



## Windsurfing with RhinoCAM

RhinoCAM gives Windsurfers on the [PWA World Tour](#) a Cutting Edge!

Michael Wazenski is a Systems Engineer with [Northrop Grumman in Annapolis, MD](#), overseeing systems integration projects on some of the most advanced satellite systems in the world including the JWST ([James Webb Space Telescope](#)). By night Michael, and his business partner Keith McCulloch operate CNCFins.com where he designs the CAD and CAM data to manufacture his custom windsurfing board wave and weed fins. These are not just any fins - Michael's world class fins are machined at and sold by [Tectonics Maui](#), a confirmed leader in windsurfing boards and gear.



Want to see how RhinoCAM can help you? [Click Here](#) to download a demo!

Unlike traditional wave surfing boards, windsurf boards travel much faster thru the water so the size, shape and position of each fin is of critical importance. A windsurfer board will have multiple fins, each designed to affect specific drag and lift characteristics which taken together contribute to the board's performance as it travels through the water. The outer fins for example are asymmetrical giving the inner and outer sides of that fin unique and specific characteristics. Mike found the stock fin designs mounted on the latest production boards to be lacking and felt that he could design a better fin!

## The RhinoCAM Difference

Michael originally started out evaluating Mastercam but soon found that software to be both difficult to use and lacking in functionality. That's when Michael turned to [RhinoCAM](#) and [MecSoft Corporation](#). Learning RhinoCAM was not difficult which Michael found to be amazing! Read more below on what Michael Wazenski thinks about his RhinoCAM CNC software.

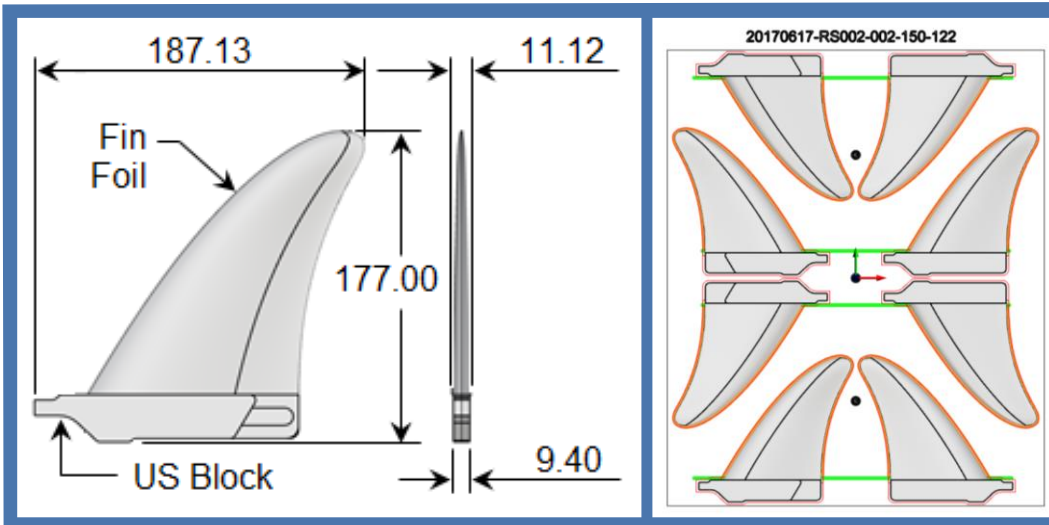
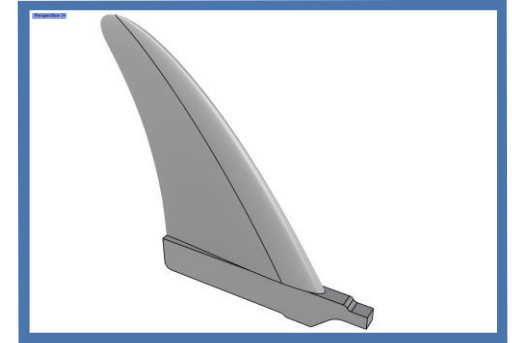


*“Learning RhinoCAM was not difficult which in itself was amazing. When I first loaded RhinoCAM, it already had a Centroid post-processor for my CNC router. After learning how to create a toolpath, I took the g-code over to my router and it worked great the very first time! This was after I completed an evaluation of Mastercam, uncovering many shortcomings in the software.”*

