

the BoardCAD book



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1. INTRODUCTION

BoardCAD is an open source CAD/CAM-system for surfboards. It is aimed at facilitating the design process and to stimulate creativity by allowing the shaper to play with different parameters in the design. The result can be immediatly visualized in 3D, giving important feedback to the shaper. BoardCAD also allows the shaper to print full scale templates or even send the design to a CNC-machine to have it produced and taken for a ride. While it is only in the water that it is possible to validate a design, knowing exactly what has been changed between different boards allows the shaper to learn much more from each of them. BoardCAD doesn't automatically make you into a good shaper, but used in the right way it can help you both to learn faster and to become more productive.

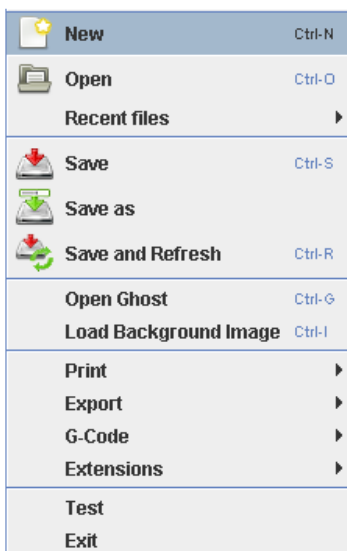
This book is both a guide on how to use BoardCAD, and a detailed reference for its functionality. It is suggested that you first read the quick tutorial in chapter two to get a feeling for the overall workflow and the functionality offered by BoardCAD. The following chapters focus on more specific topics and can be read in any order. For information on how to get and install BoardCAD, and for more general information about the project, we refer to the project's homepage <http://www.boardcad.com> and our wiki at <http://www.boardcad.org>.

2. QUICK TUTORIAL

This chapter provides an overview of the most important functionality and the workflow for designing a board, from defining the basic outline and rocker, to generating and fine tuning a complete 3D-model.

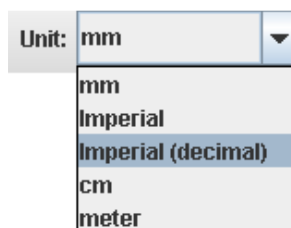
2.1 Creating or opening a board

Normally you don't create a board from scratch, but start by opening one of your existing models. From version 2.0, BoardCAD mainly works with STEP-files (.stp), but it can still read and save files in the previous formats (.brd and .cad). Apart from these native formats, BoardCAD can read files from aps3000, shape3D, surfcad and akushaper.



If it's the first time you use BoardCAD it is natural that you don't have any existing models to start from. Therefore BoardCAD comes with three basic shapes (funboard, shortboard, and longboard) that can serve as a starting points. You can find them by choosing new in the file menu. For this tutorial we choose the shortboard. This creates 2D drawings of the outline, rocker, and a number of cross sections along the board.

2.2 Editing the curves

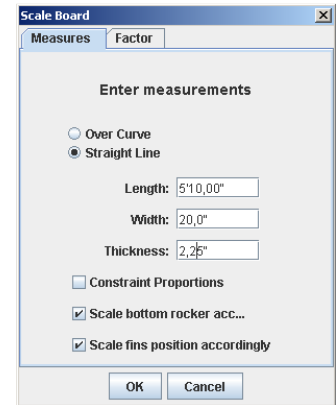


The first thing we want to do is to scale the board to the desired size. If you, like most shapers, have your head setup to work with feet and inches, you should make sure that BoardCAD does the same in order to avoid having to convert all your measures to mm. This can be done from the drop down list named unit. For this tutorial we choose Imperial (decimal) as our unit. Now we can comfortably click the scale button and type in our desired measures, e.g. 5'10" x 20" x 2.25". There is a lot more that can be said about scaling, but that's a chapter in its own, and for now

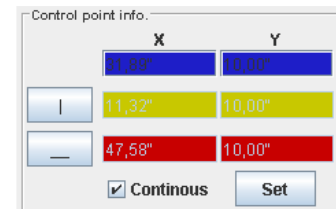
we don't need to care about all the details.

Now we are ready to start editing our curves. Let's start with the outline. There are lots of tricks you can use to facilitate the design, like using another board model or image of a board as a template. By having them shown in the background it is easy to trace their outline when editing the curves. This will be shown in chapter 4, but here we do our outline without any aid.

The outline is defined as a Bezier curve which is made up of a number of segments. Each segment starts at a blue control point and ends at the next blue control point. Between those two blue points there is a red and a yellow point. These define the form of the curve within the specific segment. You can control the shape of the outline by simply clicking and dragging the control points. To force the tangent of the curve to be continuous between two segments, you can click on the blue control point between them and mark "continuous".

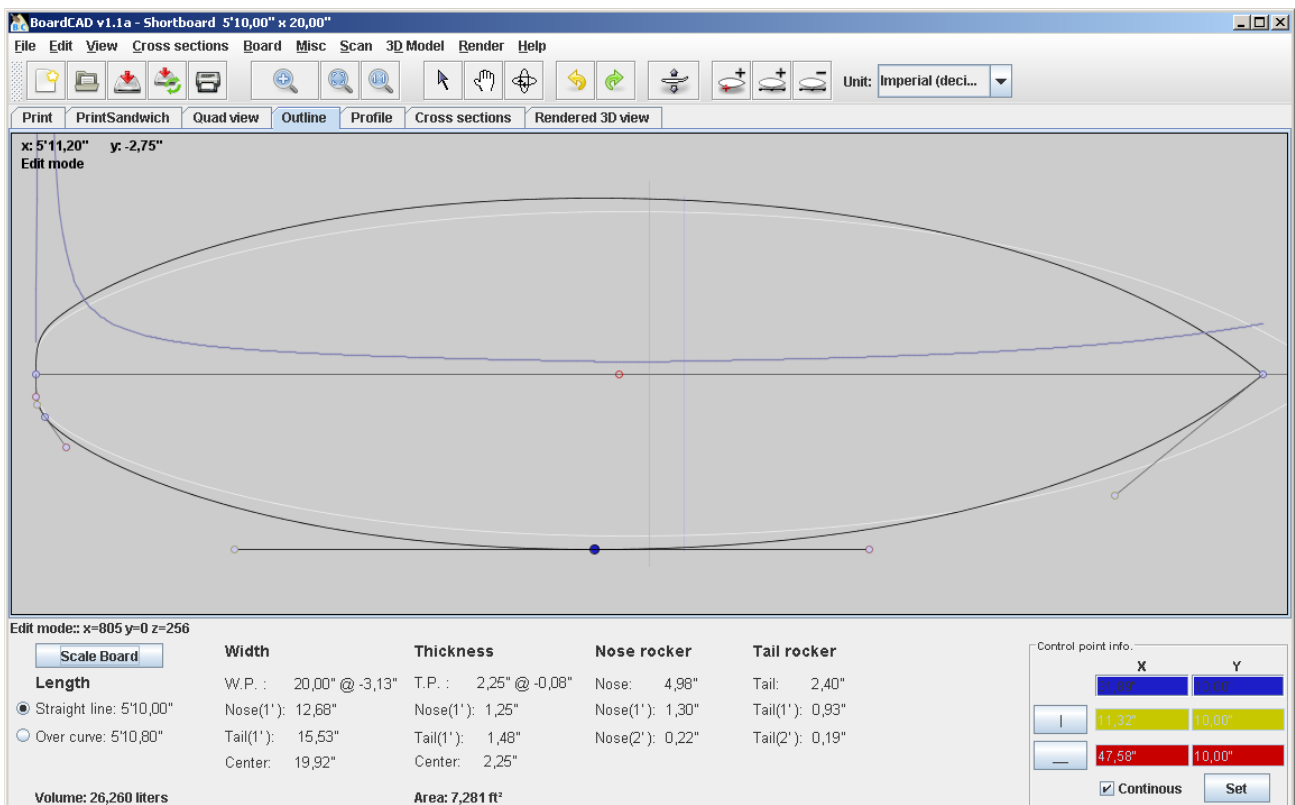


Scale Board dialog box, Measures tab. It contains fields for Length (5'10,00"), Width (20,0"), and Thickness (2,25"). There are checkboxes for Constraint Proportions, Scale bottom rocker acc..., and Scale fins position accordingly. OK and Cancel buttons are at the bottom.



Control point info. dialog box. It shows a table of control points with X and Y coordinates. The first point is blue (11,89", 10,00"), the second is yellow (11,32", 10,00"), and the third is red (47,58", 10,00"). There is a checkbox for Continuous and a Set button.

	X	Y
Blue	11,89"	10,00"
Yellow	11,32"	10,00"
Red	47,58"	10,00"



BoardCAD v1.1a - Shortboard 5'10,00" x 20,00"

File Edit View Cross sections Board Misc Scan 3D Model Render Help

Unit: Imperial (decl...)

Print PrintSandwich Quad view Outline Profile Cross sections Rendered 3D view

x: 5'11,20" y: -2,75" Edit mode

Scale Board

Length: ☒ Straight line: 5'10,00" ☐ Over curve: 5'10,80"

Volume: 26,260 liters

	Width	Thickness	Nose rocker	Tail rocker
W.P. :	20,00" @ -3,13"	T.P. : 2,25" @ -0,08"	Nose: 4,98"	Tail: 2,40"
Nose(1'):	12,68"	Nose(1') : 1,25"	Nose(1') : 1,30"	Tail(1') : 0,93"
Tail(1'):	15,53"	Tail(1') : 1,48"	Nose(2') : 0,22"	Tail(2') : 0,19"
Center:	19,92"	Center: 2,25"		

Area: 7,281 ft²

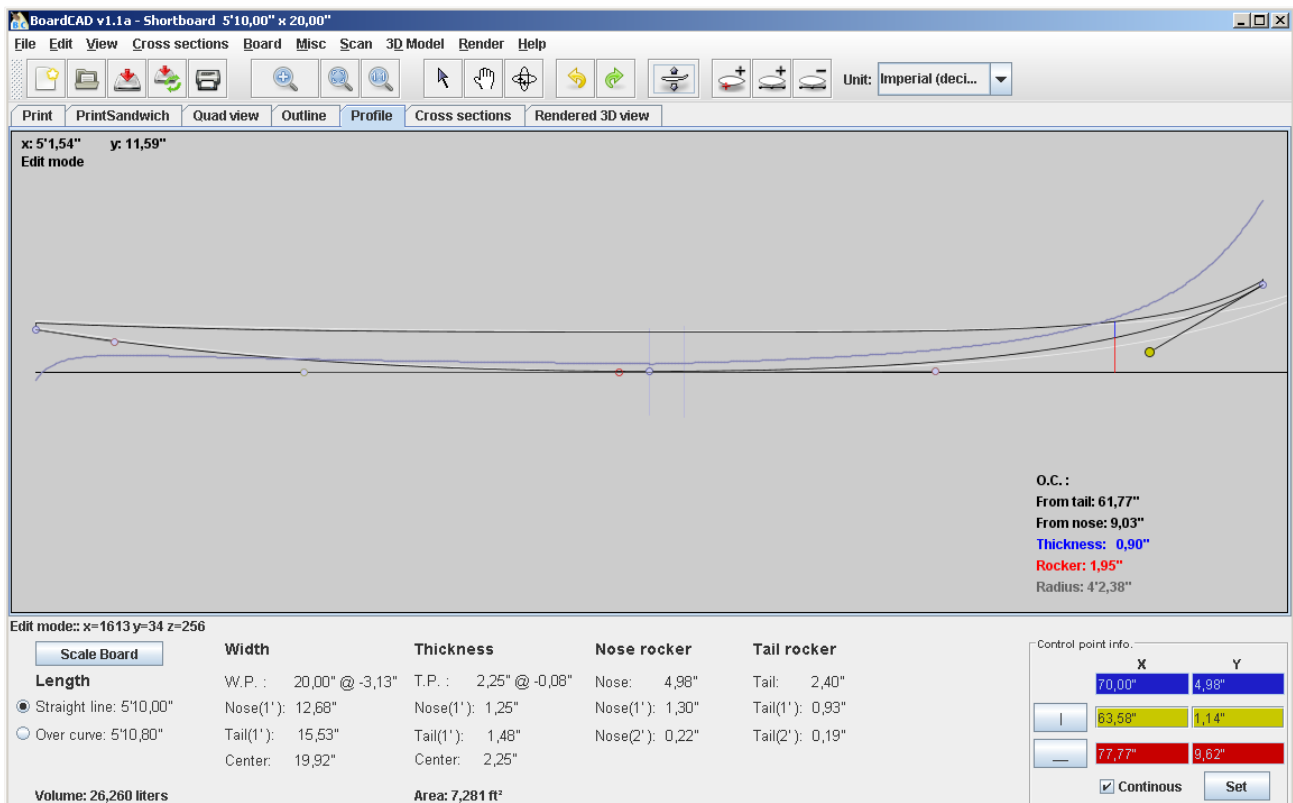
Control point info. dialog box (repeated from above)



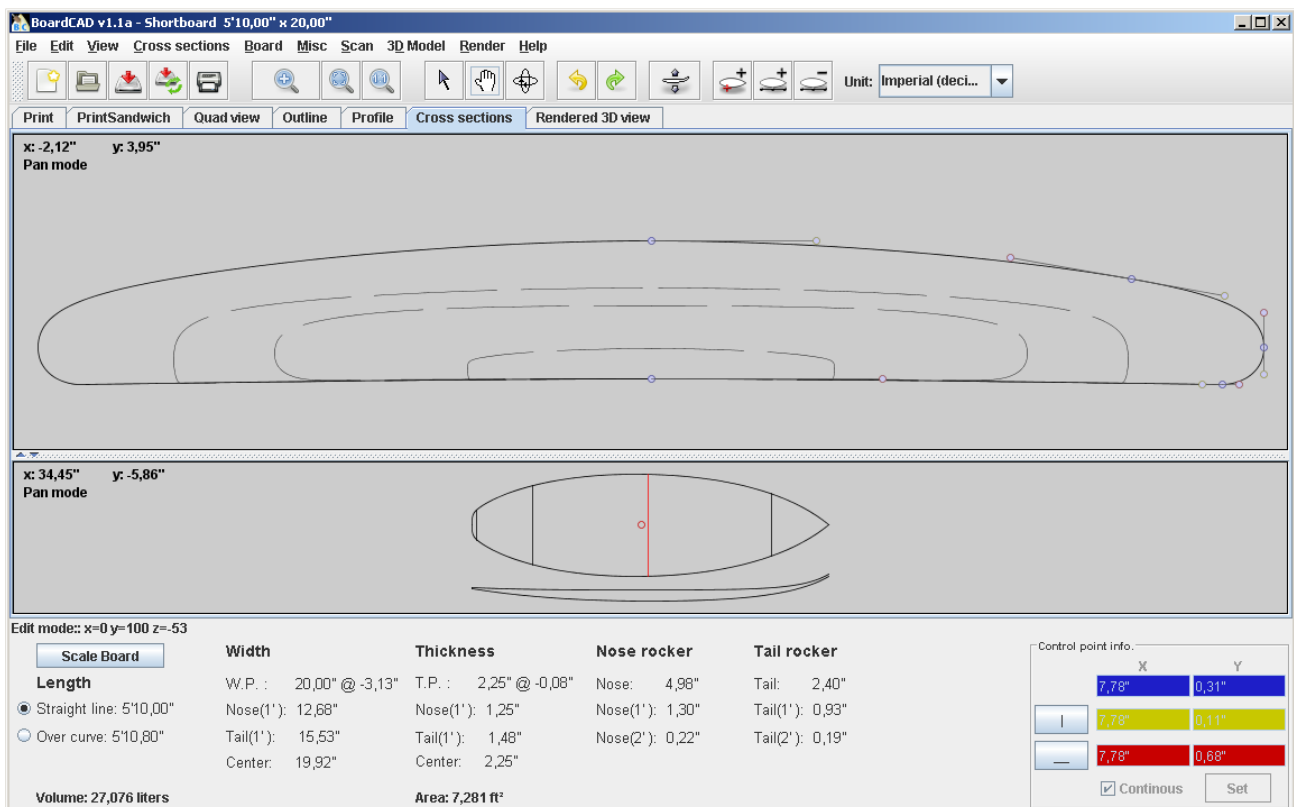
If needed you can also add or remove control points. While more control points give more freedom in design it also make it harder to create smooth lines, so only add guide points when strictly necessary. Details on how to work with the control points are given in chapter 5.



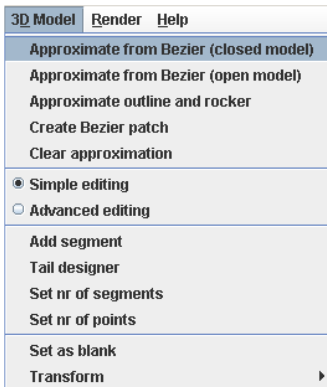
Next we define the rocker by clicking on profile. There is one Bezier curve for the deck and one for the bottom. You can switch between them by clicking the "Toggle Deck/Bottom" icon. For the deck it is good practise to follow the rocker of the blank when possible. Again we refer to chapter 4 for details on how to show a blank model in the background, or chapter 11 for instruction on how to scan a blank using a CNC machine. Here, we use our artistic freedom to define the rocker. Just as for the outline, we can edit our curves by clicking and dragging the control points. It is possible to select several control points and move them at the same time, which is especially useful for changing the rocker in the tail and nose while maintaining the same thickness.



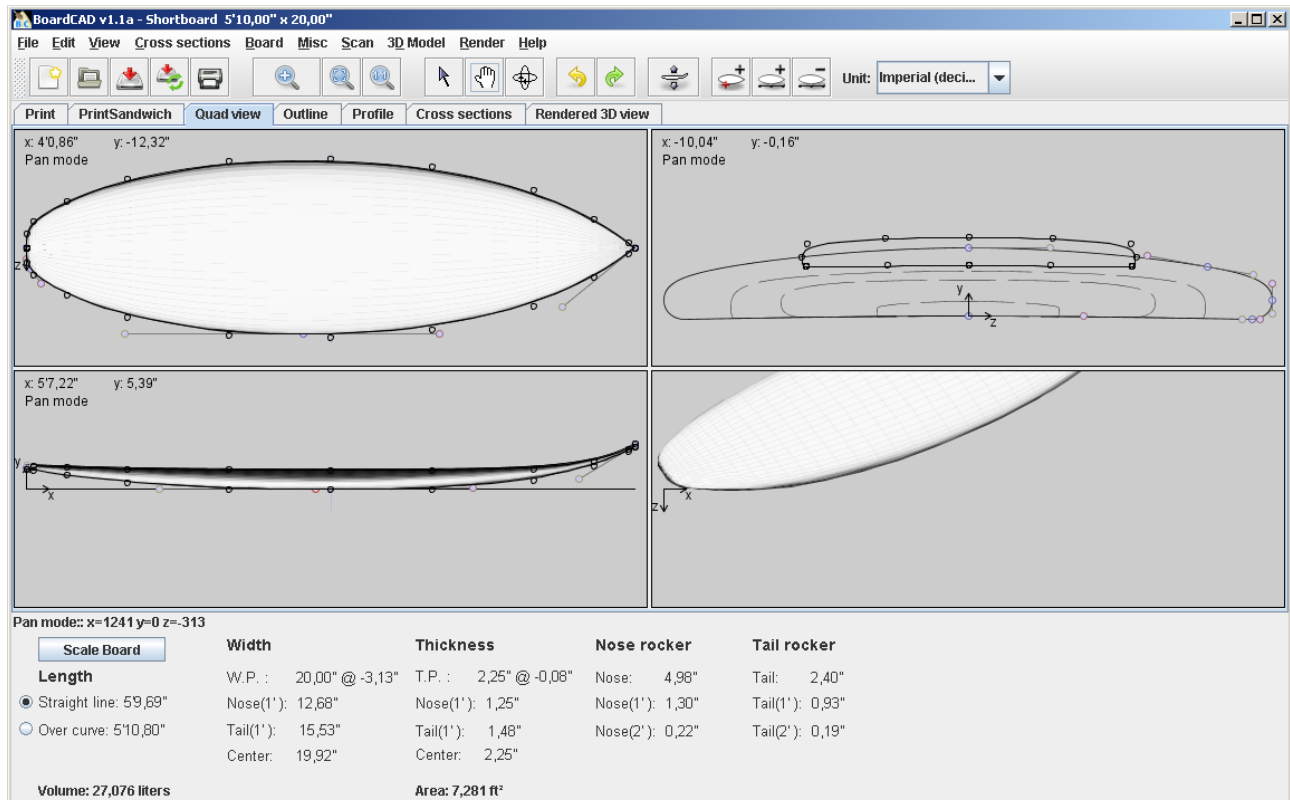
Finally we define our cross sections. The cross sections are responsible for the form of the rails, and how all the lines flow in 3D. To ensure a good flow it is advisable to use few cross sections. One trick is to start with only one cross section in the center of the board and edit that to the desired form. Next you add cross section for example at 1 foot from the tail and 1 foot from the nose. These cross sections will now be copies of the cross section at the center of the board and it is easy to control how you want the flow of rail to change towards the tail and towards the nose. Typically you'll want a harder rail and less tucked under towards the tail, and a higher rail with more tucked under in the nose. It may also be necessary to define extra cross sections for the last few inches of the board. By doing this after we have edited the cross sections at one foot off the tail and nose, we again make it easy to change the rail without breaking the flow.



