



Preparation for Adults Through
Training and Higher Education

CUNY CareerPATH
Subtractive Fabrication
New York City College of Technology
February 6, 2014

www.cuny.edu



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Syllabus :: Subtractive Fabrication Processes

Technique is the engagement of real logics...and their conversion into potential. Specifically, into apprehensible formative potential. Technique is design from within.

Sandford Kwinter, *Leap in the Void, The New Organon*

Description:

This course focuses on the development of parametric tools and digital prototyping techniques & practices. Students will develop proficiency in applying this knowledge in constructing associative/parametric digital models that utilize modeling & simulation tools to generate alternative variations to these systems. We will begin with a study of precedents in contemporary architecture and design fabrication, both digital and analog, to develop a comprehensive understanding of exemplary tectonic systems. Projects will provide students with experience in the use of a variety of tools, materials, equipment, concepts, and emerging digitally-driven technologies including: parametric rule-based design, subtractive fabrication techniques, and iterative design processes. Students will come away from the course with digital and material models, prototypes, and documentation of the structural characteristics of the materials and fabrication techniques used.

Objectives:

- Demonstrate a knowledge of fundamental CNC and laser cutter mill operations: (ie. safety procedures, tool selection, job setup, step-over calculation, and spindle speeds).
 - *CNC Milling: Demonstrate knowledge to create profiling, drilling, and surface modeling drawings for use with a CNC mill. Show applied understanding of mill software interfaces (ie. RhinoCAM/ MadCAM).*
 - *Laser Cutting: Demonstrate proficiency in best practices for 3D modeling for laser cutter operation through surface flattening/building and contouring, and for laser cutter operation..*
- Demonstrate a solid foundation in visual programming and parametric modeling as applied to digital fabrication problems.
 - *Visual Programming: Demonstrate skills in Rhino3D's Grasshopper module to create integrated design models that operate at multiple scales including: Massing, Structure, Skin, and Tectonic Connections.*
 - *Parametric Modeling: Demonstrate and ability to connect design & production parameters to control individual architectural design and CNC fabrication systems.*
- Demonstrate and ability to design and fabricate materials systems through iterative prototyping and production CNC fabrication and assembly.
 - *Prototyping: Demonstrate facility to produce physical prototypes of digital design models at multiple scales at progressively increasing levels of complexity.*

- *Production: Demonstrate ability to product full scale productions of digital architectural designs.*

Software:

- Rhinoceros 3D (v5) & RhinoCAM (v2012)
- Grasshopper (v?) :: Paneling Tools :: RhinoNest :: Python :: Other Grasshopper Modules...

Materials:

- 1 sheet 4' x 8' x 1/2" NAUF plywood
- 4 sheets 4' x 8' x 3/4" NAUF plywood
- 4 sheets Blue Foam Insulation
- 2-4 sheets 2 ply chipboard
- Shared sets of CNC Router Bits (1/4" ball/down cut, 3/8" ball/downcut/compression)

Equipment:

- 3-axis CNC Router (Precix...)
- 4-axis CNC Router (Roland MX540)
- Laser Cutter (...)

Projects:

- ***Project 1 :: ParaRIBS :: Parametric Rib Structures :: Massing => Structure***
 - Translating a multi-sided surface massing model into a parametric structural rib model.
 - Laser Cutting & 2.5D CNC machining for iterative prototype development.
- ***Project 2 :: Project 2: ParaSRF :: Parametric Skins :: Massing => Skin***
 - Translating surface massing model into parametric skin/panel system model
 - Parametric surface patterning and micro behaviors
 - 3D CNC Surfacing
 - Initial Skin/Structure overlap
- ***Project 2 :: Project 3: ParaWALL :: Parametric Wall System :: Skin + Structure***
 - Design & Fabrication, in groups, of a full scale parametric wall system.
 - Parametric Joint Strategies between ParaSRF & ParaRIBS.
 - Project documentation for exhibition

Deliverables:

- (3+) Digital Models & Scripts/Programs
- (3+) Digital Cut Files / Digital Prototypes
- (3+) Physical Prototypes
- (3+) Final Fabricated Material Assemblies
- (1) 36" x 24" Documentation Board for each Project

Assessment:

Through computer based fabrication projects and oral presentations, students will demonstrate their ability to:

1. Create digital parametric modeling projects of medium complexity.
2. Produce fabrication projects that utilize fundamental skills involving key set up, work flow, and assembly techniques, as well as best safety practices.
3. Produce fabricated tectonic material systems of their own design
4. Explain the uses of rapid prototyping and iterative design processes.

Attendance Policy

No absences accounting for more than 10% of class time are permitted during the course. For purposes of record, two latenesses are considered as one absence. Exceeding this limit will expose the student to failing at the discretion of the instructor.

Grading

Students successfully completing the course will receive a grade of pass or of pass with distinction. At the end of the course certificates will be given.

Schedule:

Week 1 (04/05):

Introduction to Subtractive Fabrication:

Part 1 (09:00 - 11:45)(RB+TD): What is subtractive fabrication in architecture/design?

Introduce instructors and course outline/goals.

Introduction to design & fabrication systems explored through this course.

Project 1: ParaRIBS :: Parametric Rib Structures :: Massing => Structure

Part 2 (12:15 - 15:00)(RB+TD): Analog Rib Structures for complex surfaces.

Design double sided complex surface based on (concept)

Demonstrate & Develop Analog Rib + Joint System

Draw Joint Prototypes for Laser Cutter and CNC

Week 2 (04/12)*:

Parametric Rib Structures :: Model Prototype I:

Grasshopper.

Part 1 (09:00 - 11:45)(TD): Generate Para::Rib Structure from surface mass in

Massing Model => Parametric Rib Structure :: Grasshopper

Grasshopper Refresh

Part 2 (12:15 - 15:00)(TD):: Workshop project development & laser cut prototype.

Parametric Model Development Cont.

Utilize RhinoNest to create efficient part layouts for laser cut.

*****Laser Cutter Demo + Production of chipboard prototype (8" x 8" x 4")***

Production of chipboard laser cut prototype

Week 3 (04/26):

3-Axis CNC Machining :: Material Prototype II:

& Drilling

Part 1 (09:00 - 11:45)(RB): 2.5D Toolpathing with RhinoCAM :: Profiling, Pocketing,

Review & Translate initial rib model prototype

Plywood prototype development & sheet nesting

*****3-Axis CNC Demo***

Part 2 (12:15 - 15:00)(RB): 3-Axis CNC Toolpathing Workshop.

Developing Fabrication Files for 1/2" plywood prototype (36" x 36" x 18")

Case Studies: Larival Bench, Zaha Cirrus, SU11 Shelf, PED Bus Shelters

Production of plywood CNC prototype

Week 4 (05/03):

Parametric Surfaces :: Details & Paneling :: CNC Surfacing:

Part 1 (09:00 - 11:45)(TD): Parametric Surfacing Strategies.

Grasshopper to produce dynamic micro surface deformations over original rib system

Grasshopper/Paneling Tools to break down surface into panels (infill & or overlay)

Perforations and apertures (trimming v. splitting)

Geometry control (CV efficiency & density strategies, Normal control, Curve & Surface direction)

Project 2: ParaSRF :: Parametric Skins :: Massing => Skin

Part 2 (12:15 - 15:00)(RB): 3-Axis Surface CNC Machining.

Extracting & orienting surfacing panels for CNC programming.

3-axis surfacing parameters & virtual prototyping.

Case Studies: Expressions SRS; Sensation Tectonics; Toolhide

*****Single and Double sided Surface Programming & Machining Demo***

Week 5 (05/10):

Connecting Skin to Structure :: Advanced Surface Production Strategies:

Part 1 (09:00 - 11:45)(RB): Joint Systems Intro & Mold Making Techniques.

Integrated and Mechanical Joint Connections

Intro to mold making & casting (silicone + plaster)

Case Studies: Sensation Tectonics; Egg Plate

Part 2 (12:15 - 15:00)(RB + TD): Project 2 Development.

Workshop

Production of foam surface CNC panels for plywood prototype

Week 6 (05/17):

Project Development:

Part 1 (09:00 - 11:45)(TD): Complex Parametric Systems :: Skin + Structure.

Grasshopper: Parametric joint strategies between surface panels & rib

Grasshopper: Building complex parametric models: Massing + Structure + Skin + Design

Project 3: ParaWALL :: Parametric Wall System :: Skin + Structure

Part 2 (12:15 - 15:00)(TD+RB): Complex Parametric Systems Cont.

Establish Project 3 Groups

Project Development.

Production of foam surface CNC panels for plywood prototype

Week 7 (05/31)*:

Final Project Fabrication & Documentation Workshop:

for Final Project.

Part 1 (09:00 - 11:45)(TD+RB): Documentation Workshop & Fabrication Assistance

Presentation on Documentation – Process :: Shop Drawings :: Drawings :: Photography

Material Finishing Techniques.

Tool pathing & fabrication workshop.

for Final Project.

Part 2 (12:15 - 15:00)(RB+TD): Documentation Workshop & Fabrication Assistance

Tool pathing & fabrication workshop.

Production Sessions for Project 3

MM/DD/YYYY

Final assignment & all deliverables due @ 23:59

References & Inspiration:

Readings:

Aranda, Benjamin & Lasch, Christopher. Tooling. 2005. New York: Princeton Architectural Press.

Bourelly, France. 2002. Hidden Beauty: Microworlds Revealed. New York, NY: Harry N. Abrams

Deleuze, Gilles. 2005. Francis Bacon: The Logic of Sensation. Minneapolis, MN: University of Minnesota Press.

Francis, George K. 2006. A Topological Picturebook. New York, NY: Springer.

Haeckel, Ernst. 1974. Art Forms in Nature. Dover Publications.

Thompson, D'Arcy. 1992. On Growth and Form. Dover Publications

Iwamoto, Lisa. 2009. Digital Fabrications: Architectural and Material Techniques. New York: Princeton Architectural Press.

Klinger, Kevin & Kolarevic, Branko. 2008. Manufacturing Material Effects: Rethinking Design and Making in Architecture. New York: Routledge - Taylor and Francis Group.

Kolarevic, Branko. 2005. Architecture in the Digital Age: Design and Manufacturing. New York: Routledge-Taylor and Francis Group

Designers/Architects:

Xefirotarch (Hernan Diaz Alonso): <http://www.xefirotarch.com/>

New Territories (Francois Roche): <http://www.new-territories.com/>

Kokkugia (Roland Snooks): <http://www.kokkugia.com/>

Supermanoeuvre (David Pigram): <http://www.supermanoeuvre.com>

Ezio Blasetti: <http://www.ezioblasetti.net/>

Daniel Widrig: <http://www.danielwidrig.com/>

Fabrication Shops:

Associated Fabrication LLC (Brooklyn) <http://www.associatedfabrication.com/>

Timbur LLC (New Jersey) <http://www.timburllc.com/>

Tietz & Baccon (Long Island City) <http://www.tietz-baccon.com/>

SITU Studio (Brooklyn) <http://www.situstudio.com/>

Milgo Bufkin (Brooklyn) <http://www.milgo-bufkin.com/>

New York City College of Technology

The City University of New York

CareerPATH Program - Green Advanced Manufacturing Collaborative (GAMC)

Course: Subtractive Fabrication

Assignment: CULMINATION PROJECT \ paraWALL

Description: Student groups will design and develop full scale parametric wall systems. The project is intended to synthesize the prior two projects, paraRIBS & paraSRF, utilizing the full range of 3-axis machining's capabilities. The project also addresses the issue of scale, now working at the size of an actual architectural assembly. Greater emphasis is placed in this project on the crafting of custom fabricated joinery, dealing with issues of material finishing techniques, fit & machine tolerances, and performance of materials in holistic systems.

	Unsatisfactory [0-69%]	Average [70-79%]	Good [80- 89%]	Excellent [90-96%]	Exceptional [97-100%]
Proficiency with Rhino (cleanliness of model, organization, clarity, scale, proper part labeling, efficiency of material use relative to part geometry (Rhino Nest)) - 20%					
Proficiency with Grasshopper (organization & clarity of parametric definition, labeled outputs & inputs, definition results in clean geometry) - 20%					
Use of iterative design workflow - 20%					
Proficiency with RhinoCAM (efficiency of material use relative to part geometry, proper part labeling) - 20%					
Demonstration of ability to connect design and production parameters - 10%					
Proficiency with CNC Mill/Laser Cutter (machine set-up & safety, properly registering tools, cut quality based on machine settings) - 20%					
Totals					

Overall Total:

Feedback:

Robert Lee Brackett / \

robert.brackett3@gmail.com

Miscellaneous Projects
www.miscproj.com

Digital Nouveau
www.digitalnouveau.com

Contents

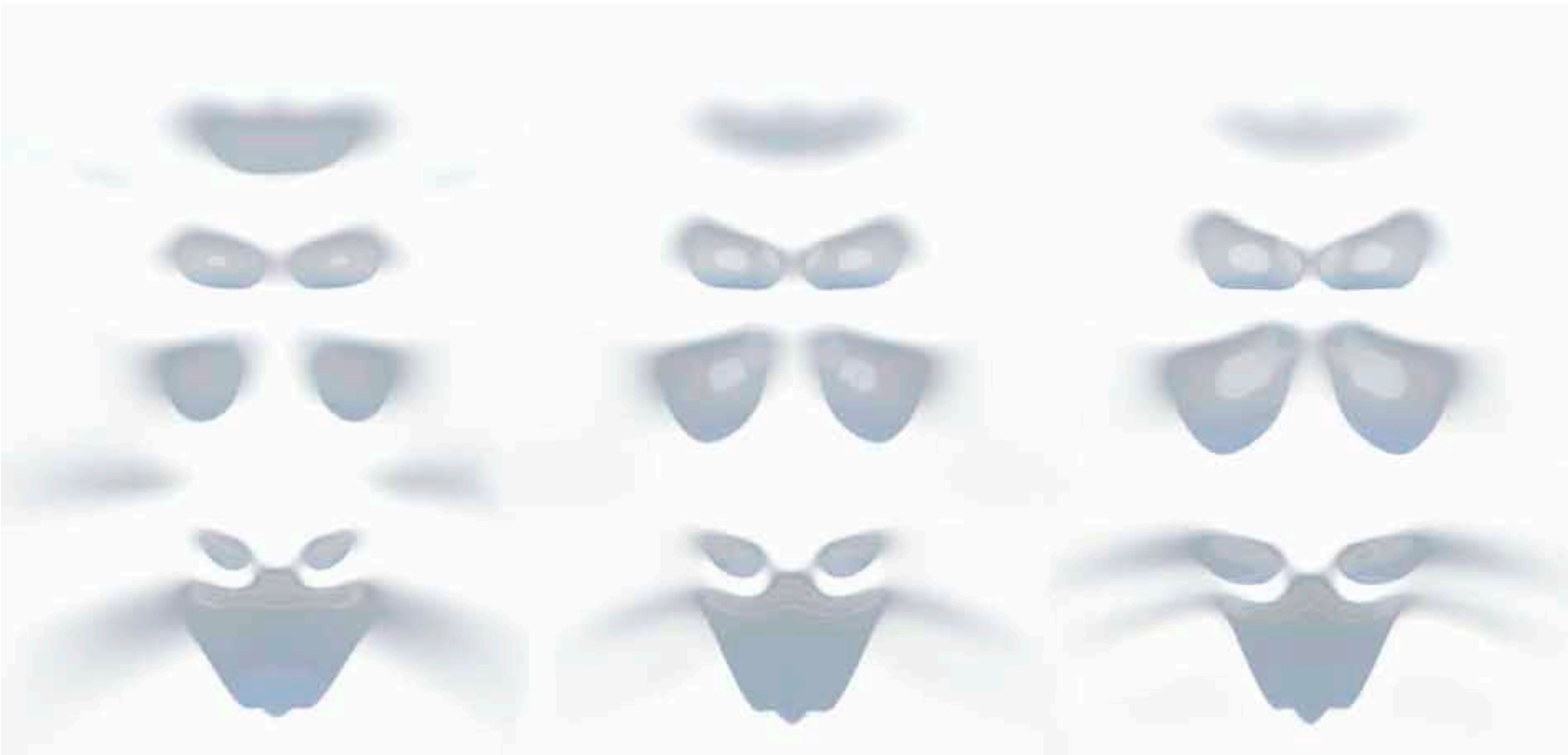
Expressions :: Synaptic Resistive Skin	4
Digital Nouveau Ruicci Residence Hyper Space Storage	14
Lily Pad Ruicci Residence High Performance Space	22
UES Apartment SU11 & Associated Fabrication	28
Design Build W 11th St Residence Rachel's Wardrobe	40
Performance Shelters Whistler Olympics Athlete's Village	46
Cirrus Zaha Hadid Architects CAC Architects at Play	62
Visage Walnut Jewelry Case	78
Selected Writings	86