*Michael Wazenski, Owner/Operator  
CNC Fins, Annapolis, MD*

## The RhinoCAM Project

In this project Michael machines 8 windsurf board fins in two setups (one per side). The stock material is G-10, a fiberglass epoxy composite, the same material used to manufacture printed circuit boards. In this example each fin measures 187 x 177 x 11.12 millimeters. Each fin component consists of the fin foil - this is the portion that extends out of the board and makes contact with the water. Extending below the fin foil is the insert US Box block. This is the portion that is mounted within the board proper and is fixed in place with mounting screws. Both the fin foil and the US Box block are machined together from the same stock as a single component. The fin foil component is shown here and is dimensioned below.

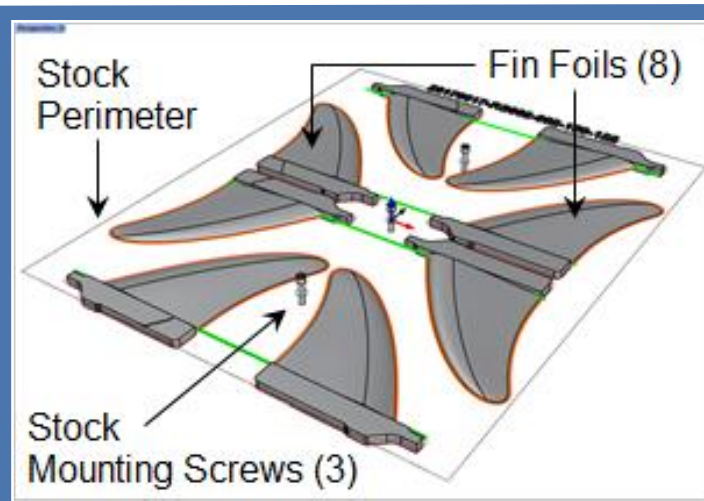


On the left we see the completed fin foil component with some basic dimensions. The fin foil is the portion that extends below the windsurf board and the US Box block is the portion that is insert-mounted into the board. The component is 187.13 x 177.00 x 9.40 millimeters.

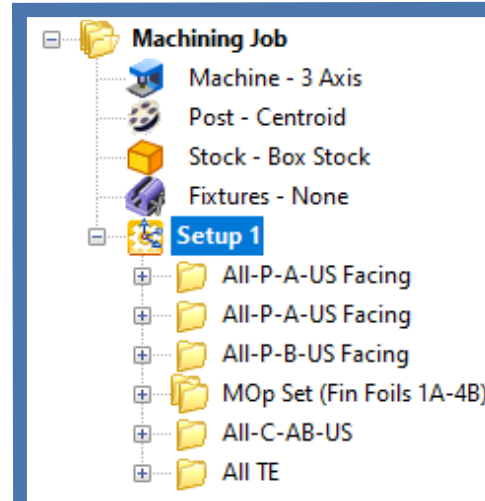
## Part and Setup

The RhinoCAM Machining Job tree for Side A is shown below on the right. It consists of the Machine, Post, Stock and Fixture definitions as well as each machining operation (MOP). The Machine Coordinate System origin is located at the X,Y,Z center of the stock block. Three 2 Axis Facing operations appear first under Steup 1. These are followed by one Machining Operation Set (MOp Set) that contains each of the eight 3 Axis Parallel Finishing operations.

The remaining 2 Axis Profiling operations cut the perimeter of the US Box block and the receding edge of each fin. All operations are cut using a 1/4" (6.35mm) diameter Corner Radius Mill with a corner radius of 0.762mm. [See Sequence of Operations](#) below for Side B.



(A)  
The physical CAD geometry setup contains 8 fins arranged within a stock perimeter of 464 x 560 x 12.8 millimeters. Each fin is a 3D solid model.



(B)  
The Machining Job tree shows Setup 1 for Side A containing 2 and 3 Axis machining operations. The MOp Set contains the 8 3 Axis finishing operations.