2.3 Creating a 3D model



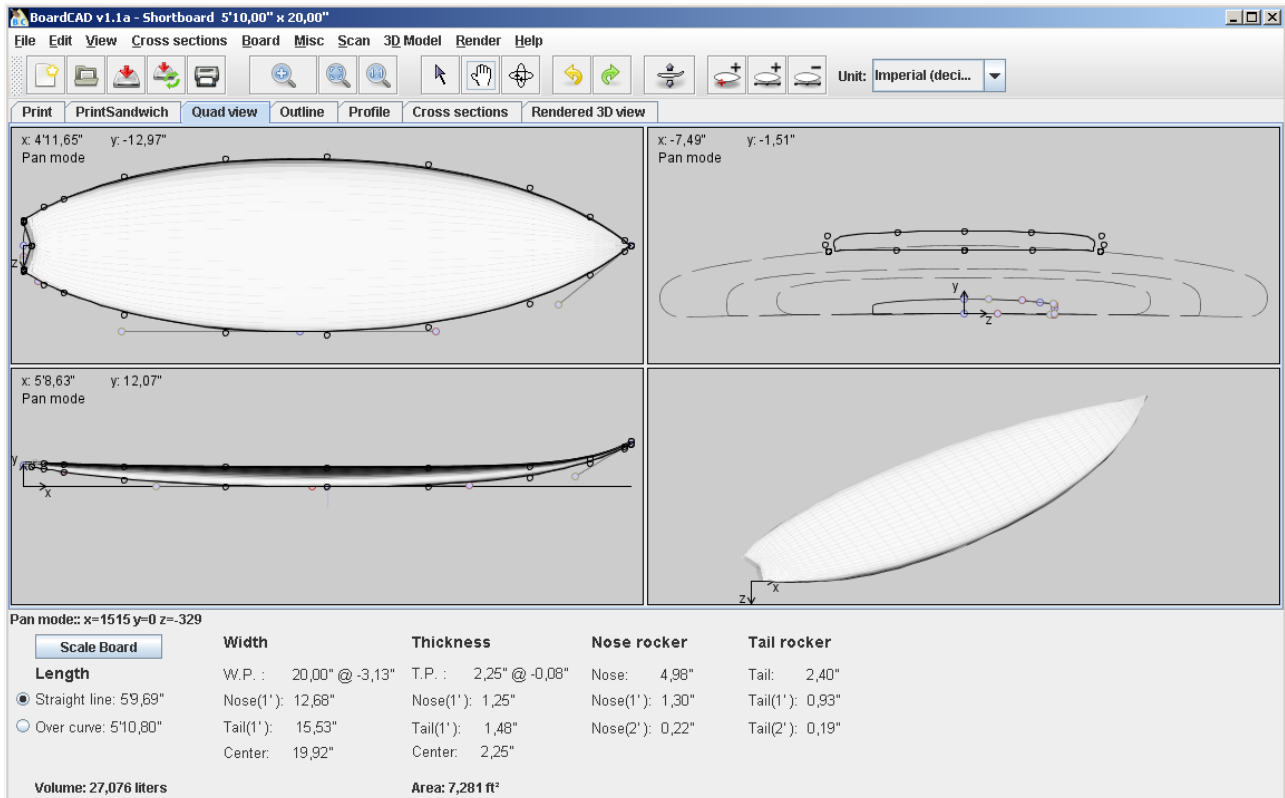
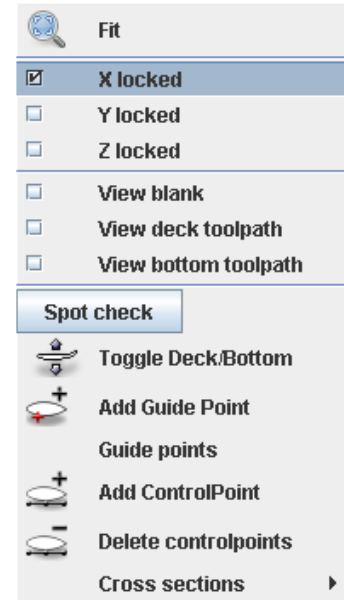
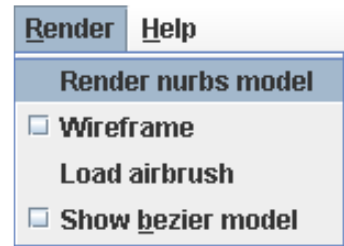
Now the main design of the board is already done, and if we want to print 2D templates (as described in chapter 8) we can actually do that directly without creating a 3D model. On the other hand, if we want to use the model in another CAD-system, or have it shaped in a CNC machine, we cannot do that without a 3D model. In any case, at this point you are probably eager to see what your board looks like in 3D, so we simply create a 3D-model by choosing "Approximate from Bezier" in the 3D-menu. As the name suggests, the 3D-model only approximates the 2D curves. The reason for that is that we want a 3D model that can easily be modeled further in order to achieve things such as swallow's tails, that cannot be modeled in 2D. The standard 3D model is able to approximate most board shapes quite accurately. However, it is possible to increase the resolution of the 3D-model or edit the position of its control points in order to improve the approximation when necessary, see chapter 6 for details.



In version 2 of BoardCAD, the 3D-model is shown directly in the same window as the Bezier curves. This makes it easy see how well the curves were approximated. While the 3D-model shown in these windows gives a good idea of how the board looks, an even better visualization is available in the redered view. To render the board choose "Render nurbs model" from the Render menu.

Now let us do some editing and create a one inch swallow tail. First we move the segment placed at 20 mm from the tail forward so that it does not get affected by the swallow tail. To move a segment forwarded we first have to uncheck "x-locked" from the popup menu that appears when you do a right-click on the mouse. Now we can click on the outline point and drag it forward. Note that since the points are defined in 3D-space, all views are affected and even the rocker is changed by moving the segment forward. We can adjust the rocker either by hand or by reapproximating the 3D-model.

Next we adjust the tail segment to the desired width, and select "Tail designer" from the 3D menu to set the depth of the swallow tail. The 3D model always works with mm, so



we type in 25. The result is a retro-looking swallow. We can fine adjust the tail by selecting "Advanced editing" in the 3D-menu and move the individual points.

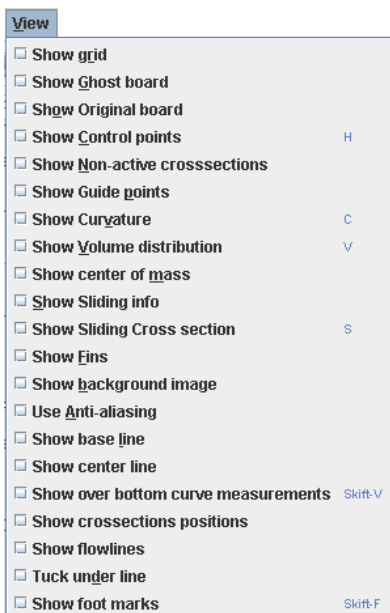
2.4 Saving the board

Finally we save our model. As already stated, BoardCAD version 2.0 has a new STEP-based file format. To save the board as a STEP-file, select "Save As" and name the file using .stp as the file extension. Using this format both the 2D Bezier curves and the final 3D-model are saved in one single file. Before version 2.0, the 2D model was saved using .brd-format, and the 3D model using .cad as file extensions. For backward compatibility these formats are still available. It is also possible to export the board model using a number of standard CAD-formats. More information about these can be found in chapter 9.

3. SETTING PREFERENCES

BoardCAD is intended to be used by anyone who is interested in designing surfboards, from the backyard shaper to the full-time professional. Of course, different users have different needs and preferences. BoardCAD is therefore highly configurable and it is possible to control both the visual appearance of the board models and what kind of design aids you'd like to be present on the screen. It is also possible to select a different language for the menus.

3.1 Viewing design aids



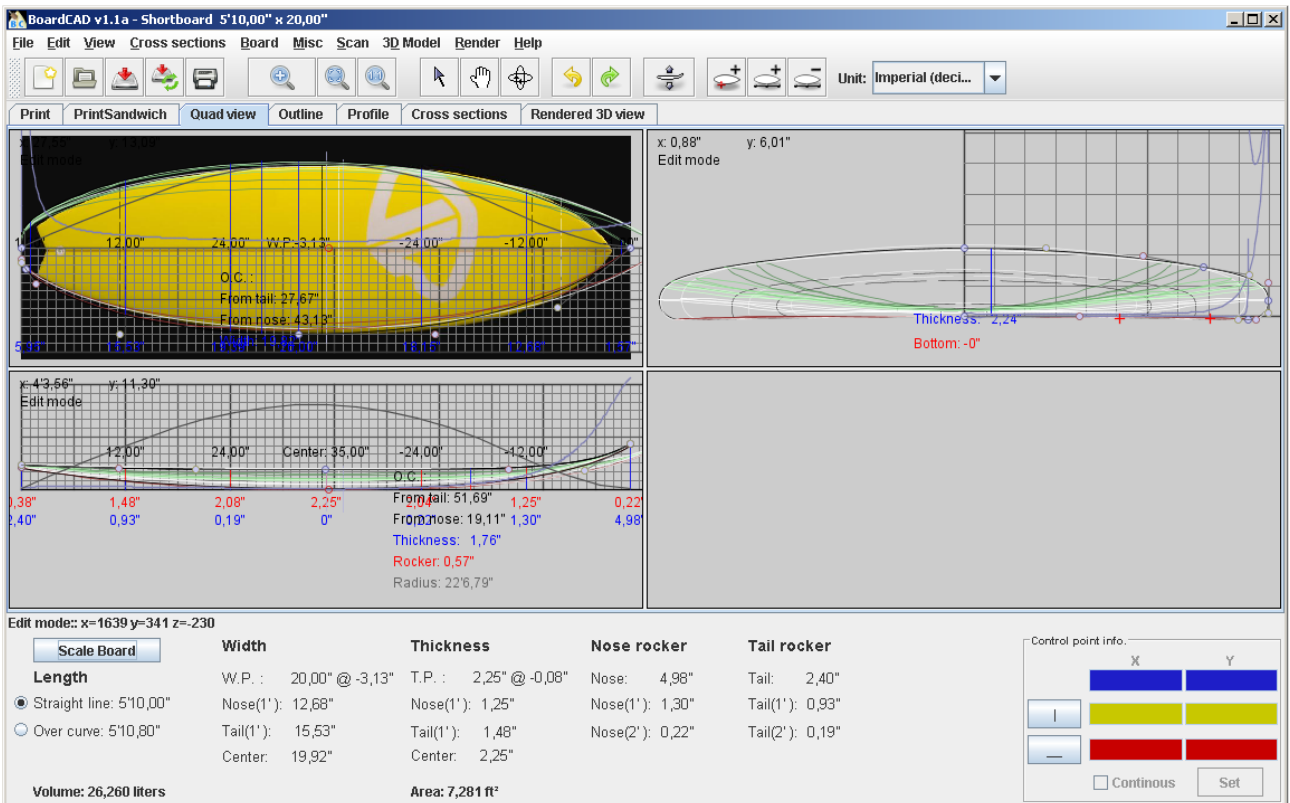
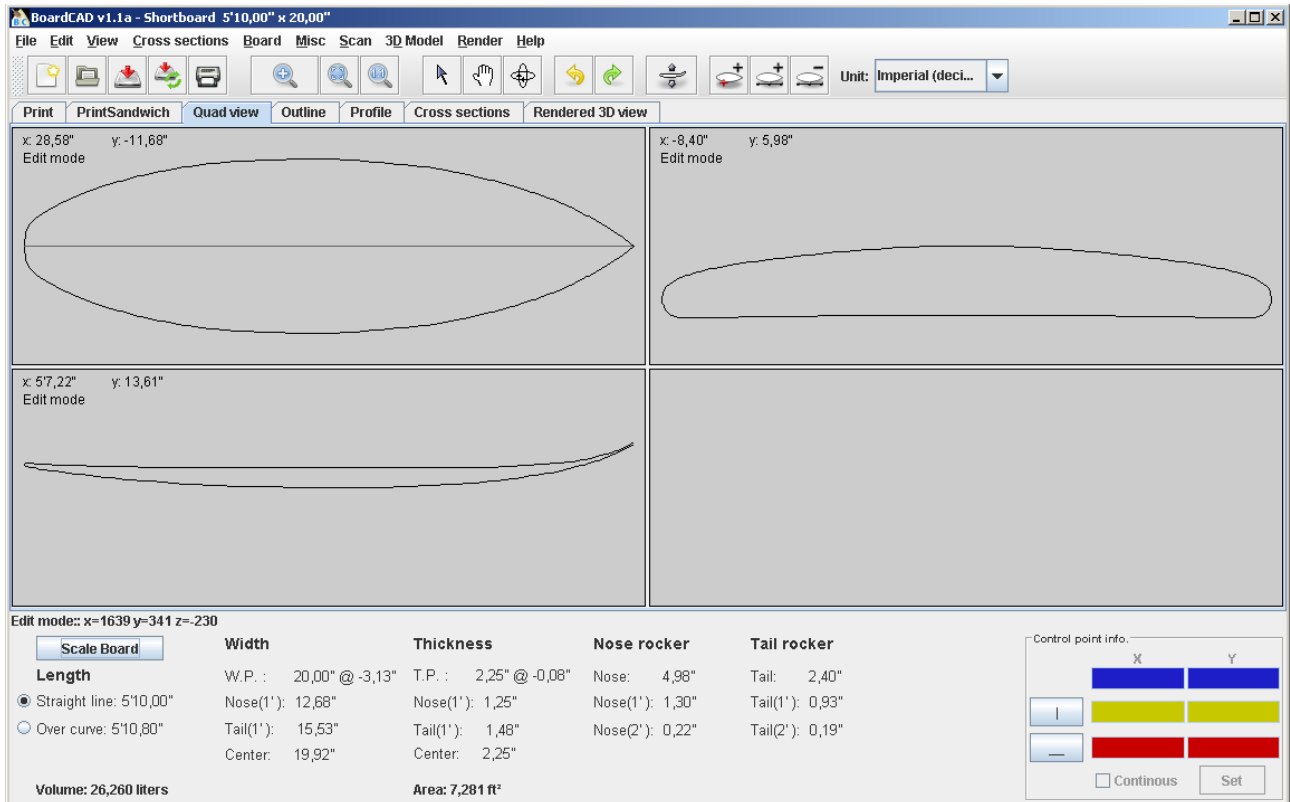
Under the View-menu you'll find a list of different design aids that can be switched on and off. While all are useful, having all shown at the same time tend to clutter the workspace and make it more difficult to edit the board. Most of the design aids are self-explanatory, but below you will find a short description on each of them.

Show grid - Shows a grid in the background. Depending on whether the unit is set to metrics or imperial, the distance between each grid-line is set to 1 cm or 1 inch respectively.

Show Ghost board - Shows the curves of another board in the background, given that a ghost board has been loaded. More details on ghost boards are available in chapter 4.

Show Original board - Shows the curves of the current board before they were edited.

Show Control points - Show the control points that allows the curve to be edited. By hiding these no editing can be done to the curve. This can be useful when editing the surface model in order to avoid that the bezier curves get moved by mistake.



Show Non-active cross sections - Show all cross section simultaneously in the cross section view.

Show Guide points - Guide points are explained in chapter 4.

Show Curvature - The curvature is a measure of how far from flat a curve is. For a flat line the curvature is equal to zero, and for other curves the curvature is equal to the inverse of its radius at every point. This means that if the curvature of the rocker is equal to zero, the rocker is totally flat at that point, and if it goes below zero it means that the board has negative rocker.

Show Volume distribution - Shows much volume each part of the board has.

Show center of mass - This shows the volume center

Show sliding info - The sliding info gives information about the width and thickness of the board at the point where the mouse is placed.

Show Sliding Cross section - Shows the cross section at the point where the mouse is placed.

Show Fins - Shows fin position

Show background image - Shows a background image if such image is loaded. More info on background images can be found in chapter 4.

Use Anti-aliasing - Using anti-aliasing smoothens the jagged lines that occurs due to the low resolution of computer screens.

Show base line - Shows a zero-line under the board

Show over bottom curve measurements - Shows the distance over the bottom tail, from the tail and the nose, to the current mouse position.

Show cross section positions - Shows where the cross sections are placed.

Show flowlines - Shows the flow of the rail at 30, 45, 60, and

90 degrees

Tuck under line - Shows the tucked under

Show foot marks - Shows rocker and width of board at tail, nose, center, one-foot-off and two-foot-off.

3.2 Setting visual appearance

By choosing Misc, Settings, in the menu you get a dialog window where it is possible to configure the visual appearance of the board model and all the design aids described above. The dialog window has three tabs.

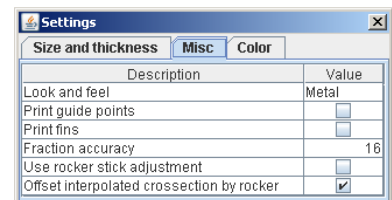
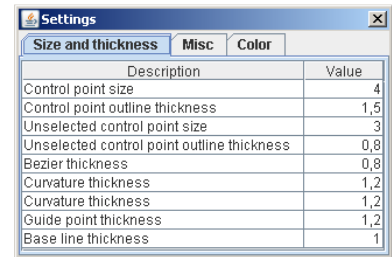
Size and thickness - In the size and thickness you can control the size of the control points and the line thickness of the board model.

Misc - A number of different configurations that didn't fit under the other tabs. Look and feel lets you set the appearance of the GUI, in order to give BoardCAD either a platform independent look and feel like Metal or a native look and feel that make BoardCAD look more like a native application and less java-like. Print guide points, and Print fins, configures whether those will be visible when printing board information sheets or templates. The fraction accuracy configures to what fraction of an inch that measurements will be shown, when imperial units are used. Default value is 16, i.e. 1/16 of an inch. If Use Rocker Stick Adjustment is turned on, the rocker will be adjusted so the center tangent is level. This is similar to the industry standard way of measuring rocker with a rocker stick. Offset interpolated cross sections by rocker means that the cross sections will be drawn in their full 3D-position rather than flat. This is especially useful when comparing the rail of the 3D-model with the rail of drawn in the 2D-view.

Color - Let you set the color of the board model and the different design aids.

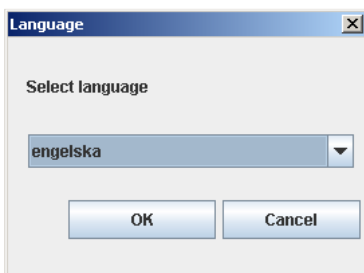
3.3 Choosing Bezier interpolation

Finally it is possible to configure how the cross sections are interpolated in the Bezier model. This affects how new cross sections will be calculated when a they are added between



two existing cross sections. It also affects how the form of the sliding cross section, if you have chosen to view this. The two methods should give similar results, but generally Cross section interpolation gives the best result if all cross sections have the same number of control points, while S-blend interpolation is more reliable when different number of control points are used.

Currently the 3D-model is generated independently, using a different type of interpolation, and is therefore not affected by which type of interpolation that is chosen for the Bezier curves.



3.4 Setting menu language

It is possible to change the language of the menus in BoardCAD. This is done under the menu Misc, Language. Currently six languages are supported: English, French, Portuguese, Spanish, Norwegian, and Dutch. You will need to restart BoardCAD for the changes to appear.

4. USING TEMPLATES

When designing a new board it is common to get some inspiration from other designs, by copying for example the outline, or just comparing the current design with other designs. Depending on what you have at hand, this can be done in different ways. If you already have the model of the other board you can simply put that model in the background as a Ghost model. If you only have the physical board, the best thing is take as many measures as possible (preferable using a scanner as in chapter 11) and add those as guide points. Even in the case that you only have a picture of the board it is still possible to use that as a template by showing the picture in the background. Here we show you each of these alternatives.

4.1 Ghost board

A ghost board can be loaded in the background to compare designs. The ghost board can be moved by holding down G (brings it into focus) and using the arrow keys.

