



# Digital Studios Tool Orientation

## Rapid Prototyping Studio

# Multicam CNC Router

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# Orientation Summary

This orientation serves as a training on the Multicam Computer Numeric Controlled (CNC) Router at CCA. During this orientation you will learn the basic access policy and safety rules of the CNC Router, how CNC operates and what is required of CCA users when setting up a CAD file for CAM. Once completed, this orientation will certify you to use the Multicam branded CNC router at CCA.

In this orientation guide, you will find information on CCA rules and policies and how they relate to the CNC Router. You will also find information relating to the basics of how CNC Routers are to be used, followed by the appropriate software and hardware setups and safe use.

## **What is the CNC Router?**

The CNC (Computer Numerically Controlled) Router is a digitally driven, coordinate based prototyping and production machine. The CNC mills materials utilizing a cutting bit fixed in a rotary spindle which traverses along an overhead gantry system. The gantry delivers the bit along the X,Y, and Z axes based on coordinates developed in relation to a 3D Model in the form of a tool path. Unlike a 3D Printer, which creates an object through additive manufacturing printing a part layer by layer, the CNC Router will incrementally remove waste material revealing the part from within solid stock. A wide array of materials may be milled with the CNC Router when paired with the appropriate cutting bits including. Though generally subtractive in its nature, the CNC can also be implemented in augmented additive processes (ie. drawing, marking, scoring).

## Safety Considerations

- Collision and Moving Blade Danger
  - **DO NOT ENTER THE MACHINE ROOM WHILE THE CNC IS ON:** The CNC Router will NOT see you and will harm you if it comes in contact with you.
  - **ALWAYS treat the machine as if it were “live” and about to start cutting:** The “End Mill” cutting tools loaded in the CNC machine is dangerous. They will cut and chop you if it comes in bodily contact.
  - In the event of collision, hit the red “E-Stop” button on the controller
- Fire Danger!
  - Friction can cause heat buildup which can set your material on fire
  - Always watch the machine
  - If a fire occurs, **put out the fire immediately** and **report the fire** to shop’s staff
- Additional Safety considerations
  - **Close Toe Shoes Required:** To protect your feet and toes from falling material and debris all shops spaces at CCA are closed toed shoe spaces. **You must have closed toed shoes while in the CNC machine and Computer rooms.** You will be asked to leave if you do not have appropriate footwear. No exceptions.
  - **Safety Glasses Required:** The CNC router machine room is a shop environment which “throw” debris at any time. Eye protection is required.
  - **Hearing Protection Required:** The ventilation and compressed air systems used in the CNC router is loud. Hearing protection is required, please use earplugs or earmuffs. Do not use “in ear” or “ear covering” music playing devices. **Music Headphones are not allowed in any CCA shops spaces** including the RPStudio.

## Use Disclaimer

CCA shops and studios provide tools and staff to support your projects. However, unforeseen circumstances do occur which can disrupt the making process. Please note the following policies:

- Studio Staff is not responsible for project outcomes
- Reservations prioritize access but do not guarantee machine use

# CCA, Shops, and Digital Studios Rules and Policies

## CCA Student Code of Conduct

### Violations of the Student Code of Conduct

CCA expects its students to uphold the college's values of artistic and academic excellence, compassion, integrity, and global citizenship. The following list, while not exhaustive, illustrates those behaviors that, when determined to have occurred in the judgment of the college, necessarily violate the values of the college; impinge upon the rights, safety, and well being of its constituents; and therefore represent misconduct subject to disciplinary action:

- Attempted or actual theft of or **damage to college property** or property of college community members.
- Conduct that could result in the violation of any federal, state, or local law.
- **Conduct which threatens or endangers the health or safety of any member of the college community** including but not limited to physical abuse, verbal abuse, threats, verbal or nonverbal intimidation, bullying, stalking, or coercion.
- **Failure to comply with the directions of college officials**, law enforcement units, and emergency personnel acting in authorized performance of their duties. **This also includes failure to identify oneself to such persons when requested.**
- Failure of a student to act in a responsible manner to assure that the student's guest is preserving the rights of the college community as outlined within the Student Code of Conduct.
- Forgery, alteration, or misuse of college documents, records, or identification.
- Hazing or conspiring to engage in similar acts that actually or potentially injure, endanger, or humiliate any fellow student or member of the college community, whether the hazing is consensual or not.
- **Interference with, obstruction of, or disruption of the teaching or learning process, administration, or any other college-sponsored activity.**
- **Knowingly furnishing false information to the college.**
- Possession, distribution, or use of any controlled substances on college property or at college-sponsored activities.
- Possession, distribution, or use of alcohol on college property or at college-sponsored activities, except under the conditions specified in the **Alcohol Policy**.
- Possession, distribution, or use of cigarette or vapor products on college property or at college-sponsored activities, except under the conditions specified in the **Smoking Policy**.
- Possession or use of a weapon or a replica thereof, such as a firearm, knife, explosives, or any other instrument used or potentially used to intimidate, threaten, and/or injure any member of the college community.
- Retaliation -- adverse action taken against a person because of the person's good faith opposing, reporting, or threatening to report a violation of the Code of Conduct or for participating in good faith in investigations, proceedings, hearings, or remediation related to college policies, including the Code of Conduct.

- Soliciting, assisting, or inciting another college community member to perform an act that violates the Student Code of Conduct or attempting to do the same.
- **Unauthorized entry or use of college property**, which includes unauthorized residence.
- Unauthorized possession, distribution, use, or duplication of keys or access cards for college property.
- Unauthorized use of electronic or other devices to record any person while on college property, disseminate personal information, or otherwise violate privacy without prior knowledge or consent.
- Unlawful harassment or discrimination based on race, color, religion, sex (including gender identity and pregnancy), national origin, age, disability, genetic information, sexual orientation, or parental status.

The CCA Student Code of Conduct can be read in its entirety at <https://portal.cca.edu/thriving/student-handbook/student-code-conduct/>

### CCA Shops Safety Procedures, Community Standards, and Policies.

Please note that repeated violations or any severe violation of the Shops Safety Procedures, Community Standards, and Policies may result in mandatory retraining, interim suspension of shop access, and can be elevated to the Student Code of Conduct Process.

- **Shop users must follow the instructions of staff and student shop monitors.**
- **Shop users must have their CCA ID with them and show it to shop staff if requested.**
- Be respectful to all shop users and shop staff.
- **Training and approval is required to operate equipment.**
  - This training may be provided by shop staff or by your instructors in classes.
- **Do not use the shops while impaired** by substance use, lack of sleep, stress, or other issues.

**Impairment due to lack of sleep, stress, or the use of any substance is a severe safety concern. Behaviors associated with this impairment jeopardizes the health and safety of the community and will be referred to the Student Code of Conduct Process and may result in disciplinary action.**

- Ask for help or information whenever you need it.
- Wear clothing that is appropriate to the shop and process you are using .
- Wear appropriate personal protective gear for the shop and process you are using. This may include safety glasses, ear protection, respiratory protection.
- **Headphones or earbuds may not be used in shops** where posted.
- Clean up after every process and reset or return your tools.
- Keep walkways clear and safe.
- No distracting other shop users.
- No running, yelling, or rowdy behavior.



- **Report machine or tool problems, or damage immediately to staff.**
- Report injuries and accidents immediately to staff.
- The shops are not responsible for the security of student projects or materials left in spaces.
- Guidelines on material use and disposal must be followed.

