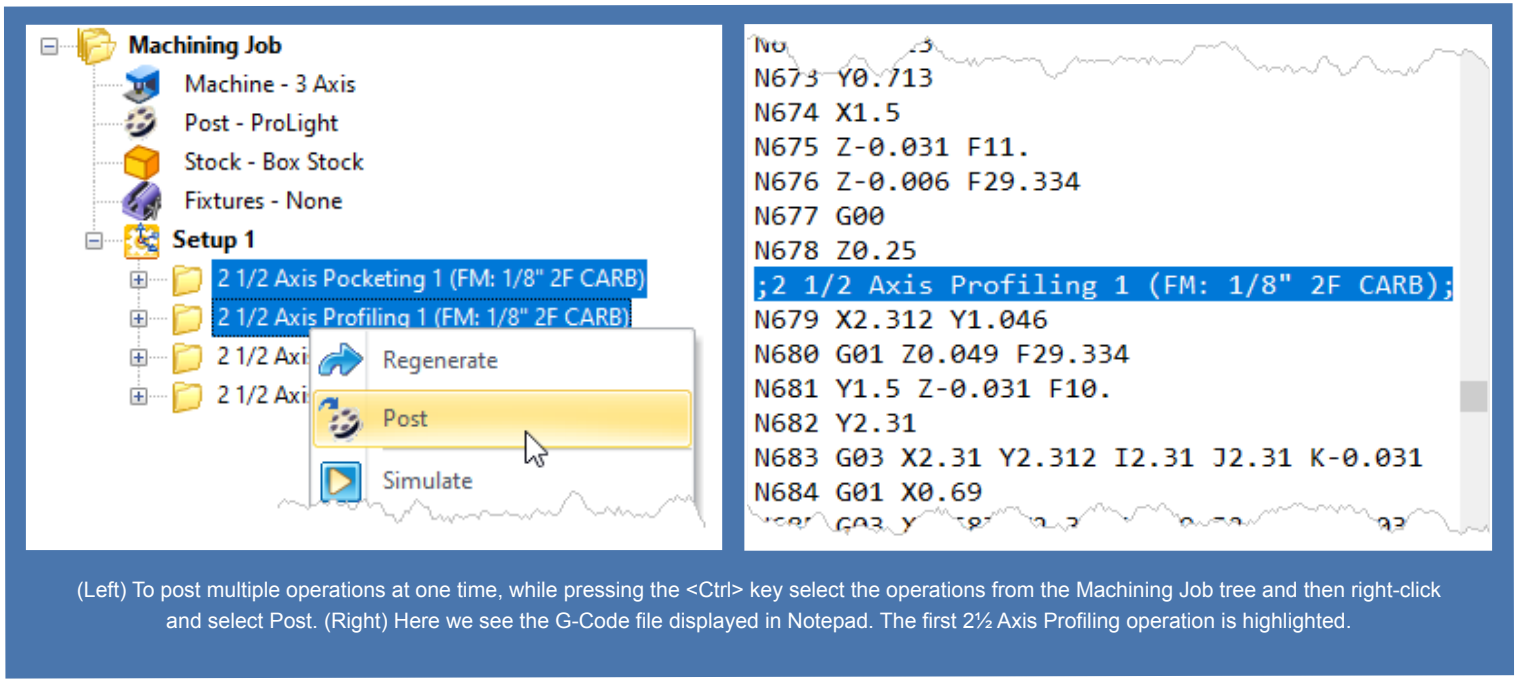
Posting G-Code to the ProLite CNC Mill

With our toolpath operations complete and we are satisfied with our Cut Material Simulation we can start posting G-Code to the ProLite CNC Mill. RhinoCAM provides flexibility in how you want to post your G-Code. You can post the entire setup by selecting Setup 1, right click and pick Post from the popup menu. Since all 4 operations use the same cutting tool, this method will work fine. You can refer to the illustrations below.



(Left) Right-click on Setup 1 from the Machining Job tree and select Post to create one G-Code file that contains all 4 operations.
(Right) Here we see the G-Code file displayed in Notepad. The first 2½ Axis Pocketing operation is highlighted.