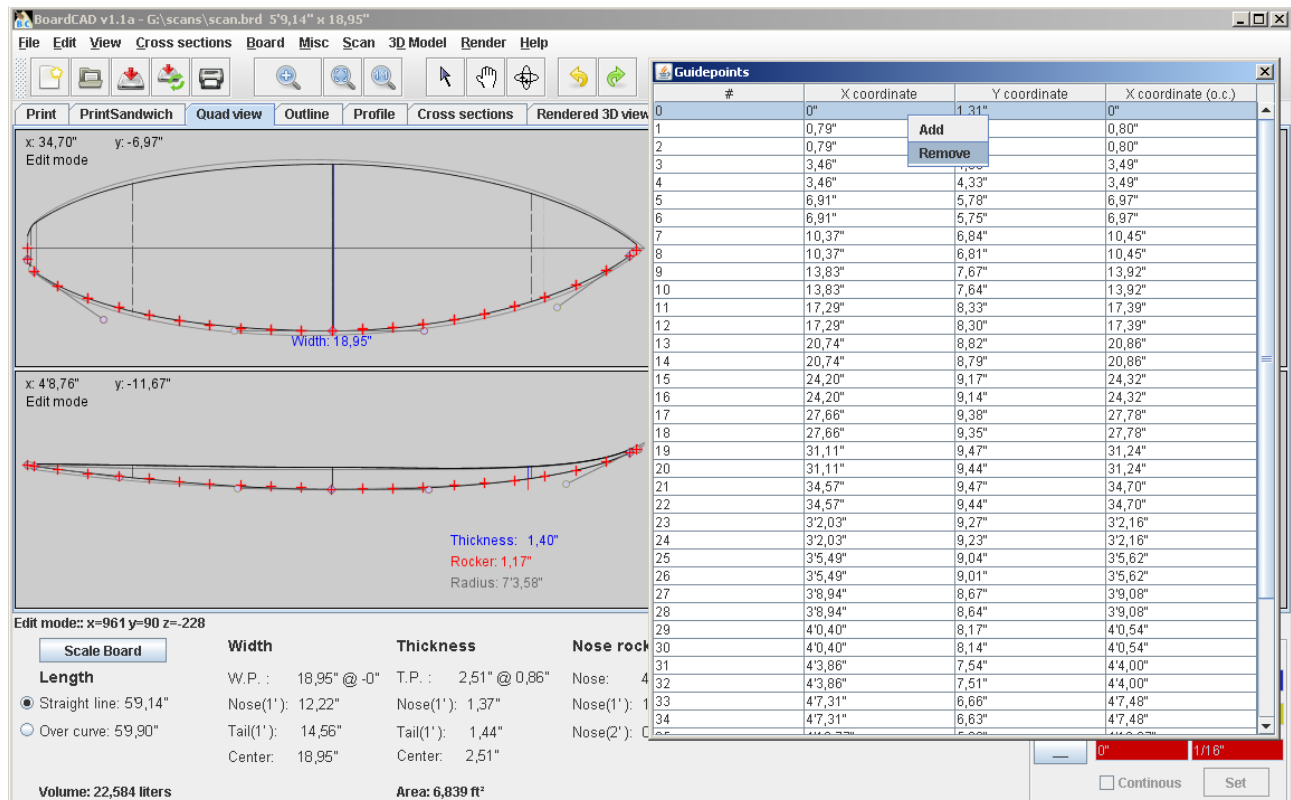
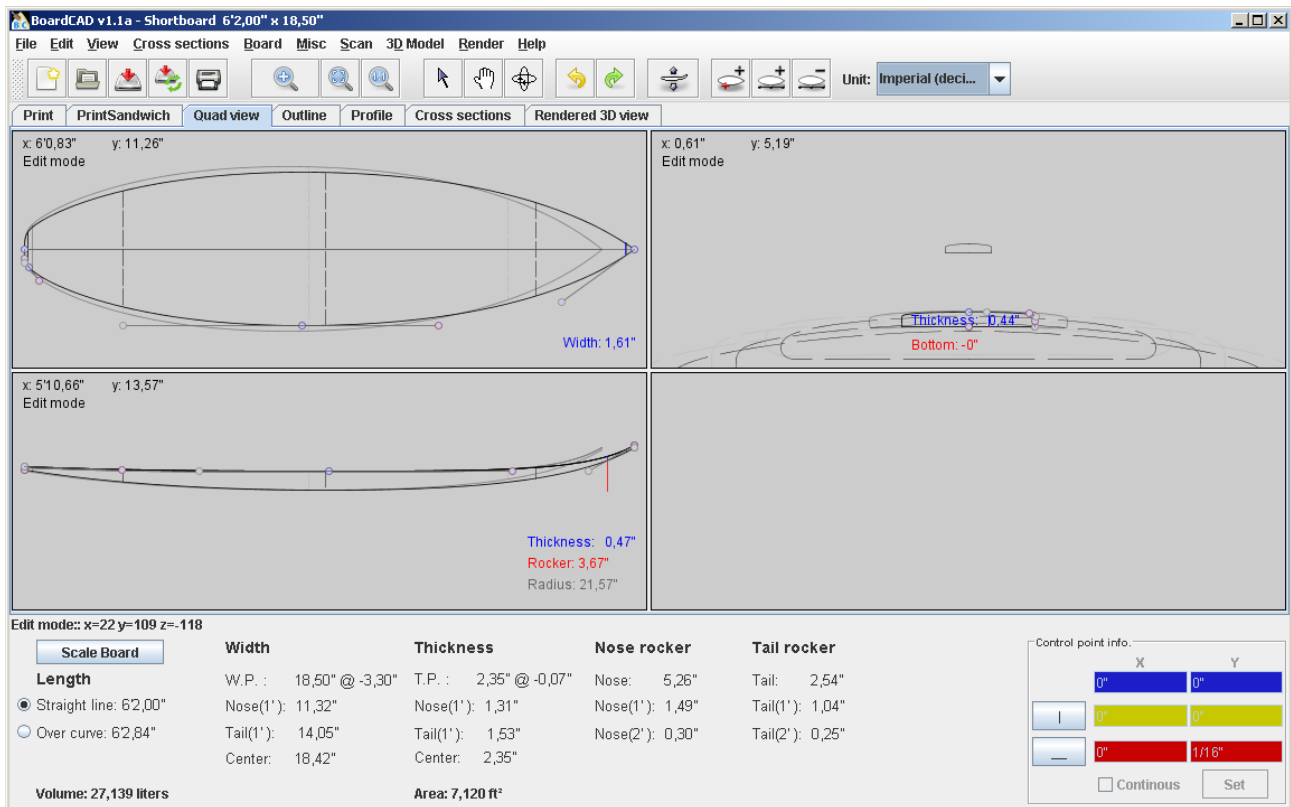
The ghost board can also be scaled to the same size as the current board using the respective command at the Board menu.

4.2 Guide points

You can add guidepoints by clicking the Add guide point button and directly insert the point in the 'board area' by clicking.

You can also open the Guide points table either via the Board menu or via Right click of the mouse. Once the table is open you can directly edit any existing guide points by

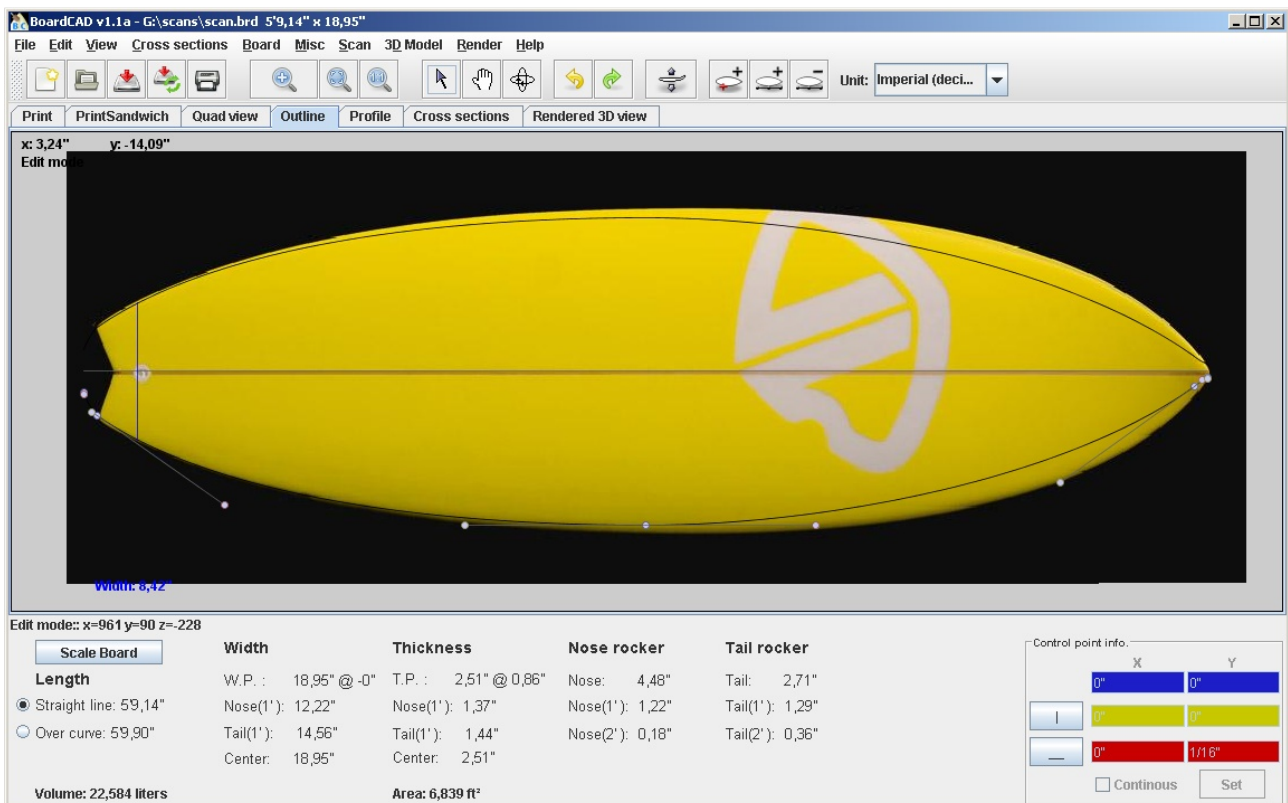
Board
Scale current board
Scale ghost to current board size
Info
Fins
Guide points
Weight calculator
Flip



double clicking. By right clicking the mouse you can choose to add new guide points via (x,y) coordinates or you can choose to remove any highlighted guidepoints.

4.3 Background image

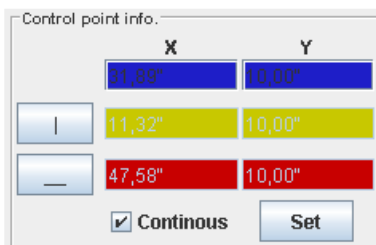
A background image can be loaded in every view. This is positioned by holding down T and clicking on the tail, and holding down N and clicking on the nose. Note that if the board is positioned vertically the image needs to be narrower than wide for this to work properly and visa versa.



5. BEZIER EDITING

This chapter gives more detailed information on how to edit the Bezier curves, i.e. the outline, rocker, and cross sections of a board.

5.1 General tips for editing curves



The curves are edited by clicking and dragging the control points. You can also move these points with the keyboard arrow keys (more precise) or input the exact coordinate in the respective text boxes (in the lower, right corner) and click the set button. To make a tangent longer press E (extend), to make it shorter press R (retract). To rotate the control point clockwise press W, to rotate it counter-clockwise press Q.

By holding down the ALT key you make every editing operation 1/10th of normal operation. This gives you good precision even when dragging the points with the mouse.

By clicking while holding down Ctrl or Shift, or by clicking and dragging a rectangle box around the points you can select multiple center points that can be moved all together with the mouse or moved by steps with the keyboard arrow keys (this is useful for adjusting the rocker without changing the thickness at the nose tip and tail tip) In the Deck View select all nose and/or tail control points and drag/move. It's also useful for adding vee's or concaves without distorting the rail shape, select all the center points of the rail and move them together.

The "h" key hides/shows the control points.

Use the < key to cycle through the tangents and center point of a control point. Use the c key to cycle through the control points of a curve.

Click add point to go to add point mode. Click on the curve to add a control point to the curve. The curve will not change. Click delete point to delete the selected points.

Undo/redo can be done on every change you make to the curves. The number of operations you can undo is only limited by available memory.

Pan and zoom by selecting the pan and zoom mode clicking on the respective buttons. To go back to edit mode (for selecting control points), press the edit button in the toolbar or in the right click pop-up menu , or even hit "Esc" on the keyboard. You can also pan by holding the mouse scroll wheel button (very useful!) and dragging the board. Spinning the mouse wheel zooms in and out when in edit mode.

5.2 Input values

All inputs that take measurements can take the following formats: FEET/INCHES (ex. 6'10" or 3 1/4"), METERS (ex. 0.5m), CENTIMETERS (ex. 50cm), or MILIMETERS (ex. 2200mm).

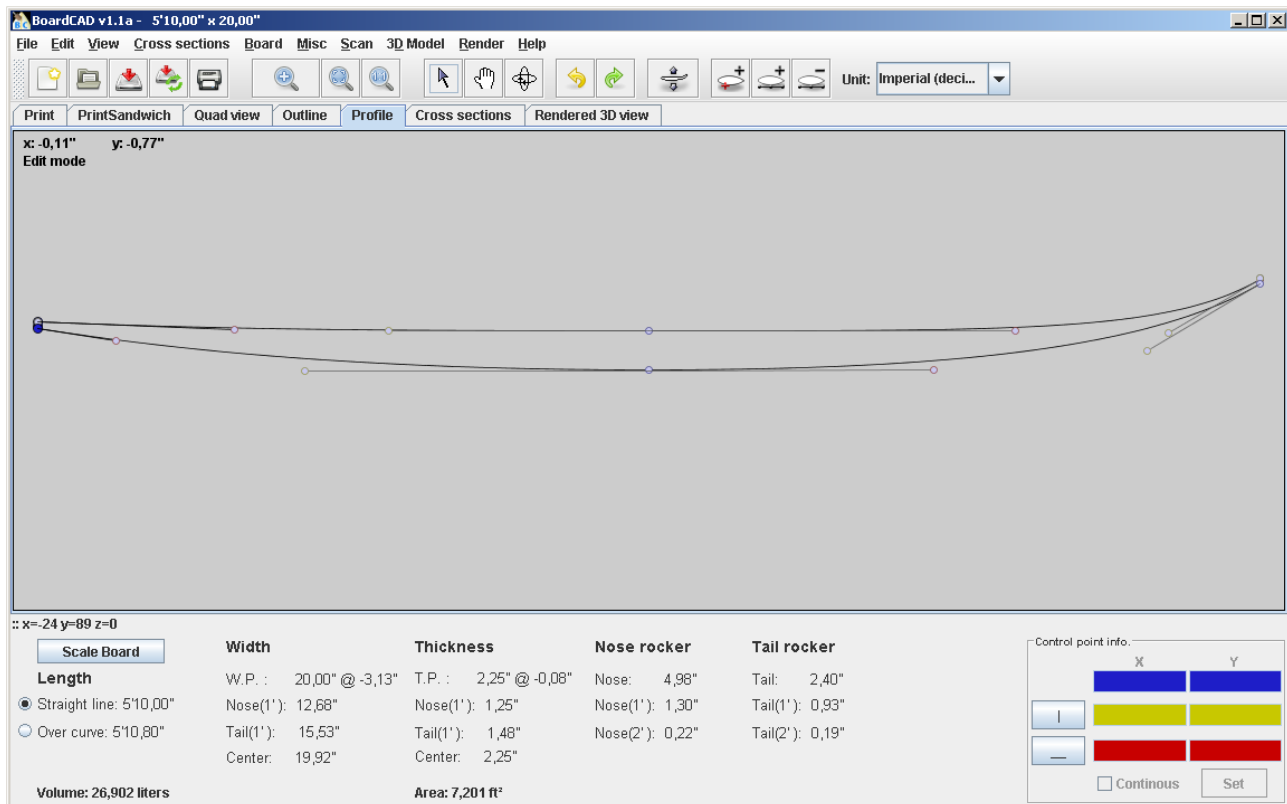
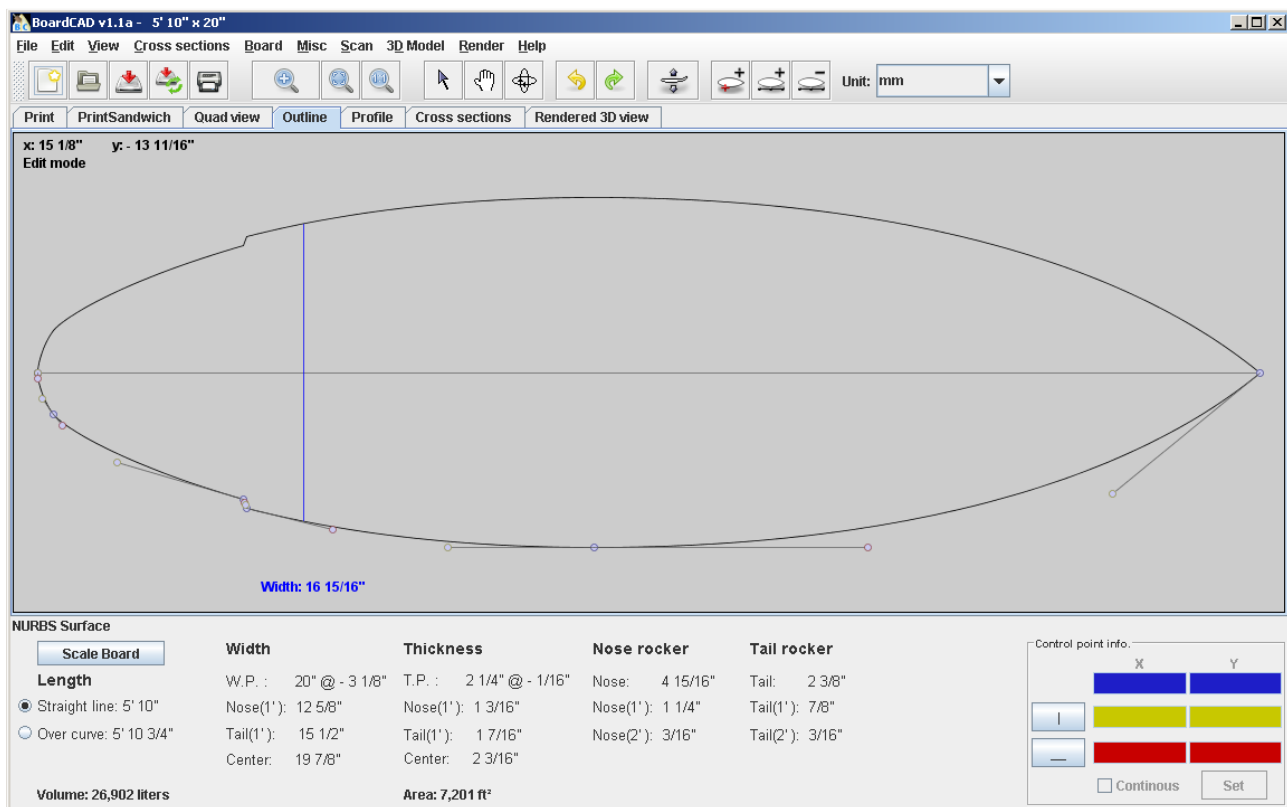
If you don't specify a unit, the current unit will be used. In the case of feet/inches the input value will be inches.

5.3 Outline

Click on the Outline tab to view the outline in a single window and facilitate the editing. The outline is edited by clicking and dragging the control points. Normally you will want to have the Continuous checkbox marked for all control points. That means that the tangent will be maintained continuous between different segments of the Bezier curve, creating a smooth outline. On the other hand, unchecking continuous will allow you to easily create wingers in the outline.

5.4 Profile

The deck and bottom rocker are most easily edited in the Profile tab. If you have access to a model of the blank from which you intend to shape the board, it is practical to load



the blank model as a ghost board to make sure that the final board model will fit inside the blank.

The deck and the bottom are edited just like any other curve. Use the Toggle Deck/Bottom to switch between the two curves. To change the rocker in the tail or nose without changing their thickness you can use the Toggle function so that both curves are opened simultaneously and then mark both the points on the bottom and the deck before changing their positions.

5.5 Cross Sections

In the cross section view, the lower view shows the position of the crosssections on the outline. The currently selected cross section is show with a red line.

Click near any crossection to select it, or use +/- to cycle through the cross sections. Cross sections can be added, moved and deleted using the menus.

When adding cross sections the new cross section depends on the interpolation method used, this setting is in the misc menu. If blend or S blend interpolation is used, you will get a copy of the nearest cross section, if control point interpolation is used the new cross section will be the interpolated slice at this point. Copy and paste of cross sections can also be done.

While it is possible to use different number of control points in each cross sections, it is often easiest to get a good flow of the rails if the same number of points is used in all cross sections. To generate high quality 3D-models from the cross sections it is advised to always leave a slight tucked under and to use a control point with vertically placed tangent points at the rail apex.