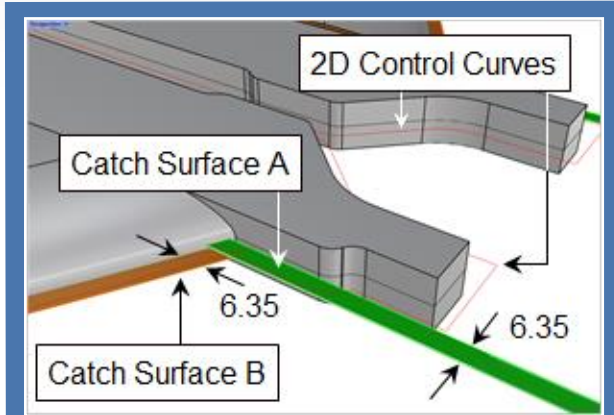
## Sequence of Operations

The Machining Job and Setup 1 shown above will machine Side A of the stock. 2 Axis Facing will cut the tops of the US Box blocks, followed with 3 Axis Parallel Finishing that cuts side A of the fins. A 2 Axis Profiling operation is then used to cut the perimeter of the blocks down to the mid plane. At this point the stock is flipped over on the CNC router. For Side B, the top facing of the US Box blocks and side B of the fins are then machined. To complete the process a 2 Axis Profiling operation will clear the perimeter of the fins while a final Profiling operation cuts the remaining perimeter of the US Box blocks, thus releasing the 8 fins from the stock. Note that for Side B, Catch Surface B (see Control Geometry below) remains -0.762 below the mid plane.

## Control Geometry

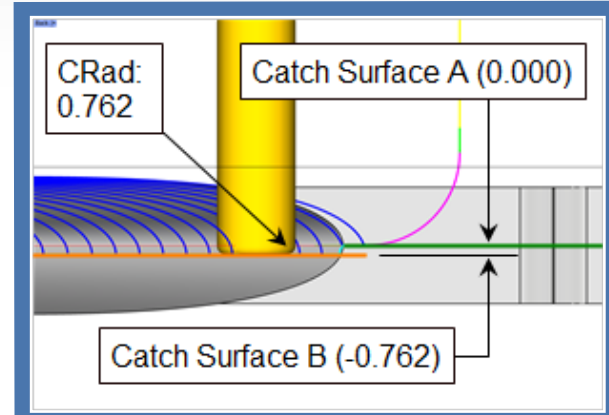
The two images below illustrate the positioning of the part and related control geometry. Make note of the location and elevation of Catch Surfaces A and B. Catch Surface A is positioned at the Z 0.000 mid plane of the part and controls the elevation of the cut start point. Catch Surface B is positioned at -0.762 below the mid plane.

Catch Surface B allows the cutting tool to drop below the mid plane by 0.762mm which is the same value as the corner radius of the cutter. This means that the full cutting width (6.35mm) of the tool is located at the mid plane. The width of Catch Surface A and the extension of Catch Surface B past the fin need only be a minimum width equal to  $\frac{1}{2}$  x the tool diameter.



(C)

The CAD geometry includes the fin and US Box block (grey), catch surface A (green), catch surface B (brown) and 2D planar curves (red).



(D)

Here you see an elevation view with catch surface A located at the midplane (Z0.000) and Catch Surface B positioned at (Z-0.762) which equals the radius of the cutter.