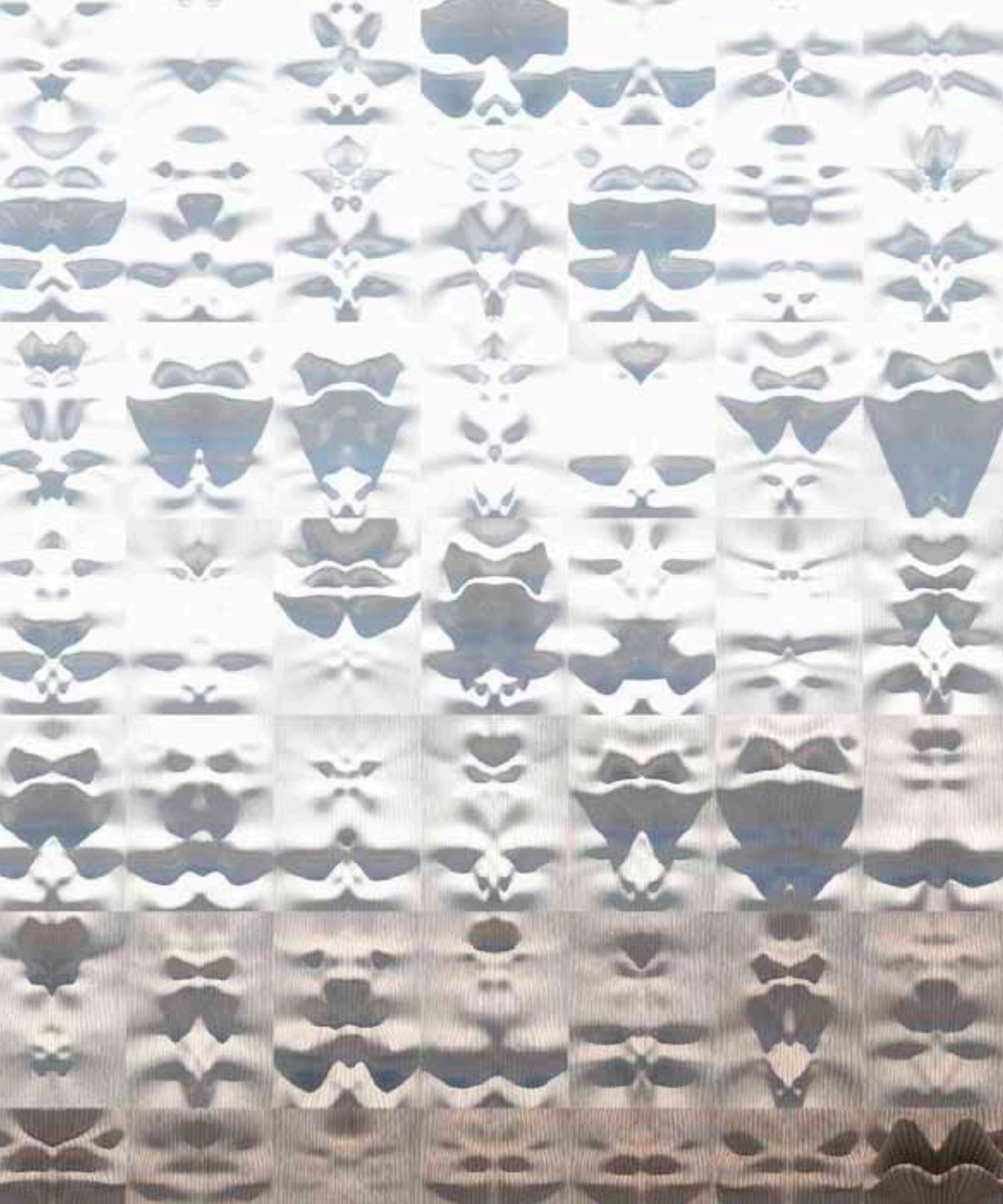


Layered relationships incorporating synaptic impulses, behavioral dependencies, tectonic resistance & temporal latency converge, producing a space of emergent surface patterns. A resistive skin dances to an adaptive pseudo-aperiodic rhythm generated through digital simulation and animation. The presence of time shifts from a linear index of progressing behavior to a generative component with instantaneous emergence. The E:SRS employs Maya's expression engine to generate micro-scale relationships among distinct surface geometry families. Synaptic signals inform each family to pulse, scale, translate and contract within bounded randomly generated ranges. The surface searches the extents of these constraints, deforming, probing behavioral possibilities. Dynamic simulation tools: particle systems, proxy geometry linking & tectonic spring systems produce latent temporal rhythms that propagate and converge across the active surface. Expressions; faces emerge within the behavioral matrix to explore infinitely variable, constrained, spatial pattern generation. An aperiodic landscape of mechanical precisions rises through the layers of laminated wood.

Expressions :: Synaptic Resistive Skin

Faces emerge from the digital ether as complex dynamic rhythms ripple through the elastic surfaces.





This project sprang from originally abandoned research during a studio with Hernan Diaz Alonso at Columbia's GSAPP; I was intrigued to re-explore the idea of synaptic deformations while setting up NYCCT's 4-axis CNC (computer numerically controlled) machines in an intensive push to bring digital fabrication to the forefront of their architectural technologies curriculum. Initial inspiration for the e:srs spawned from an obsession with the final confrontation between Major Kusanagi and the Spider Tank in Mamoru Oshii's classic, *Ghost in the Shell*. Just before the living skin tears from the bio-mechanical structures beneath there is a violent and beautiful flutter of formal expressions. Micro-worlds, hyper-dense moments strung together into fully synaptic manifestations, giving form to disintegration. Explorations of these events through digital simulation resulted in organic living surfaces housing chaotic mechanical nerve impulses searching for freedom, unaware of their own impending destruction.

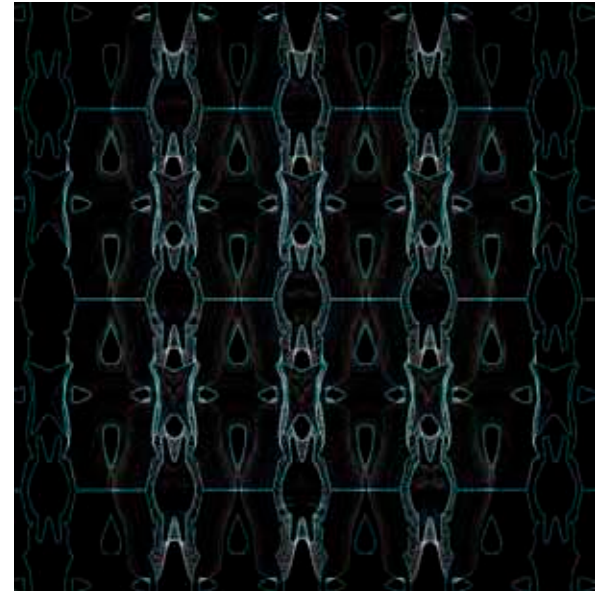
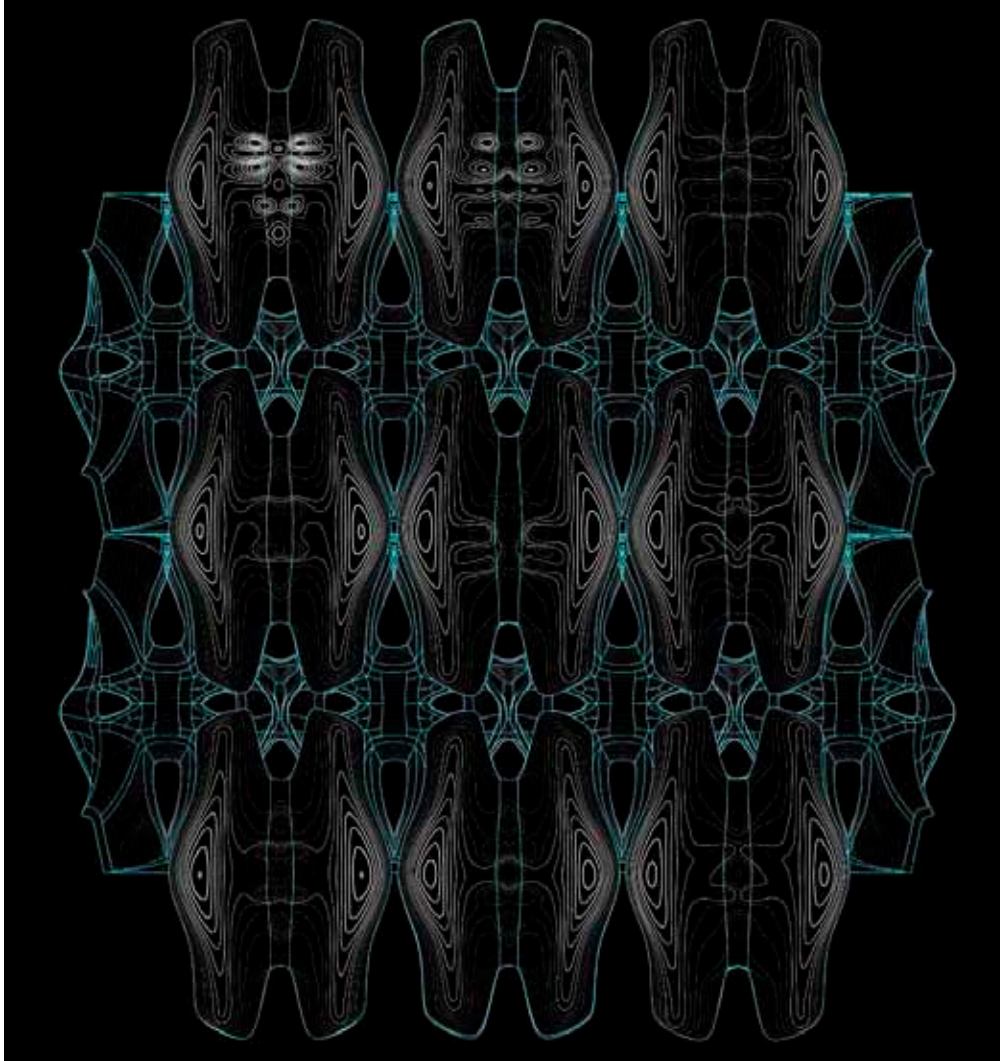
Expressions :: Synaptic Resistive Skin



The multilayered tectonic system incorporates 3 and 4 axis CNC machining with 3D printing and resistance joinery to form a spatial wall section.