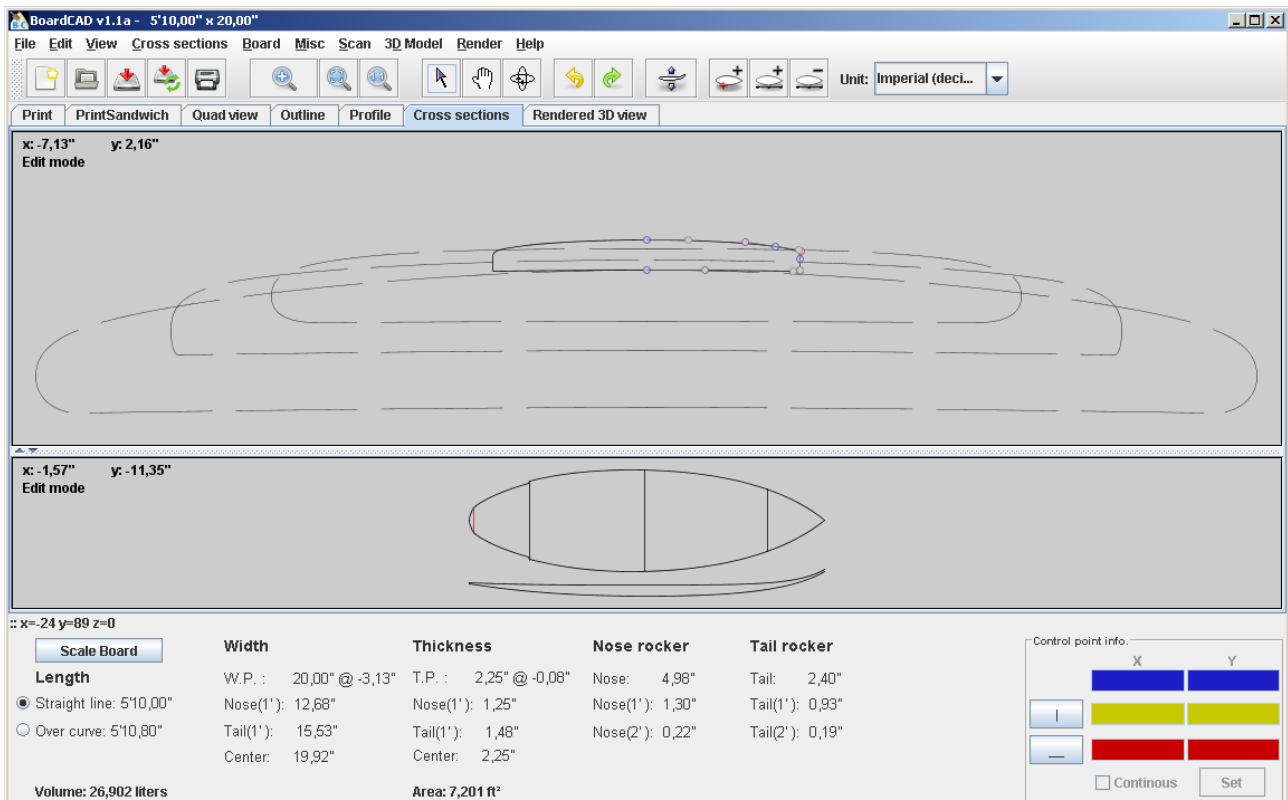
5.6 Other useful features

* There is a sliding info bar for measurements at any given point along the length of the board. In it, you can also show over curve measurements which makes it possible to get accurate measurements at any given point over the bottom curve. Very useful to get measurements as exactly as possible as it's hard to measure on the actual blank unless

you measure over the bottom curve. On the other hand, if you look at these measurement with regards to the x position the difference is not that big.

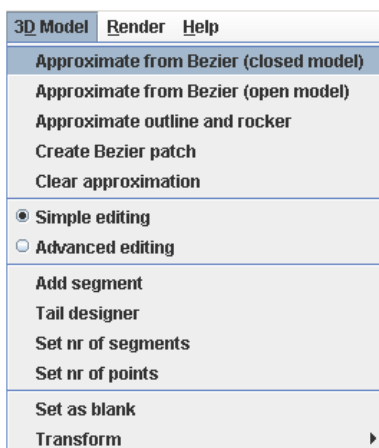
* You can view the curvature of the board to ensure that the curve is smooth. In particular around a control point the curvature graph may be discontinuous. This may be visible in a cut board or a template. The curvature graph can also be used to analyze the curves beyond what is otherwise possible visually. Note that the sliding info for bottom shows the radius of the curvature at any point which is also useful for analyzing the curvature of the rocker. Curvature can be compared between boards by loading a ghost board, when G is pressed the curvature of both the current board and the ghost board are shown (if 'show curvature' is selected).

* If you have zoomed in close and want to see how your changes affect the greater picture, you can click the spot check button or space bar to view the entire board, when you let go it returns to the previous zoom.



6. NURBS EDITING

BoardCAD has already from the beginning been using nurbs surfaces to model the boards in 3D. In the first version that was released, BoardCAD 0.5, all editing was done directly on the nurbs surfaces. However, in version 1.0, the user interface was changed and editing was mainly done in 2D using Bezier curves, while the 3D functionality was hidden to the majority of the users. With the release of version 2.0, the nurbs surfaces has again become more visible. In this chapter we show how to create nurbs surfaces from the Bezier curves, and how to edit the nurbs surfaces directly.

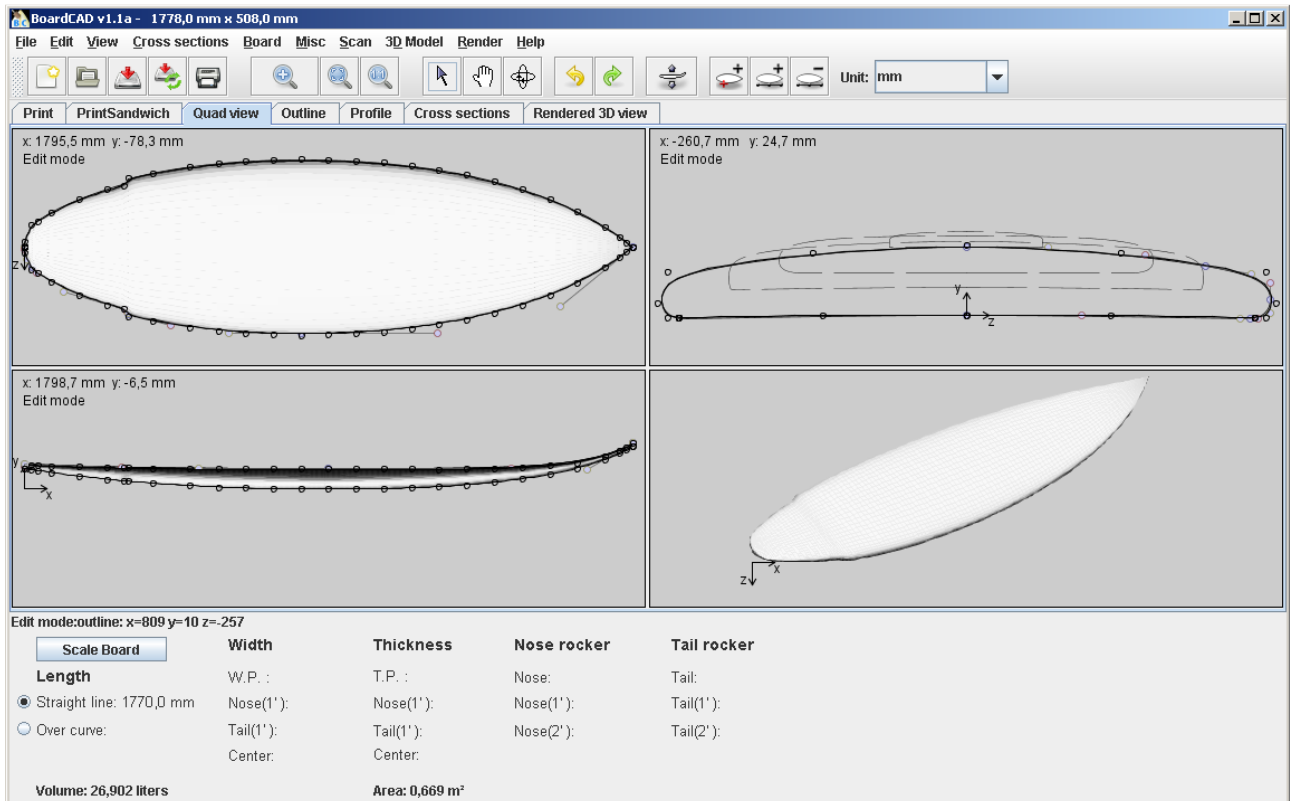
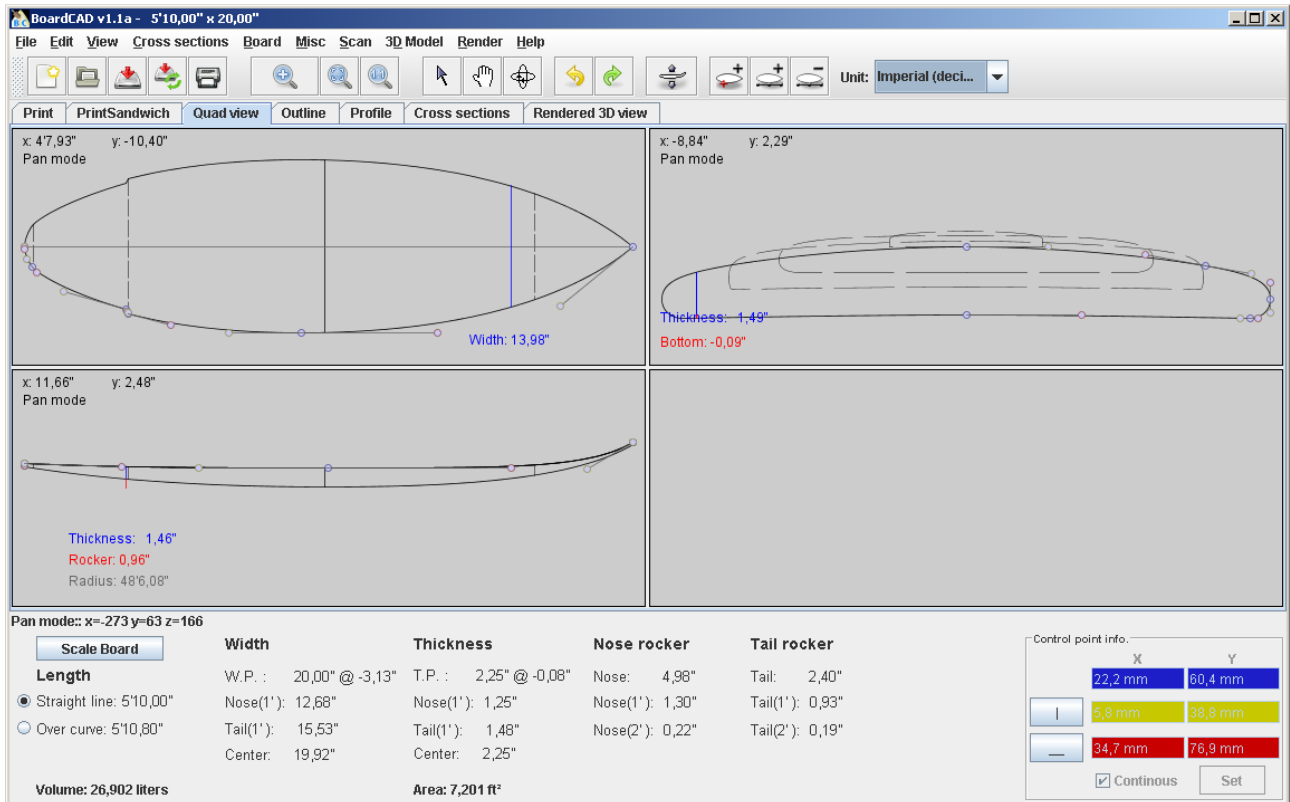


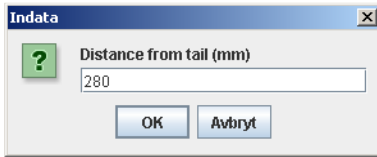
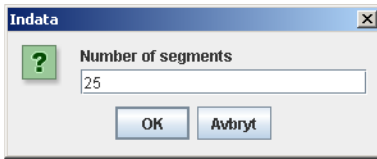
6.1 Generating nurbs surfaces

The nurbs surfaces are generated by choosing Approximate from Bezier in the 3D menu. You can chose to either close the surface in the tail and nose which gives the deck a rounded finish, or to simply leave it open which allows the surface to better approximate the deck line drawn in the 2D view. Note that the options Approximate outline and rocker, and Create Bezier patch, are not yet available in version 2.0.

Compared to version 1.0, BoardCAD version 2.0 uses much less control points in the default surfaces. To still get a good approximation, the segments are placed closer in the tail and the nose and more sparse in the center of the board. Reducing the number of segments is important to get a model that is small, easy to edit, and fast to cut on a CNC-machine.

As long as the Bezier curves are smooth, the default surfaces typically gives a good enough approximation of the Bezier curves. However, if there are some bumps, e.g. in the outline, it may be necessary to increase the number of segments. This can be done by selecting Set nr of segments in the 3D menu. We can also add more segments where





they are needed, or move the existing segments to a different position. In the example illustrated below we have increased the number of segments to 25 (default is 7), added another segment close to the winger, and finally moved a few of the segments a little closer to the winger. After this we have done a new approximation from the Bezier curves. This results in a 3D model very close to the original 2D curves.

6.2 Simple editing

It is possible to select between simple and advance editing by clicking on the radio buttons in the 3D menu. When simple editing is selected only points on the outline are shown in the outline view and only the central points along the rocker is shown in the profile view. If advanced editing all points are shown in the outline and profile view. In the cross section view all points in the selected segment are shown indifferently if we have chosen simple or advanced editing.

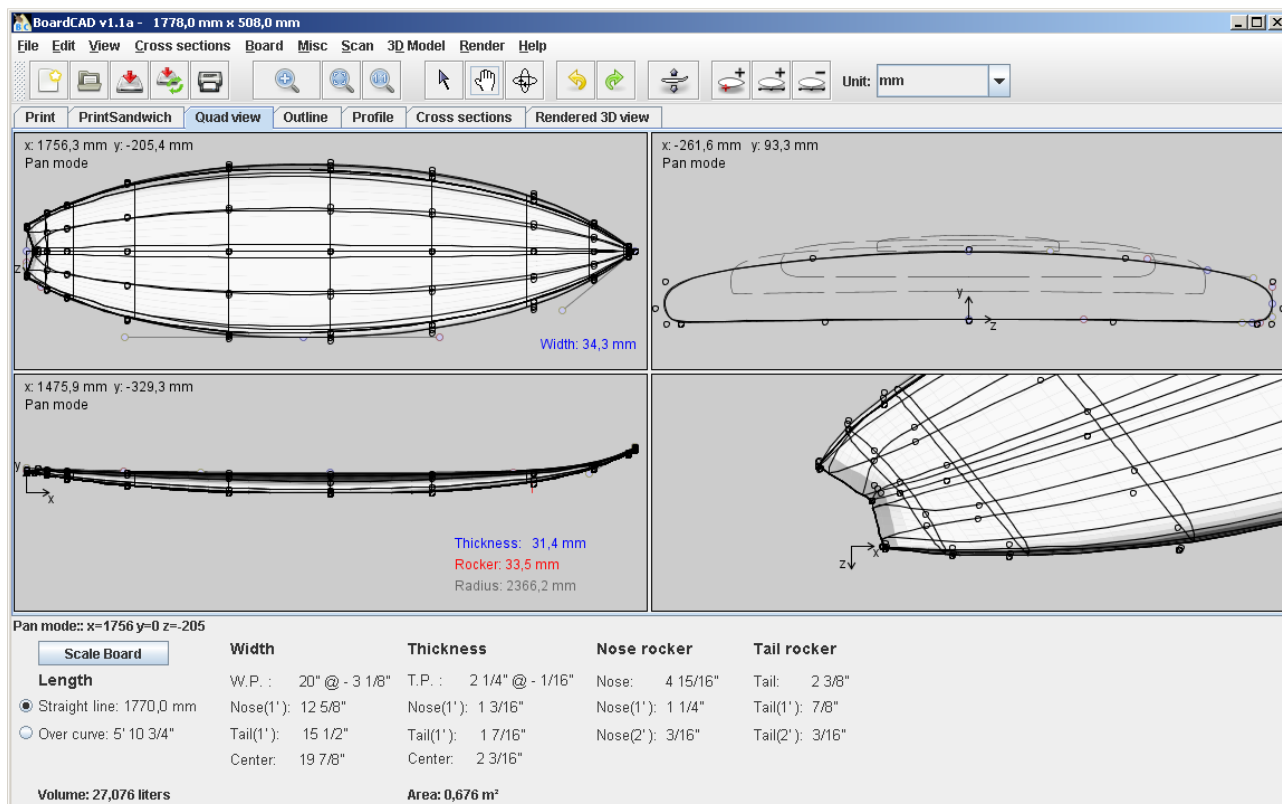
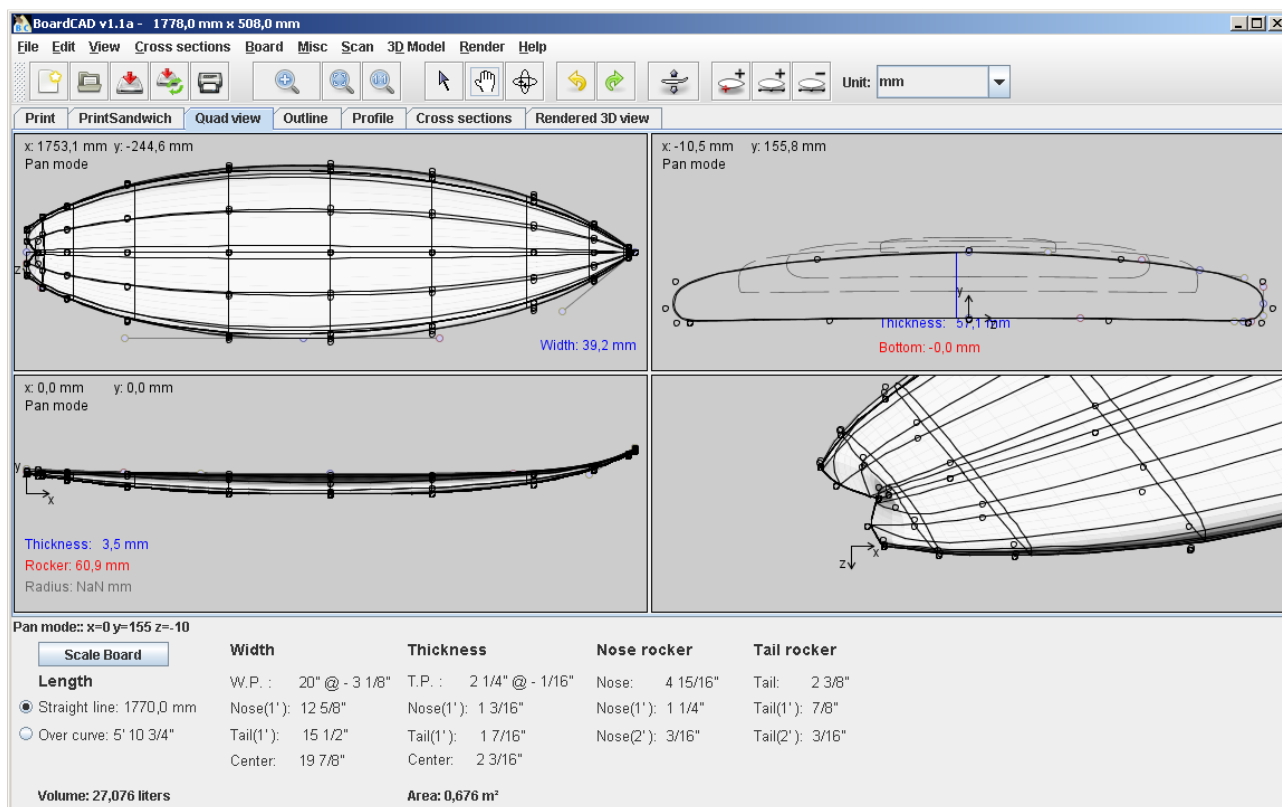
When we move an outline point and simple editing is chosen the width of the whole segment is scaled. Also, if a point is moved along BoardCAD's x-axis, all points in the same segment are moved to the same position. This makes it quick to do larger changes to the model or to fine tune the model in order to better approximate the Bezier curves.

6.3 Advanced editing

When advanced editing is chosen, each control point can be moved independently in 3D space. This is especially useful when working with swallow tails.