These shop specific policies and standards are set in each studio by the Studio Manager. **They cannot conflict with the rules above or the Student Code of Conduct.**

- Specific attire and PPE rules
- Storage of materials or projects in shops
- Food and drink guidelines
- Material use procedures
- Access times
- Cleanup procedures

**Please ask the studio manager if you are not clear on any of the policies or procedures in the shop you are working in. We want the shops to be safe, efficient, and easy to work in for all of the community.**

## Digital Studios Orientation Policies

The CCA Shops including the Digital Studios and the RPStudio **requires all users attend an orientation** to learn how to safely operate our shop equipment **before use**. To facilitate access to our tools, the Digital Studios run numerous orientation trainings throughout the semester. A full orientation schedule of the RPStudio can be viewed here: <https://portal.cca.edu/learning/shops/rps/>

- When attending an orientation:
  - **Be on time.** Attendees arriving more than 10 minutes late after the scheduled start time will have missed essential safety information and will be asked to leave and will not be “certified” for tool use.
  - **Participate and pay attention.** These orientations are your safety in addition to increasing your knowledge. You are encouraged to ask questions while attending the orientation. Do not engage in disruptive behavior while attending the orientation.
  - **Sign in and fill out the attendance sheet.** Without this information we will not have a record of your attendance for the orientation. Tool certification will not be granted to anyone who has not signed in on the attendance sheet.
- “Open” orientations are:
  - Available to any “active” CCA user including enrolled students, active staff and active faculty.
  - Scheduled approximately once (1) a week until the final four (4) weeks of the semester.
  - **NOT scheduled during the final (4) weeks of the semester to accommodate student use during finals.**
- “Class” orientations may be requested to train entire class groups on Digital Studios Tools. Class orientations:
  - Must be requested by the **faculty** member teaching the course.
  - Must be scheduled with the appropriate Digital Studio Manager via email with at least 1 week notice to schedule “ahead” of student reservations.
  - Must provide a class syllabus to the appropriate Digital Studios manager at least 1 week in advance of the orientation.
  - Will be scheduled in the order they are requested.
  - **Must be attended by the requesting faculty member.**
- Only CCA Digital Studios management staff can train you on Digital Studios Tools.
  - Other students or faculty cannot certify other users on Digital Studios machines.
  - Only certifications performed by Digital Studio Managers will be honored.

# Multicam CNC Router Rules and Policies

## Use Disclaimer:

- Studio Staff is **not** responsible for project outcomes
- Reservations prioritize access but **do not guarantee machine use**

## Multicam CNC Router Use and Access Policies

The Following Rules apply to ALL users at CCA. Violation of these rules and policies may result in immediate suspension of access to the Multicam CNC Router and RPStudio. Reinstatement of access will be at the discretion of a Digital Studios Manager.

- **All users must be a current CCA student or active staff or faculty member.**
  - CCA alumni or other outside users are NOT allowed to use ANY of the shops equipment at CCA including the RPStudio.
- All users must attend a recent Multicam CNC orientation before using the Multicam CNC Router
  - **Multicam CNC orientations attended by ANY and ALL users before 9/2/2019 are no longer valid.**
- CNC Router hours are different from other tools in the Rapid Prototyping Studio such as the Laser cutter **and are only available when management staff are present.** (hours are subject to change, see patron portal for up to date hours)
- Users may not leave a machine that is running unattended.
  - You must personally supervise your “cuts”. Do not leave the CNC office while the CNC Router is running.
  - Do not schedule your cutting appointments during class time or other appointments that will conflict with your ability to stay with the machine
- Users may use only one (1) RPStudio machine at a time.
  - Multiple machines cannot be used by the same person at the same time in a safe manner. Simultaneous RPStudio reservations for the same user will not be honored.
  - Do not book simultaneous Laser and CNC appointments
- Only approved CNC Router Material may be used on the CNC Router.
  - CNC Router Safe Materials are covered in detail in the material policies section of this orientation guide.
  - Some Approved CNC Router Materials can be purchased from ARCH.
  - All “laminated” materials must have been glued, clamped, and trying for at least 24hrs
  - RPS Staff reserves the right to not cut files/materials that are unsafe/unknown.
- Any material not listed in this manual must be approved by the Digital Studio Manager and must have a Safety Data Sheet (SDS) on file.
- If a fire occurs, **put out the fire immediately** and then report the fire to shop staff.
  - Unreported damages to the tools result in increased and significant damage to our machines. Early reporting usually means we can quickly fix the machines.



- **Failure to report fires or machine damage will result in “tool abuse/repair fine” for the value of the parts damaged in addition to suspension of access to the laser cutters and RPStudio.**
- Users must clean the CNC router room and work areas when done.
  - Cut up and place large cut offs in the trash.
  - Vacuum and sweep all dust and small pieces out of the room.
  - The RPStudio does not offer any storage options. Materials left in the studio will be removed or absorbed into “free use” scrap.
- **Users must Follow all staff instructions.**
  - If you do not understand something, please let us know!

## Multicam Reservations Policies and Procedures

All Users are required to reserve time on the Multicam CNC Router so that ALL users at CCA plan accordingly for their projects. The reservation schedule is one of the key ways CCA communicates the availability of the machines and RPStudio. Due to unforeseen circumstances such as broken or damaged machines reservations may be cancelled without notice.

### Reservation Policies

- Reservations may be made on the Multicam CNC Router by clicking on the “Digital Fabrication Studios” group at: <https://cca.webcheckout.net/sso/patron#/>
- Reservations are required to use the CNC Router
- There are 2 types of reservations/appointments: “file prep” and “cutting”
- Both appointments may be booked up to 1 weeks in advance
  - During heavy use times (such as finals) please allow for up to 2 weeks to complete your project.
- Users must book their “file prep” through the patron portal.
- Students are allowed up to two (2) “file prep” reservations a week, each up to 4 hours long.
- Before coming to a “file prep” Users must have their design finished and set up as dictated by the “Software: Preparing and Sending your Files from Rhino/RhinoCam” section later in this guide
  - Designs and a digital copy of your stock material separated into individual layers
  - All objects placed within the stock
  - The stock placed at 0,0,0 on the coordinate plane
  - All extra designs/text removed or placed onto a hidden layer
- At the end of your “file prep” appointment and once your file has been approved by a RPStudio Manager, your “cutting” appointment will be booked manually by shops staff.
  - Staff will NOT book a cutting appointment without the completion of a file prep appointment.
- Users are allowed one (1) 4 hour “cutting” appointment reservation per week.
- **Reservations are non-transferrable.** Do not share your CNC reservation with anyone including friends or studio classmates. If you are signed up, you must be the one using the laser.
- In the case of group projects, the person making the “file prep” time must be present during the file prep appointment, and must be the person reserving the “cut time” and be present for the cutting appointment.

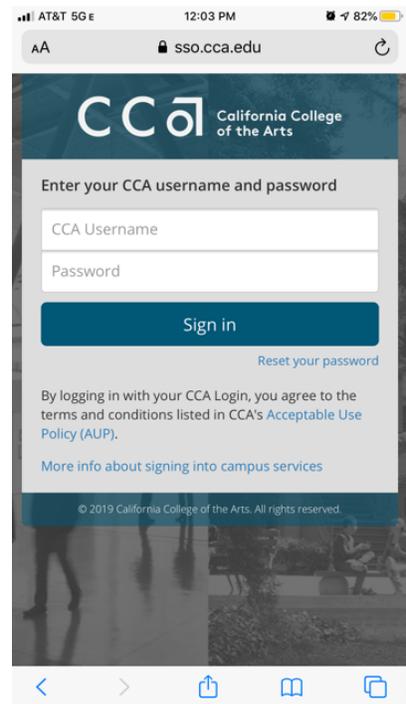
## Faculty and Staff Reservation Policies

To accommodate preparations for classes and CCA projects CCA faculty and staff have additional privileges for reserving time on the CNC Router. Faculty and Staff are encouraged to reduce their use of the equipment during peak student use times such as finals. Normal user reservation policies apply to faculty and staff in addition to the following policies.