Expressions :: Synaptic Resistive Skin





```

neg_z_ridge_neg_y_z.translateZ = 0;
neg_z_ridge_pos_y_l.translateZ = 0;

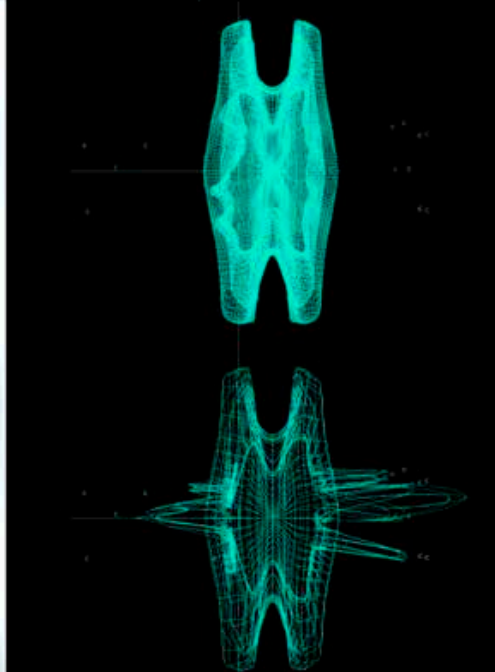
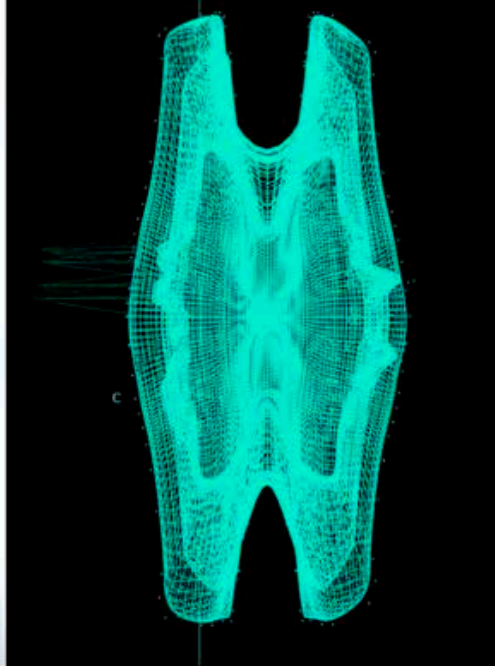
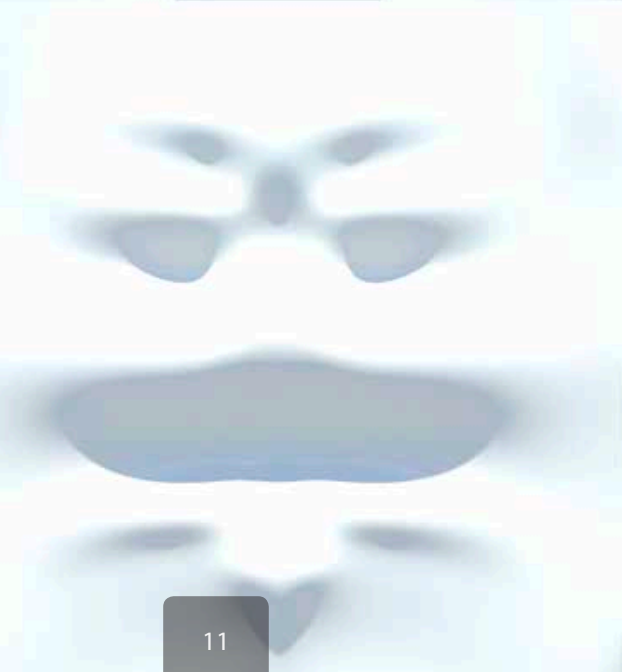
// set new random time interval
int $t3 = rand(1, 10);
}

// scale dependent groups when extreme transform in Z
// these are rare and have large scale effects
if (neg_z_ridge_center_box.translateZ > 0){
    neg_z_ridge_center_cross.scaleX = rand(2);
    neg_z_ridge_center_cross.scaleY = rand(2);
    neg_z_ridge_center_cross.scaleZ = rand(2);
}
else{
    neg_z_ridge_center_cross.scaleX = 1;
    neg_z_ridge_center_cross.scaleY = 1;
    neg_z_ridge_center_cross.scaleZ = 1;
}

// when the center cross cluster passes extension threshold
// activate bend deformers
// this controls the macro contraction of the surface
if (neg_z_ridge_center_cross.translateZ < -1){
    bend2.curvature = rand(5,10);
}
else{
    bend2.curvature = 0;
}

if (bend2.curvature >= 7){
    bend1.curvature = bend2.curvature;
}
else{
    bend1.curvature = 0;
}

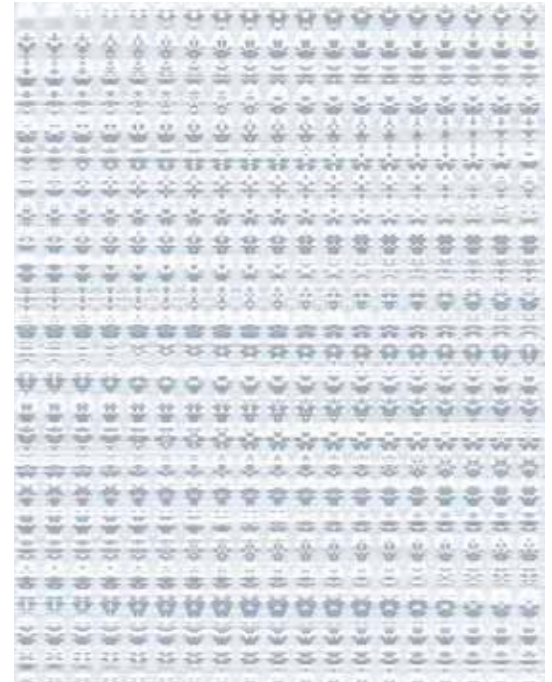
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The E:SRS project takes advantage of 4th axis CNC fabrication technology, extracting these infinite patterns from the virtual simulation & rapidly translating digital form into unique physical objects. The final sculptural wall system takes periodic samples of the E:SRS system and outputs them directly to RhinoCAM for CNC programming. Each component runs through a prototyped tool path system before being carved from solid stock material in a single cutting operation on NYCCT's two Roland MDX540 4-axis CNC routers. The fabrication environment produces a unique symphony of resonant harmonics with two rotary mills, a 3-axis machine, sanders, dust collection and computers all humming their own mechanical tunes.

Expressions :: Synaptic Resistive Skin

The result is an aggregate spatial paneling system generating quick infinite surface and formal variation straight through to production. Material expressions, material behavior.







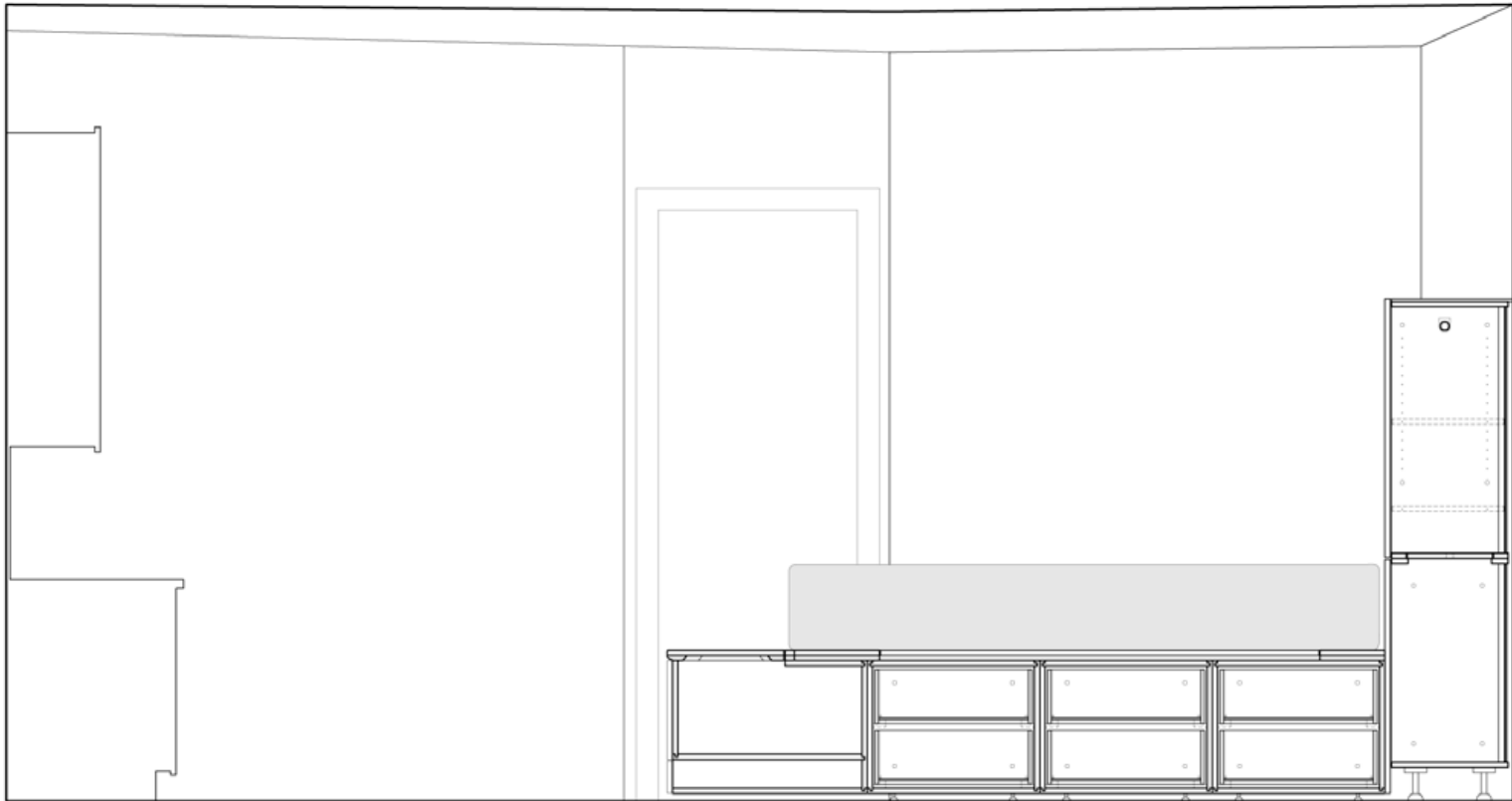
Digital Nouveau challenges the depth, experience and perception of plywood surfaces.

Lauren, a fashion and jewelry designer with a voluptuous sense for material & Steve, a graphic designer and typographer whose sharp style adorns the walls of their apartment, contracted me to engage their dwellings severe lack of storage space. The seemingly unlikely synergy of Lauren's and Steve's styles inspired the graphic and sensuous design of their hyper storage digital nouveau sleeping platform.



CNC carved plywood door surfaces with milled Corian inlay pulls.





Section - Hyper storage platform, blurring the living environment..



Subtly surfaced organic forms reveal the living tissue of the plywood. A fine finish of meticulous hand sanding and polishing with rich linseed oil and wax bring out the vibrant character of the baltic birch plywood. The focal nodes escape the plane of the plywood creeping into the living space, drawing the user into the plywood.



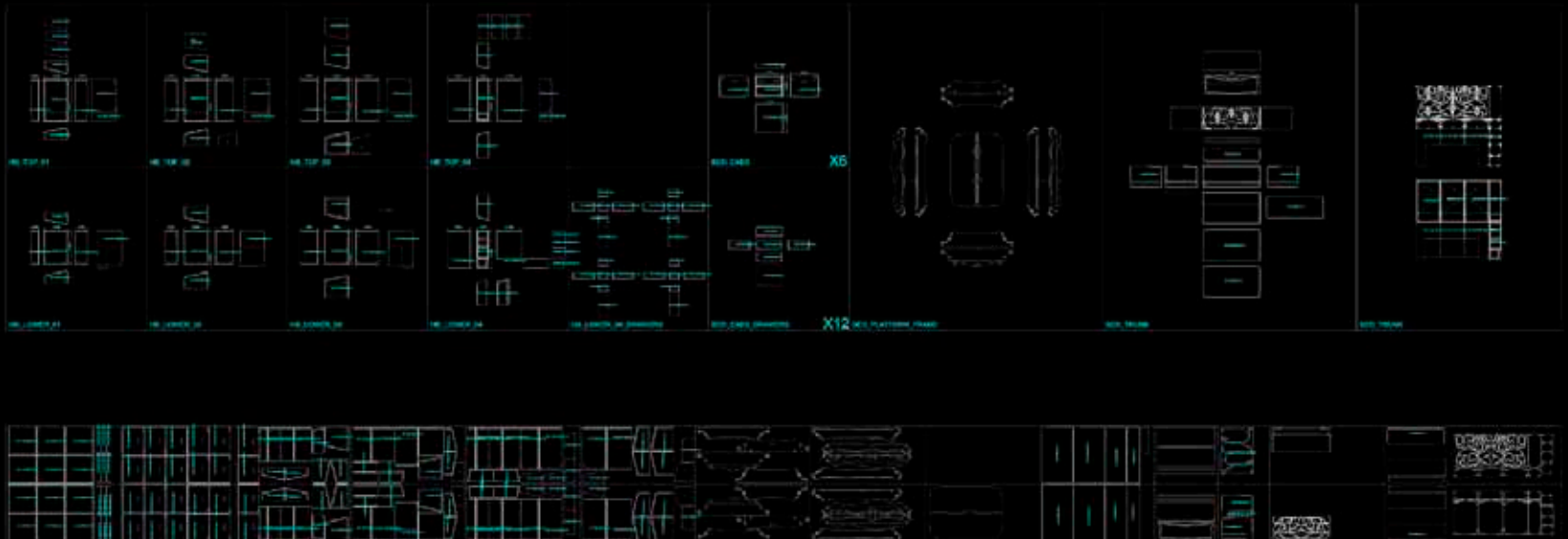
Hyper node detail - the organism invades the wounded plane and spreads through the layers.

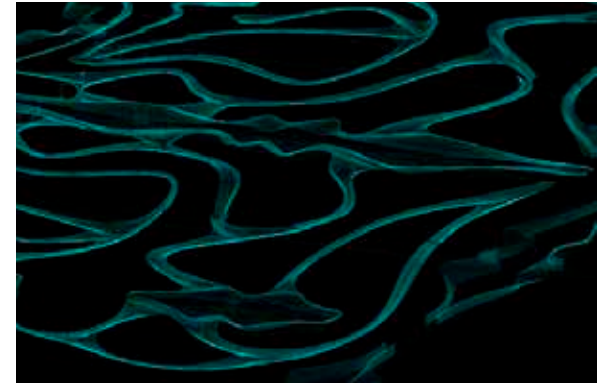
Frontal elevation from dining space. Storage trunk doubles as additional guest seating.

Digital Nouveau | Ruicci Residence | Hyper Space Storage

Utilizing standard sheet plywood for the primary structure the bed makes efficient use of material while allowing for greater attention to developing sensual details. This constraint helped to integrate the storage platform into the close space while still providing a provocative user experience through subtle forms and tactile interaction.

Material nesting for CNC Fabrication





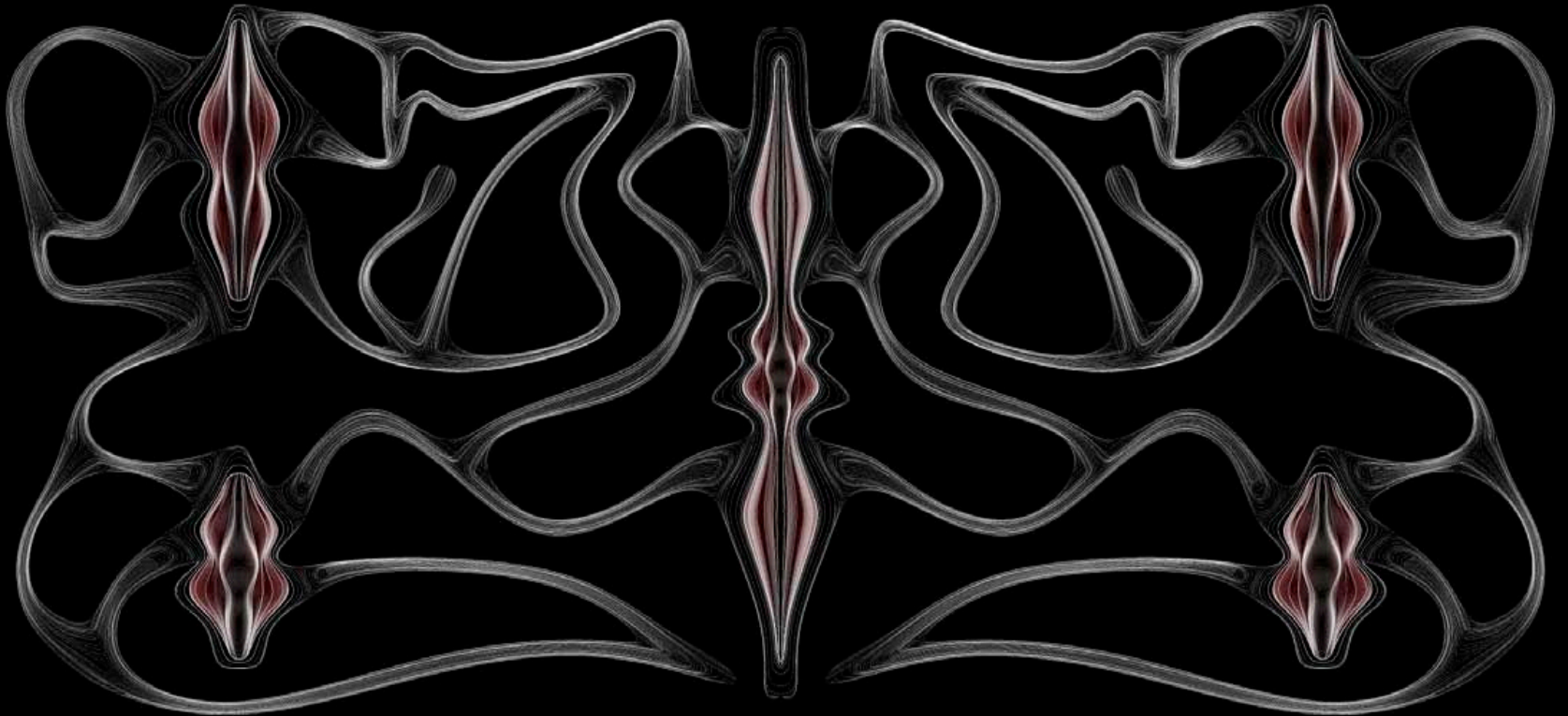