6.4 Tail designer

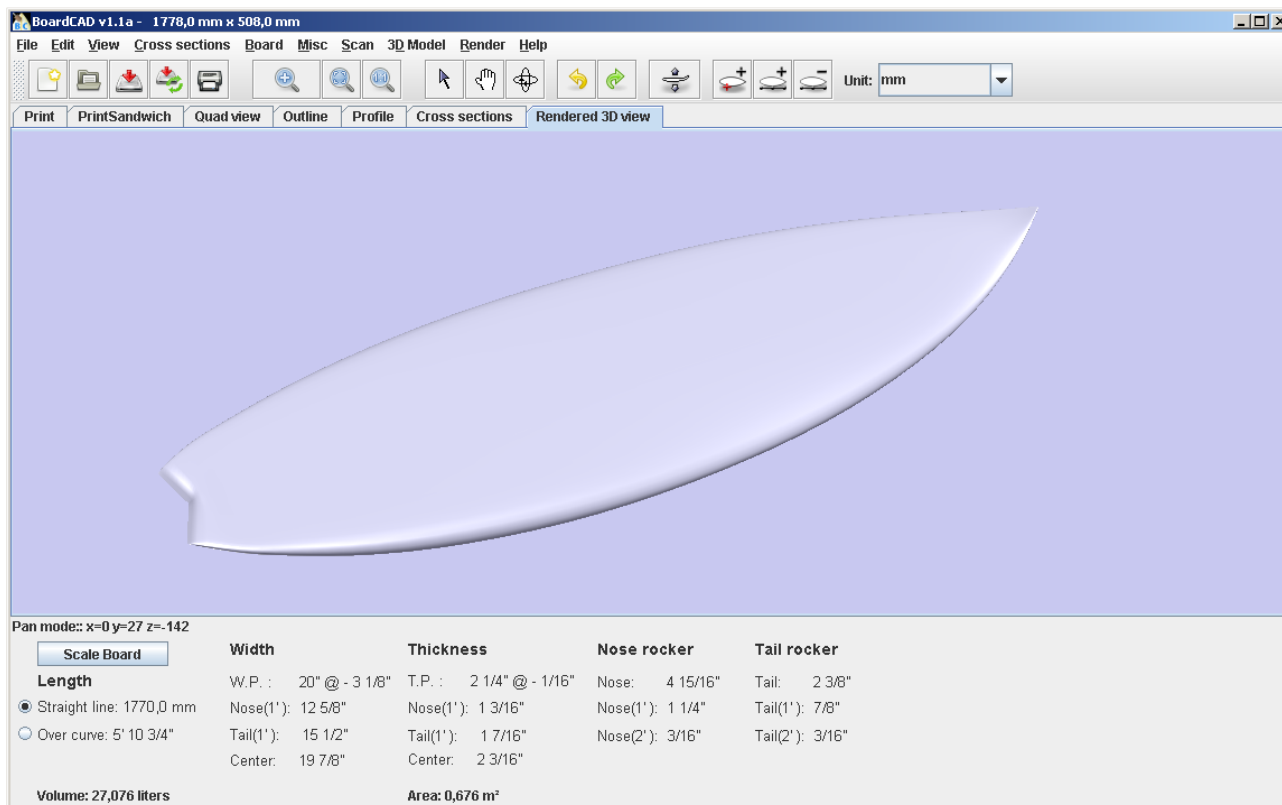
The tail design dialog is useful for creating swallow tails. By default, the last segment of the nurbs surface is collapsed into a single point. What the tail designer does is that it spreads out the points by setting the outline of the tail segment to the same z-value as the outline of the next segment. It also moves the center point of the tail segment forward to the desired position. This gives a good starting point for further editing the tail.





The first step, before even using the tail design dialog, is to make sure that the second segment has the width that we want for the swallow tail. This is done by simply clicking and dragging the outline point of the segment. We also want to make sure that the following segments all lies in front of the swallow tail. In order to move a segment forward we need to make sure that the x position is not locked. We do this by right clicking the mouse in the workspace and unmarking the X locked checkbox. Now we can click and drag the segment forward. Remember that we need to be in the simple editing mode in order to move the complete segment and not only the marked control point.

Now we are ready to use the tail designer, which can be found under the 3D menu. The tail designer creates a retro looking swallow tail. Further editing can be done by clicking and dragging the individual control points. In order to do that we first switch to advanced editing. The initial and final swallow tails are illustrated above.



6.5 Rendering 3D models

Finally we can view the 3D model under light using the Rendered tab. For the board model to appear in the rendered model we first have to render the nurbs surfaces. This is done in the Render menu.

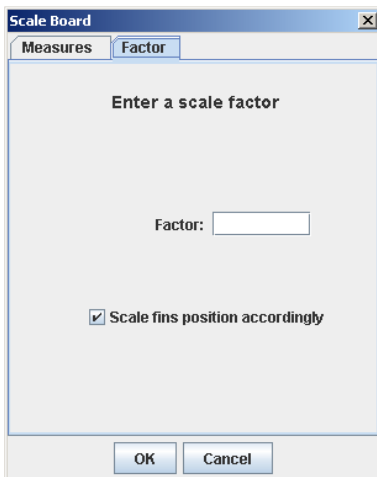
It is also possible to view a wireframe model of the board.

7. SCALING

Scaling board models is one of the most common operations, especially when it comes to customizing an existing model to a specific client. In the simplest form, we want to scale the whole board by a factor, i.e. to a certain percentage of the original size. However, in many cases we do not want to scale all dimensions equally. We may, for example, only want to change the length of a board. This can be done by scaling the board to a different measure.

In the current implementation the scaling dialog only works on the 2D-model, i.e. the Bezier curves. Separate functions are available for scaling the 3D-model.

7.1 Scaling by factor



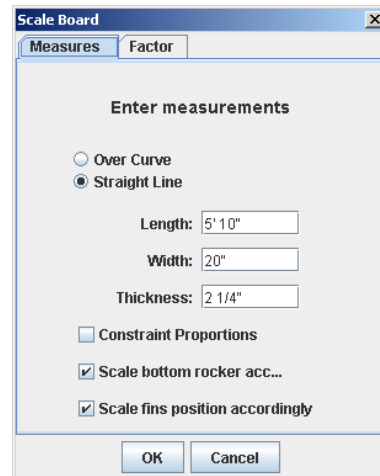
Scaling by factor is very easy. Bring up the scale dialog by clicking the Scale board icon, or by choosing Scale current board in the Board menu. In the Scale dialog, click on the tab Factor. Now you can simply type in the factor by which you want to scale the board. To make the board 10% larger use the factor 1.1, and to make the board 10% smaller - use the factor 0.9.

Scaling a board by a factor is very simple and it makes sure that the board model looks exactly as the original board (just a little bigger or smaller). On the other hand, if you are not very good with numbers or have a calculator by your side, it can be hard to predict exactly what will be the final measures of the board after the scaling is done. Also, the method is not very flexible as you can not control the different dimensions independently.

7.2 Scaling to measures

Scaling to measures is a much more powerful function than scale by factor. However, it has to be used carefully as some scale operations can result in undesired results such as bumps or S-decks, especially when scaling thickness and rocker independently. An extra warning is also issued for using Constraint proportions together with the imperial unit (especially if low fraction resolution is used). In those cases it is preferable to work with Imperial decimal or Metrics. Both these issues will be explained more in detail below.

First let us have a look at the Scale measures dialog window. As seen it is possible to enter the measures either as measured over curve or along a straight line. Next we have three input fields where we can type in the desired Length, Width, and thickness of the board. Below we have three check boxes.

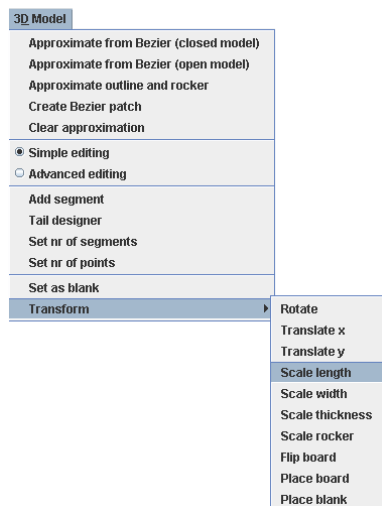
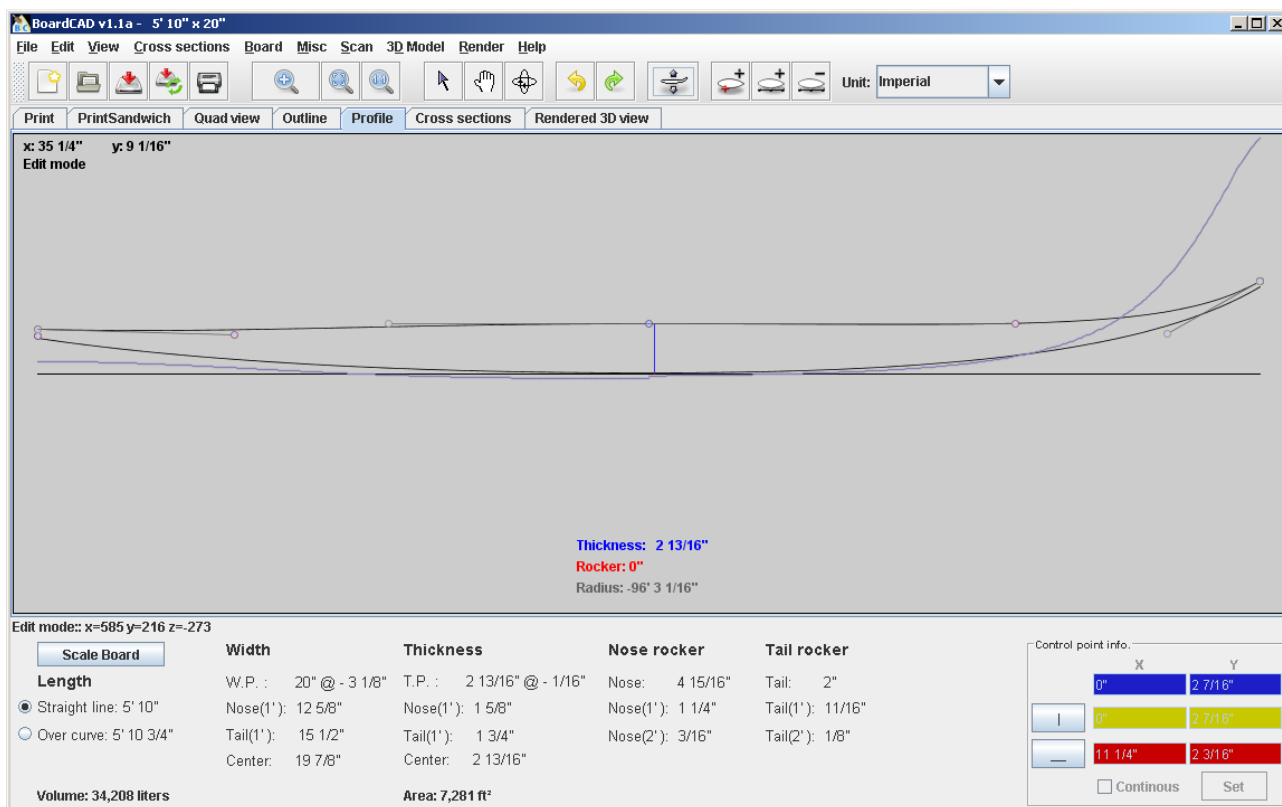


The screenshot shows the 'Scale Board' dialog box with the 'Measures' tab selected. The 'Enter measurements' section contains three radio buttons: 'Over Curve' (unselected) and 'Straight Line' (selected). Below these are three input fields: 'Length' with the value '5'10"', 'Width' with '20"', and 'Thickness' with '2 1/4"'. At the bottom, there are three checkboxes: 'Constraint Proportions' (unchecked), 'Scale bottom rocker acc...' (checked), and 'Scale fins position accordingly' (checked). 'OK' and 'Cancel' buttons are at the bottom right.

Constraint proportion - If checked, changing one of the measures will also change the others. This means that if you change the width from 20" to 22" in the dialog window shown, the length will automatically change to 6'5" and the thickness to 2,47". The values are updated when you click in one of the other fields, e.g. the input field for the thickness. Now, if we are using Imperial with 1/16 as fractional resolution, the thickness will be rounded to 2 7/16" (which is only 2,44"). As a result, if we then scale the width back to 20", the board model will be both shorter and thinner than the original board.

Scale bottom rocker accordingly - If checked, the rocker will change by the same fraction as the thickness. This ensures that we will not get any bumps in the deck surface as a result of the scaling. If we change the thickness without changing the rocker, the deck will rise more in the center of the board than in the tail and nose. As an example we have changed the thickness from 2 1/4" to 2 7/8". As can be seen by the negative curvature the deck gets an undesired S-form.

Scale fins positions accordingly - If checked, fins positions are scaled with the same factor as the rest of the board.



7.3 Scaling nurbs surfaces

The scale dialog does not affect the nurbs surfaces of the 3D model. Instead the 3D-model can be scaled by using the scaling commands in the submenu Transform under the 3D menu. Separate scale commands are available for Length, Width, Thickness, and Rocker. The scale of each measure is given as a scale factor. Just as fore scaling to measures, some care has to be taken when scaling thickness without scaling rocker to the same factor.

8. PRINTING

The board templates can be printed in full scale. In addition a spec sheet page can be printed or saved to an image file. Printing to pdf is not supported, however a virtual pdf printer can be used to generate a pdf file.

8.1 Printing specification sheets

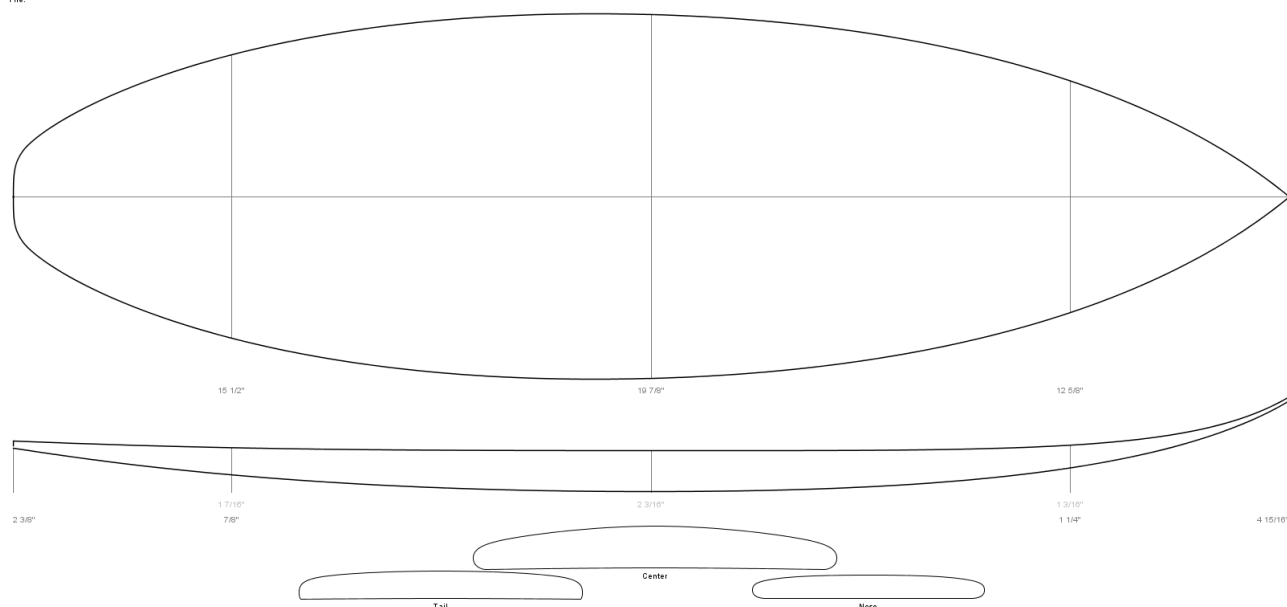


You can print a specification sheet by simply clicking the "Print spec sheet"-icon, or from the submenu Print under the File menu. The specification sheets can either be sent directly to the printer or be saved as a file.

BoardCAD

Spec sheet
Designer:
Surfer:
Measurements: 0' 10" by 10' 7/8" by 2' 3/16"
File:

Date: 21.17.2010
Model:
Volume: 27,076 liters

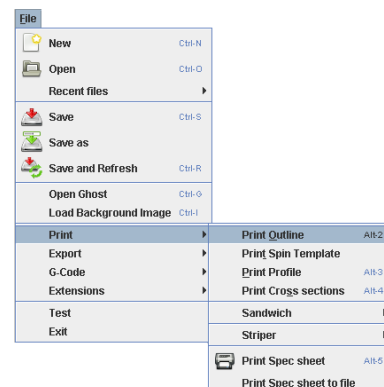


Fins
Fin type:

Comments:

8.2 Printing templates

When printing templates, the margins should be adjusted to the absolute minimum your printer can handle to minimize the amount of paper used. The difference between a wide and narrow margin can easily be the difference between one and two strips of paper being used. If you loose data in the print, adjust the margins up. You can check the print against the grid where each square should be an inch. Note that the printer may distort the image somewhat when print due to the paper feeder being inaccurate. Therefore it is recommended that you check the accuracy against the grid. You can not trust the edge of the paper being true to the print.



9. EXPORTING MODELS

One of the strength of BoardCAD is the possibility to exchange the board models with third party commercial CAD/CAM-systems. From version 2.0 we even base our native file format on STEP. This means that our board models can now be read directly by most CAD-systems without the need for exporting the board model. However, while STEP is an international standard it is still not supported by all systems. BoardCAD therefore support several different file format. The board can be exported in 3D in the formats step, dxf and stl to be cut by most standard CNC machines. To export in these formats you need to convert the board to 3D first. The board profile and template can also be exported in two different dxf formats to be used for cutting foam block with a hotwire cutter or cutting templates. Here we give a short introduction to the different formats and what is included in each of them in order to understand their strengths and limitations.

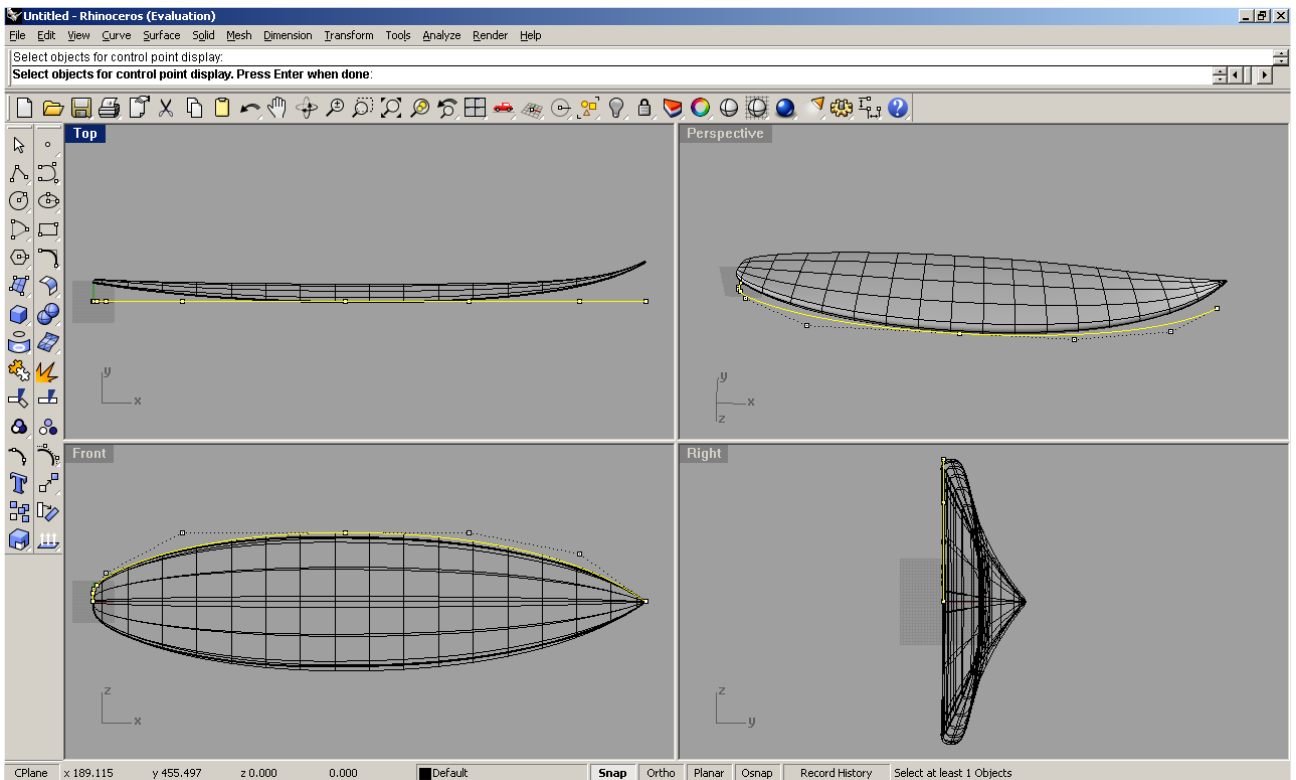
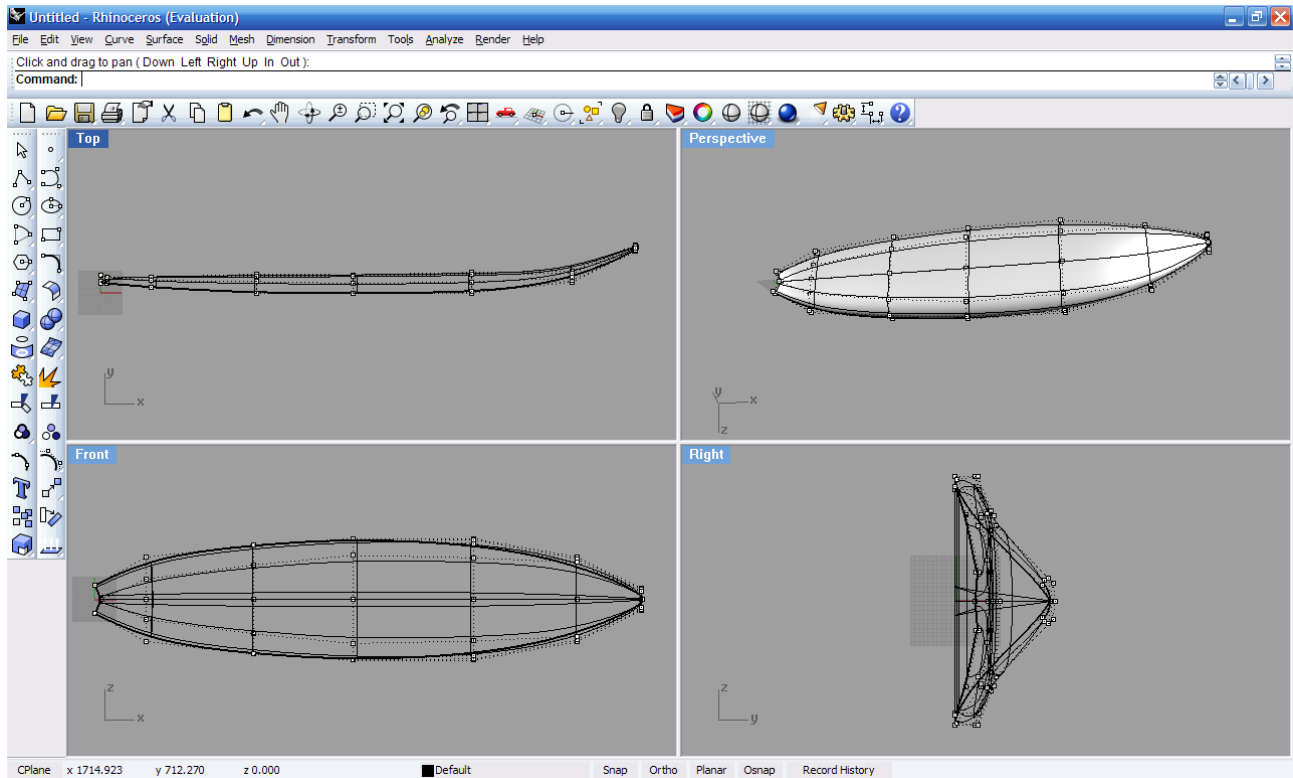
9.1 STEP



STEP (ISO 10303 - Standard for the Exchange of Product models) is an international standard for exchanging CAD data. This is a very large standard including not only the geometry model, but also large amounts of meta-data. Due to the large size, the STEP standard is divided into several APs (Application Protocols). The geometry data is defined in AP42, but most CAD-system implements AP203 (Configuration Controlled Design) and AP214 (Automotive Design).