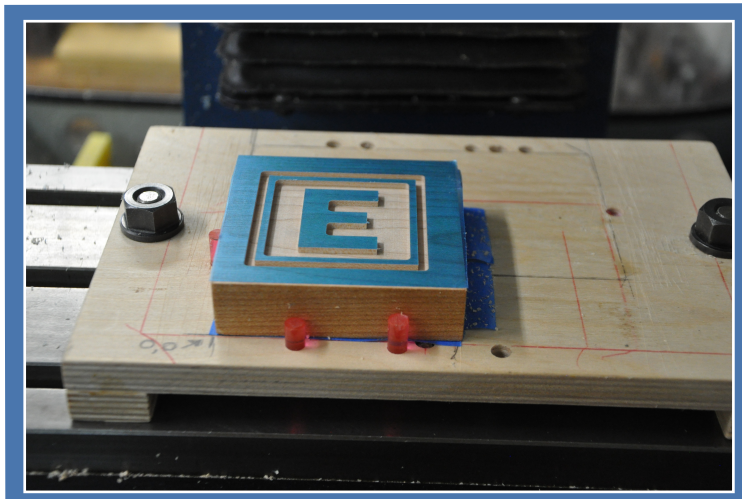
Alternatively, you can post one or more operations at a time into one or more G-Code files. Just press and hold the <*Ctrl*> key while you select multiple operations and then right-click and select Post from the popup menu. Only the select operations will be posted to the G-Code file. Again, you can refer to the illustrations below.



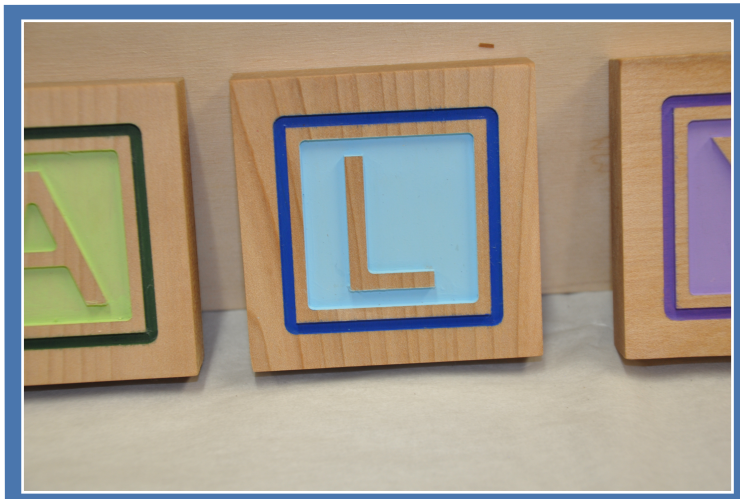
(Left) To post multiple operations at one time, while pressing the <Ctrl> key select the operations from the Machining Job tree and then right-click and select Post. (Right) Here we see the G-Code file displayed in Notepad. The first 2½ Axis Profiling operation is highlighted.

Machining Pics

Here are some cool images of the letter tile blocks after masking and machining and then before and after painting.



Here is the part still on the CNC machine prior to painting with the ORACAL Oramask 813 Stencil Film still attached.



Here are the letter tiles after painting after removing the ORACAL Oramask 813 Stencil Film.

Cool Teacher/Student project Pete!
Thank you for allowing us to showcase your work!