Precise surface control translated through CNC fabrication



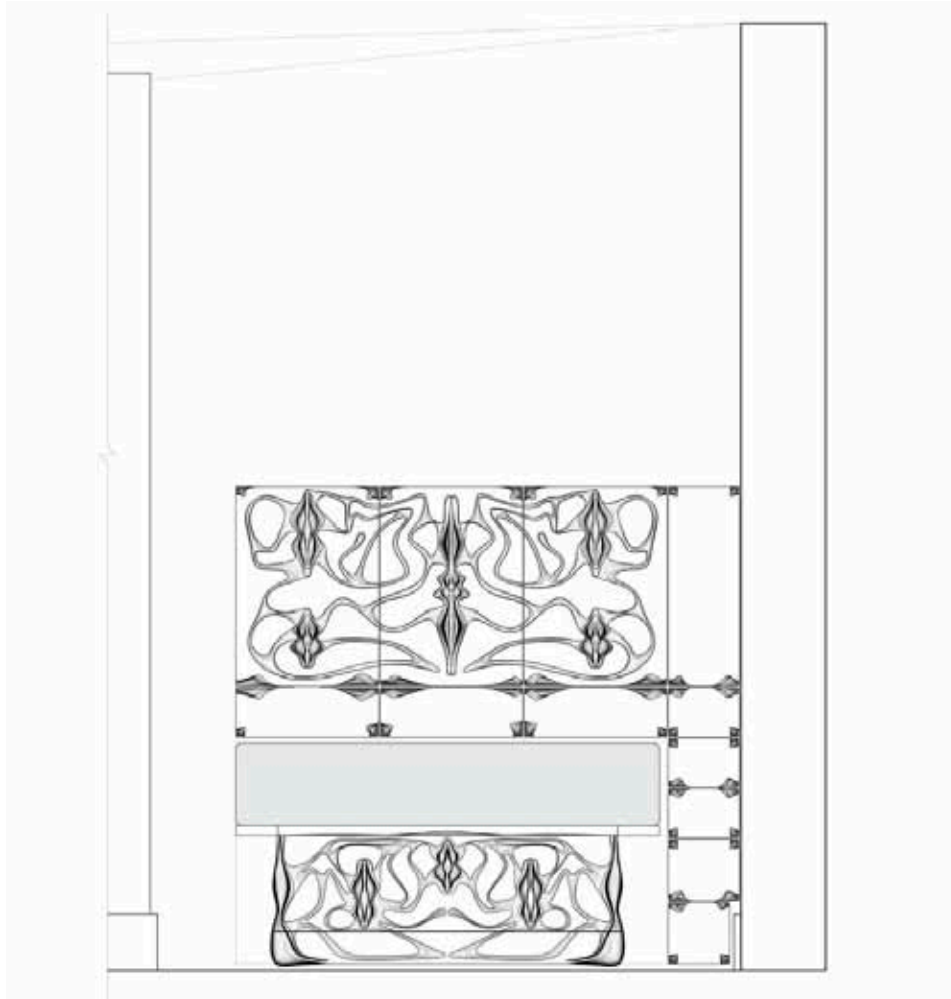
Building up multiple layers of plywood to escape the rigid surface of the sheet material.

CNC milling the vertical storage door panels at Associated Fabrication LLC. 3-axis Thermwood CNC Router.

Controlling the subtle surface layers of the plywood doors. The living nodes transcend the limiting depth of the plywood and dramatically increase the density of surface curvature.

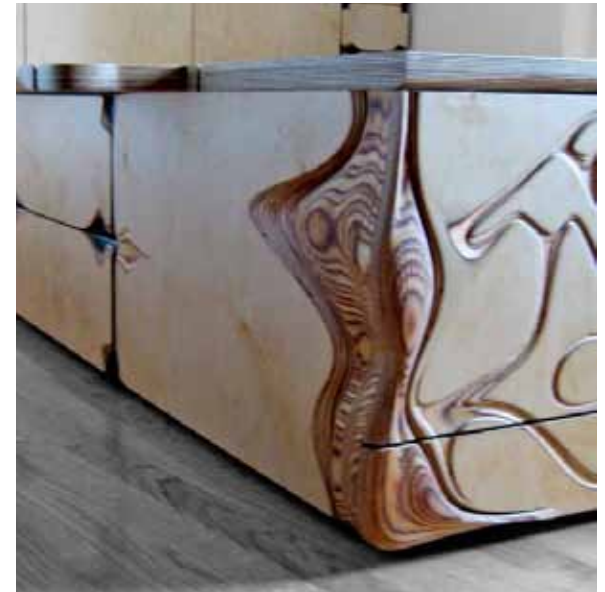


Digital Nouveau | Ruicci Residence | Hyper Space Storage



The project is about feeling. The smooth finished surfaces of the wood. Textured surfaces emerging from within. Subtle details encountered through the sense of touch. Milled surfaces guide the hand to pressure sensitive drawers. The edges are defined with textured Corian inserts inspired by Steve's graphic razor blade paintings.

The corner bleeds out into the space,, softening the edge and guiding the users into a new environment.



Driven to reclaim the nooks and accidental spaces of their 350 square foot living space, Steve and Lauren commissioned an integrated work zone with an open cantilevered desk and storage solution. The design continues to extend the simple plywood sheet into space with a strong and minimal 3D branching structure to support an elegant work surface.

Managing and challenging the relationship between digital forms, CNC fabrication techniques and material detail pushed the work station out from the wall, growing a spatially integrated organism for high performance in minimal space.

The desk provides a sleek and spatially aware computer workstation for advanced jewelry design by LaRuicci and exciting graphic styling by Steve Walker.



View of branching.
(Test assembly in Associated Fabrication Shop)

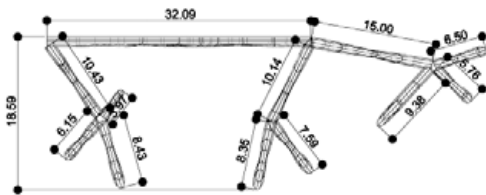
Lily Pad | Ruicci Residence | High Performance Space



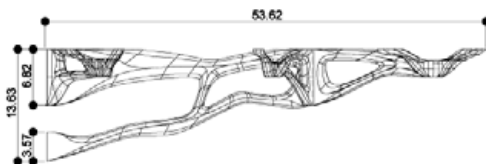
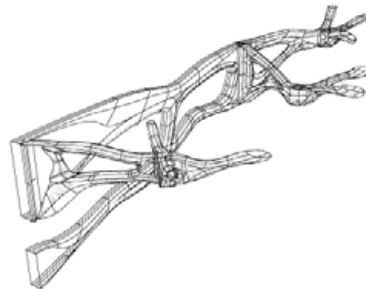
Branched feet support the contoured pads providing structure to the desk surface.



Polished black Corian desktop. The keyboard tray was later extracted and used to make cantilevered shelving nooks beside the desk.



TOP VIEW

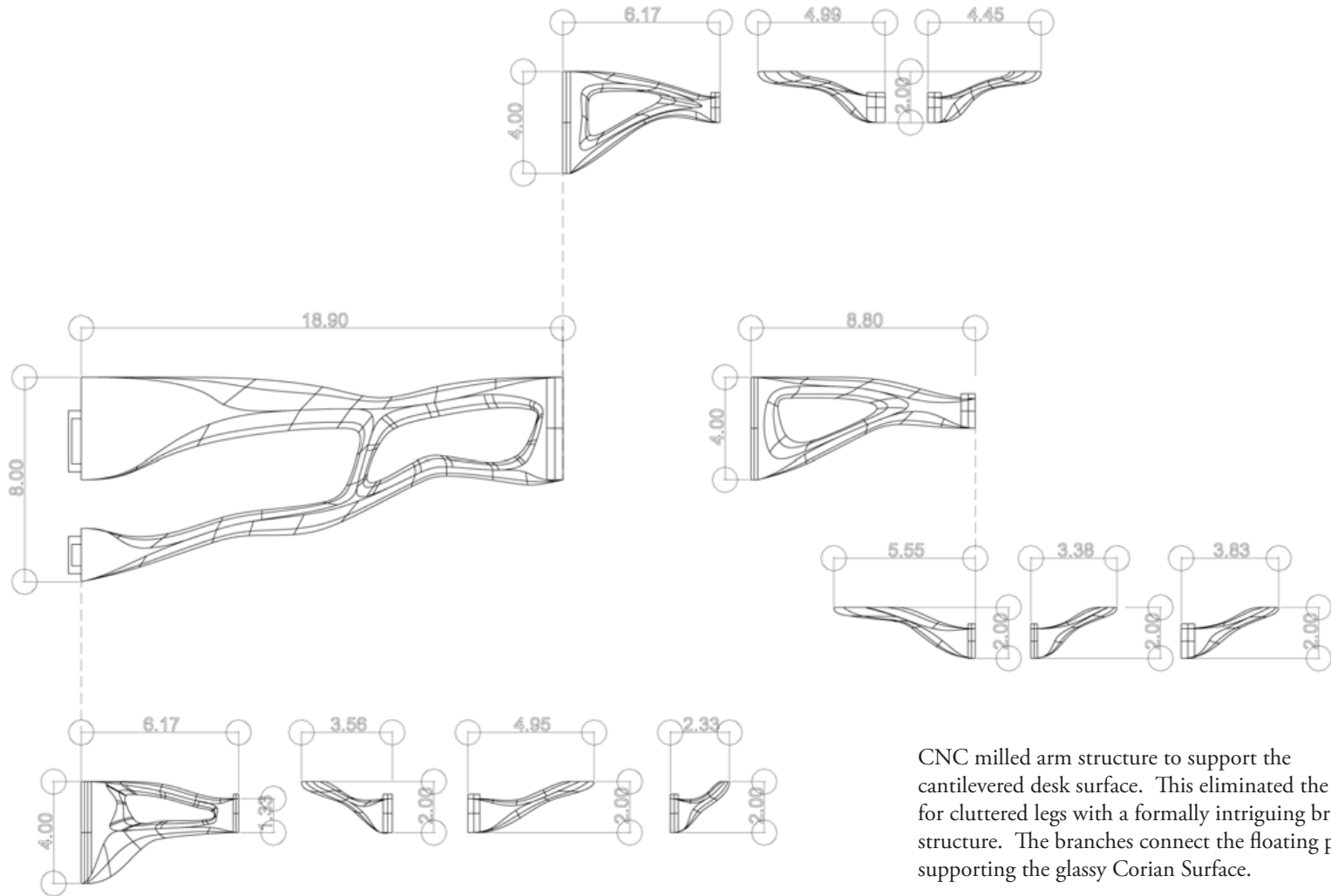


FRONT VIEW



SIDE VIEW

Lily Pad | Ruicci Residence | High Performance Space



CNC milled arm structure to support the cantilevered desk surface. This eliminated the need for cluttered legs with a formally intriguing branch structure. The branches connect the floating pads supporting the glassy Corian Surface.



CNC milled arm structure to support the cantilevered desk surface.



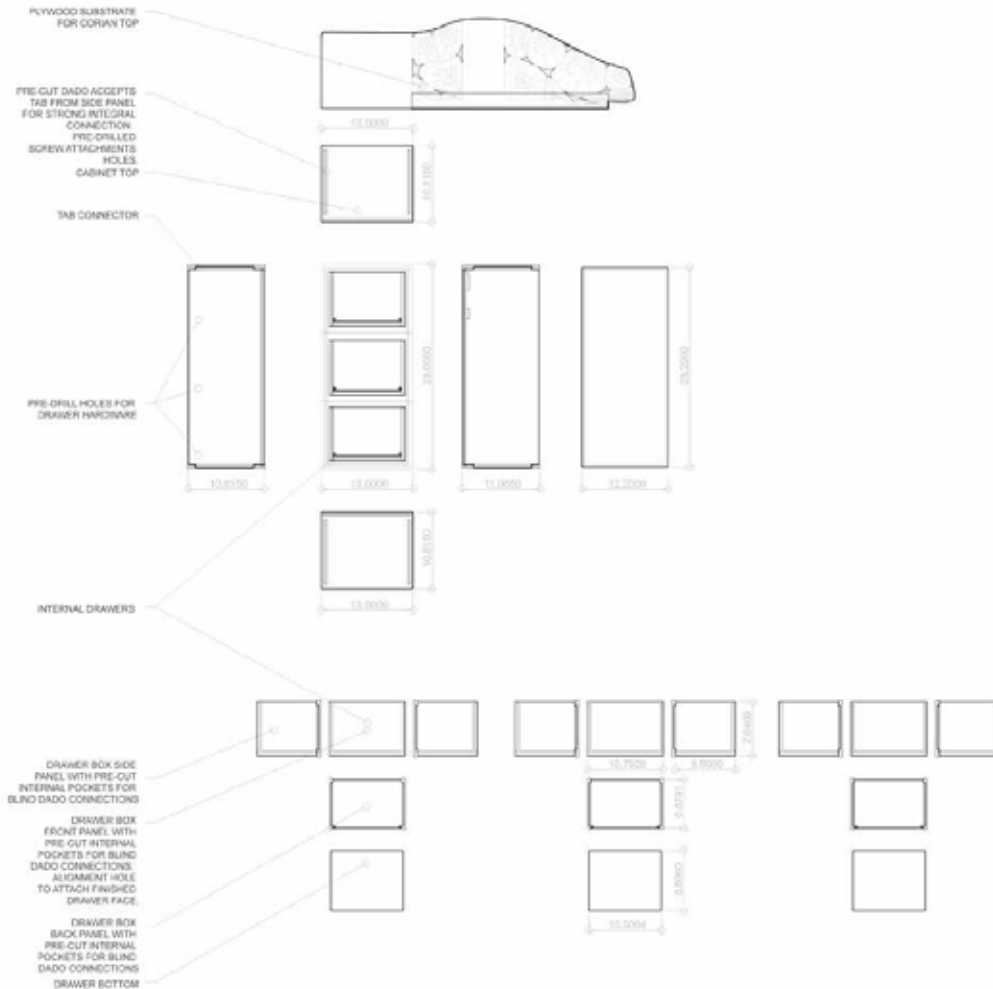
The desk floats off the wall, keeping as much horizontal space open through the apartment.

Lily Pad | Ruicci Residence | High Performance Space

The desktops curvature molds to the confined corner space. The cutting surface provides full access to the window while continuing the datum of the mantel.

This simple wall mounted desk, topped with polished black Corian helped to ignite Steve's freelancing potential. It serves as the base for his graphic design workstation, giving him a productive work zone out of the main apartment flow.

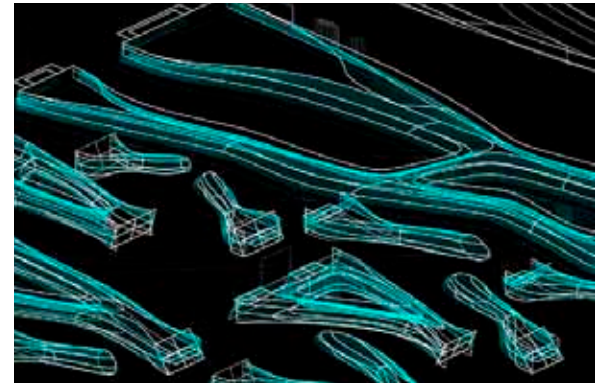
Gently nestled into the awkward corner nook, this bizarre space gains new function without sacrificing the primary living room setup.



Cantilevered desk cabinet breakout.



The desk surface extends the fireplace mantel mutating the horizontal datum along the west wall of the living



CNC machining tool paths. Precisely controlled geometry allows for exact manipulation of the fabrication tools and processes.

Raw milled plywood branches adorn the unfinished Corian surface.



Design: SU11 Architecture + Design

Fabrication: Associated Fabrication LLC