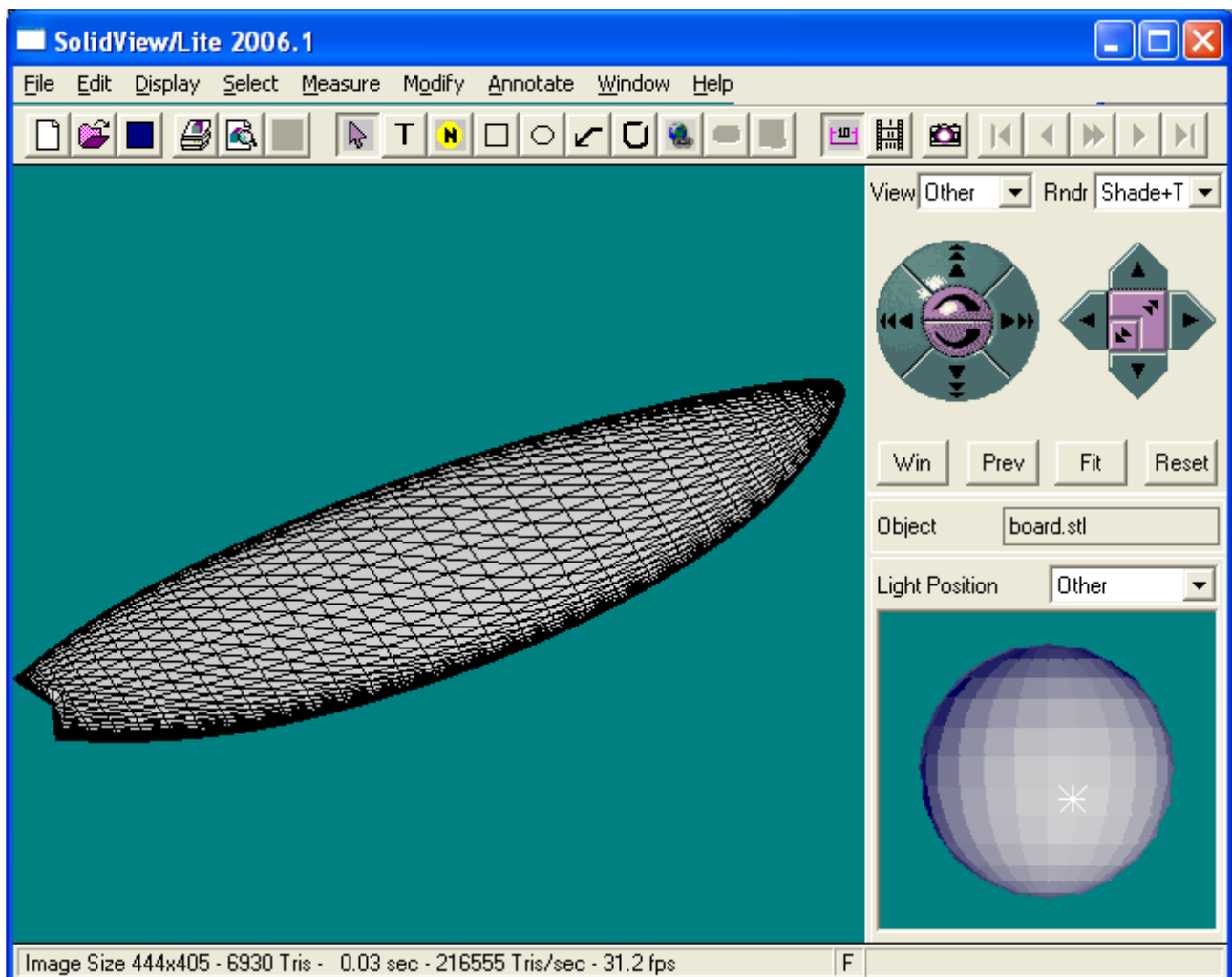
BoardCAD exports models based on AP203. The exported model include Bezier curves for outline, rocker, and cross sections, as well as well nurbs surfaces for the 3D-model.

Most CAD-systems will read the files, but in many cases only the 3D-model will be shown.



9.2 STL

STL is a file format native to the stereolithography CAD software created by 3D Systems. This file format is supported by many other software packages; it is widely used for rapid prototyping and computer-aided manufacturing. An STL file describes a raw unstructured triangulated surface. For BoardCAD this means that the original Bezier curves and nurbs surfaces cannot be described. Instead a triangulated model of the board is exported, i.e. the nurbs surfaces are converted into lots of small triangles. This makes the model very hard to edit when imported in another CAD-system. However, as long as the model will not be edited further the triangulated models work fine.

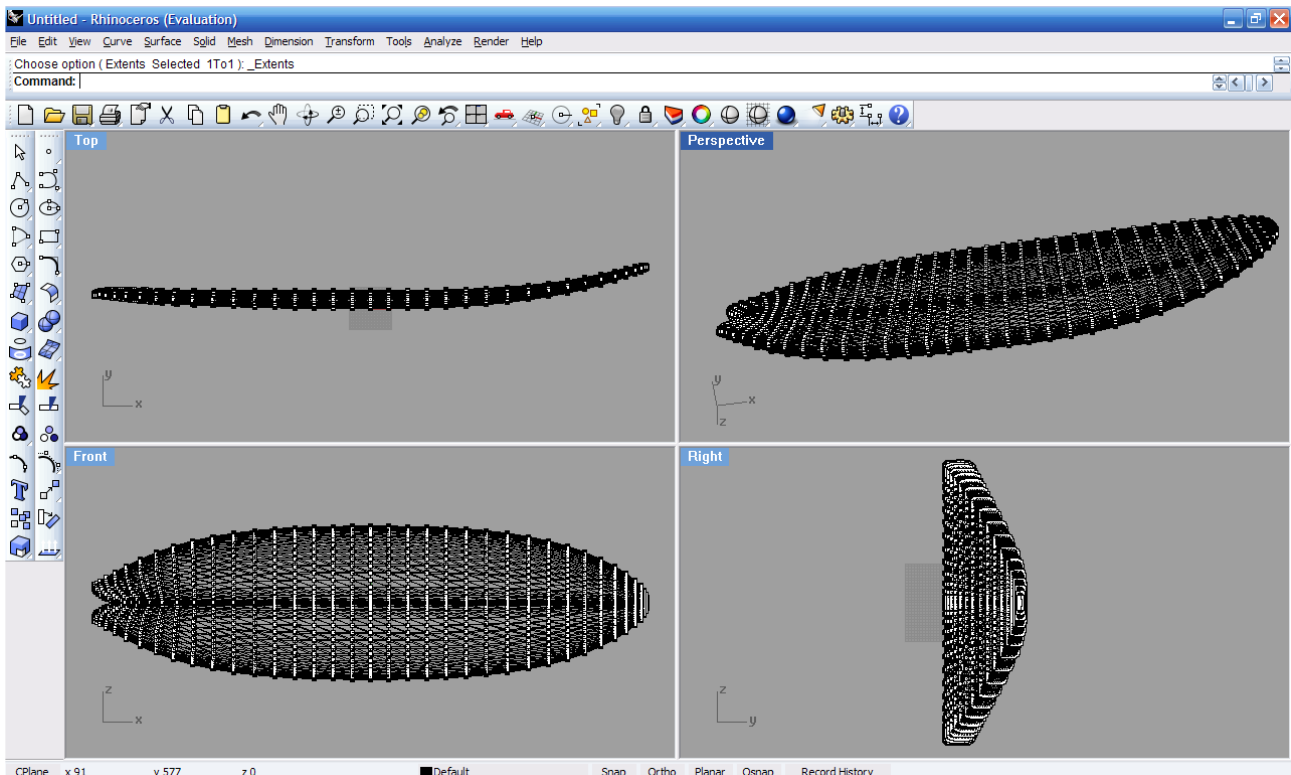


9.3 DXF

AutoCAD DXF (Drawing Interchange Format, or Drawing Exchange Format) is a CAD data file format developed by Autodesk for enabling data interoperability between AutoCAD and other programs.

With DXF, the 3D-model is limited to triangulated surfaces, just like in an STL-file, and therefore not suited for further editing.

Apart from the 3D-model, DXF-files can also export 2D Bezier curves. This is useful for exporting the outline, rocker, and cross sections for creating templates.

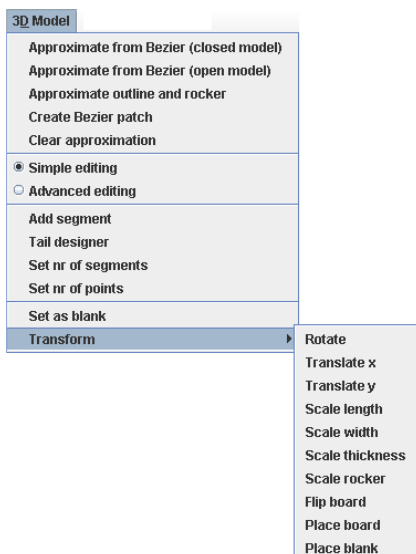


10. GENERATING AND EXPORTING G-CODE

With the release of version 2.0, BoardCAD does not only include full support for CAD (Computer Aided Design), but also for CAM (Computer Aided Manufacturing). BoardCAD can be configured to work with most types of 3-axis and 4-axis CNC machines (see Appendix A for instructions on how to configure your machine). This chapter gives step by step instructions on how to generate the G-code that controls the CNC-machine. All operations are done on the 3D-model and does not work with Bezier-models. If your boards or blanks are saved as .brd-files they should first be converted to NURBS-models and saved with .stp or .cad extension.

G-code is generated separately for the deck and for the bottom. You can start either by cutting the deck or by cutting the bottom. Here we start by cutting the deck.

10.1 Placing board model inside the blank



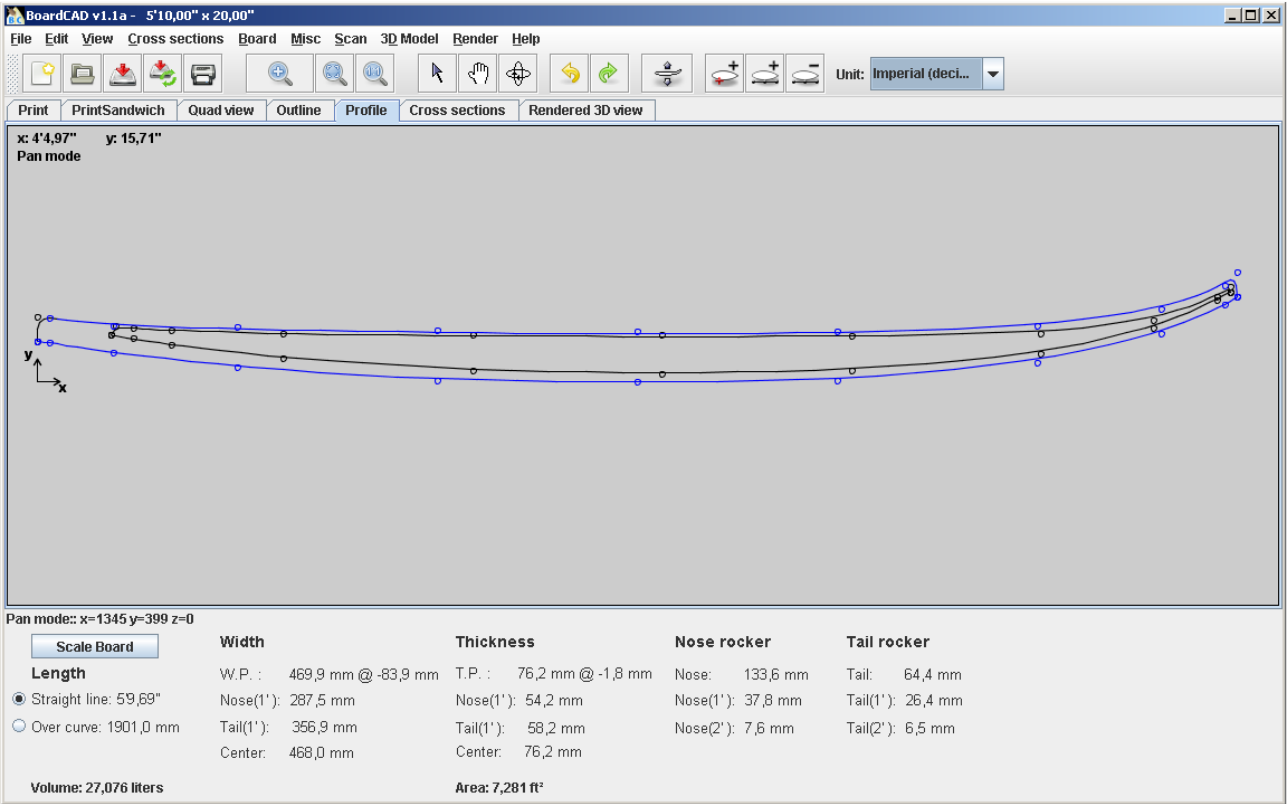
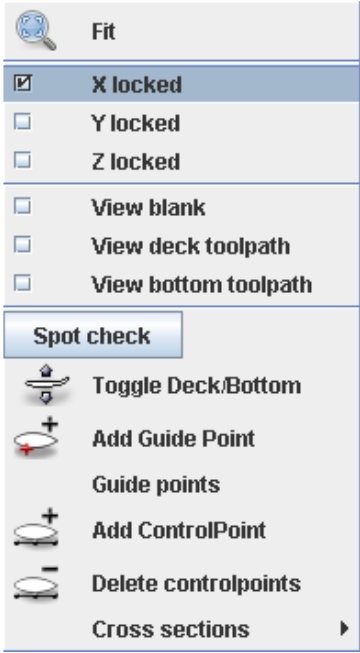
First we open our blank model. The blank model is just like any board model and is open through the File menu, Open board.

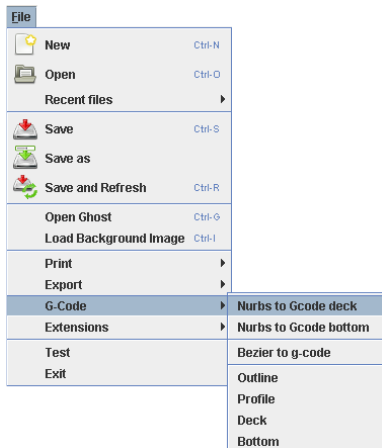
It is important to verify that the X-position of the blank model corresponds to the X-position of real blank in the machine. The routine for how to do this may differ slightly between different machines. However, all machines have an X-position that corresponds to $X=0$ in BoardCAD and that should be clearly marked (in Appendix A we show exactly how to setup this point). Now, if the blank is placed 100 mm in front of this point, but the blank model is placed at $X=0$, we need to translate the blank model to $X=100$ mm. This is done with the "Translate X" in the 3D-menu, under the submenu Transform.

Personally I've premarked the position of each blank size in the machine, and saved all my blank models in the correct position, in order to minimize the work.

Now let's assume that the blank model is already in the correct X-position. The blank is like any board model in BoardCAD, so the first thing we have to do is to tell BoardCAD that this model should be used as our blank. This is done by selecting "Set as blank" in the 3D-menu. When doing this the model will disappear from the workspace. To see the blank you have to right click the mouse in workspace and choose "view blank" in the popup menu.

Next we load the board that we want to cut. The board model must be placed inside the blank. This can easiest be done in the profile view. Use the commands "flip board", "translate x", "translate y", and "rotate" in the 3D menu to move the board model. One useful trick when rotating a board is to mark a control point in the board model that the board will rotate around. If no control point is marked the board will rotate around origo. Once you have positioned the board inside the blank it is good practise to save the model so you don't have to do this again if you want to cut the same board using the same blank in the future.

