This document is to discuss the considerations to make a supplemental threaded spoil board for a Shapeoko 3 CNC Router. My discussion will be based on the XXL Model but it applicable to the Standard and XL models. The Shapeoko Pro model has a different style of base board and will not be discussed here. There are other types of spoil board designs and parts of this document can be used to aid in making another type of spoil board.

1. The first consideration of a threaded spoil board are the types of threaded inserts you will use. I prefer the Tee type threaded inserts. The Tee type is mounted from underneath of the spoil board and cannot be pulled out. The EZ-Lock type are threaded in from above and if enough pressure is put on them can be pulled out. The third type of threaded insert are the steel/brass threaded inserts. Again this type of insert is threaded from above and can be pulled out as well.

TEE Nuts



EZLock Threaded Insert



Brass/Steel Threaded Insert





Tee Nuts Pros and Cons to Consider

The Tee nut is mounted from underneath of your spoil board making it almost impossible to pull out. I like to use a 5/16" tall Tee Nut so I can surface my spoil board many times without hitting the top of the Tee Nuts. The only down side, which is minor, is it takes two machining operations to fit the Tee nut into the bottom of the spoil board. The first is the recess for the head and then the through hole for the barrel of the Tee Nut. The Tee Nut has to be seated into the recess and through hole during initial installation but you can remove the Tee Nuts and reuse them for subsequent spoils boards. You must consider the type of clamps you use with all threaded inserts and how long your hold down bolts are. You do not want the bolts to bottom out and over drive into the base board. This causes an uneven spoil board and will come through on your projects. *Carefully measure your maximum bolt lengths and as you surface your spoil board replace the bolts as necessary.*

EZLock Threaded Inserts Pros and Cons to Consider

The EZLock Threaded Inserts only require one hole to drill. However the threaded insert only comes in one length and that puts the top of the threaded insert close to the surface of your spoil board reducing the amount of material you can remove before either hitting the inserts or making a new spoil board. The insertion of the EZLock Threaded Inserts is done with an allen wrench. You need to champher the top of the through hole in the spoil board to get the threaded insert to start perpendicular with the spoil board surface. Additionally on MDF many times erupts on the surface and this needs to be cleaned up before using the spoil board.

Brass/Steel Threaded Inserts Pros and Cons to Consider

Brass/Steel Threaded Inserts have the same cons as the EZLock Threaded Inserts. The Brass/Steel only come in one length and limit the surfacing you can do to the spoil board before having to replace it. The Brass/Steel inserts are either inserted with a large bladed screw driver or you can get a T-Handled wrench with threads at the bottom to insert them. You need to champher the hole slightly to get the threaded insert to go in perpendicular to the surface of the spoil board. Additionally on MDF many times the surface erupts and this needs to be cleaned up before using the spoil board.

All three types of threaded inserts can be obtained in either Imperial or Metric sizes. All three types of insert are similar in price. So pick your type of insert and whether you want Imperial or Metric threads.

2. The next consideration is the size of your finished spoil board. The Shapeoko CNC Router has published specifications for the width and length of maximum cuts. The width (X) is pretty straight forward but you have to consider your ability to level your spoil board. If you make the maximum width spoil board you may not be able to cut the full width with your cutter without crashing in to the Y rails or hitting the limit and losing steps. Also consider the type of dust collection you have because some dust collection attachments are outside the dimensions of the Z axis and you must reduce your X travel to avoid your dust collections from crashing into the Y rails. So you should sacrifice about ¹/₂ inch of your spoil board to ensure you can fully level your spoil board and not crash into the Y rails.

The Length (Y) is slightly more complicated. All models of Shapeoko consider the area in front of the steel frame on the front of the Shapeoko as cutting area for a maximum cut. It is not practical to have the spoil board stick out the front because it is unsupported and machines with a BitSetter would be no place sit. So you must sacrifice some Y direction of your spoil board so you can surface the whole spoil board front to back. If you make your spoil board too long in the Y direction you get a ridge at the back of the spoil board that makes tiling over sized projects not sit level on the spoil board during cutting. So for my XXL I made a 32.125" (X) by 29.875" (Y) spoil board for my Shapeoko XXL machine. This gives me room to cut the entire surface of my spoil board with a Whiteside 6210 1" Fly Cutter.

How to Determine the maximum size of your Spoil Board

Specifications and GBRL settings for Shapeoko XXL

Will Adams recently posted these specs for the default parameters of different machines and configurations on the Carbide3d Community Forum.