Position: Production manager, design consultant, fabricator, installer

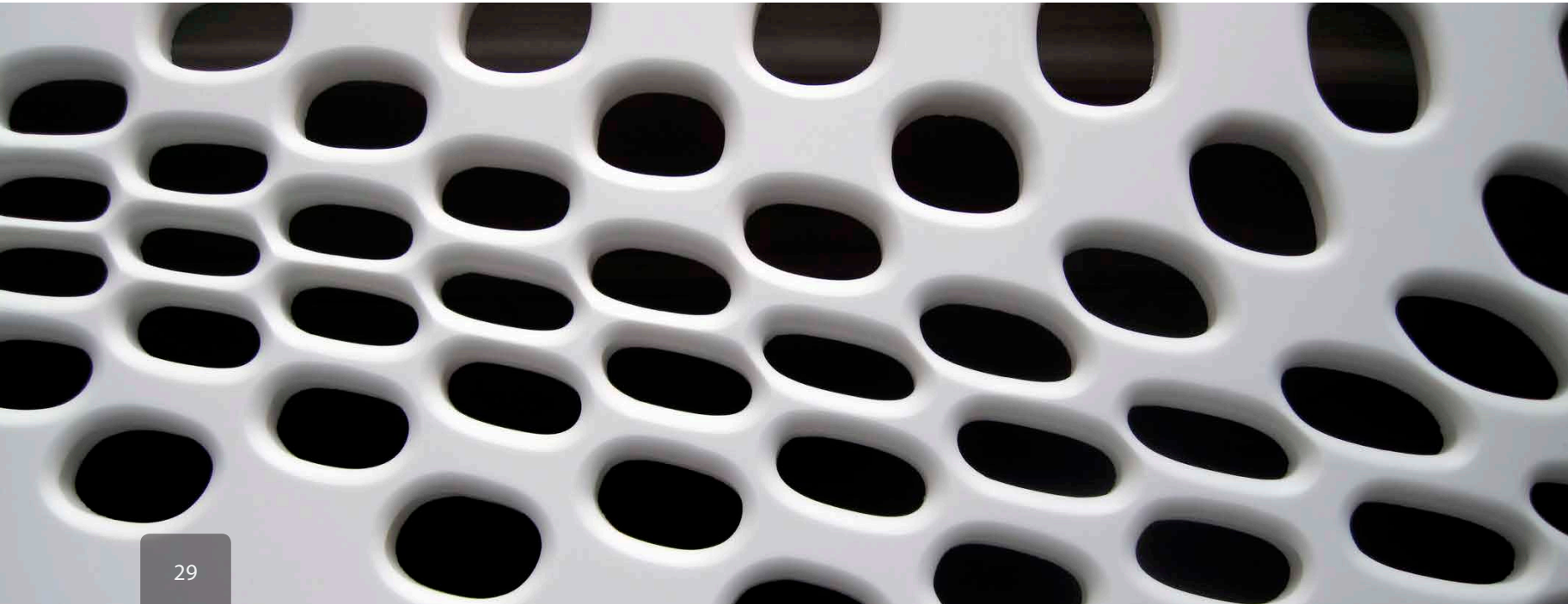
This Project presented some of the most intriguing fabrication challenges for forming non-planar double curved forms. Each molded form is reused in part or in whole as a more economical molding solution. This often meant that no flat trimming surface would be available so every seam edge is cut along a 3D curve.

The shelf and attached banquette wrap this New York apartment with elegant thermoformed Corian surfaces. The pure white provides a excellent backdrop to fully take advantage of the ample natural sun light entering the skylights.

UES Apartment | SU11 & Associated Fabrication

Textured surface pattern skinning the corian above a radiator unit. The holes allow enough hot air to escape to reduce risk of discoloration or deformation.

This gentle flourish emerge through the close collaboration between the design team at SU11 and our fabrication expertise at Associated Fabrication.





SU11 worked with Associated Fabrication to coordinate subDiv surface designs with efficient and economical production strategies in order to deliver the full design intent to the clients.

Many of the molds were extremely complex, but also reused many times, reducing their overall cost. We utilized the complexity of the forms to drive a more efficient production process.

Seamed and assembled Corian surface sections.



Non-planar double curved mold taxonomy.

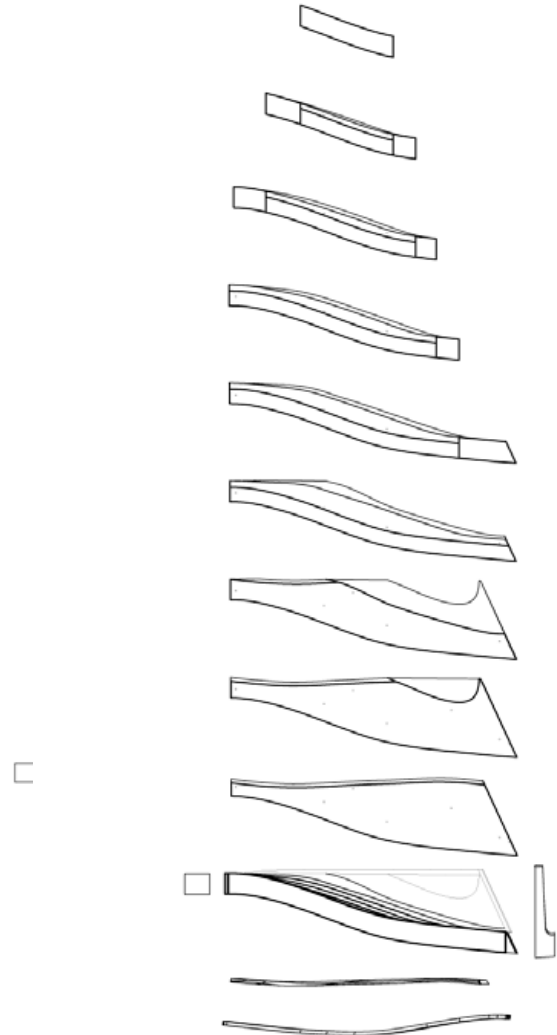
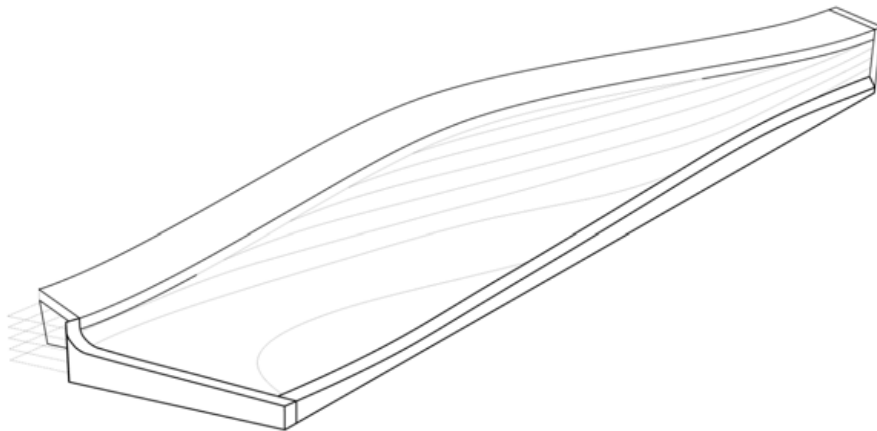


Reusing molds to form small similar surfaces for complex assemblies.

Sections seamed and assembled in shop from multiple molds. Self supporting kinks help reduce structural loads.

Complex molding apparatus to take full advantage of the uniform pressure exerted by the vacuum press. This is necessary to make the tight radius at the end of the mold.





Contoured mold surface. Building the complex surface molds in layers reduced cutting time and material waste.



On site seaming & finishing required for delivery constraints.

UES Apartment | SU11 & Associated Fabrication



We designed the entire system to break down into components small enough to fit into the buildings elevator and be assembled in the apartment with a crew of two experienced Corian fabricators. I was able to put my Corian skills to good use and run the installation of the shelf and banquette over the course of a week.

Trimming flat surfaces to fit site inconsistencies.

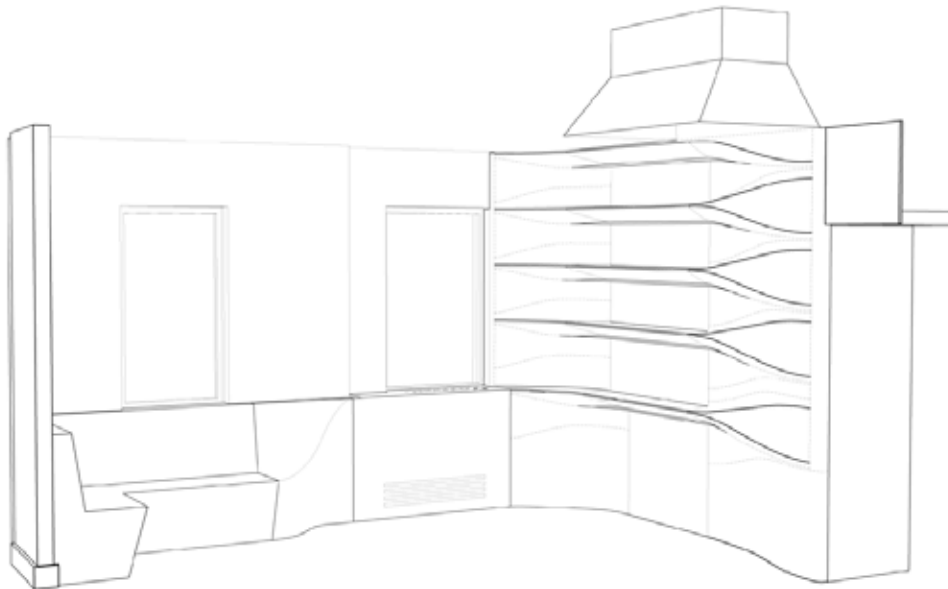


Cleaning and prepping the surface before sealing the expansion joints.

Many varied seams join into a smooth single surface.

The Corian surfaces continue to wrap around the living room and form the dining nook.

Featured in the NYC edition of Dwell Magazine, March 2011



UES Apartment | SU11 & Associated Fabrication



UES Apartment | SU11 & Associated Fabrication

The white corian enhances the intense natural light penetrating the windows along the West wall and the two overhead skylights.



Wrap around banquette and dining nook.





Design: 4-Pli

Fabrication: Associated Fabrication LLC

Position: Designer, modeler and fabricator

CNC Carved floor to ceiling walnut panels for an East Village apartment. The massive CNC router peels away the thick rich walnut, layer by layer, cell by cell to uncover the dynamic natural beauty of the wood.

Working with the rich natural materials is an intensely rewarding experience. The intimate relationship with the wood informed and guided the design and fabrication process. Each step of the process responds to new forces, new tactile and tectonic sensations.

Design Build | W 11th St Residence | Rachel's Wardrobe

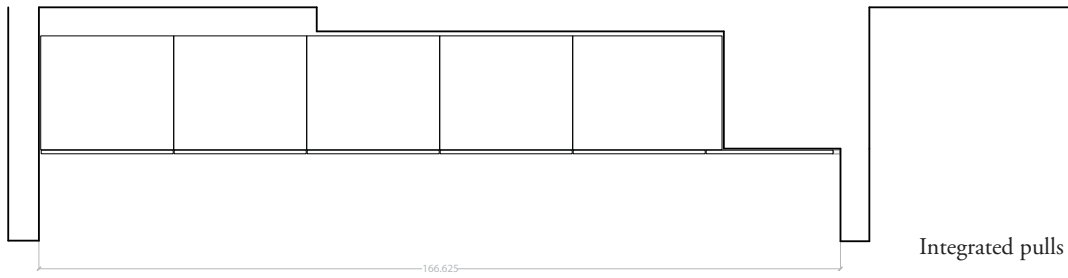