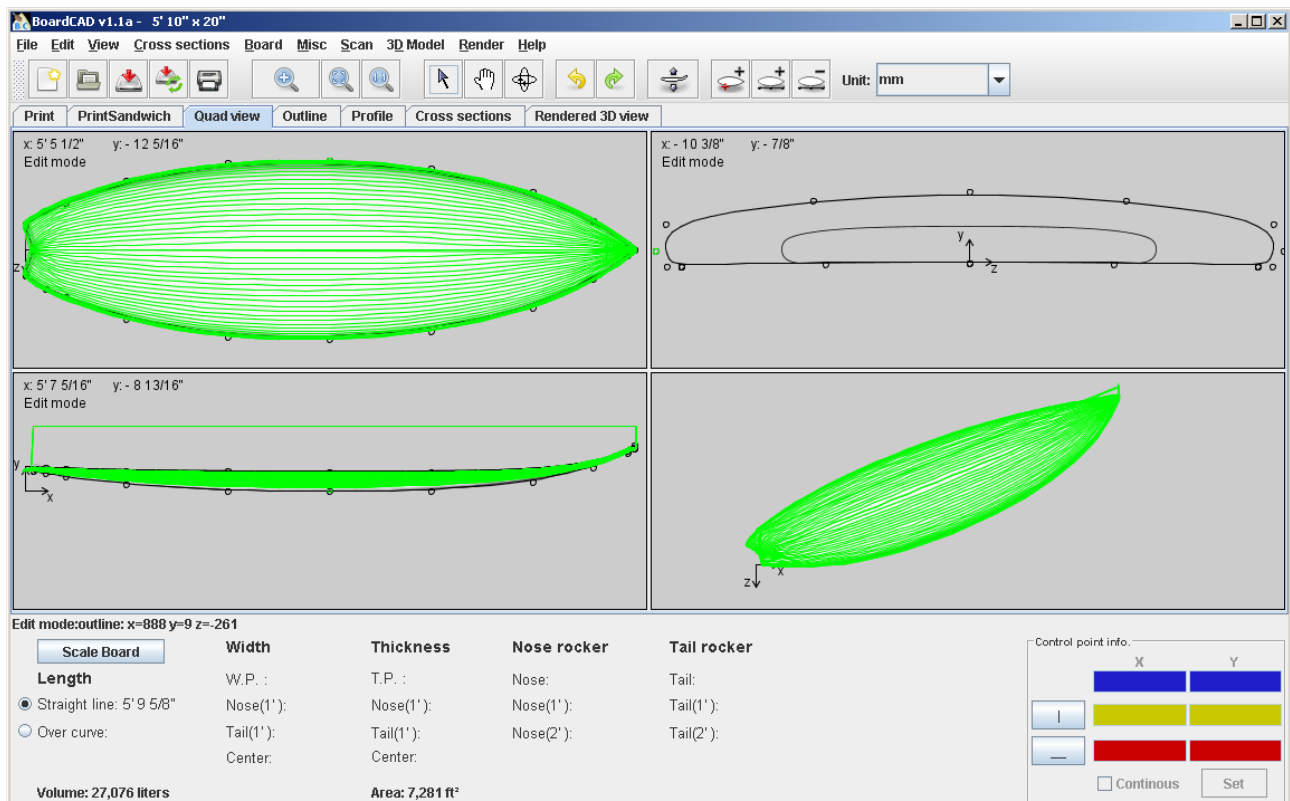




10.2 Generating deck cuts

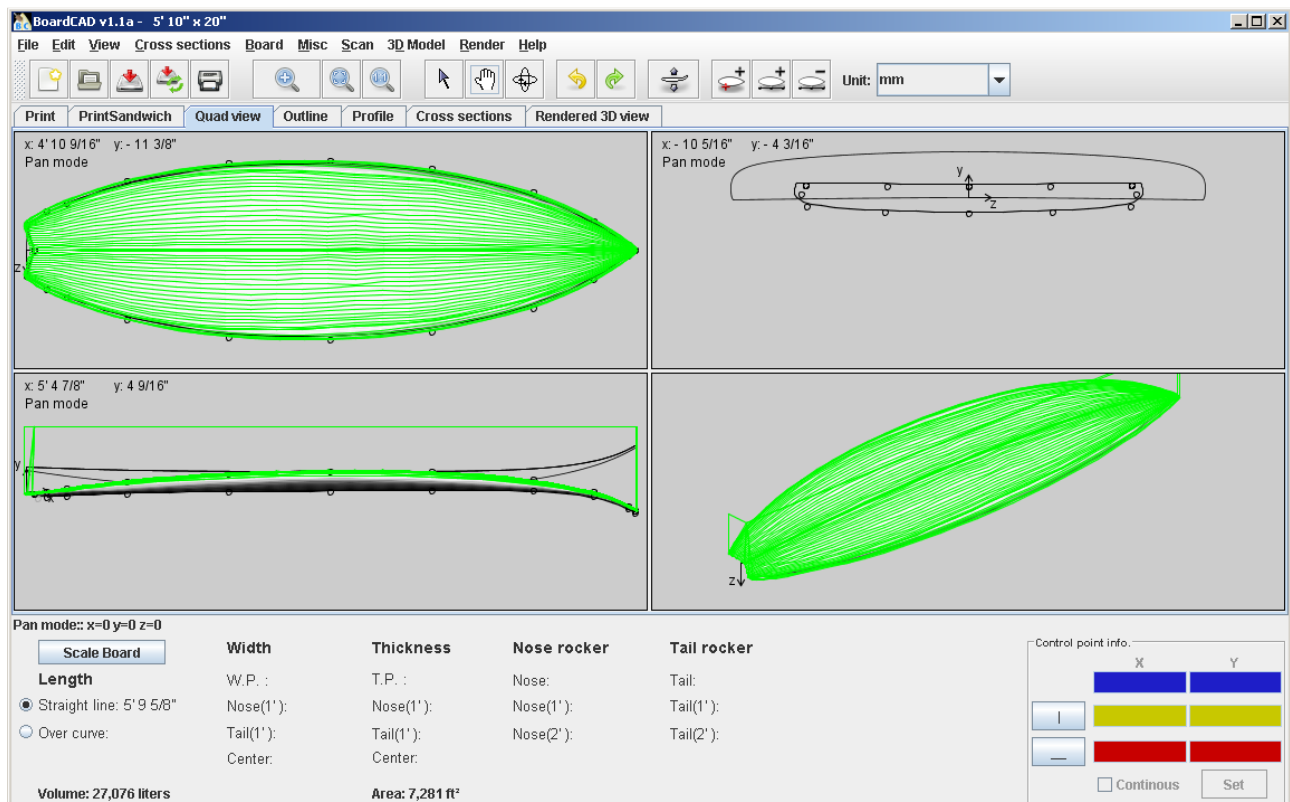
While we have already made sure that the horizontal position of the blank model corresponds to the horizontal position of the real blank in the machine, the same has to be done with the vertical position. This is done with the function "Place blank" in the 3D menu. This function will read the position of the blank supports from the machine configuration and move the blank, and the board inside the blank, until the blank rests on the supports. Now we can generate the cutting paths for the deck. This is done by choosing File, G-code, Nurbs to Gcode deck. Enter the file name for the cutting paths. While the file itself contains plain text, different machine controllers look for different file extensions. For example, machine controllers based on Linux CNC want the file name to end with the extension .ngc, so here we name the file deck.ngc.

We can visualize the cutting paths by marking "View deck cuts" in the popup menu.



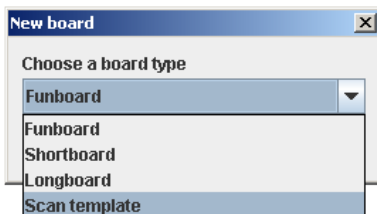
10.3 Generating bottom cuts

Generating tool paths for the other side of the board is easy. All we need to do is to choose "Flip board" in the 3D menu, followed by "Place board". This turns the board and make sure it is correctly placed on the machine supports. We are now ready to generate g-code by selecting File, G-code, Nurbs to Gcode bottom. We name the file bottom.ngc. Again we can visualize the cutting paths by marking "View bottom cuts" in the popup menu.



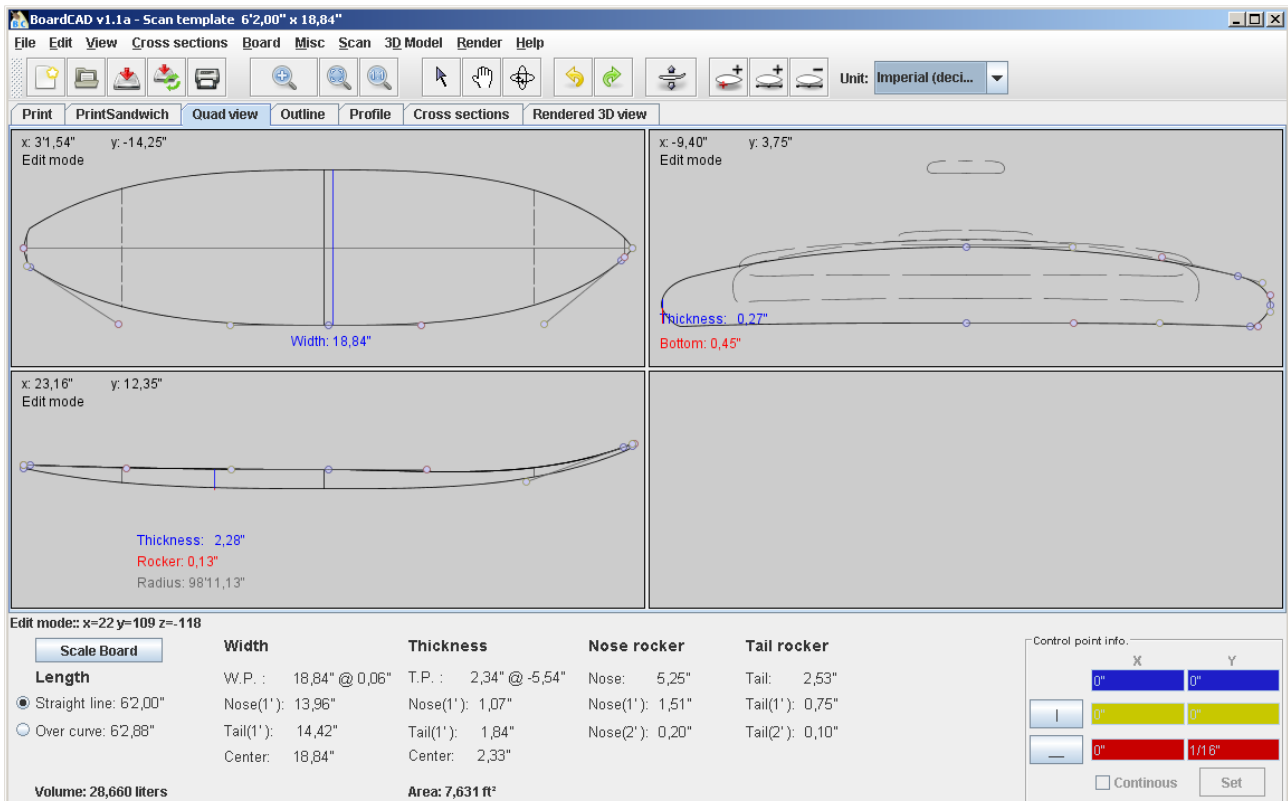
11. SCANNING BOARDS

This chapter shows how to measure an existing board and create a model of it in BoardCAD. The measurements can be taken either by hand or by using a CNC machine with a probe. We also show how measure the position of a blank, which is useful when you want to cut a board, but do not want to do a full scan of the blank.



11.1 Creating a scan template

Before making a scan it is necessary to create a scan template. A default template can be created by choosing File, New, and select the Scan template. This opens an initial board model that will later be fitted to the measured points. It is important to note that the scanning function will not



create a model that exactly fit all the measured points. Instead it tries to adapt the scan template to the measured points. This make sure that the final board model will be easy to edit. At the same time, the scan template puts some constraints on the final model that allow boardcad to create a complete model even with few measurements, and it also make the model more robust to noise in the measurements.

The scan template decides at which x-values the control points are placed, while the position of the tangent points are completely estimated from the measurements. As a result, the placement of the tucked under line will be mainly decided by the scan template. While the default scan template works well for most boards, in order to scan boards with a very rounded underside of the edge it may be necessary to edit the position of the tucked under line in the scan template. Currently it is not allowed to add or remove cross sections in scan template.

11.2 Manual scan of boards

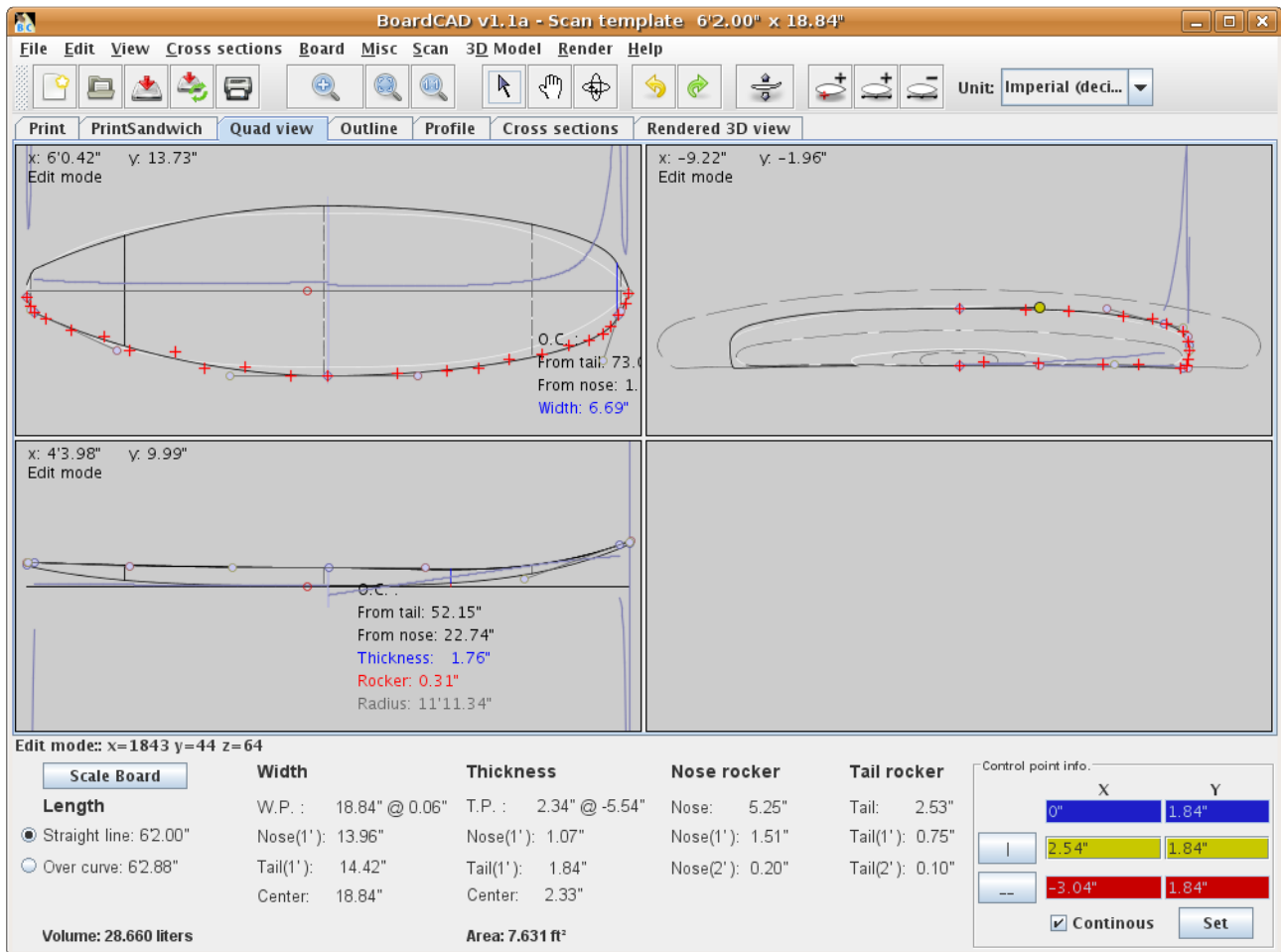
While the scan interface was originally developed to be used with a machine, several users have asked for a manual interface. To do a scan manually, the first step is to measure the board. The measurements can be taken either flat or over the bottom curve of the board. It is even possible to combine the two and for example take measurements of the outline at different at different positions from the tail, measured over curve, while taking the rocker measurements flat.

Next, the scan template has to be scaled to the length of the board. This is done in the same way as for any board model, by clicking scale board.

Now we need to type in all the measurements. This is done one curve at a time. Let's start with the outline. The measurements are added as guide points. We can do this either by selecting Add Guide Points and clicking in the outline window, or by bringing up the Guide Points dialog and write the measurements.

The final step is to fit the outline of the scan template to the measurements that we have typed in. This is done by selecting "Fit curve to guide points" in the Scan menu.

Scan
Read scanned board
Fit curve to guide points
Open scanned blank position
Hide scanned blank position



The same procedure can be used for the bottom, deck, and cross sections. When doing a manual scan there are no restrictions to the placement or the number of cross sections you use. Each cross section is handled individually.

11.3 Scanning board with a CNC machine

Taking measurements and typing them in by hand is very time consuming. Using a CNC machine can both reduce time and improve the accuracy of the measurements.

To take measurements with a CNC machine it has to be equipped with a probe. The probe can be either mechanical or optical, such as a laser probe.

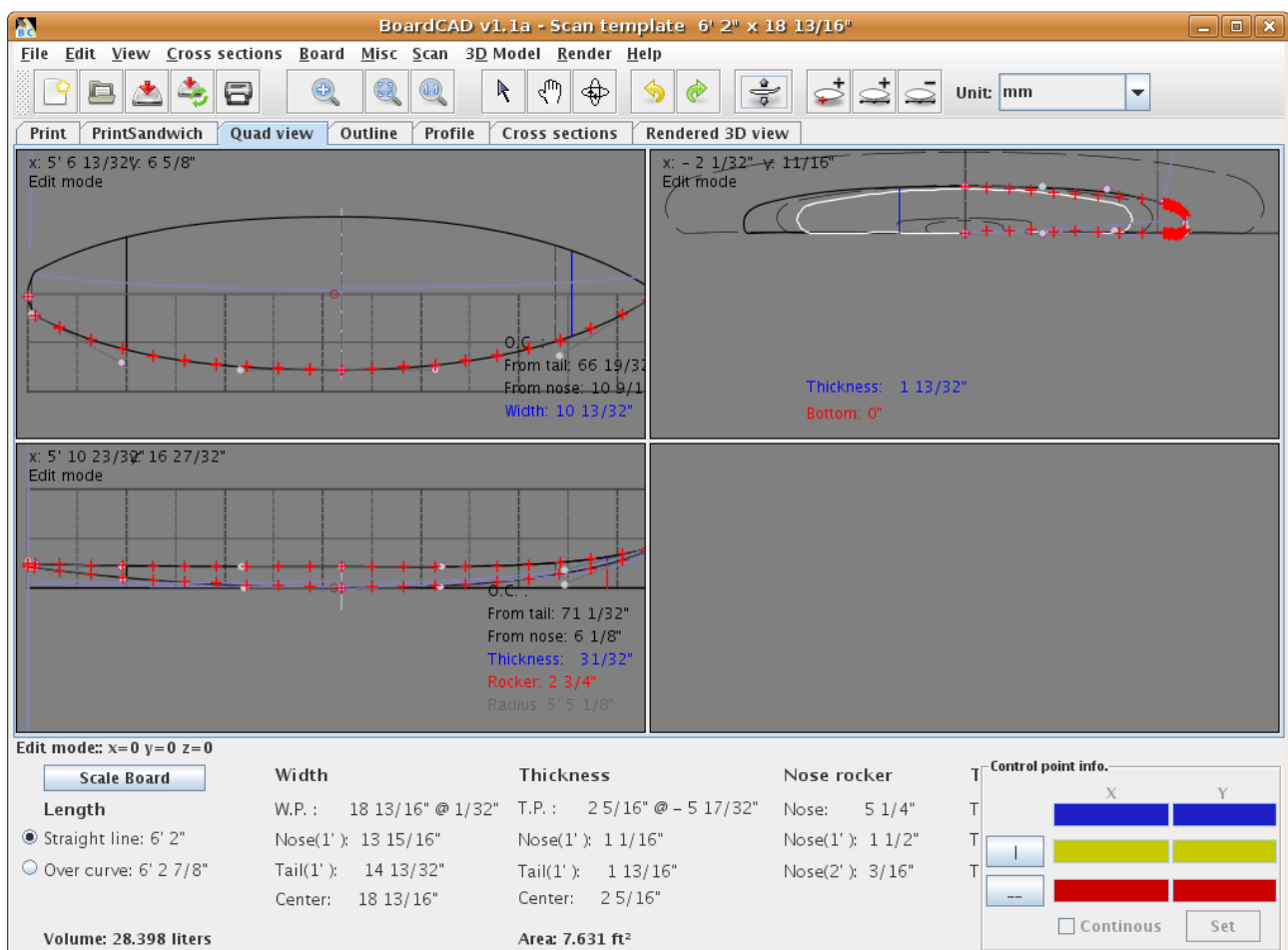
The main difficulty is to setup the machine to measurements of the board. BoardCAD expects the machine to first

measure the bottom of the board along the stringer, outline, and for three cross sections (1' from tail, center, and 1' from nose). Currently, no alterations are allowed regarding where the measurements are taken and how the files are named. Furthermore, the positions must be stored in separate files named:

bottom.txt
outline.txt
bottomsection1.txt
bottomsection2.txt
bottomsection3.txt

The board should then be turned and measurements should be taken along the stringer and for the cross sections. The positions should again be stored separately in the following files:

deck.txt
decksection1.txt



decksection2.txt
decksection3.txt

Getting the machine to take those measurements and store them in the files typically requires some script in the machine controller. How to write such a script is outside the scope of this book. Further, the position of the probe must be configured in order for BoardCAD to transform the measurements into BoardCAD coordinates. This is done in the shapebot.properties-file and described in Appendix A.

Once the machine is setup and the measurements have been taken, creating a model in BoardCAD from those measurements is very easy. The only thing we have to do is to create a new scan template and then select "Read scanned board" in the Scan menu. An example of a scanned board is shown above.