Shapeoko Default Sizes for GBRL Configuration

To allow folks to confirm their Grbl configurations, here are the settings for:

Setting Belt Drive Z-axis Z-Plus (inc. Pro) HDZ

\$100	40	40	40
\$101	40	40	40
\$102	40	200	320

The Travel Dimensions for the various machine sizes and options are:

Machine size and Z-axis type	Х	Y	Ζ
Shapeoko 3 Standard Belt Drive	420	430	100
Shapeoko 3 Standard Z-Plus	420	430	95
Shapeoko 3 Standard HDZ	420	430	140
Shapeoko XL Belt Drive	830	430	100
Shapeoko XL Z-Plus	830	430	95
Shapeoko XL HDZ	830	430	140
Shapeoko XXL Belt Drive	830	850	100
Shapeoko XXL Z-Plus	830	850	95
Shapeoko XXL HDZ	830	850	140
Shapeoko Pro XL	870	440	95
Shapeoko Pro XXL	870	850	95

Note that it is possible to increase X-axis travel if using an HDZ w/o a dust collection system which limits X-axis travel.

To determine your actual settings you would open Carbide Motion and go to the MDI Interface and type "\$\$". On the screen you will see nothing but go to the log and the output will be there. Take a look at the following settings to determine your current settings:

\$130, \$131, \$132 – [X,Y,Z] Max travel, mm

This sets the maximum travel from end to end for each axis in mm. Carbide Motion enforces these settings and not the GBRL settings.

So when your Shapeoko homes these settings are encoded into Carbide Motion and wont allow the Shapeoko to travel beyond these settings. However if you use third party gcode senders these settings can be enforced with hard and soft limits. I will not discuss how to use these 3rd party gcode applications but they are available.

How to Determine your Maximum Size Spoil Board

To determine your maximum available dimensions that your Shapeoko can travel follow this procedure. This was done with Carbide Motion 5.36 and is subject to change.

a. Power on your Shapeoko and connect with your computer.

b. Initialize machine and let it complete.

c. Recommend you install a ¼ inch #201 end mill. Any end mill would work but this is the standard bit sent with a Shapeoko and almost everyone has one.

d. Use the rapid position and move your machine to the front left corner. You can jog the Z down but do not get it so low that it hits the spoil board or any other obstructions on your machine. From there jog your machine to line up with just inside the front of your steel frame and all the way to the left. Zero your X axis in the jog screen. Now jog your machine all the way to the right side of the machine until it stops. Record the distance where your Shapeoko stops. This is your maximum amount of travel your Shapeoko can travel in the X direction.

e. Now that your machine is jogged to the extreme right side of your machine and the bit is in line with just inside the steel frame on the front of your machine set the Y zero. Now jog your machine to the rear right corner until it stops and record the distance Y traveled. This is your maximum distance

from the front of your Shapeoko to the maximum rear travel. This is not your maximum Y distance because you can move the machine outside of the front frame.

f. Now you have the maximum measurements of your Shapeoko for X and Y. Take these measurements and subtract ½ inch from the total length for each direction. This will ensure you have enough room to surface your spoil board and not hit the limits of your machine. If you hit the limits you could lose zero and cause problems when surfacing your spoil board.

g. Here are the examples from my Shapeoko XXL. Your results may be different.

1. Here is my XXL jogged all the way to the left hand side and just inside the steel frame of the Shapeoko. I set X to zero. You can see in the picture that my spoil board is set too far to the left. I had not written this procedure when I installed this spoil board. Do not make my mistake.



 X:
 0.000
 ZERO X

 Y:
 0.000
 ZERO Y

 Z:
 0.000
 ZERO Z

2. Now jog your machine to the right in the X direction until it stops. The bit should be just inside the steel frame on the Shapeoko. Now set Y to zero. Note that the maximum X is 32.368". You can see that my spoil board is not perfectly centered on my base plate. I have more room on the right than on the left. If you follow the instructions your spoil board will be centered.



Set Current Position

X:	32.638			ZERO X
Y:	0.000			ZERO Y
Z:	0.000			ZERO Z
	CLEAR ALL OFFSETS	ZERO ALL	DONE	

3. Now jog your machine to the back until it stops. This is your maximum Y movement. Note the maximum Y movement from the rear of the front frame to the rear of the machine is 29.452". This is not the maximum Y movement because you could jog off the front of the Shapeoko and that is the maximum Y cutting area. This measurement is the maximum Y movement from the inside front of the steel frame to the rear of the Shapeoko.