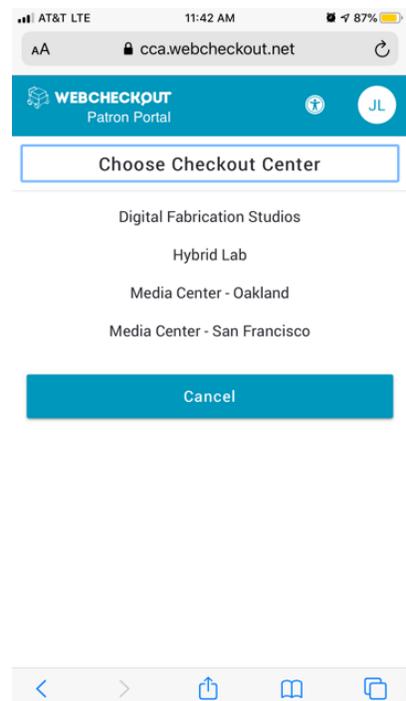
- For CCA “in class” manufacturing projects faculty may request up to **two (2) days of CNC Router reservations** per class during the current academic semester (except for the final 4 weeks of the semester).
  - All projects being manufactured “in class” must be small (under 1 square foot in size), single sided (no flip cuts), and relatively similar in design/shape.
  - The faculty member must be on hand to approve designs and assist in workflow.
- For CCA related manufacturing projects (example: signage for commencement) Faculty and Staff may make reservations up to four (4) weeks in advance.

How to: make a reservation

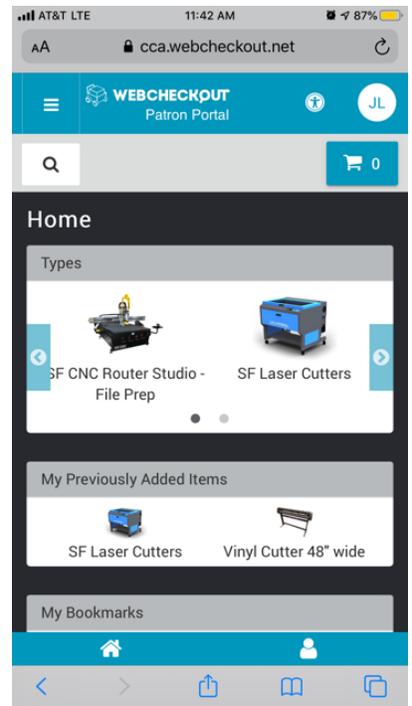
1. **Navigate to <https://cca.webcheckout.net/sso/patron#/>** in a web browser.
2. **Log in to CCA Single Sign-On.** If not prompted to log in, refresh the page to display the CCA SSO prompt for username and password. To log in to a different user account, click on the initials in the top-right corner, select “ Log Out ”, exit the web browser, and return to Step 2.



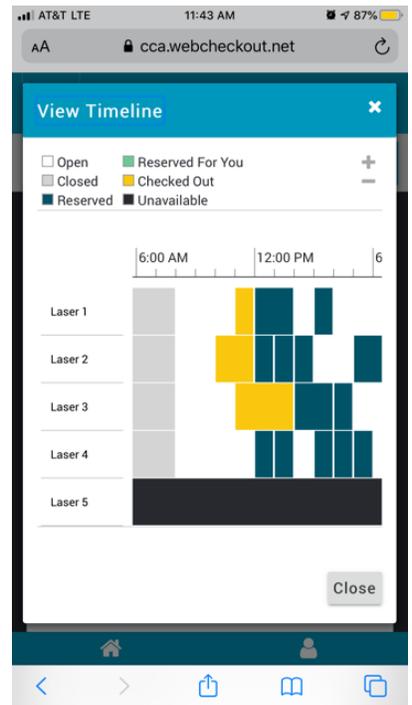
3. **Select “Digital Fabrication Studios”** from the list of checkout centers.



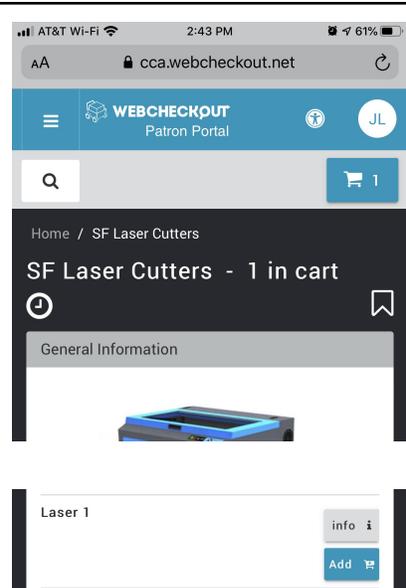
4. **Select the appropriate digital fabrication tool from the “Types” menu.** As an example, this guide will continue with “SF Laser Cutters.”



5. **Click the “ⓘ” icon near the top of the page to view a timeline of equipment availability and make a note of the date and time when you would like to reserve your desired machine.** For the laser cutters, details such as bed size and material thickness can be shown by clicking the “” icon next to each laser cutter.



6. Click the “” icon next to your desired equipment when you are ready to start making your reservation.
7. Click the “” icon near the top of the page and then click “Create Reservation”.

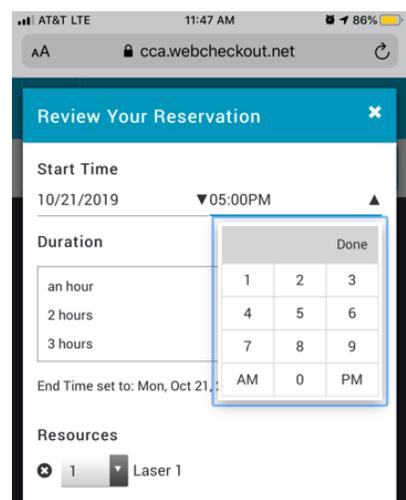


8. Enter the “Start Time” you noted in Step 6 and choose a duration for your appointment.
9. Click “Submit Reservation” to finalize your appointment. If the “Submit Reservation” button does not appear, read the notes under “Reservation has errors.” You must correct any errors in order to continue.

Common mistakes include:

- Reserving equipment when it is already booked
- Booking too many appointments in a single week
- Attempting to book more than one machine during the same time period
- Attempting to reserve equipment when you have fines or holds on your Patron Portal account

Please refer to our official reservation policies for details.

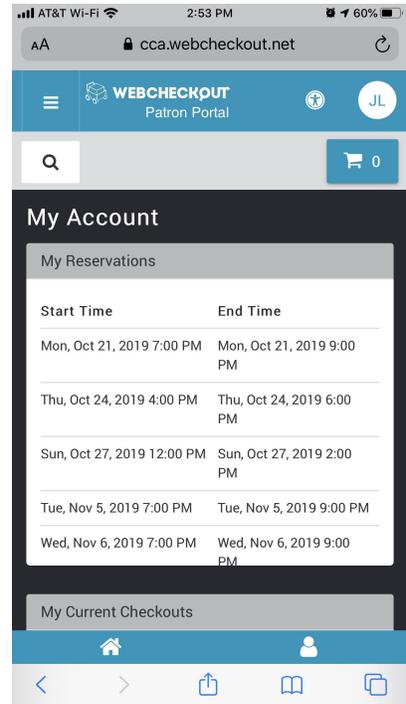


You're all set! Please be on-time and remember to check in with the lab monitor at the beginning of your appointment.

## How to: cancel a reservation

Reservation Cancellations can only happen to “upcoming” reservations, or reservations that have not occurred yet. Please cancel your reservations before your appointments start.

1. Log in to the Patron Portal.  
(<https://cca.webcheckout.net/sso/patron#/>)
2. Click the “☰” button at the top of the Patron Portal page and select “My Account”.
3. Under “My Reservations”, click on the appointment you would like to cancel. (You may need to empty your shopping cart in order for the page to load.)
4. Click “Cancel Reservation”.



## Material policies

The Multicam CNC Router uses an “end mill” to “carve” through your material. When cutting or engraving “safe” material, considerable amount of dust and particles will be generated which will have to be cleaned up after your cut has finished

- Only approved Safe Material may be used with the CNC Router.
  - Some Approved Materials can be purchased from ARCH.
- **Do not use any “Prohibited Materials” with the CNC Router. EVER!**
  - Use of “prohibited materials” can destroy the primary motor of the router, rendering the CNC Router inoperable for more than a month. **Use of “Prohibited Materials” is a will result in immediate suspension of access to the CNC Router and RPStudio.**
- Any material not listed in the section must be approved by a Digital Studio Manager and the RPStudio must be provided a Safety Data Sheet (SDS) by the user to have on file.