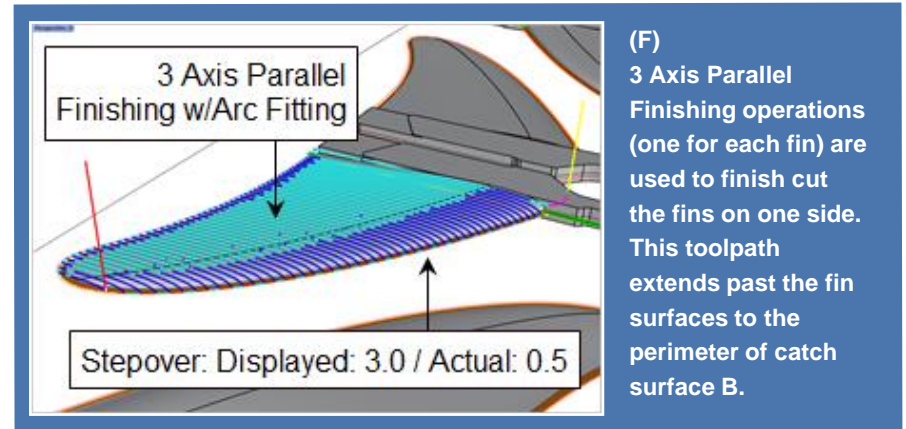
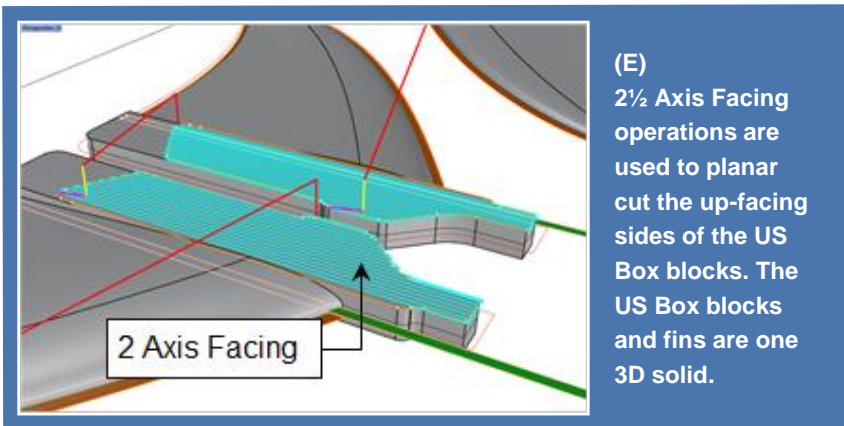
## 2 Axis Facing

As mentioned above the machining operations in this setup include both 2 Axis and 3 Axis strategies. The 2 Axis Facing operations (shown in image E below) are controlled by the perimeters of the US Box block geometry defined as Part Regions and with the perimeters of the catch surfaces defined as Avoid Regions. For Facing the spindle speed is 6,300 RPMs with a cut feed rate of 2,000 mm/minute. With a linear cut pattern and mixed cut direction the tool steps over 1.58mm per pass, at one level, with a 10 degree ramp entry.

### 3 Axis Parallel Finishing

All 3 Axis operations in RhinoCAM are gouge-free. This means that the cutting tool will not violate any surface as long as it is visible at the time the operation is generated. A 