Bathed in natural light from above, the view as you ascend the spiraling stair to the fifth floor sleeping level leaves you breathless (not just from the climb). A powerful statement of natural beauty enhanced by design and digital surfacing engages you, creating a space to pause and wonder at the depth of the materials and subtle supple surface curvature.





Front Elevation - No doors

Section



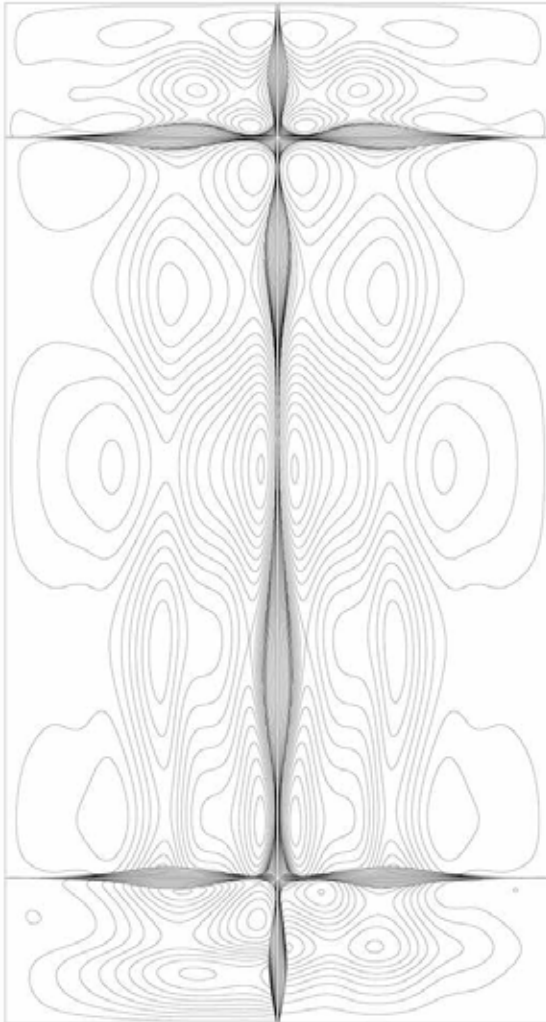
Plan

Integrated pulls and handles undercut the surface.

Design Build | W 11th St Residence | Rachel's Wardrobe



Design Build | W 11th St Residence | Rachel's Wardrobe



Each door is a unique contoured surface derived from the dialog between the natural variation in the wood and the precise control of the surface with the CNC router.

The peeling intensifies at the intersection between panels, guiding the hand into the integrated undercut pulls and begging to be touched. Like leaves of paper the surface is delaminating the solid hardwood.

Integrated handles undercut the surface. Supple surface peeling, ready to touch, ready to feel, alive.





Design: Urban Movement Design

Fabrication: Associated Fabrication LLC

Position: Production manager, lead modeler, lead fabricator, installation oversight.

Design and fabrication collaboration between Urban Movement Design and Associated Fabrication around a series of three dynamic bus shelters for the Whistler Athlete's Village at the 2010 Vancouver Olympic Games.

Through a series of prototypes we developed a system of changing ergonomic and activated profiles that transmute and deform along the length of each shelter. The benches manifest motion and provide an armature for a more engaging transportation experience. The adaptive profiles expand for lounges seating and contract to welcome short stands and handicap individuals.

The benches are constructed of thermoformed Corian solid surface material with a plywood ribbing structure and high strength aluminum canopy to withstand Whistlers forty foot snow loads.

Performance Shelters | Whistler Olympics Athlete's Village

The canted shelters interact with the beautiful natural landscape and lighting designed by Tom Barrat LTD. Tom was the Landscape Architect for the Whistle Village and local coordinator for installation.

This was Associated Fabrications largest fabrication project. My primary responsibilities for the project included design collaboration and fabrication engineering of the structures, Corian surfaces, molding, and installation. I served as Production Manager for the project with a team of five designers and fabricators. The complex surfaces utilized very precisely integrated and constructed digital models translated to built structures and complex thermoforming molds through 3-axis CNC milling.



Performance Shelters | Whistler Olympics Athlete's Village

This project required over thirty unique molds to build the complex double curved surfaces. It pushed the boundaries of what we could accomplish with thermoforming and digital CNC fabrication. Such massive forms require tight tolerances in surface forming and careful attention to detail to maintain the seamless smooth flowing surfaces.

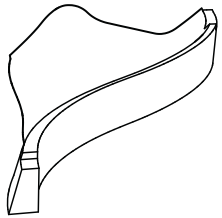
Molding strategies: deep draw, double sided compression, vacuum-forming



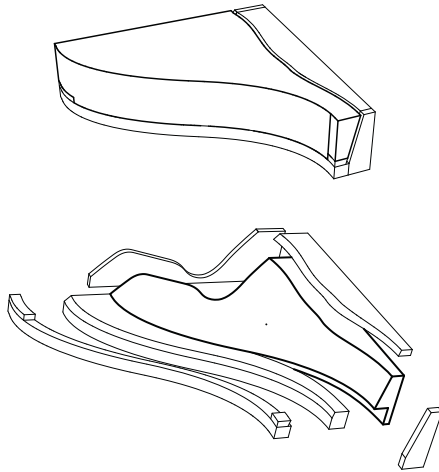
Deep draw molding process. A 3D model of the surface section is used to extrude a precise two part mold. The two part mold allows for greater pressure over wide areas that vacuum forming cannot accomplish or to handle deeper draws that the vacuum cannot accommodate.

The surface geometry then has to be flattened using software tools to get a estimate of the general flattened shape. Tolerances and adjustments to accuracy and material properties help bring this approximation closer. A safety margin is applied and the surface is prepared for forming.

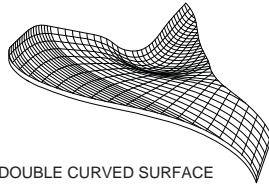