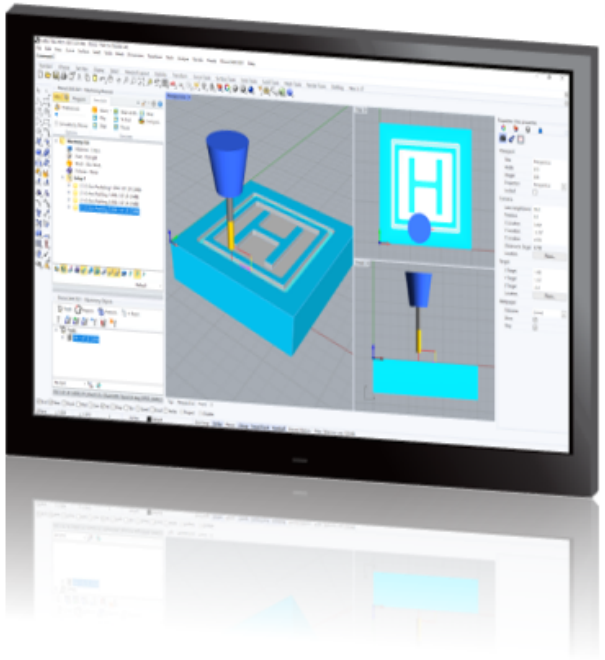
More about Pete Sorenson

Pete Sorenson is a retired High School technology instructor from Kirkland, Washington. Currently Pete is one of three Education Specialists with Robert McNeel & Associates in Seattle, WA performing Rhinoceros CAD and Rhino plugin workshops for educators at all levels. Pete has been a RhinoCAM user since the product's release in 2002 and runs his own shop providing CNC services for an exclusive list of clients including Eastside Tooling.com. Pete's current cool project is restoring the inner working components for the 36" diameter historic Carol's Clock located in the Museum of History & Industry on the shores of Lake Union. Pete recommends all educators and students to visit the Rhino Education Resources page here. You can reach out to Pete Sorenson at pete@mcneel.com.

The historic Carol's Clock located at the Museum of History & Industry (MOHI) on the beautiful shores of Lake Union

More about RhinoCAM

RhinoCAM - MILL from MecSoft Corporation is available in five different configurations (Express, Standard, Expert, Professional and Premium). The part shown here was programmed using the Standard configuration. Here are some additional details about each of the available configurations. For the complete features list, visit the RhinoCAM Product Page.



- **RhinoCAM MILL Express**: This is a general-purpose program tailored for hobbyists, makers and students. Ideal for getting started with CAM programming. Includes 2 & 3 axis machining methods. Includes ART & NEST modules as well!

- **RhinoCAM MILL Standard**: This configuration includes everything that is in the Express configuration and additional 2-1/2 Axis, 3 Axis & Drilling machining methods. Also now includes 2½ Axis Turning!

- **RhinoCAM MILL Expert**: Suitable for 4 Axis rotary machining. Includes the Standard configuration, plus 4 Axis machining strategies, advanced cut material simulation and tool holder collision detection.

- **RhinoCAM MILL Professional**: Ideal for complex 3D machining. Includes the Standard and Expert configuration, plus advanced 3 Axis machining strategies, 5 Axis indexed machining, machine tool simulation, graphical toolpath editing and a host of other features.

- **RhinoCAM MILL Premium**: Tailored for complex 3D machining with both 3 Axis and full 5 Axis methods. Includes the Standard, Expert and Professional configurations, plus 5 Axis simultaneous machining strategies.

For the complete features list, we invite you to visit the
RhinoCAM Product Page: mecsoft.com/rhinocam

Try RhinoCAM Today!

Powerful production CAM for Rhino users!

More about MecSoft Corporation

MecSoft Corporation was founded in December of 1997 by a team of programmers from Unigraphics Solutions (now Siemens PLM) with the aim of providing affordable yet powerful CNC software solutions to the manufacturing industry. Our founding and operating principles are based upon the notion that our most important partner is our customer. This allows us to:

Develop quality products that meet or exceed customer needs and to deliver them at a price to performance value that is unbeatable in the industry.

Provide excellent customer service and support.

MecSoft Corporation is based in coastal Orange County, CA, south of Los Angeles.

RhinoCAM®

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More about Robert McNeel & Associates & Rhino

Robert McNeel & Associates, founded in 1980, is a privately-held, employee-owned company with development, sales support, training offices, and affiliates in Seattle, Boston, Miami, Medellin, Barcelona, Rome, Tokyo, Taipei, Seoul, Kuala Lumpur, Beijing, Shenzhen, and Shanghai. We also have more than 700 dealers, distributors, OEMs, and training centers around the world.

Rhino geometry is based on the NURBS mathematical model, which focuses on producing mathematically precise representation of curves and freeform surfaces in computer graphics (as opposed to polygon mesh-based applications). Rhinoceros is developed for the Microsoft Windows operating system and macOS.

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