3 Axis Parallel Finishing operation is used to cut each side of the eight fins. The selected control geometry for this operation are the perimeter edges of Catch Surface B. Catch Surface B is a planar surface that extends out past the perimeter of the fin by 6.35mm. The cutting tool will follow the fin surfaces and then drop onto Catch Surface B and stop at its perimeter. This is best illustrated in the elevation Image (D) above.

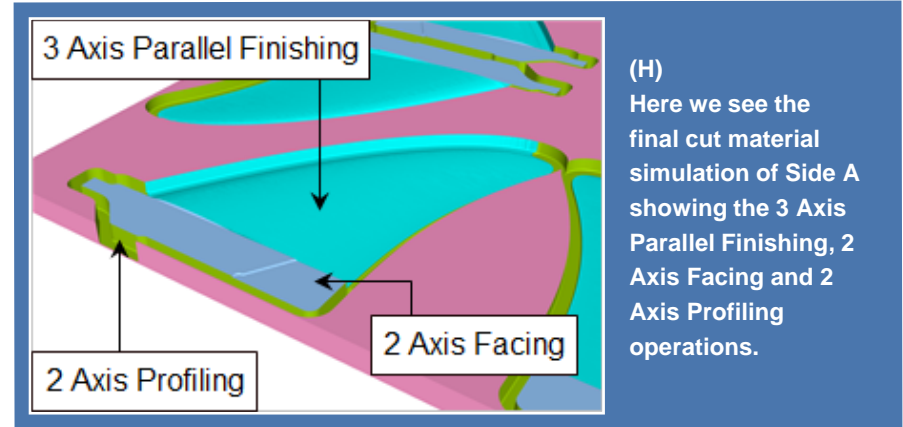
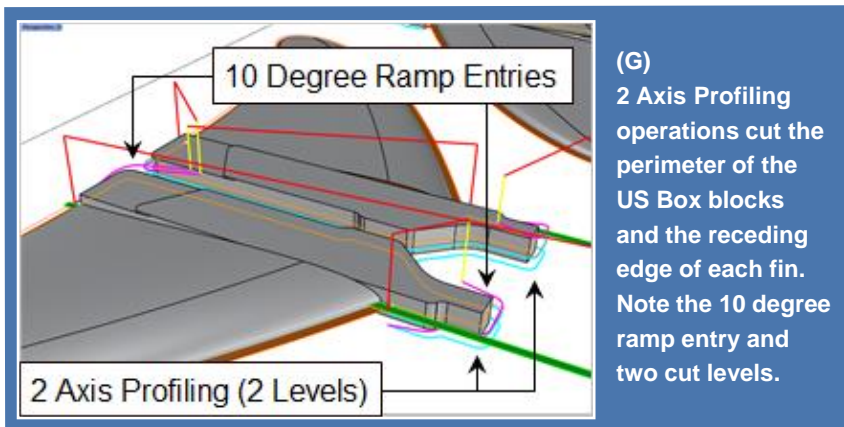
The spindle speed for this operation is 6,300 RPM and a cut feed rate of 5,500 mm/minute. A mixed cur direction, a cut angle of zero degrees (along the X Axis) and a stepover of 0.5 is applied. The cut time for each fin is approximately 3 minutes. You can refer to the [Machining Information](#) section below.