(:	32.638	ZERO X
<i>(</i> :	29.452	ZERO Y
Z:	0.000	ZERO Z

4. Now you know on this machine that the maximum cutting area is 32.638" X and 29.452" for Y. I recommend that you subtract ½ inch from each measurement and that would give you a ¼ inch border in which your leveling bit can go past the border of the spoil board and not hit the limits of the X and Y movements. You would not hit the maximum Y direction in the front but there is a BitSetter on some machines and you do not want to hit the steel frame with your fly cutter when leveling the spoil board. So for this machine I would make the spoil board 32.368 -.5"=32.139" X and I would round it off to 32.125" X. For the Y the maximum would be 29.452"-.5"=29.952" Y and I would round it off to 29.875". Now I have an optimized spoil board size that I can safely level. The spoil board is not the maximum size it could be but I have to be realistic about what the machine is capable of. Rounding down to the nearest 1/8" makes it easier to cut the spoil board blank in preparation for cutting the spaced holes for the threaded inserts.

3. Now that you have a finished size for your spoil board the next consideration is the spacing of your threaded spoil board holes. This decision depends on your personal preference. I made mine with a 2" spacing. If you are going to use metric you need to determine your optimal spacing. The Carbide3d Nomad uses the following spacing for their threaded spoil board which is 1" spacing. The holes along the edge are ½" from the edge but spaced 1" apart and are offset from the inner field by 1/2" and the inner field is spaced 1" apart. The Nomad Threaded Table is approximately 1/2" thick and contains over 50 M6x1 threaded holes in it.

a. The next consideration is your options for fences and clamps. You can make a fence to go around the front and left side perimeter. You can also make L shaped brackets to use in the interior of your spoil board. Clamps can be commercial like the Carbide3d Tiger Claw and Gator Tooth clamps and stops, the Suckit Oops clamps or a lot of other options. I made my fence from MDF and my cam clamps from oak. With the spacing set you can make many other optional fences, stops and clamps.

b. With my spoil board spacing set for 2" you can plan your spoil board in Carbide Create generate gcode to cut the spoil board with Carbide Motion.

1. Set your material size in Carbide Create to 32.125" Wide and 29.875" Tall with a thickness of .75". These dimensions may be slightly different for your individual machine and material thickness. Use the origin as the lower left corner.

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2. Now measure the threaded inserts you decided on. I will be using Tee Nuts that are threaded for 1/4-20 bolts. The large head on the bottom of my Tee nuts measures exactly .75" round so I will make that object .80" to give me some room for variances in manufacturing. The thickness of the large head is 0.049" so I will make my pocket for these 0.060 to allow for manufacturing variances. Additionally this will give me some extra room to I can seat the Tee nuts so they do not protrude on the bottom of the spoil board against the base board. This would cause the spoil board to be uneven. The threaded portion of the Tee nut measures 0.306" so I will make the through hole .325" to allow for variances in manufacturing.

3. Now I know my spoil board size and the exact sizes for my threaded inserts I will need to machine.

4. In Carbide Create set your grid size to 1". This will aid you to place the objects exactly at the 2" spacing. Also make sure snap to grid is checked. When you machine the spoil board you are machining the bottom of the spoil board. So plan accordingly and what appears at the back of the spoil board will become the front closest to the operator when you turn it over. The left hand side will still be the left hand side just flipped 180 degrees when you install the spoil board. So do not worry about the fractions of an inch and snap to grid at the 1" intersections of your grid.

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5. Now start with the 0.80" (0.40" radius) Tee nut head pockets. Draw a circle and adjust its size to 0.80"(0.40" Radius). Now select the circle and make sure you selected the center node of the circle and move it to the upper left corner of the material and drop it over the grid 1" from the back of the spoil board and 1" from the left hand side of the spoil board. Make sure your circle is selected and copy (Control C) the first circle and move the second circle to the next grid spacing at 2" from the first across the back of the spoil board. After getting the first row completed you will select them all and copy (Control C) and place them 2" below the first row and repeat this until you get to the back side of the spoil board (front on screen). You will have to decide where to end because the spoil board and across the back (front) of the spoil board as viewed. I would not recommend you place the Tee nuts too close to the right side or the back (front as viewed). Use your own judgment. Select all of the 0.80" holes and group them together. This will make it easier to move things around if required later. It is vital that you look at each 0.80" pocket and make sure it is centered on the grid. It is easy to not pick the center node when moving this number of objects. If the pocket is not lined up with the grid your finished product will not line up. Double check your work before moving on.