11.4 Editing a scanned board

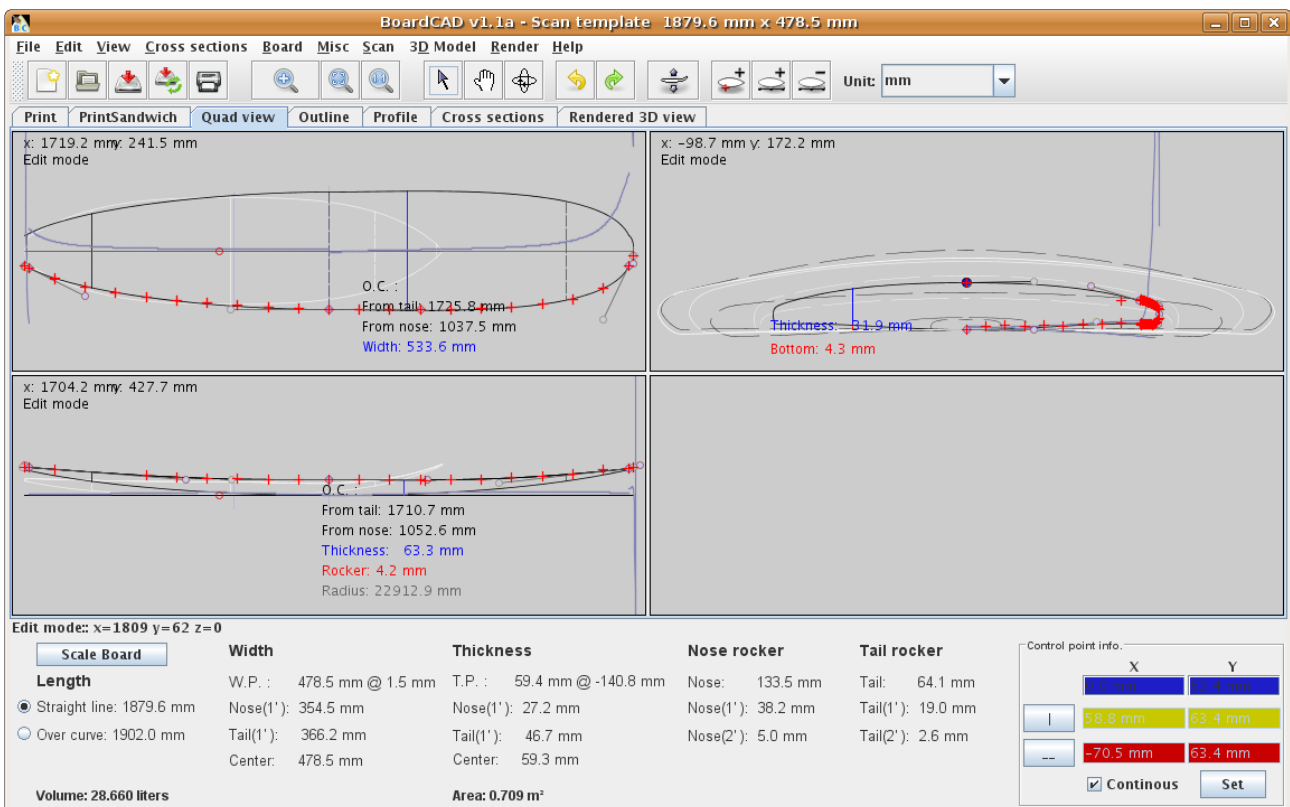
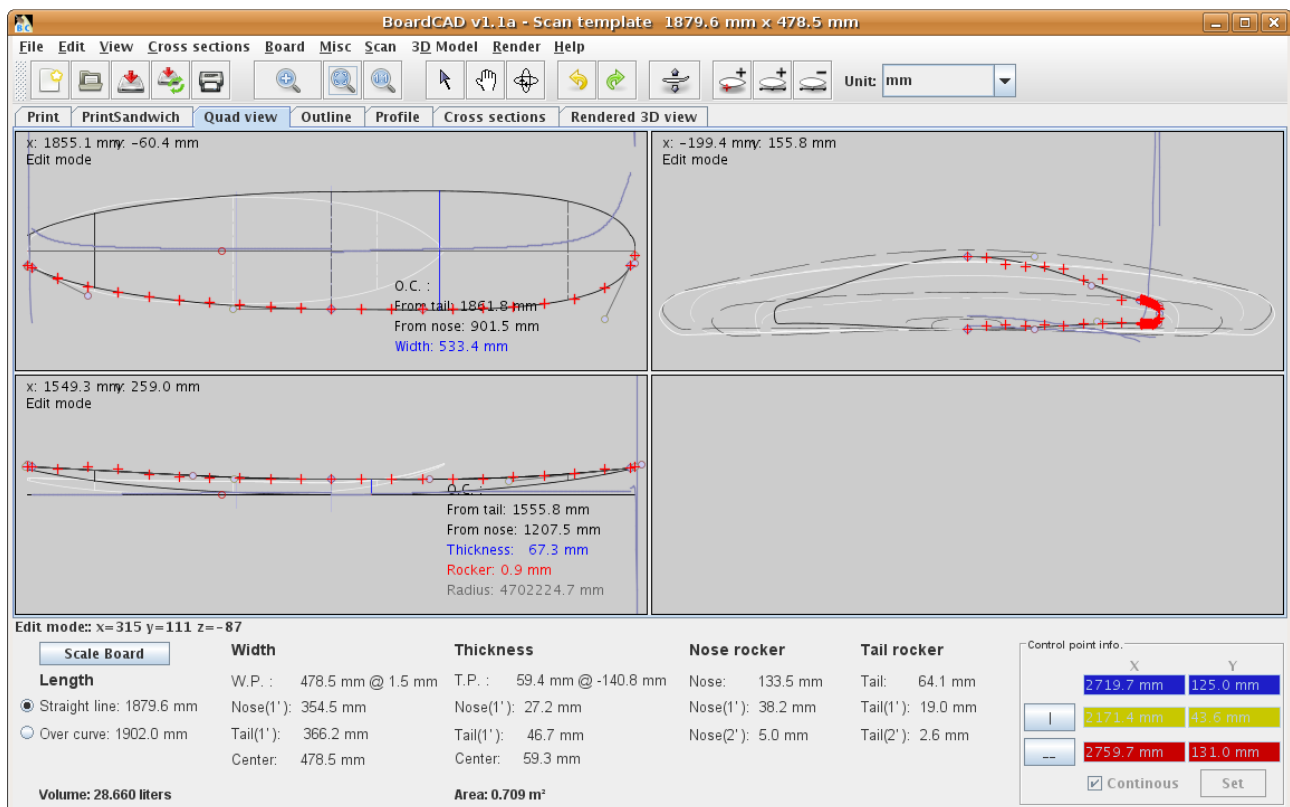
It is possible to edit a scanned board in two different ways, either by editing the measured points and reestimating the curves, or by directly editing the curves just like any board model.

The measured points are stored as guide points and can be edited just like any other guide point using the Guide Point dialog. This is an effective way to remove outliers, i.e. points that have large errors in the measurement. Such outliers can be a result of either problems with the probe or for example the presence of tail pads or straps on the board when measurements were taken. In many cases these points can simply be removed and the curve can be fitted again by selecting "Fit curve to guide points" in the Scan menu.

Editing the guide points and reestimating the curves is also necessary in order to set the thickness of the tail and nose.

11.5 Finding blank position

The scanner interface can also be used to show the position of the blank in the machine. This is useful if no blank model exists and you do not want to do a full scan of the blank. Again, this functionality is supposed to be used together



with a script in the machine controller that finds the tail and the nose of the boards and take measurements along the stringer. Those measurements should be stored in a file named scan.txt. Given that this file exists, the measured points can be opened and visualized in BoardCAD using "Open scanned blank position" in the Scan menu. The guide points can be used when positioning the board before generating g-code.

APPENDIX A – MACHINE CONFIGURATION

The CNC module in BoardCAD version 2.0 has been specifically developed for the Shapebot machine (www.shapebot.com), but can be configured to work with most types of 3-axis and 4-axis machines.

The machine configuration is done in a text file named `shapebot.properties`. This file should be placed in your home directory when using java webstart, or in the same directory as `BoardCAD.jar` when using the standalone executable jar-file. Note that you have to download this file separately from BoardCAD as it is not included in the jar-file. You will also need to download or create a model of your tool as an STL-file.

The Shapebot

In order to configure the machine interface it is necessary to know what the different parameters refer to, and how the Shapebot operates. The Shapebot is available with either three or four axis. The coordinate system is shown in the figure below. The X-axis goes along the surfboard, Y from right to left, Z upwards, and A rotates clockwise around the X-axis. The home position (0,0,0) is placed in the lower left corner.

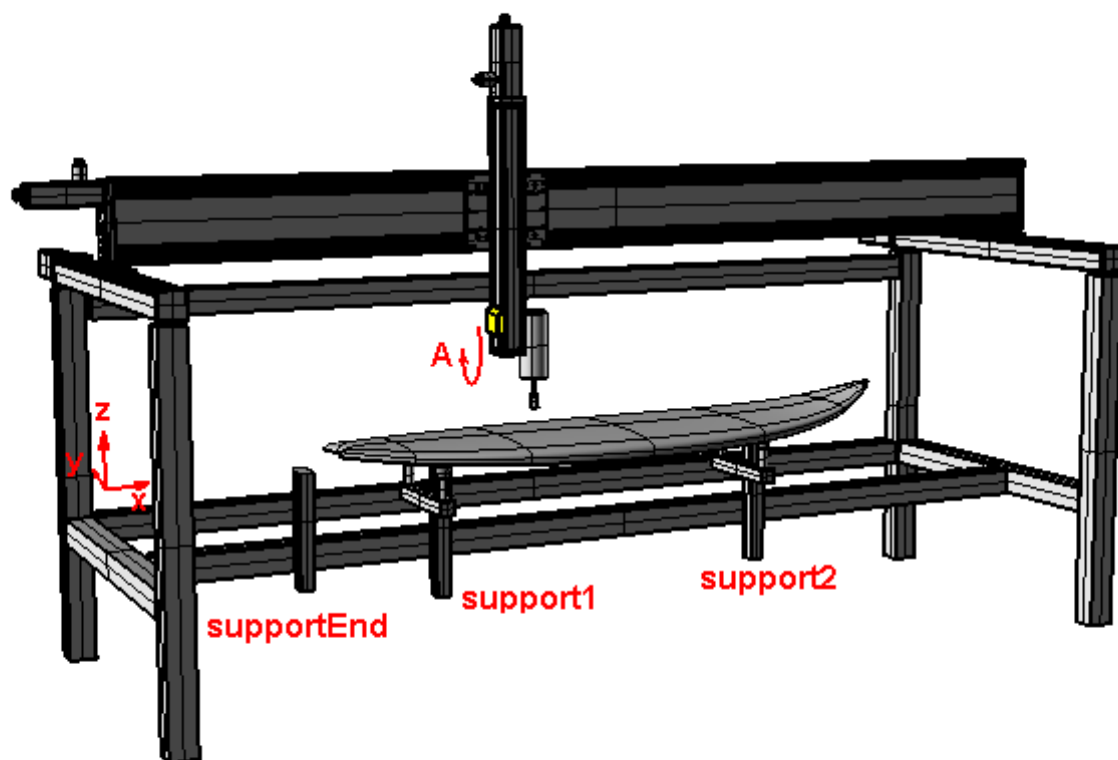
The blank is put on two fixed supports (`support1` and `support2`), where each support has two fixed cups of given radius and separated by a given width. The tail of the blank is put against a movable end support (`supportEnd`). When configuring the machine it is advisable to put the end support at a position that allows your most common blanks to rest evenly on the supports. We will later describe how to handle the case when you need to move the end support.

The shapebot can optionally be equipped with a laser probe.

The laser is mounted on the Z-axis and points downwards.
The laser probe is used for scanning blanks and boards.

Configuring shapebot.properties

All configuration is done in the file shapebot.properties. Here we first show the complete file content and then go into details on how to set the different parameters.



```

# G-Code settings

# Speed settings
g.lengthStep = 2
g.crossStep = 4
g.speed = 10000.0
g.outlineSpeed = 4000.0
g.stringerSpeed = 1000.0

# Optional cuts
g.cutStringer = 0
g.apexExtraDepthDeck = 20.0
g.apexExtraDepthBottom = 0.0
g.cutExtras = 1
g.outlineOffset = 3.0
g.stringerCutoff = 55.0
g.cutRail = 0

# Cutter model
g.toolName = flatcutter.stl
g.toolScaleX = 1.0
g.toolScaleY = 1.0
g.toolScaleZ = 1.0

# Collision detection
g.checkCollision = 0
g.collisionToolName = flatcollision.stl
g.collisionToolScaleX = 0.9
g.collisionToolScaleY = 0.9
g.collisionToolScaleZ = 0.9
g.collisionOffsetZ = 1.0

# Sandwich settings
g.sandwichThickness = 0.0
g.perimeterSize = 0.0

# G-code settings for formatting the output.
g.includeComments = true
g.commentStart = (
g.commentEnd = )
g.stopSign = M2

# Machine settings
g.zMaxHeight = 430.0
machine.support1.distance = 955
machine.support1.widthBetweenSupports = 200
machine.support1.height = 300
machine.support1.radius = 35
machine.support2.distance = 1902
machine.support2.widthBetweenSupports = 200
machine.support2.height = 300

```

```
machine.support2.radius = 35
machine.supportEndX = 418
machine.supportEndY = -461
machine.supportEndZ = 300

# Axis configuration
machine.axisForBoardcadX = X
machine.axisForBoardcadY = -Z
machine.axisForBoardcadZ = Y
machine.aliasX = Y
machine.aliasY = Z
machine.aliasZ = X
machine.aliasA = A
machine.multiplierX = 1.0
machine.multiplierY = 1.0
machine.multiplierZ = 1.0
machine.multiplierA = 1.0

# Scanner settings
scanner.supportEndX = 227
scanner.supportEndY = -461
scanner.supportEndZ = 224
scanner.path = /home/jonas/scan/

# 4th axis settings
machine.axis = 3
machine.axis4.offsetX = 0
machine.axis4.offsetY = 0
machine.axis4.offsetZ = 125
machine.axis4.offsetRotation = 133.4
machine.axis4.rotationAxis = X
machine.axis4.railStart = 135
machine.axis4.railStop = 135
```

Speed settings

Simply speaking, g-code is a list of points that the machine will pass through. Each point is connected with a straight line and together these lines make up the cutting path. The more points that we specify, the closer the cutting path will approximate the shape of the board. However, it will also take longer to cut the board. Generic g-code generators typically distribute the points at equal distances, e.g. at each cm along the board. BoardCAD instead follows the parameterization of the surfaces. That means that it automatically generates more points at the tail, nose, and rail where the surfaces have more control points. The same is done at places where you've added extra control points, e.g. at a bump. By changing `g.lengthStep` and `g.crossStep` you will specify the number of points that will be generated between each control point in the cutting path. The `lengthStep` decides how many intermediate points that will be generated along each pass from tail to nose (and back from nose to tail) while `crossStep` will decide how many passes that will be done. Multiplying the `crossStep` with 2 will also increase the cutting time by 2. Changing the `lengthStep` has less effect than changing the `crossStep`, but depending on the acceleration of the machine it can still be an important factor in order to obtain the desired cutting speed. The desired cutting speeds for the center stringer, outline, and the rest of the board are configured by the parameters `g.stringerSpeed`, `g.outlineSpeed`, and `g.speed` respectively.

```
# Speed settings
g.lengthStep = 4
g.crossStep = 8
g.speed = 10000.0
g.outlineSpeed = 4000.0
g.stringerSpeed = 1000.0
```

Optional cuts

Apart from following the parameterization of the surface, it is possible to add or remove a number of optional cuts. By setting `g.cutStringer` to 0, the cutting path will stay away from the center of the board in order to avoid cutting the wooden stringer. By setting `g.cutExtras` to 1, two additional cuts will be made for the stringer (one at 10mm above the board and one at 5mm above the board) and an additional cut will also be made 20mm above the outline of the board (and for 4-axis machines

also at the apex and 30 mm below the apex). The latter cuts can be made slightly outside the final outline by setting `g.outlineOffset`. If `g.cutExtras` is chosen the machine will also cut off the stringer by making a deeper cut in the tail and nose using the value specified at `g.stringerCutoff`.

On a three axis machine the deck will be cut until the apex of the rail. The last cut at the apex can be done at an extra depth by specifying `g.apexExtraDepthDeck` in order to completely remove the foam of the rail. On a three axis machine, the underside of the rail is cut together with the bottom by setting `g.cutRail` to 1. As for the deck it is possible to add some extra depth to the apex cut by specifying the value in `g.apexExtraDepthBottom`.

```
# Optional cuts
g.cutStringer = 1
g.cutExtras = 1
g.outlineOffset = 3.0
g.stringerCutoff = 55.0
g.apexExtraDepthDeck = 0.0
g.cutRail = 1
g.apexExtraDepthBottom = 0.0
```

Cutter model

In order to compensate for the cutter, it is necessary to provide BoardCAD with a CAD-model (in .stl file format) of the cutter used by the machine. A number of standard cutters can be downloaded from BoardCAD's homepage. It is possible to change the scale of the file by changing the values for `g.toolScale`.

```
# Cutter model
g.toolName = flatcutter.stl
g.toolScaleX = 1.0
g.toolScaleY = 1.0
g.toolScaleZ = 1.0
```

Collision detection

The g-code generation includes a simple version of collision detection that verifies that no part of the tool enters inside the board model. For smooth surfaces, the risk of getting a collision is relatively low, but for sharp corners such as

wingers, collisions are quite common. The current collision detection only look for collisions in the near neighborhood of the desired cutting point in order to keep the algorithm reasonably fast. Collisions are shown as red lines in the cutting path preview. The collision detection is enabled by `g.checkCollision = 1`. It is possible to use different tools for cutting and for collision detection. Typically a less detailed tool model can be used in order to speed up the collision detection, but the model can also include part of the router and Z-axis in order to make sure that these do not hit the foam during cutting. Just as for the cutter model it is possible to scale the tool model. It is also possible to change z-position of the same.

```
# Collision detection
g.checkCollision = 0
g.collisionToolName = flatcollision.stl
g.collisionToolScaleX = 0.9
g.collisionToolScaleY = 0.9
g.collisionToolScaleZ = 0.9
g.collisionOffsetZ = 1.0
```

Sandwich settings

For sandwich boards it is necessary to make a deeper cut in order to compensate for the thickness of the sandwich. This is done by setting the `g.sandwichThickness`. By setting this to a positive value more foam will be removed. It is also possible to use this parameter in order to leave some extra foam that will be removed by hand by setting the parameter to a negative value.

If a perimeter stringer is used and the sandwich does not wrap the rail it is possible to set the distance from the rail at which the sandwich will start by using `g.perimeterSize`. Note that you'll first have to cut the complete rail using 0.0 as perimeter size and then do a second cut with whatever value you want for the perimeter.

```
# Sandwich settings
g.sandwichThickness = 0.0
g.perimeterSize = 0.0
```

G-code formatting

It is possible to control if and how comments are added to the g-code and to specify a specific stop sign that will be written in the end of the file.

```
# G-code settings for formatting the output.
g.includeComments = true
g.commentStart = (
g.commentEnd = )
g.stopSign = M2
```

Machine settings

The machine settings controls how the board will be transformed from BoardCAD coordinates to shapebot coordinates and is configured by adding the machine coordinates for the supports that holds the board. The first parameter `g.zMaxHeight` specifies the Z-value at which the machine can make rapid movements without having to worry about hitting the blank. The coordinates for `machine.supportEnd`, `machine.support1`, and `machine.support2` are all measured in machine coordinates. It is also necessary to add the distance between the cups on which the board is placed and the radius of each cup.

```
# Machine settings
g.zMaxHeight = 430.0
machine.supportEndX = 418
machine.supportEndY = -450
machine.supportEndZ = 130
machine.support1.distance = 955
machine.support1.widthBetweenSupports = 200
machine.support1.height = 130
machine.support1.radius = 35
machine.support2.distance = 1902
machine.support2.widthBetweenSupports = 200
machine.support2.height = 130
machine.support2.radius = 35
```

Axis configuration

If your machine use different names for the axis than the shapebot, it is possible to rename each axis my setting the `machine.alias`. It is also possible to change the sign or the scale by using the `machine.multiplier` parameters. Note that you should not edit the `machine.axisForBoardCAD` parameters.

```
# Axis configuration
machine.axisForBoardcadX = X
machine.axisForBoardcadY = -Z
machine.axisForBoardcadZ = Y
machine.aliasX = Y
machine.aliasY = Z
```

```
machine.aliasZ = X
machine.aliasA = A
machine.multiplierX = 1.0
machine.multiplierY = 1.0
machine.multiplierZ = 1.0
machine.multiplierA = 1.0
```

Scanner settings

A probe can be used to scan blanks and boards. To scan a board I place it in the machine with the bottom facing up and take measurements along the stringer, outline, and for three cross sections (1' from tail, center, and 1' from nose). G-code for taking these measurements is supplied with the shapebot machine. For other machines you'll have to write this code yourself. The positions should be stored in separate files named:

```
bottom.txt
outline.txt
bottomsection1.txt
bottomsection2.txt
bottomsection3.txt
```

Then turn the board and again take measurement along the stringer and the cross sections and store the positions in the files:

```
deck.txt
decksection1.txt
decksection2.txt
decksection3.txt
```

Currently no alterations are allowed regarding where the measurements are taken and how the files are named.

Before you can read the scanned positions in BoardCAD we have to configure the scanner in the shapebot.properties file. There are four lines we need to edit. The first three lines gives the coordinates for the end support in the scanner's coordinate system. These can be found by simply probing the end support. There is also a line for setting the path to where the probe data is stored.

```
# Scanner settings
scanner.supportEndX = 227
scanner.supportEndY = -461
scanner.supportEndZ = 224
scanner.path = /home/jonas/scan/
```

Four axis settings

In order to use four axis machine it is necessary to set `machine.axis = 4`. It is also necessary to set the offset between the tooltip and the rotation center by setting the parameter `machine.axis4.offsetZ`. It is also necessary to set the angle at which the tool points straight down by using `machine.axis4.offsetRotation`. It is possible to cut the rail either with the tooltip or with the side of the cutter. Specify the angle at which you want to start using the side of the cutter by setting `machine.axis4.railStart`, and the angle at which you want to stop cutting the rail by setting `machine.axis4.railStop`.

```
# 4th axis settings
machine.axis = 3
machine.axis4.offsetX = 0
machine.axis4.offsetY = 0
machine.axis4.offsetZ = 125
machine.axis4.offsetRotation = 133.4
machine.axis4.rotationAxis = X
machine.axis4.railStart = 135
machine.axis4.railStop = 135
```