## 2 Axis Profiling

The final cuts in this setup include two 2 Axis Profiling operations illustrated in Image G below. One for the US Box blocks perimeter and another for the trailing edge of the fin surfaces. The control geometry for these operations are open and connected merged curves. The spindle speed for these operations is 6,300 RPM at a cut feed rate of 600 mm/min with a stock allowance of zero.

A 10 degree ramp entry is used with a mixed cut direction. The US Box block perimeters use two cut levels, the second level being at 4.5mm below the mid plane. The fin trailing edge perimeters are cut at 1,000 mm/min with a stock allowance of 0.1 and one cut level that stops at the midplane. You can see the cut material simulation of all operations in Image H below.





## Machining Information

The machining information for this setup is shown in the RhinoCAM dialog below. Note the Cut Feed, Spindle Speed and the # of GOTO motions for each operation, the largest being Fin 4A at 62,400 motions. The total machining time is estimated to be 1 hr and 35 minutes. This is based on the accumulated cut feed rates for each operation plus the transfer feed rate which is set to 200% (2x) the cut feed rate.

Machining Operations Information

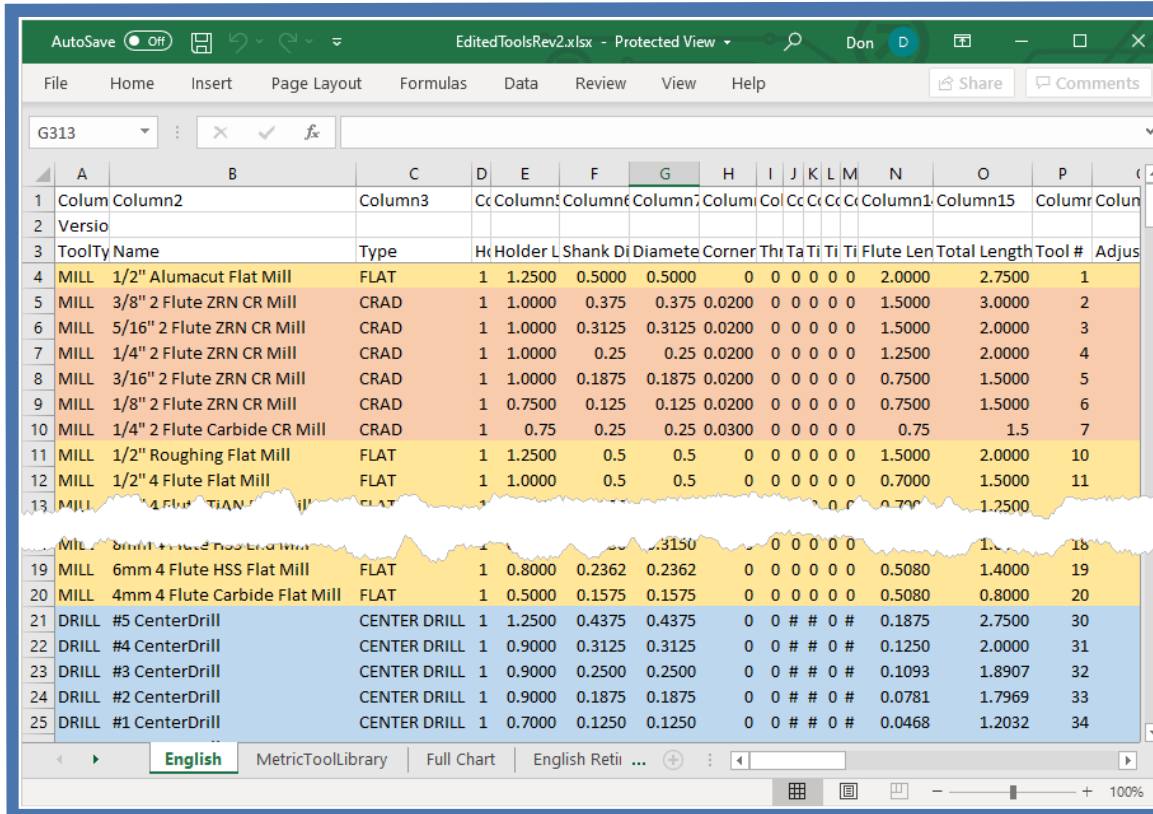
Mops Information

Name	Status	Tool	Too...	Cut Feed	Spindle S...	# of G...	Machining Time
Setup 1							
All-P-A-US Facing	Clean	1/4" Corner Radius Mill	115	2000.00 mm/min	6300 RPM	891	7.97 min
All-P-A-US Facing	Clean	1/4" Corner Radius Mill	115	2000.00 mm/min	6300 RPM	851	5.26 min
All-P-B-US Facing	Clean	1/4" Corner Radius Mill	115	2000.00 mm/min	6300 RPM	871	9.03 min
Fin 1A Foil	Clean	1/4" Corner Radius Mill	115	5500.00 mm/min	6300 RPM	62389	5.09 min
Fin 2A Foil	Clean	1/4" Corner Radius Mill	115	5500.00 mm/min	6300 RPM	62374	5.09 min
Fin 3A Foil	Clean	1/4" Corner Radius Mill	115	5500.00 mm/min	6300 RPM	62477	5.08 min
Fin 4A Foil	Clean	1/4" Corner Radius Mill	115	5500.00 mm/min	6300 RPM	62471	5.08 min
Fin 1B Foil	Clean	1/4" Corner Radius Mill	115	5500.00 mm/min	6300 RPM	62432	5.08 min
Fin 2B Foil	Clean	1/4" Corner Radius Mill	115	5500.00 mm/min	6300 RPM	62426	5.08 min
Fin 3B Foil	Clean	1/4" Corner Radius Mill	115	5500.00 mm/min	6300 RPM	62342	5.09 min
Fin 4B Foil	Clean	1/4" Corner Radius Mill	115	5500.00 mm/min	6300 RPM	62327	5.09 min
All-C-AB-US	Clean	1/4" Corner Radius Mill	115	600.00 mm/min	6300 RPM	6487	20.92 min
All TE	Clean	1/4" Corner Radius Mill	115	1000.00 mm/min	6300 RPM	3723	11.70 min
						Setup t...	1 hr 35 min

Print

OK Cancel Help

(!) The machining information for this setup is shown in this RhinoCAM dialog. Note the Cut Feed, Spindle Speed and the # of GOTO motions for each operation, the largest being Fin 4A at 62,400 motions. The total machining time is estimated to be 1 hr and 35 minutes.