<u>Approved Materials</u>	<u>Material Notes</u>
Cardboard	Using a “v bit”, cardboard can have “crease” lines carved into it
Softwoods	
Hardwoods	
Plywoods	Use a “combo” or appropriate “up” and “down” bits to get a clean edge
MDF	Formaldehyde is carcinogenic, wear a mask when cleaning up MDF dust
Pink/Blue Insulation Foam and Styrofoam	
Acrylic	Use correct feeds/speed to get an ideal finish
Masonite	
“Natural” Cork	Use “natural” cork only, no synthetic cork. “Freeze” cork to reduce flexibility.

## Prohibited Materials

These materials are extremely flammable, poisonous, exceptionally carcinogenic, and usually a combination of the 3. They are not to be used with the CNC Router under any circumstances. **Use of prohibited materials will result in immediate suspension of access to the CNC Router and RPStudio.** If you have a material that you are unsure about, find an SDS (safety data sheet) from the manufacturer of your material and a Digital Studio Manager will review it.

<u>Prohibited Materials</u>	<u>Prohibited Material Notes</u>
"Unknown", "Found" or "Mystery" material	<b>"If you cannot identify a material, neither can we!"</b> Found fabric cannot be identified and cannot be used. If you do not know what a material is, then an SDS is impossible to identify.
"Wet" material	<b>"Wet" material can push liquids into essential electronics on the machine, damaging the machine. This would include wet sand or plaster</b>
Plaster	<b>The dust from carving plaster will destroy the mechanics of the machine</b>
Stone/Rock/Glass	<b>We do not keep cutting tools in stock for these materials. Addition, the dust generated will destroy the mechanics of the machine</b>
Metals	<b>Although many CNC machines can carve metal, all require oil/lubricant to do so. Due to the high volume of wood projects carved at CCA, we cannot accommodate metal projects as the oil/lubricant does not mix well with ambient wood dust.</b>

# Machine Use Guide: How to use the Multicam CNC Router

## Use Disclaimer:

- Studio Staff is **not** responsible for project outcomes
- Reservations prioritize access but **do not guarantee machine use**

## Multicam CNC Router Basics: concepts, machine capabilities, limitations

The CNC (Computer Numerically Controlled) Router is a digitally driven, coordinate based prototyping and production machine. AT CCA, we have a “Multicam 3000 series”, 3 axis CNC Router. The CNC router mills materials utilizing a cutting bit fixed in a rotary spindle which traverses along an overhead gantry system. The gantry delivers the bit along the X,Y, and Z axes based on coordinates developed in relation to a 3D Model in the form of a tool path. Unlike a 3D Printer, which creates an object through additive manufacturing printing a part layer by layer, the CNC Router will incrementally remove waste material revealing the part from within solid stock. A wide array of materials may be milled with the CNC Router when paired with the appropriate cutting bits including. Though generally subtractive in its nature, the CNC can also be implemented in augmented additive processes (ie. drawing, marking, scoring).

The CNC Router is primarily suited for working within its relatively large work bed but with a relatively low head clearance. The MultiCam 3000 CNC Router has an XY work bed of 48” x 96” (a full sheet of plywood) and a preferred Z thickness of 3” or less. While the CNC gantry has a maximum clearance of 5.5”, cutting deeper than 2” puts undue stress on the machine and cutting bits, and limits the range of milling tools available for use. Whenever possible, models thicker than 3” should be split into slices 3” thick or less to be assembled after milling.

**While Rhino is our primary 3D model interface for the CCA CNC Router output, 2D and 3D files may be imported into Rhino** from other programs such as: AutoCAD, Maya, 3D Studio Max, Revit, Solidworks, Blender, Adobe Illustrator, etc. Whino Files will produce the best result.

## Types of Machining

Loosely speaking all milling operations are divided into 2 categories; 2-D and 3-D. 2-D milling (aka 2.5 axis) works, very much like the laser cutter, cutting only in profile curves and at planes while 3-D milling (aka 3 axis, 4 axis, 5 axis) allows for the creation of form and topography through 3-Dimensional machine operations. Here are a variety of “types” of machining operations that our CNC router is capable of:

<p><b>2 1/2 Axis Machining</b> These operations create toolpaths that follow 2D lines, or at-surface geometry, to cut to a programmed depth. Cuts run in the X and Y direction along a surface or line. Used primarily for sheet materials.</p> <p><b>Facing:</b> Toolpaths machine the entire surface to flatten or dimension the material.</p> <p><b>Profiling:</b> Toolpaths follow the edges of surfaces to create profile.</p> <p><b>Pocketing:</b> Toolpaths cut away all of the material inside of a selected region to create pockets.</p> <p><b>Engraving:</b> Toolpaths follow lines on the center to apply text or engrave a design.</p> <p><b>V-Carving/V-Carve Roughing:</b> Toolpaths are cut using a V router bit thus giving the finished product sloped edges and a fine center line.</p> <p><b>Hole Pocketing/Hole Profiling:</b> Toolpaths are generated in order to guide the CNC to machine high precision holes.</p>	<p><b>3 Axis Machining</b> These operations create toolpaths that follow 3D surfaces to carve objects. Cuts run in the X, Y, and Z directions along a surface/modeled object.</p> <p><b>Horizontal Roughing:</b> Operation is used to cut large portions of hard material quickly. It cuts the rough estimate of a model using step-down increments when cuts are too deep for a finishing cut.</p> <p><b>Finishing:</b> Operation is used to accurately carve your geometry. It follows the surface of your model precisely. Parallel Finishing makes cuts in line with each other at a constant step-over.</p> <p><b>Horizontal Finishing:</b> makes cuts in a constant Z step-down, for drastic changes in the Z dimension.</p> <p><b>Projection Pocketing:</b> Toolpaths are generated when the stepover is projected onto the geometry in order to have even stepover across the 3D surface.</p> <p><b>Curve Machining:</b> Toolpaths are defined by lines modeled by the student. These lines will define the path of the center tip of the bit.</p>
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Available Cutting Tools or “Bits”

The RPStudio loads and calibrates the following tools daily. This allows for “standardized” tools for our users, allowing for faster set up times. The 6 following tools typically cover 95% of requested CNC tooling.

<b>Slot 1:</b> ½” Hogger	<b>Slot 2:</b> ½” Ball-nose	<b>Slot 3:</b> ¼” Straight-edge	<b>Slot 4:</b> ¼” Ball-nose	<b>Slot 5:</b> ¼” Ball-nose	<b>Slot 6:</b> ⅛” Ball-nose
					
Horizontal Roughing Profiling Pocketing Engraving Hole Pocketing Projection Pocketing Curve Machining	Engraving Finishing Horizontal Finishing Curve Machining	Profiling (small) Pocketing Engraving Hole Pocketing Projection Pocketing Curve Machining	Pocketing Engraving Finishing Horizontal Finishing Projection Pocketing	Pocketing Engraving Finishing Horizontal Finishing Projection Pocketing Curve Machining	Pocketing Engraving Finishing Horizontal Finishing Projection Pocketing Curve Machining
Typically 3” or longer	Typically 3” or longer	Typically 1 1/2” or longer	Typically 1 1/2” or longer	Typically 1” or longer	Typically 1” or longer

*\*Additional bits are available advanced users, ask a monitor for more info*

*\*\*Target cut-depth may not reflect Actual cut-depth on the day of your appointment. Check with monitor for daily Actual cut-depth*

## Finishes

A major factor in the use of the CNC router is time. Users are limited to 4 hours of cutting reservations per week. A Typical 3 dimensional carve involves a “roughing” cut, and a “finishing” cut. When finishing, you have a couple different choices: The size of your cutting tool, and the step of (or overlap form the previous cutting path). Generally, the smaller your cutting tool, the higher quality your finish, but more cutting paths and thus longer your project will take. In a similar manner, the less step over (the less new material you carve into for each path) the more cutting paths and thus longer your project will take. This chart describes the length of time

	3/8" Bit	1/4"Bit	1/8" Bit
25% Stepover	5 - 8 min	7 - 13 min	19 - 43 min
20% Stepover	6 - 9 min	9 - 16 min	23 - 54 min
15% Stepover	7 - 12 min	12 - 22 min	31 - 71 min

\*Finishing times are approximate for a 1'x1' surface, and range depending on material being cut and adjusted speeds.