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6. Now draw a circle that is 0.306" (0.153" radius) and select it and make sure you on the center node. Drop the circle on the center of your first 0.80" pocket. Now copy the 0.306" circle and align with the center of the first row of 0.80" pockets. Then select all the 0.306" holes and copy and align them with the second and subsequent rows until fully populated. It can be hard to select just one object when two objects are close together. If you are finding it hard to select the objects you want select all of the 0.80" holes, group them and move them off your visible work surface. Then make the 0.306" holes and group them. Now you can select the 0.80" holes and move them back over the center of the 0.306" holes. This completes the design of the spoil board and you are ready to make tool paths. It is easy to not pick the center node when moving this number of objects. If the pocket is not lined up with the grid your finished product will not line up. Double check your work before moving on.

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7. Select the 0.80" circles and create a tool path. If you grouped them you have selected all of them at once. Select the tool #201 1/4" 3 flute end mill. Then select Pocket and start at the top and make a pocket 0.060" deep. Name the tool path something unique. For me shapeoko_xxl_spoilboard_large_holes_201.

8. Select the 0.306" holes and create a tool path. If you grouped them you have selected all of them. Select the tool #201 1/4" 3 flute end mill. Then select the Pocket and start at the depth of 0.060" and go to the stock bottom. Name the tool path something unique. For me shapeoko_xxl_spoilboard_small_holes_201.

9. Now save your two tool paths separately if you do not have a BitSetter and together if you have a BitSetter into one file. Use a unique name for the gcode file. For me shapeoko_xxl_spoilboard_optomized_201. Both tool paths are combined for BitSetter.

10. You are finished with the design of your spoil board and ready to machine it. Be sure to save your project and your gcode. You can quit Carbide Create.

4. You are now ready to machine the new spoil board. Earlier in this procedure we determined the maximum X and Y. We will use these maximum positions to set the new spoil board on the base of the Shapeoko so we get the new spoil board square to the router.

a. Jog your router over to the left side of the machine until it stops and the bit just behind the steel front frame of the Shapeoko and the Z is almost touching the base board. Make sure your bit does not contact the steel front frame. Now place your new spoil board blank on the base of the Shapeoko and line up the left front corner with the bit so the left front corner of the project is on the right side of the bit and on the rear side of the bit giving the spoil board ¹/₄ inch from the limit of the X and ¹/₄ inch from the front steel frame. Jog the Z up above the front steel frame and jog the router over to the right side until it stops. The project if properly sized should be close to the right hand edge of the project. It may not perfectly line up but make sure the front of the left side of the spoil board is even with the back edge of the bit. You can jog the bit back over to the left so you can line up the front of the spoil board with the back of the bit. You want to jog the router back and forth to make sure the front edge of the spoil board is exactly even with the back of the router bit. Just give your self room to not run the bit into the front steel frame while jogging. When you get the spoil board lined you can clamp it down in position. The base board can be screwed into directly through the new spoil board. Just make sure your spoil board cannot move during machining. You could use some brads, nails or screws. Just make sure if you use brads that they do not penetrate the base board more than 1/4" to make removal easier when the machining is done. Screws would be easiest but use whatever method you want.

b. Now that you have the new spoil board lined up and square with the router you are ready to start machining the spoil board. You can use a BitZero on the front left edge of the spoil board or use the paper method if you do not have a BitZero to set up the origin. Start the gcode and let it complete. I highly recommend dust collection because MDF will make a mess of your shop and is harmful to breathe. When complete you can remove the spoil board from the base board. Now keep the spoil board upside down and on a solid surface, not the Shapeoko, install your threaded inserts. I would recommend doing this on the floor so you have a solid surface below the spoil board to drive the Tee Nuts in fully. After installing all your Tee nuts double check all of them to make sure they are all seated fully with none of them above the surface of the bottom of the spoil board. This is critical for the new spoil board to sit flat on the Shapeoko base board.

5. At this point you are ready to install your new spoil board to your Shapeoko base board. Turn your new spoil board upside down so it is flipped 180 degrees from the machining position. The side that was on the left side during machining is still on the left and the back side during machining is now in the front.

a. We will use the same method to line up the new spoil board as we did when machining it. Jog the router over to the left as far as it will go. Jog the Z down until it is just behind the steel front frame. Now line up the corner of the new spoil board with the front edge on the back side of the router

bit and on the right side of the router bit. Then jog your router over, being careful not to hit the steel front frame, and line up the front edge with the router bit. Jog back and forth until you have the front edge of the spoil board even with the back side of the router bit.