Tool #	Tool Name	Type	Holder	Shank Dia	Tool Dia	Corner	Flute Len	Total Length	Tool #	Adjust
4	MILL 1/2" Alumacut Flat Mill	FLAT	1	1.2500	0.5000	0.5000	0	2.0000	2.7500	1
5	MILL 3/8" 2 Flute ZRN CR Mill	CRAD	1	1.0000	0.375	0.375	0.0200	1.5000	3.0000	2
6	MILL 5/16" 2 Flute ZRN CR Mill	CRAD	1	1.0000	0.3125	0.3125	0.0200	1.5000	2.0000	3
7	MILL 1/4" 2 Flute ZRN CR Mill	CRAD	1	1.0000	0.25	0.25	0.0200	1.2500	2.0000	4
8	MILL 3/16" 2 Flute ZRN CR Mill	CRAD	1	1.0000	0.1875	0.1875	0.0200	0.7500	1.5000	5
9	MILL 1/8" 2 Flute ZRN CR Mill	CRAD	1	0.7500	0.125	0.125	0.0200	0.7500	1.5000	6
10	MILL 1/4" 2 Flute Carbide CR Mill	CRAD	1	0.75	0.25	0.25	0.0300	0.75	1.5	7
11	MILL 1/2" Roughing Flat Mill	FLAT	1	1.2500	0.5	0.5	0	1.5000	2.0000	10
12	MILL 1/2" 4 Flute Flat Mill	FLAT	1	1.0000	0.5	0.5	0	0.7000	1.5000	11
13	MILL 1/4" 4 Flute HSS Flat Mill	FLAT	1	0.7500	0.25	0.25	0	0.7000	1.2500	8
18	MILL 8mm 4 Flute HSS Flat Mill	FLAT	1	0.8000	0.2362	0.2362	0	0.5080	1.4000	19
19	MILL 6mm 4 Flute HSS Flat Mill	FLAT	1	0.8000	0.2362	0.2362	0	0.5080	1.4000	19
20	MILL 4mm 4 Flute Carbide Flat Mill	FLAT	1	0.5000	0.1575	0.1575	0	0.5080	0.8000	20
21	DRILL #5 CenterDrill	CENTER DRILL	1	1.2500	0.4375	0.4375	0	0.1875	2.7500	30
22	DRILL #4 CenterDrill	CENTER DRILL	1	0.9000	0.3125	0.3125	0	0.1250	2.0000	31
23	DRILL #3 CenterDrill	CENTER DRILL	1	0.9000	0.2500	0.2500	0	0.1093	1.8907	32
24	DRILL #2 CenterDrill	CENTER DRILL	1	0.9000	0.1875	0.1875	0	0.0781	1.7969	33
25	DRILL #1 CenterDrill	CENTER DRILL	1	0.7000	0.1250	0.1250	0	0.0468	1.2032	34

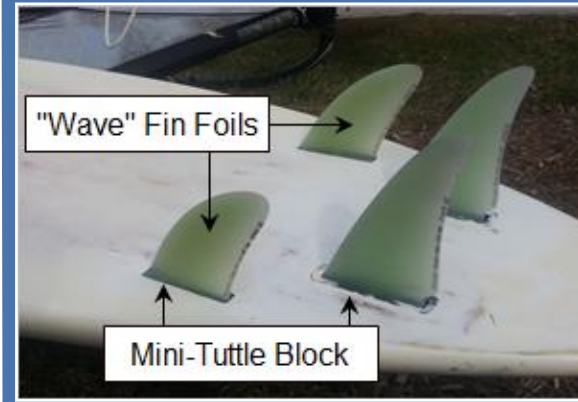
(J)  
 Here we see a view of Michael's RhinoCAM tool library in an Excel spreadsheet format. This same tool library is programmed into his Centroid controller. While he does not have an automatic Tool Changer, his Centroid controller let's him know prior to each program run, exactly what tool to load to minimize confusion.

## Machining & Assembly

The images below show Michael's custom wave fins being machined on his Centroid controlled CNC 3 Axis router on the left ([watch this short cutting video here](#)). On the right we see a set of 4 custom wave fins assembled on a multi-fin windsurf board. A mini-tuttle block, an alternate fin base standard is insert mounted within the board proper and fastened using screws fed from the top side and through the board.



(K)  
Here we see Michael's Centroid-driven CNC router cutting a set of prototype wave fins from G-10 composite stock material.



(L)  
Here we see a set of 4 wave fins assembled on a typical windsurf board. The inserted mini-tuttle blocks are mounted into the board and fastened with screws.