Kerfing (small rounded grooves) are cut into the hidden side of the surface to achieve more extreme curvatures.



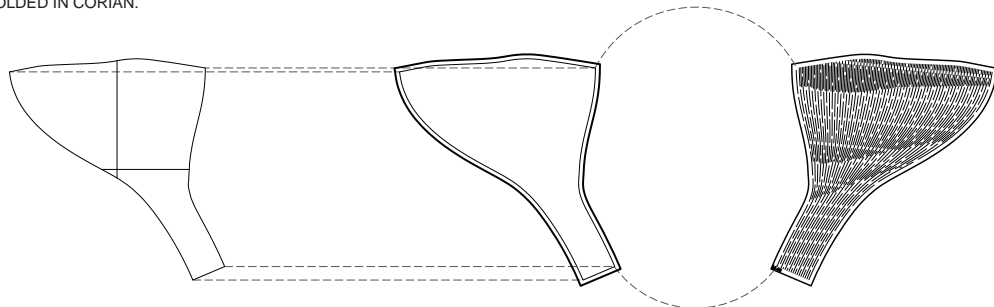
DEEP DRW MOLD
(TOP)



DEEP DRW MOLD
(BASE)



DOUBLE CURVED SURFACE
TO BE MOLDED IN CORIAN.



FLATTENED DOUBLE
CURVED SURFACE

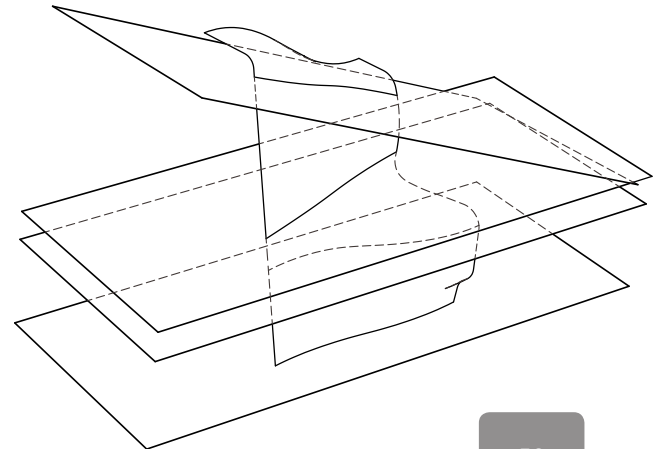
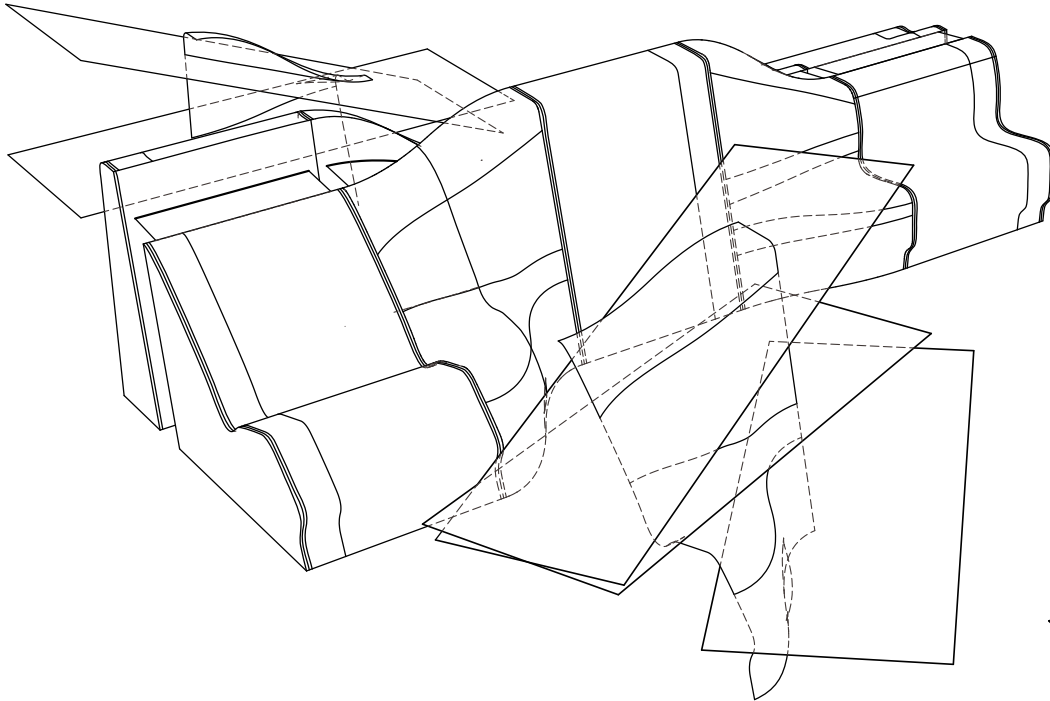
OFFSET SHAPE FOR TRIMMING
AND TOLERANCE ADJUSTMENTS.

FLIP TO ADD KERFING FOR SMALL
RADIUS DEEP DRAW MOLDS.
KERFS ADJUST TO SURFACE RADIUS.

Performance Shelters | Whistler Olympics Athlete's Village

Many of the mold were cut as oblique angles to accommodate large surface changes and material limitations.

The MDF molding surfaces were used multiple times, providing a more efficient and economic use of material. There is a quiet beauty in the molds after the forming and seaming finished.







Engineered plywood structure to resist high moisture and temperature differentials as well as withstand the forty foot snow load of the Canadian mountains. The dense plywood rib structure mediates and supports the transitions between static profiles. These transition zones required tight tolerances to ensure that the formed surface would fit within a 1/16th of an inch.

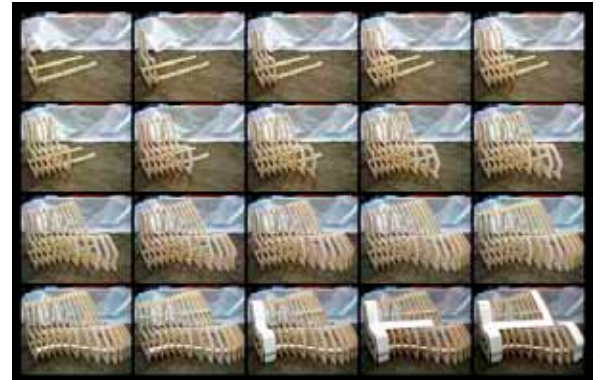
For added support and to reduce shifting the entire interior was coated with a spray polyurethane foam. This produced an intensely organic space within the benches, A living skeleton for these massive glowing organisms.

Testing forming tolerance.

Performance Shelters | Whistler Olympics Athlete's Village



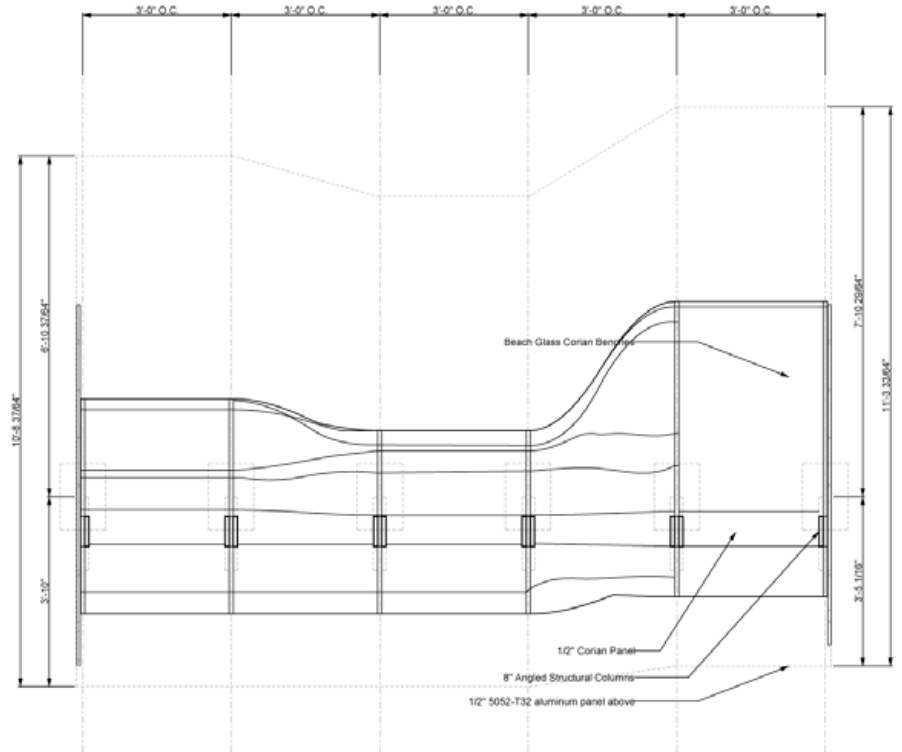
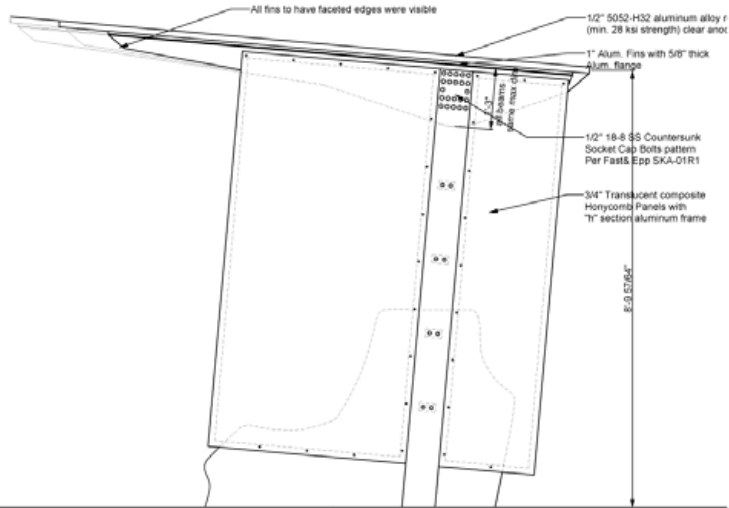
Urethane Skeleton.



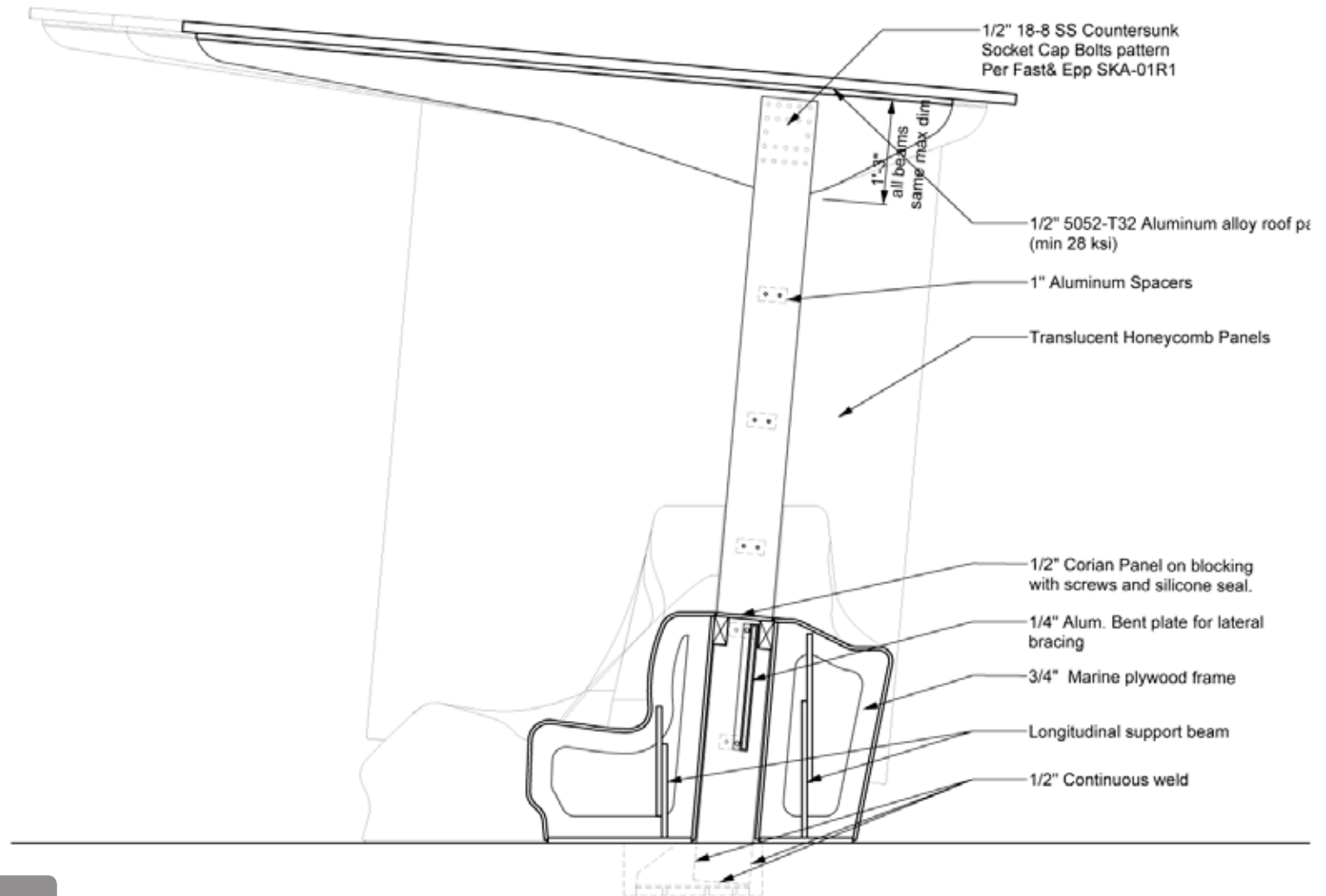
Plywood rib structure assembly sequence.

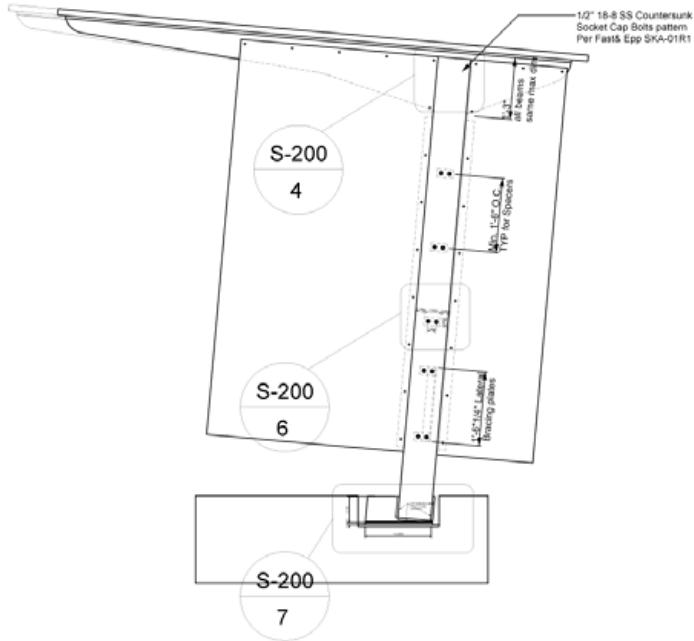
Formed corian prototype surfaces on the plywood system.

NOTE:
 All structural aluminum to be 6061-T6 alloy, clear anodized.
 Roof panels to be 5052-T32 aluminum alloy, clear anodized.
 Screws to be 18-8 Stainless Steel
 See addendum for Bolt and Aluminum Specifications



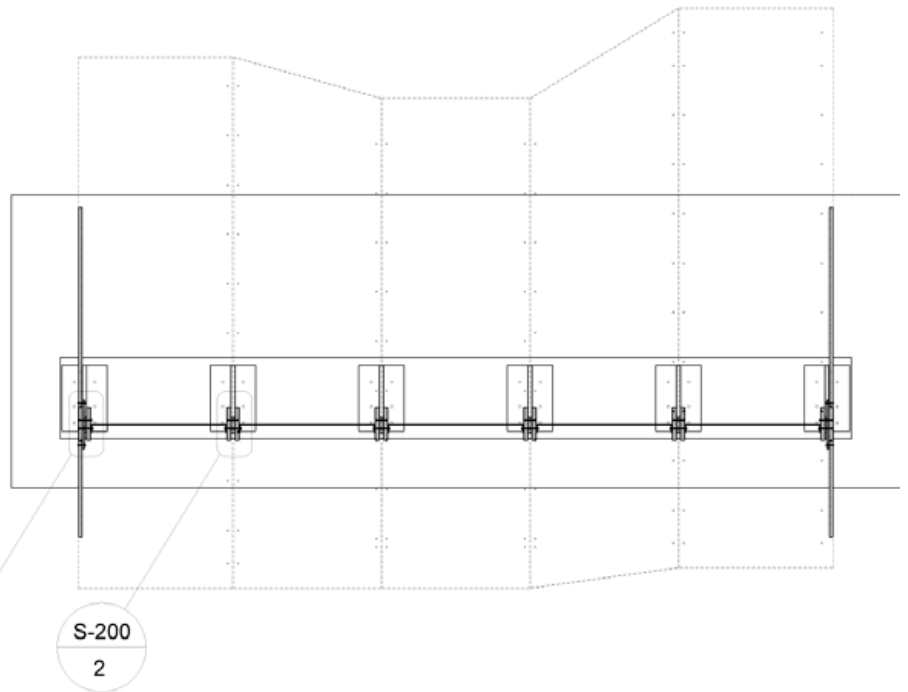
Performance Shelters | Whistler Olympics Athlete's Village





01 Typical Structural Elevation

1/2" = 1"



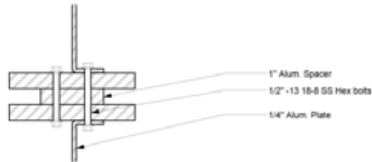
02 Typical Structural Plan

1/2" = 1"

Aluminum canopy structure



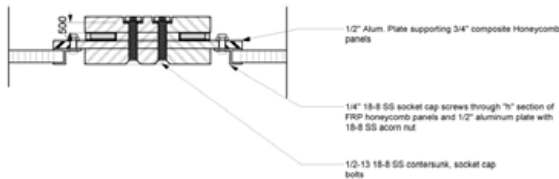
04 Aluminum Column Detail at Fin
2" = 1"



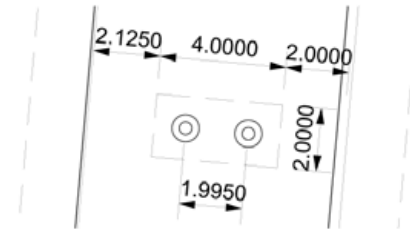
03 Aluminum Column Detail within Corian Bench
2" = 1"



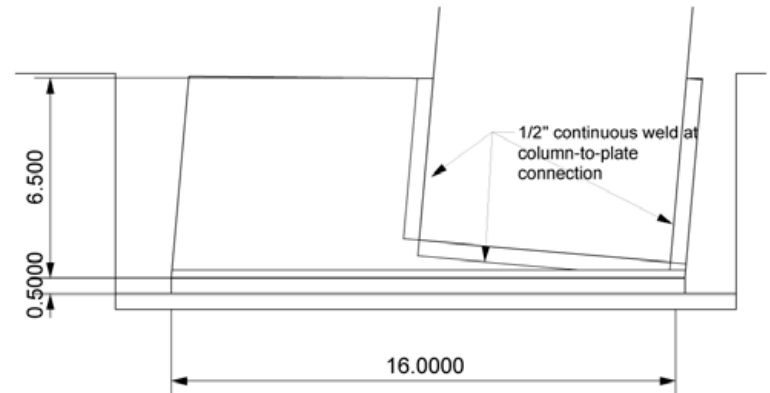
02 Aluminum Column Detail above Bench
1" = 1"



01 Aluminum Column Detail at Side Panel



06 Aluminum Spacer Detail
4" = 1"



07 Aluminum Plate Detail
2" = 1"

Aluminum structure details to withstand 40' snow load,



Surfaces were broken down into multiple parts to match material and molding tolerances, then seamlessly reassembled before being integrated into the full bench surface.

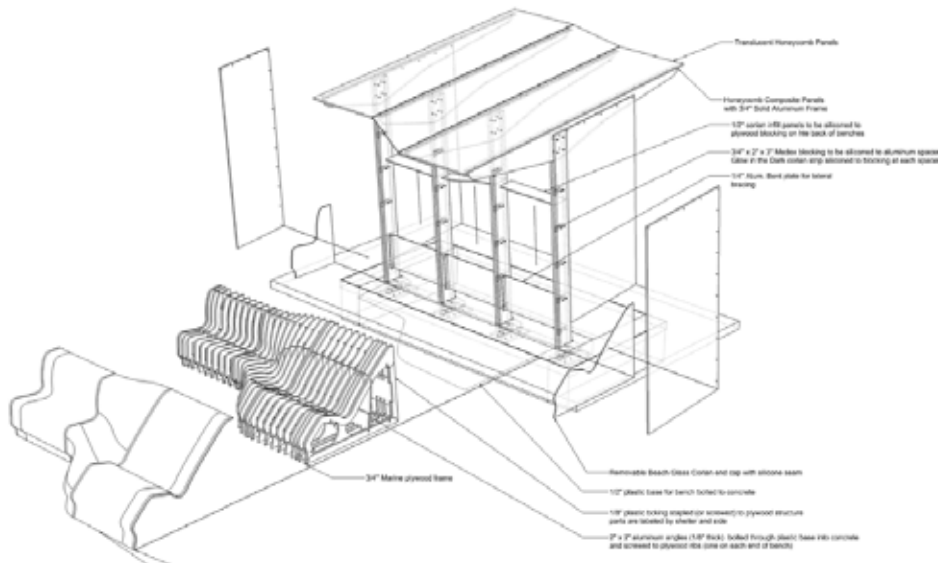
A glow in the dark solid surface band was integrated at the intersection between each profile transition, providing a subtle cool lighting for the long northern winters.

Preparation for seaming two large transitions

Performance Shelters | Whistler Olympics Athlete's Village



Fully assembled and seamed surface.



Glowing solid surface detail.

Performance Shelters | Whistler Olympics Athlete's Village



Wrapped up safe for the journey West.



Heavy duty extended fork lift.

Installation oversight as winter approaches the West Coast of Canada. Seeing the twenty foot bench balancing and flying down the street was the most stressful event of the entire project.

All parts were carefully engineered to fit within the trailer of one eighteen wheeler for their safe journey across the country.



Along road to safety.



Holding my breath.



A snug fit.