Please remember that the CNC router is intended as a production and prototyping tool, not a finishing tool. You will often still have to “sand” or finish your carved piece elsewhere.

## Software: Preparing and Sending your Files from Rhino/RhinoCam

As mentioned previously, you can design in a CAD drawing program, but you will get the best results when designing in Rhino.

Please note that the RPStudio staff will not be available for assistance with design work. Our staff will only be available to set up tool paths with you. We cannot edit/scale your designs.

Before coming to a “file prep” appointment, users must have their design finished and set up as dictated by the “Software: Preparing and Sending your Files from Rhino/RhinoCam” section later in this guide

- Designs and a digital copy of your stock material separated into individual layers
- All objects placed within the stock
- The stock placed at 0,0,0 on the coordinate plane
- All extra designs/text removed or placed onto a hidden layer

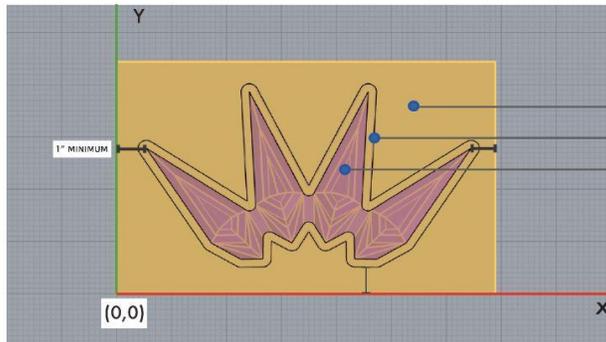
Please refer to the image on the next page. It is the “minimum” required setup for your “file prep” appointment:

# PRELIM FILE SETUP

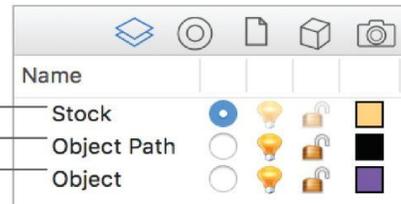
## FILE FORMAT

\_ File has to be in **.3dm (RHINOCEROS)** format

## TOP VIEW RHINO



## PROPERTIES



### STOCK LAYER

- \_ **EXACT** size of material you will use
- \_ Know your material before file prepping
- \_ **MAXIMUM** dimension [**96" x 48" x 3"**]
- \_ Place at (0,0) below the Z Plane.

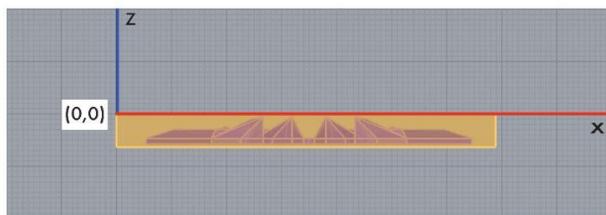
### OBJECT LAYER

- \_ Place **INSIDE** the stock
- \_ Place object **1" MINIMUM** from edge of the stock
- \_ Bottom of the object touch the bottom of the stock

### OBJECT PATH

- \_ On **TOP** of the stock, on the Z Plane

## SIDE VIEW RHINO



## ADDITIONAL INFORMATION

- \_ Place all geometry in the **POSITIVE X,Y (0,0)** quadrant, and below the Z Plane.
- \_ If geometry does not fit into the working envelope of 48" x 96" x 3", **SPLIT PARTS** into pieces and/or layers and arrange them in the correct quadrant.
- \_ If you are cutting multiple sheets, arrange them on **SEPARATE LAYERS**

## “File Prep” Detail

### **Words that we will reference in this guide:**

**Stock:** The material you are about to cut must be measured exactly accurately and then modeled in rhino.

**Geometry:** Anything you have designed that will be used to help cut your part.

**Support Material:** Material around the part you want to cut that will be left intact in order to maintain a vacuum hold on your stock, that way it won't move when we mill.

**Rhino commands:** Commands that can be typed into the rhino command line that will give specific functions.

**C-Plane:** The grid that is persistent in all views of rhino

**Part:** What you are actually cutting for your project.

**Cut regions:** The area of the material that the bit will actually engage with.

### **A. Import your Model**

Develop a CNC-specific Rhino Model by importing from your project model into a new file.

Note: most rhino models can be milled on the CNC as is, but some may demand further set-up than others.

1. Place all geometry in the positive X,Y quadrant, and below the Z Plane.
2. Duplicate important geometry onto a locked layer as a backup.
3. If geometry does not fit into the working envelope of 48" x 96" 3", split parts into pieces and/or layers and arrange them in the correct quadrant.
4. Save file as: yourname\_modelname

### **B. Create a Stock Size**

Create a box representing the raw material to be cut in the RhinoCAM system.

1. Create a “box” in Rhino on a separate layer labeled “Stock”.
2. Verify all dimensions of stock material with tape measure and/or caliper. The stock in your model must be exact, not estimated.
3. Mark any hardware (ie: screws) in stock using a circle showing the widest point on the top surface of the stock box.
4. Position the top southwest corner of the stock at 0,0,0 within your rhino model.



5. Select the box representing the stock in rhino.
6. Under the “Program” tab of the RhinoCAM Machining Browser window (to the left of the screen) click the “Stock” drop-down button and select “Stock from selection”.
7. An orange ghosted box will appear where your stock box is in the model.
8. Once the stock has been set in Rhino, turn off the “stock” layer.

### **C. Fit parts within margin**

Adjust the imported model inside the stock box to give maximum support material around the perimeter of all parts to be milled.

1. Give all parts to be milled a minimum of 1-½” clearance from all edges of stock.
2. Multiple parts should have a minimum of 1-½” of support material between them.
3. Place the parts to be milled to the bottom face of the stock box for thickness accuracy.

Note: If parts do not fit inside the margins listed above, you will need to scale your model down or switch to larger material.

### **D. Develop Cut Regions**

Develop cut regions that describe the areas to cut within or around. These cut regions will serve as selection areas for generating tool paths.

1. Use the Rhino Commands “Dupedge”, “Dupborder”, and “Project” to get outlines/silhouette of the parts to be cut.
2. Combine overlapping/adjacent outlines using the Rhino Command “Curve Boolean”, selecting the lines you want to combine, and then clicking inside the areas you want to keep. This will keep the overall outline of all the combined pieces, which shortens final cut time.
3. Use Project to C-Plane or “PCP” to bring the cut regions to the surface of the stock box, or Z Plane. *(For this step, it helps to turn the “stock” layer back on and use the box in Rhino as the projection surface, but remember to turn the layer back off when process is finished)*

4. If you are running \_\_\_\_\_ machining operations, you will need the cut regions to be offset to allow milling of the entire part. For this, use an offset size slightly larger than the size of the bit you are using for that function.
5. Some offsets will “break,” or not stay as one enclosed space. In these cases adjust curve lines and free-hand draw as needed to close the outlines.
6. All outlines must be completely enclosed. Use “join” to connect all curve lines into one geometry. You will know the join has succeed when the command line reads “Open curves joined into one closed curve.”
7. Note that if you move parts with in the stock, you will need to move the cut regions also.
8. Place all Cut Regions on separate layers labeled “Cut Regions” and “Offset Cut Regions”.

#### **E. Material Prep**

Develop cut regions that describe the areas to cut within or around. These cut regions will serve as selection areas for generating tool paths.