b. Now select a place on the four corners that is spaced away from your Tee nuts and not too close to the edge. Drill a ¼" hole through the spoil board and the Shapeoko base board. Repeat this on the four corners. Making sure that the spoil board dos not move during the drilling. You could place a 1/4" bolt through the first hole to help keep movement down to a minimum and add bolts as you subsequently drill the 1/4" holes. Once you get the four holes drilled remove the spoil board and use the 1/4" holes as a guide to drill holes big enough for brass 1/4-20 threaded inserts. Install the four brass threaded inserts. It helps to champher the hole for the insert slightly to get the threaded insert started straight. After you get the threaded insert installed just below the surface you may have to clean up the MDF as it sometimes erupts when inserting the threaded inserts. Make sure that all four holes are perfectly even with the rest of the base board. Use a chisel or sand paper to get them level with the base board.

c. Now place the new spoil board on the surface of the base board. Use a counter sink and make the counter sunk holes deep enough so the heads of 1/4-20 flat head bolts are about 1/4" below the surface of the spoil board. This is important when surfacing the new spoil board that you do not hit the flat head screws with the surfacing bit. This gives you several surfacing for the life of the spoil board. When you see that you are getting close to the tops of the flat head bolts it is time to make a new spoil board. Now install four flat head 1/4" bolts and lightly tighten all bolts. When all four are snug screw them down until tight. You are now ready to level your Shapeoko's new Spoil Board.

6. Time to level your Supplemental Spoil Board for a Shapeoko XXL. To start the leveling process make sure if you have anything attached to the spoil board you remove it. If you have fences remove them as well. Next you want to put pencil marks all over the spoil board. The pencil marks help you identify when you have the whole spoil board level. Without the pencil marks it is hard to tell if your spoil board has been completely surfaced. I made an S pattern front to back and side to side.



For me I like to make my origin in the center of the spoil board for leveling. This makes sure I cut all the way around my spoil board. If you start from the lower left you could leave material on the back and right side of the spoil board. This is personal preference. Use a straight edge to mark from corner to corner and find the center of your spoil board. Measure your spoil board exactly and when you create your Carbide Create file make the material just about a quarter of an inch larger than your actual spoil board. My actual dimensions of the spoil board were X=32.125" and Y=29.875" so in Carbide Create I made my material 32.375 Wide and 30.125 Tall. This gives me a little overlap for my Whiteside 6210 1" Fly Cutter.

Draw a box that matches your material size and use the alignment tool and align the box to the stock centered in both directions.

Choose a tool path to pocket the box you drew. I have a custom tool created that removed 0.010" per pass and has a 50% step over for a 1" fly cutter. I set the depth of the pocket 0.010" from the top so I get a single cutting pass. Save your gcode and your Carbide Create File.

Upon opening your Carbide Motion connect to your machine **but do not initialize**. Instead go to the settings and disable the BitSetter if you have one, be sure to send the configuration. The position of the BitSetter could cause it to be hit by the fly cutter. The large 1" bit will not properly fit the BitSetter button anyway so just disable it in software and send the configuration. Mark the location of your

BitSetter and remove it from the Shapeoko base. After the configuration is sent you will be prompted to initialize. Initialize and get set up to set your zeros.

Insert a 90 degree Vee bit. It is much easier to set the origin at the center with the vee bit. Jog your machine over the mark you created earlier and set your X and Y zero only. You will set the Z zero after you replace the 90 degree Vee bit. After setting the X and Y zero replace the Vee bit with your fly cutter. Jog to the center and set your Zero using the paper method. You are now ready to surface your spoil board.

Start your gcode and let the surfacing complete. Upon completion inspect the spoil board for any residual pencil marks. If there are any pencil marks jog to the areas with the pencil marks and set your Z zero in that area. Start the gcode again and resurface the spoil board. The first surfacing you referenced the center of the spoil board for Z zero. If required a second time set the zero where the pencil marks are still remaining. This saves time in surfacing and not wasting time zeroing on high spots and leaving low spots uncut if your spoil board is very uneven. The origin is still set to the center of the project in the gcode. You are setting Z zero on a low spot not changing the origin.



Hopefully two times will be enough but if required repeat until the whole spoil board is smooth with no pencil marks remaining.



Your spoil board should be smooth and ready to machine on. If you have ridges left in either the X or Y direction you may need to level your router mount. This is referred to as Tramming your router. There are many videos on youtube to do this. If you need to level your router then repeat the spoil board surfacing until it is smooth and level. If you had fences then reattach them at this time.

If you have a BitSetter go into the configuration and check the BitSetter and send the configuration. Confirm the BitSetter is reattached in the same place and if necessary calibrate its position from the BitSetter installation instructions. If you marked the location precisely you not need to calibrate the position but be sure to check it.