**Cool project, Michael!**  
**Thank you for allowing us to showcase your work!**



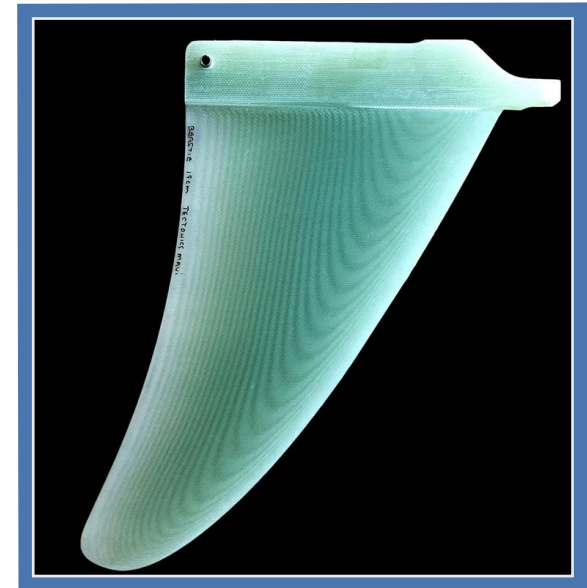
*“While I do not use RhinoCAM directly in my Systems Engineering role at Northrop Grumman, My after hours experience with RhinoCAM has taught me a lot about manufacturing processes. This has made it much easier for me to communicate with the Mechanical Engineers that I oversee on a daily basis.”*

*Michael Wazenski, Owner/Operator  
CNC Fins, Annapolis, MD*

## More about CNCFins

Michael Wazenski co-operates CNCFins.com from his home in Annapolis MD. One of Michael's windsurf board wave fins (shown here on the right) are CNC cut from RhinoCAM toolpaths in Haiku, Hawaii and sold by [Tectonics Maui](#), one of the premier retailers for windsurf racing gear. Michael's wave fins have in no small part contributed to some of the awards won on the [PWA world tour](#). Michael's wave fins have been tested in Annapolis MD, on the OuterBanks, NC and Maui, HI among others. [You can purchase Michael's wave fins at Tectonics Maui \(see below\)](#).

### Follow Michael Wazenski Online:



## More About Tectonics Maui

[Dennis Parton, Owner/Operator of Tectonics Maui](#) has over 25 years of experience, designing world title winning windsurf fins for many of the top professional windsurfers on the PWA World Tour. This heritage has led him to the development of the finest G-10 fin production facility on the planet! Their machines and software are state of the art and Tectonics only uses the finest, hand selected panels of G-10 composites available on the market. Here are just a few of the PWA wins that Michael and Dennis's fin designs have contributed to:

- [Robby Swift 6th place Tenerife on Wave Wizard](#)
- [Phoenix 2nd place at PWA Fuerteventura](#)
- [Tectonics Raptor wins race 4 in PWA Noumea Dream Cup, New Caledonia](#)
- [Robby Swift 5th place Pozo on Wave Wizard](#)

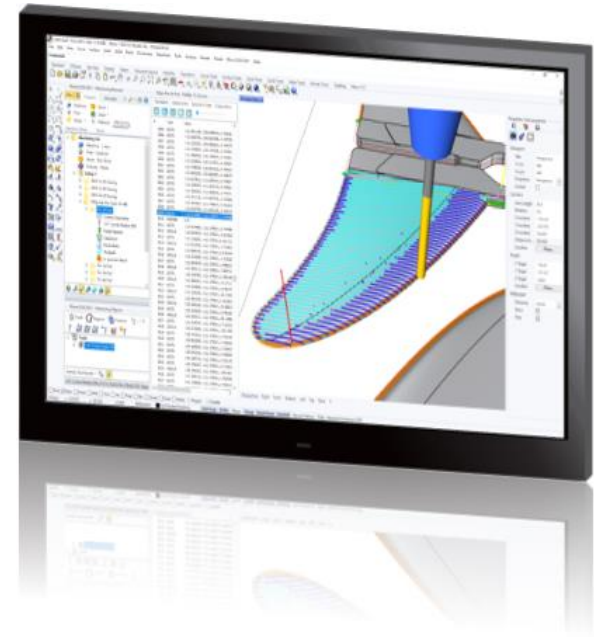
### Follow Tectonics Maui Online:



## More about RhinoCAM

RhinoCAM - MILL 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](http://mecsoft.com/rhinocam)

**Try RhinoCAM Today!**

**Powerful production CAM for Rhino users!**

Follow MecSoft Corporation Online at:



34145 Pacific Coast Highway, #616 | Dana Point, CA – 92629 | [www.mecsoft.com](http://www.mecsoft.com) | 949-654-8163

Want to see how RhinoCAM can help you? [Click Here](#) to download a demo!