1. Verify all materials with staff prior to your appointment. Staff is not responsible for missed appointments due to issues with stock.
2. Physical Stock must match Stock in File. No student will be allowed to use the CNC until both stocks are matching and verified by monitor.
3. Material can be up to 48” x 96” x 3”. Pieces may be glued together to create a larger or thicker stock so long as the overall result is within these dimensions.
4. If gluing is needed, allow a minimum of 24 hours for glue to cure. Be sure to spread glue evenly so that parts do not break off during milling.
5. Stock can not be taller than it is long or wide. Material that is too tall for its other dimensions will be pulled up from the bed by the machine and cause damage to the router. If needed, rotate the model to its side in order to mill part safely.
6. If part can not be rotated due to the nature of its cut, the stock may be screwed to a “spoil board” or a thin sheet of plywood that is wider than the stock. Be sure to measure and mark in the file where screws are located. The CNC can not cut through screws, and needs a 1-1/2” clearance between the part being milled and the screw.

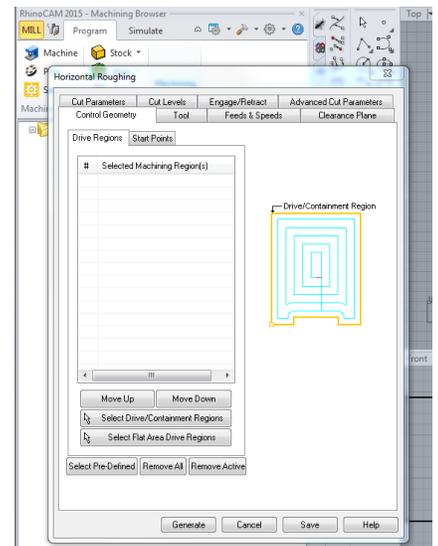
At this point, the **Preliminary File Setup** is complete. You may bring this file into a “File Prep” session with a monitor, or continue to the **Generating Toolpaths** file setup.

### CAM File Prep

1. Turn off all unused layers, including stock.
2. Click the “Machining Operations” drop-down menu and select an operation under either the 2 Axis or 3 Axis drop-down menu. *\*Refer to the Types of Machining Operations page for more information.*
3. Selecting the operation will open a dialogue box with several tabs (listed below). Fill out each of these tabs as follows:

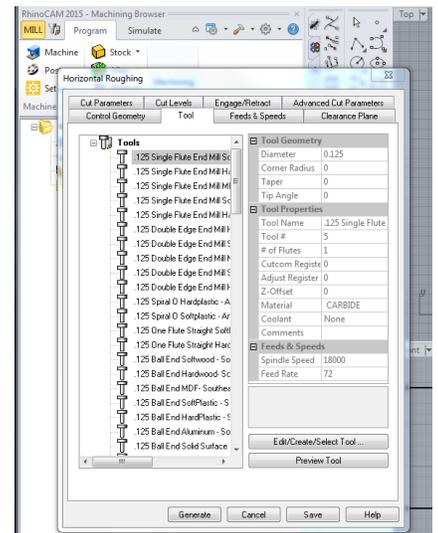
#### **A. Control Geometry** tells the machine what areas to cut, and what areas to leave untouched during an operation.

- 1) Use the Select Drive Region button to select the cut regions made in step 4 of the Basic File Set-up. Press enter to go back to the dialogue box when done.
- 2) A list of Drive regions will appear in the Drive Regions tab. Selected lines will be highlighted in yellow. If you select a Drive Region in the list in the dialogue box, it’s highlight will change to green instead.
- 3) You can remove individual lines/regions by selecting one from the list and clicking Remove Active, or all at once using Remove All.



#### **B. Tool** tells the machine what tool to use for an operation.

- 1) Choose the tool type/size you wish to use, with the correct material type in its name.
- 2) Use only the tool library that is posted to the website, or in the CNC Router computer.
- 3) If you do not have the tool library on your computer, a link on the website will show you how to download it to RhinoCAM

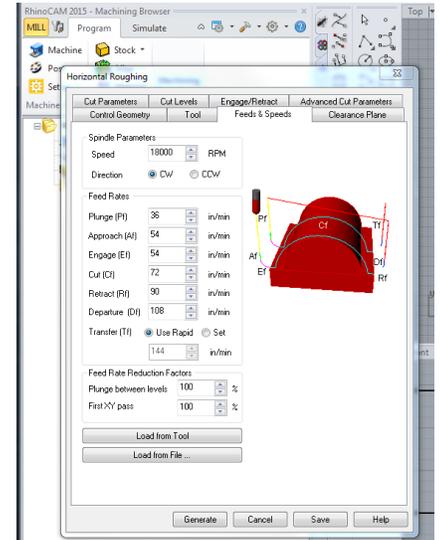


- 4) All of the settings needed for the machine should be already attached to the tool, but a monitor will check before allowing you to cut.

Note: Level 1 students may only choose a tool size from the **Available Tools** list

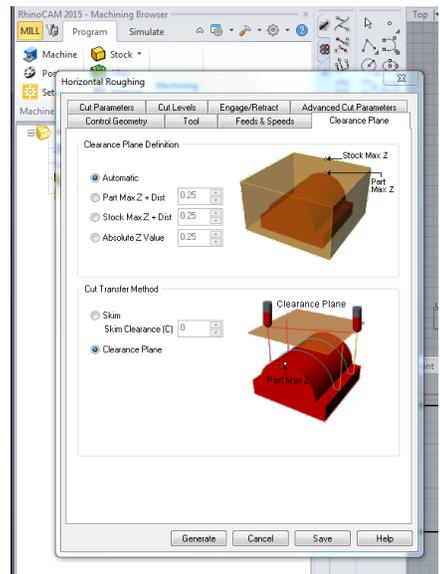
**C. Feeds & Speeds** tells the machine how fast the tool should be spinning and how fast to move in its cut.

- 1) Click the “load from tools” button at bottom of page
- 2) Tool settings will be loaded according to the material and tool you chose in previous tab.



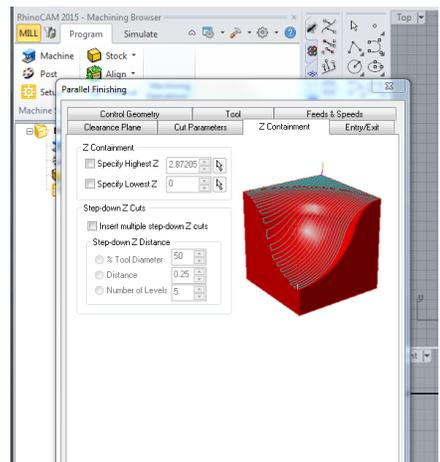
**D. Clearance Plane** controls how the machine moves the bit when it is moving from one cut to another.

- 1) Under Clearance Plane Definition, select “Part max Z + dist”
- 2) The box next to this choice should read .25
- 3) This will tell the machine to rise .25 in. above the height of the material as indicated during the machine set up.



**E. Z Containment** is used for parts with a deep plunge in their file, and limits the machine’s movement in the Z axis.

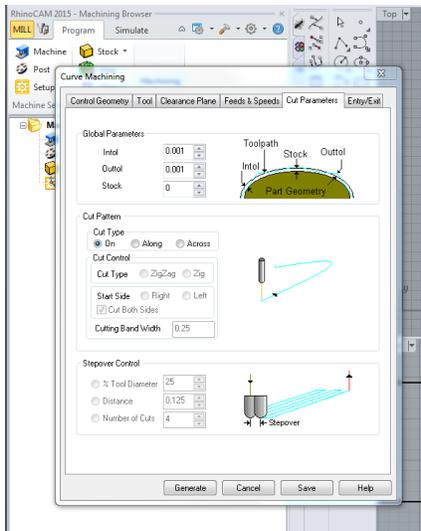
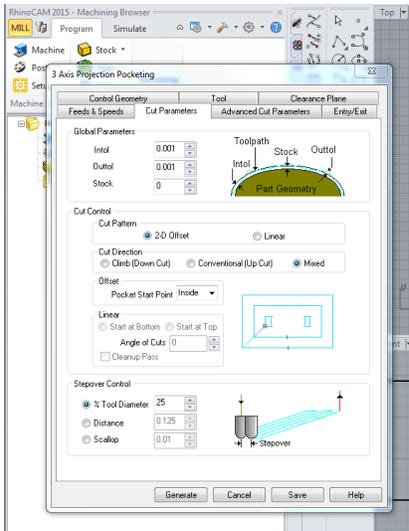
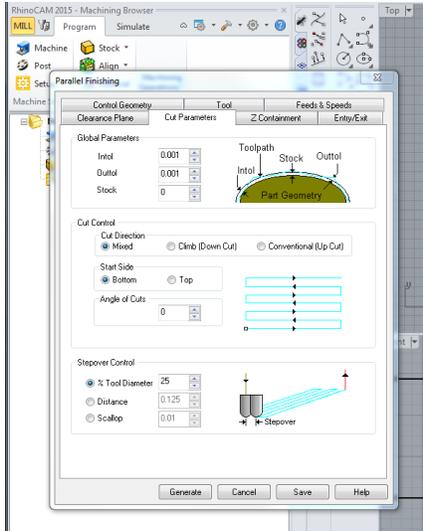
- 1) Under Step-down Z cuts select the % Tool Diameter

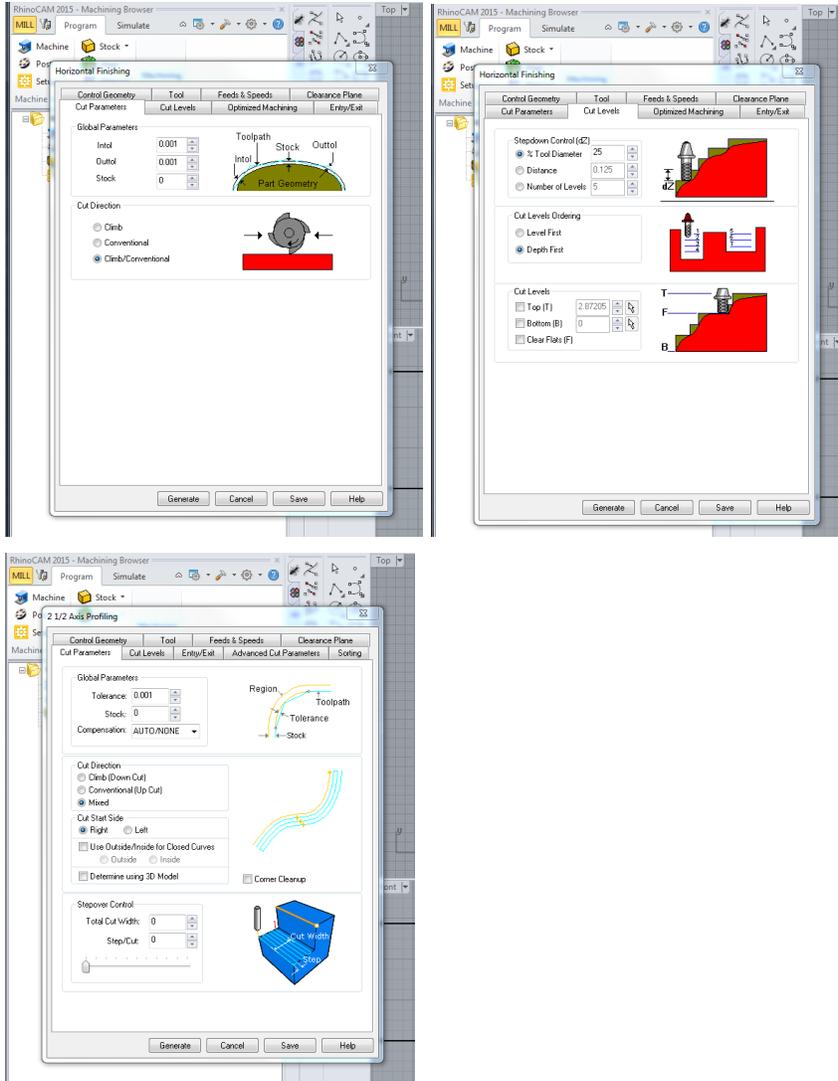


- 2) Enter into the box next to this option 25, which is the max step-down allowed for a tool.

**F. Cut Parameters** tells the machine how close together the cuts should be, and how far from the “finish” surface to stop the cut. This tab will look slightly different depending on which operation you are setting up.

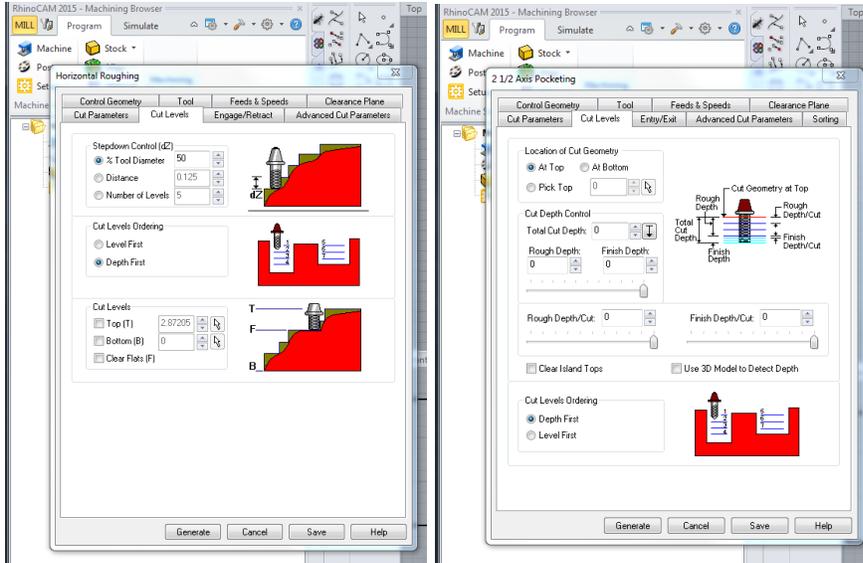
- 1) In the Stepmover Control select % Tool Diameter option and type in desired number (typically between 15-25)
- 2) In Cut Direction, select Conventional (Up Cut)
- 3) If you are doing a roughing pass, select Stock Offset (Pocketing) in the Cut Pattern portion.
- 4) If you are doing a pocketing or profiling operation, you can choose to do the “inside” or “outside” of your lines, or select either “right” or “left”. (Test these with the simulation to get desired effect)





**G. Cut Levels** control how far down machine cuts on a single “pass”.

1)



4. After filling out the tabs above, click Generate.
5. Check your work, make sure you have addressed all the variables and reference the blue cuts paths to the geometry. Look closely at anything that feels off.
6. Simulate the cut and again look at the details of the cut. Pay attention to possible collet collisions, they will be in red.
7. Check the cut time, by highlighting **SETUP** and then right clicking and selecting information. You will need the total cut time in order to make a cutting reservation.
8. Post the **SETUP** by highlighting the **SETUP** file and then right clicking and selecting post (make sure you don't post only one part of the cut operation). Select the **MultiCam-Inch** post processor from the drop-down menu below the File Name box, then save the file to **C:\DncFiles\Router** in either the 2D or 3D folders.
9. Once you have posted your file, continue to the Cutting **Guide**.

## Machine Set-up

### Clean Tool Holders

1. Find tools in drawer labeled Collet Wrenches.
2. Remove Collets from their home at the back of the machine.
3. Disassemble Collet.
4. Use compressed air valve to clean debris from Collet parts.
5. Use simple green and a rag to wipe down parts.
6. Reassemble Collet.
7. Measure and record any changes to tool placement and lengths on the chalkboard.
8. Replace Collets in their correct positions.

### Turn On Power

1. Locate the Power Switch on the control panel and rotate to the on position.
2. Turn on Compressed Air located behind the control panel by setting the red bar in line with its pipe.

### Find Home

1. Press *Shift*  key, then *Go Home*  key to index the gantry, carriage and Z assembly.
2. After homing axis, machine will prompt for spindle warm-up.

### Spindle Warm-up

1. Select a tool from the line-up by typing the tool's number using buttons 1-6
2. Spindle warms-up at 3 different speeds and takes approximately 15 minutes.

### Calibrate All Tools

1. Select a tool to calibrate

- a. Press *Menu*  key and view options on controller display.
  - b. Press *Jog Arrow*     keys to move cursor to “ATC” then press *Enter*  key.
  - c. Press *Jog Arrow*     keys to move cursor to “Cal\_Tool” then press *Enter*  key.
  - d. Controller display will read “Tool # to Calibrate”.
  - e. Press the number key corresponding to the tool to be calibrated and press *Enter*  key.
  - f. The machine will pick up the corresponding tool and center it over the calibration block.
2. Un-clip red flag and place the grounding collar on the Automatic Tool Changer mounting groove in the spindle holder.
  3. Press the *Z-Axis Jog Arrow*   keys to lower the Z-Axis until the end of the tool is just above the surface block.
  4. Press and hold the *Zero (0)*  key to begin the calibration routine
    - a. The Z-Axis will move down slowly until the tool makes contact with the surface block
    - b. Once the tool has made contact it will move up above the surface block to its “Tool Lift Height”
    - c. Watch to make sure the tool does not continue to lower past impact with the surface block.
    - d. If the tool does not automatically lift after connecting with the surface block you will need to calibrate tool manually.
      - i. Place a piece of paper on the surface block

- ii. Lower the tool manually using the *Z-Axis Jog Arrow*   keys until the paper does respond when moved.
- iii. Press *Enter* key  to accept calibration.
5. Once tool is calibrated, controller display will read “Tool # to Calibrate” again.
6. Remove Grounding Collar and re-clip red flag to machine.
7. Repeat until all tools have been calibrated.
8. Press *Cancel*  key to go back to main controller display.

### Material Set-up

#### Secure Material to Table

1. Layout Stock on MDF Table in quadrant you wish to cut on.
2. Use an Adjustable Squaring tool to line up the Stock along the metal table below the MDF until stock is squared to the machine
3. Use a pencil to mark where the Stock is on the MDF, near the corners, Flip the Stock over and use shop double-stick tape along edges and center of Stock
4. Remove protective paper from tape and flip Stock back over and secure within the pencil lines on the MDF Table
5. Press down firmly on stock to adhere to MDF Table
6. Turn on table vacuum and adjust levers on front of machine to engage correct quadrants.

#### Set Surface Height

1. Press *Jog Arrow*     keys to position the tool bit anywhere over the material to be cut.
2. Press *Set Surface*  key and enter the tool number.

- Place the grounding collar on the Automatic Tool Changer mounting groove in the spindle holder.
- Place the surface block underneath the tool and on top of the material.
- Press the Z-Axis Jog Arrow   keys to lower the Z-Axis until the end of the tool is just above the surface block.
- Press and hold the Zero (0)  key to begin the surfacing routine

This will cause the Z-Axis to move down slowly until the tool makes contact with the surface block and then move up above the surface block to its “Tool Lift Height”

### Set Maximum Depth

- Press Jog Arrow     keys to position the tool bit anywhere over the spoilboard (MDF).
- Press Set Max Depth  key to set the maximum depth for the bit.
- Place the grounding collar on the Automatic Tool Changer mounting groove in the spindle holder.
- Place the surface block underneath the tool and on top of the spoilboard.
- Press the Z-Axis Jog Arrow   keys to lower the Z-Axis until the end of the tool is just above the surface block.
- Press and hold the Zero (0)  key to begin the surfacing routine

Remove the grounding collar and surface block and return it to the side of the machine.

### Set Material Home

- Press Jog Arrow     keys to position the tool bit over the front right corner of the material.
- Press Set Home  key to set the home location for the cutter bit.

3. Press *Enter*  key to confirm this position as home when prompted.
4. If needed, set position as “soft home” by pressing Shift and Homes   keys, and selecting a number to save the soft home under.

### Run Files

1. Press DNC key.
2. Press *Jog Arrow*     keys to choose the appropriate file with the cursor.
3. Press *Start*  key to begin the cutting sequence
4. Press *Cancel*  key to abort the cutting sequence.
5. Press the *Pause*  key to yield the cutting sequence.

### Turn Off Power

1. Turn off machine only at the end of the day
2. Press Menu key.
3. Select “shutdown”
4. When prompted by the controller, turn off power switch on main control box
5. Return controller to cradle

## Other Items:

### Quick Guide

#### Working Envelope:

- Bed: 48" x 96"
- Max cut depth: 3"
- Max material size: 48" x 96" x 3"

#### Materials:

- MDF, Plywood, Hardwood, Softwood, Acrylic, Insulation Foam

#### Programs:

- All files are cut using the RhinoCam software, but students may import their 3D models from other programs into Rhino before starting the file prep process.

#### Prelim File Prep

- Import your model into Rhino
- Create Stock size using RhinoCAM
- Leave margins of 1" around edges and between parts
- Develop cut regions
- Save file as "yourname\_modelname"

#### CAM File Prep

- Select a machine operation in either the 2-axis or 3-axis menu
- Complete information for each tab in the operation dialogue box, then click generate
- Simulate operations and check for collisions
- Check total cut time by right-clicking Setup and clicking info
- Post file and save in C:\DNCFiles\Router in either the 2D or 3D folders.

#### Cut

- Verify that the CNC Router is on and calibrated
- Verify appropriate tools are loaded
- Load material and secure
- Set material thickness and max depth
- Set material home
- Load File
- Start
-

## Additional Tutorials:

[http://www.saic.edu/media/saic/pdfs/campusresources/instructionalshops/CNC\\_Rhino.pdf](http://www.saic.edu/media/saic/pdfs/campusresources/instructionalshops/CNC_Rhino.pdf)

<http://cmu-dfab.org/category/tutorials/router/>

<http://www.livearchitecture.net/resources/software/rhinocam/comment-page-1>

## CNC Router Orientation Guide:

- **Safety**
  - Always wear eye protection, closed toed shoes, ear protection ect.
  - **No one is allowed in the Router Room when machine is cutting material**
  - First aid kit on main door
  - Anyone cutting is required to stay in the CNC office while router is running
- **Introduce machines**
  - All the parts of the router (table, bits, collets, ect.)
  - Bed size (working area) 48" x 96" x 3"
  - Materials: Woods, Plywoods, MDF, Acrylic, Styrofoam
  - If material is marinated, we must wait 24 hrs for drying time
  - Want square, flat material. Material should be 1" larger than design
  - How to place material on table
  - Available bits and uses/differences ( $\frac{1}{2}$ ,  $\frac{1}{4}$ ,  $\frac{1}{8}$ , Ball vs square nose)
- **Making an appointment**
  - Maker reservations through patron portal, link on RPS portal page
  - File prep is available up to 1 week in advance, in a 4 hr block.
  - Cutting time will only be booked AFTER file prep is completed and signed off by staff. cutting time is limited to 4hrs and is also reservable 1 week in advance.
  - During peak use, expect 2 weeks to complete projects.
- **File Prep** (refer to poster above window)
  - Types of Machine Operations (show examples in class)
  - Difference between 2 Axis and 3 Axis operations (programs for each)
    - (profile cuts, pockets, rough cut 3D, finish cuts in 3D)
    - Talk about 2 time difference (the larger the cutting area, or smaller your cutting tools (detail cutting tools) the longer it will take
  - What is a **stepover**, how does it affect finished piece
  - Use Rhino model (may import part from other 3D modeler into Rhino)
  - Origin (0,0) below the C-Plane (Z-plane)
  - What is **Stock** (must be accurate measurements)
  - What are **Cut Regions** (how to make them)
  - Margins (1" around entire part) and undercuts



## Licence and Credits

This document was produced by and for the “Rapid Prototyping Studio”, a fabrication studio within the “Digital Studios” of the “Instructional Fabrication Unit” at California College of the Arts in San Francisco, California. This document was created as a supplement and aid for the instruction and use of the equipment in the Digital Studios at CCA. This document does not serve as a substitute for an “in person” training or orientation with a Digital Studio’s manager when attempting to access the equipment at CCA.

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