Athletes enjoying the bus shelters as they travel to their events. The dynamic forms provide great opportunities for creative stretching and exciting spatial occupation.

The subtle blue surface enhances the transition from clean blues sky to winters white blanket.

Waiting for the fun bus.



Design: Zaha Hadid Architects
(Melodie Leung)

Fabrication: Associated Fabrication LLC

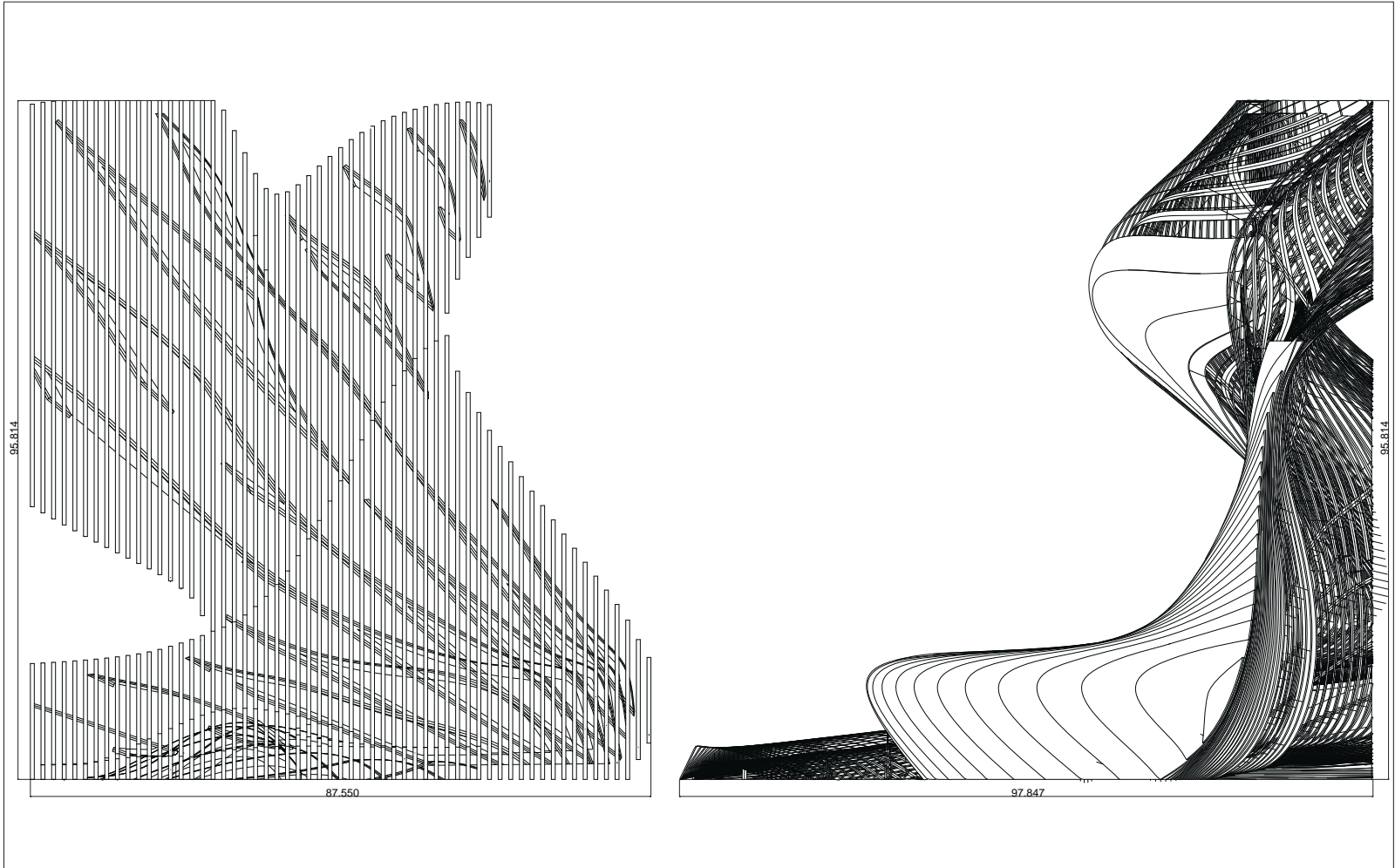
Position: Design and fabrication consultant,
production manager, delivery & installation.

The Cirrus is cloud manifested. An experimental seating sculpture designed for the CAC, Cincinnati Contemporary Art Center, exhibition “Form, Contemporary Architects At Play” held in 2008. The Original Cirrus sold for \$250,000 as part of an auction accompanying the show. Associated Fabrication was then contracted to produce four more sculptures for exhibition around the world. The original still resides in Cincinnati.

With an extremely pressed three week deadline we engineered a simple and elegant system for connecting continually changing surfaces, modeled and extracted the hundreds of intersecting fins, CNC fabricated and delivered the initial Cirrus for exhibition.

Cirrus was featured in Italian Vogue, January 2009. (Photo by Melodie Leung.)



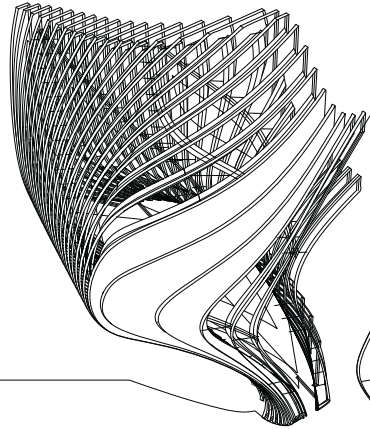


Front Elevation

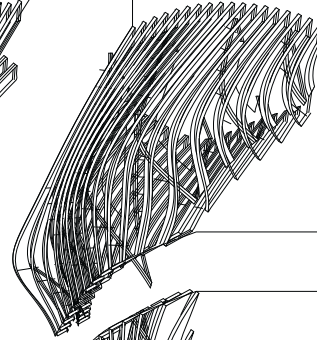
Side Elevation



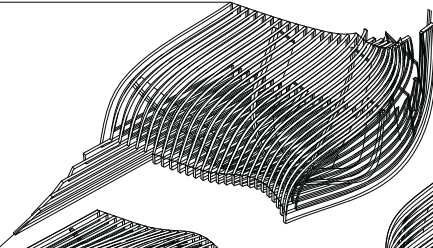
PART 01



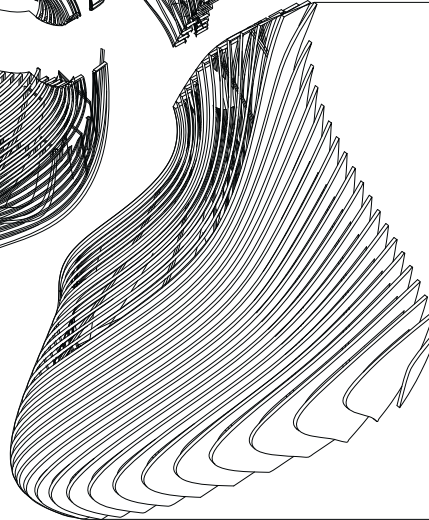
PART 02



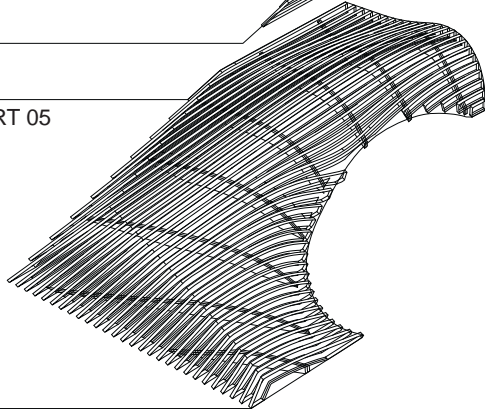
PART 04



PART 03

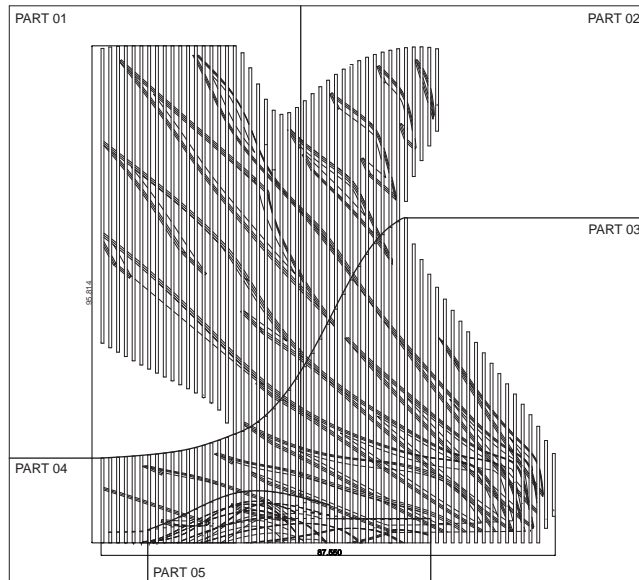


PART 05

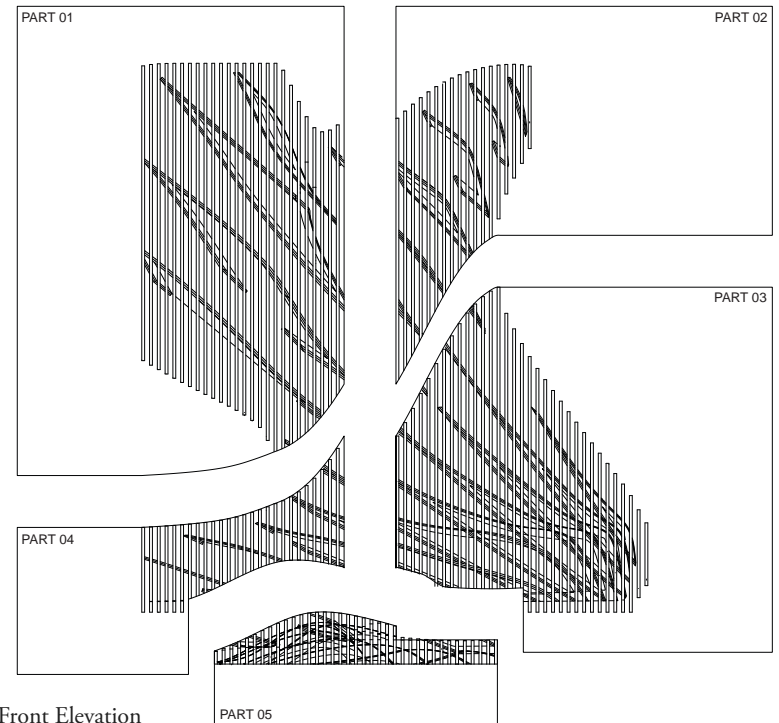


Perspective Exploded

To accommodate transportation and storage the sculpture was divided into five assembled parts that could be recombined on site by any team using our in depth installation and removal guide.



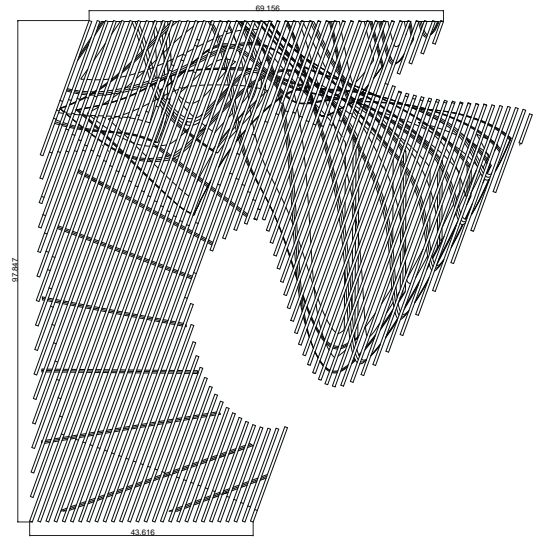
Front Elevation



Front Elevation
Exploded



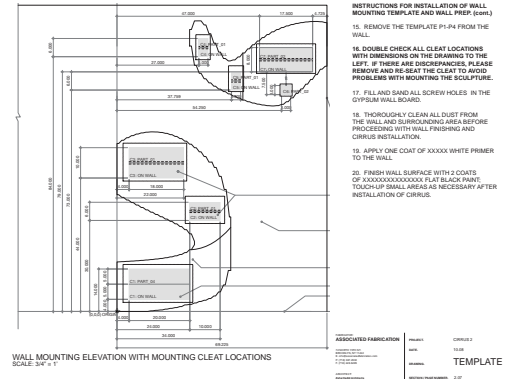
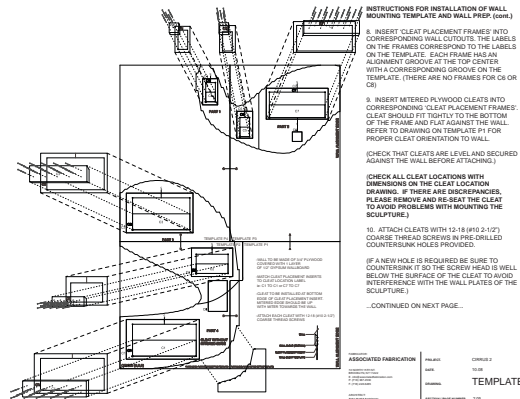
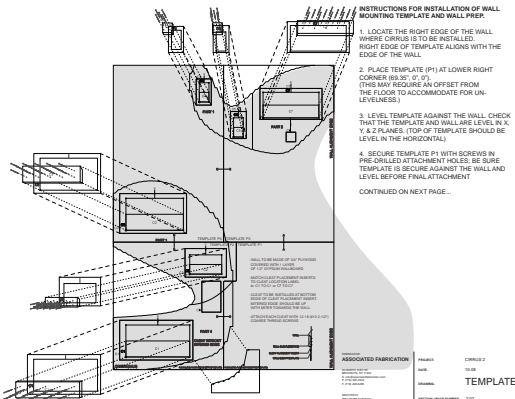
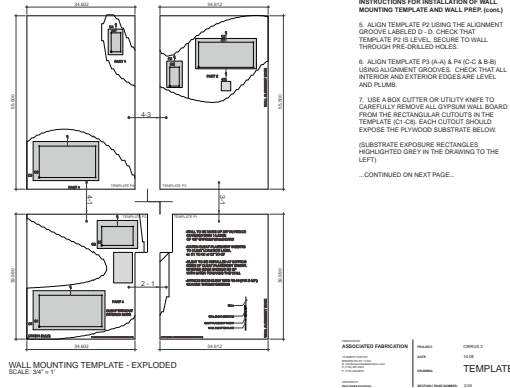
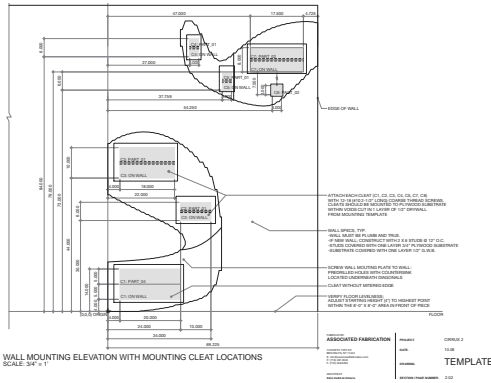
With the largest part weighing over 350 lbs a strong and talented team of museum installers helped Bill Mowat and myself hoist the cantilevered components onto the wall.

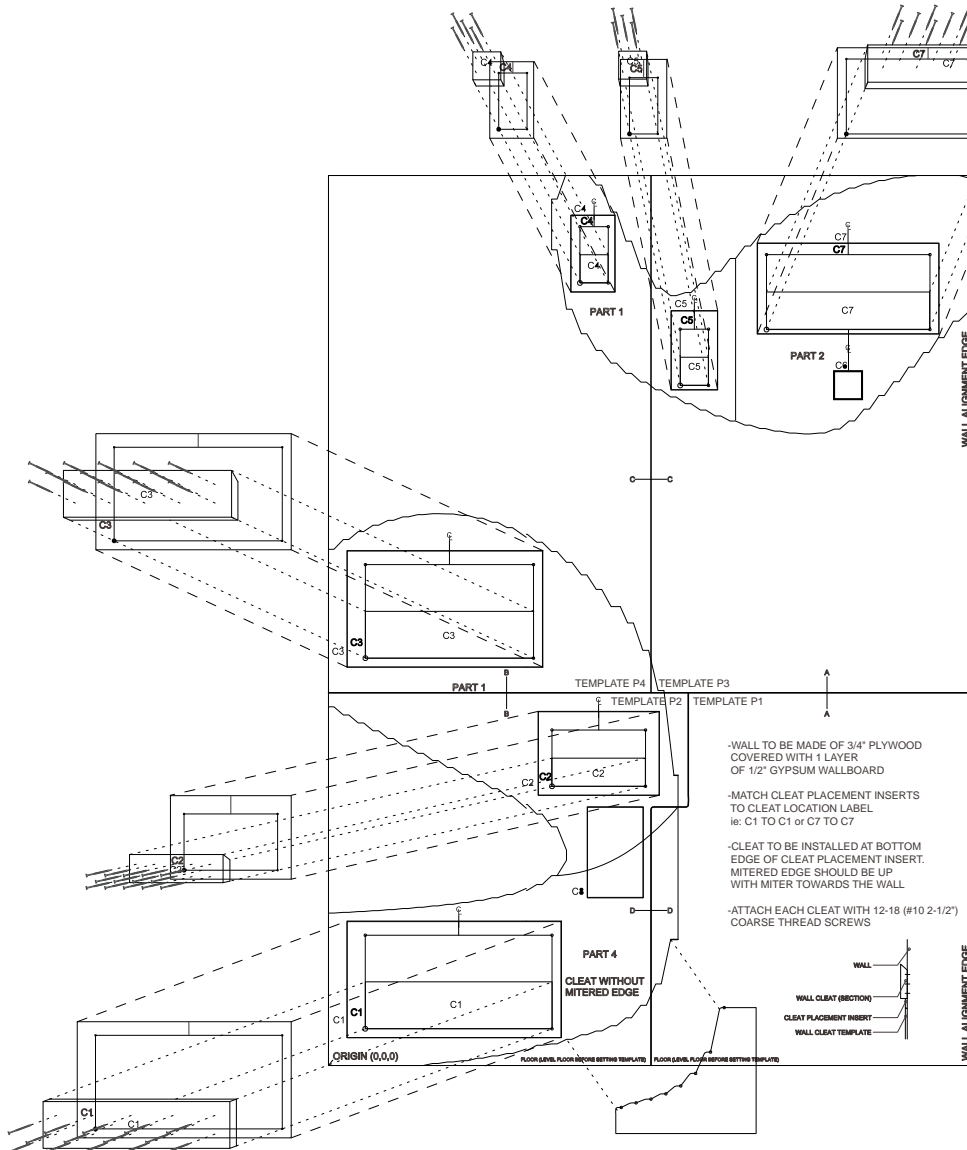




The exhibition was sponsored by Formica, they provided the slick glossy black veneer for the vertical fins as well as a very durable (and sharp) matte veneer for the interior support fins.







INSTRUCTIONS FOR INSTALLATION OF WALL MOUNTING TEMPLATE AND WALL PREP. (cont.)

11. CLEAT C1 HAS NO MITERED EDGE AND SHOULD BE INSTALLED THE SAME AS ALL OTHER CLEATS
 12. CLEAT C8 IS A 6" X 9.75" X 3/4" PLYWOOD BLOCK ATTACHED TO THE PLYWOOD SUBSTRATE IN ITS CORRESPONDING LOCATION CUTOUT.
 13. CLEAT C6 IS ATTACHED TO CIRRUS PART_02.
 14. ONCE ALL CLEATS HAVE BEEN SECURELY FASTENED TO THE WALL, REMOVE THE CLEAT PLACEMENT FRAMES
- (TRY NOT TO DESTROY THE FRAMES IN CASE YOU NEED TO ADJUST THE CLEATS LATER OR REMOUNT THE SCULPTURE ELSEWHERE.)

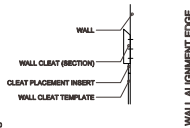
...CONTINUED ON NEXT PAGE...

-WALL TO BE MADE OF 3/4" PLYWOOD COVERED WITH 1 LAYER OF 1/2" GYPSUM WALLBOARD

-MATCH CLEAT PLACEMENT INSERTS TO CLEAT LOCATION LABEL
ie: C1 TO C1 or C7 TO C7

-CLEAT TO BE INSTALLED AT BOTTOM EDGE OF CLEAT PLACEMENT INSERT. MITERED EDGE SHOULD BE UP WITH MITER TOWARDS THE WALL

-ATTACH EACH CLEAT WITH 12-18 (#10 2-1/2") COARSE THREAD SCREWS



FABRICATOR:
ASSOCIATED FABRICATION

72 NORTH 15TH ST.
BROOKLYN, NY 11222
E. info@associatedfabrication.com
P. (718) 387.4530
F. (718) 228.6285

ARCHITECT:
Zaha Hadid Architects

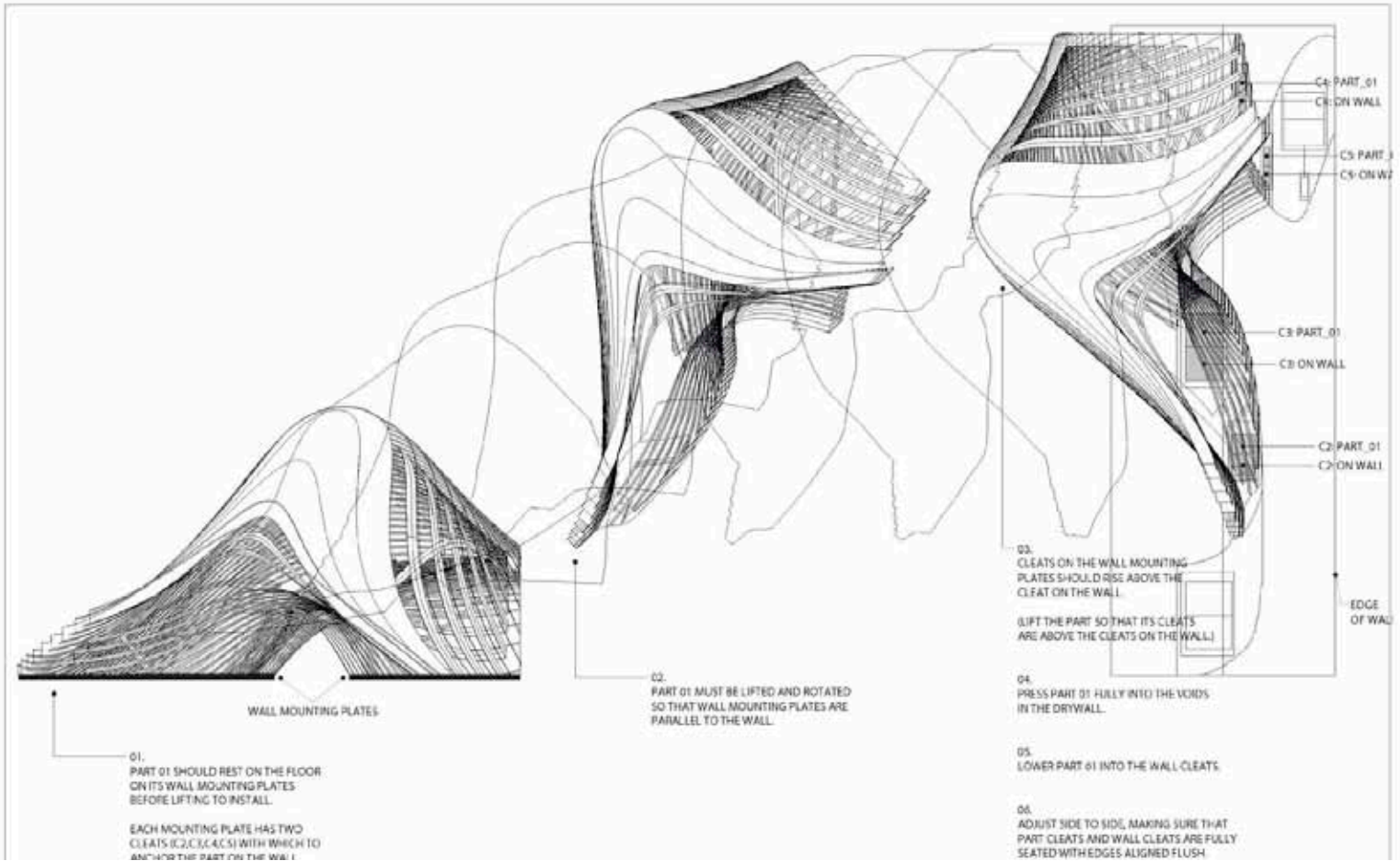
PROJECT: CIRRUS 2

DATE: 10.08

DRAWING:

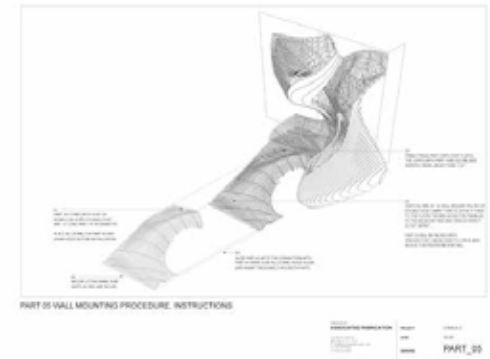
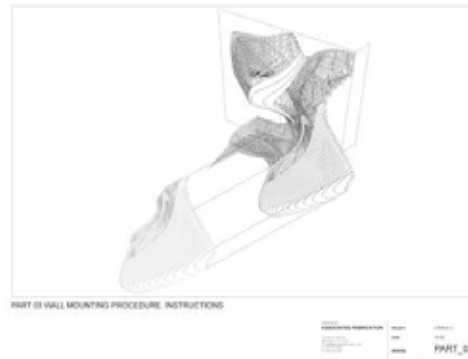
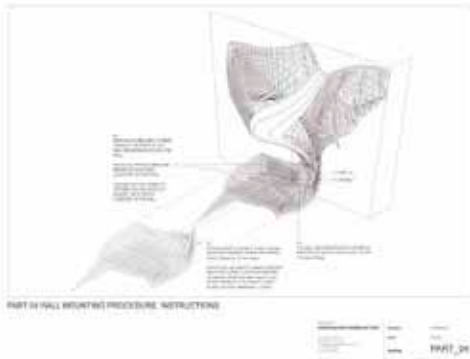
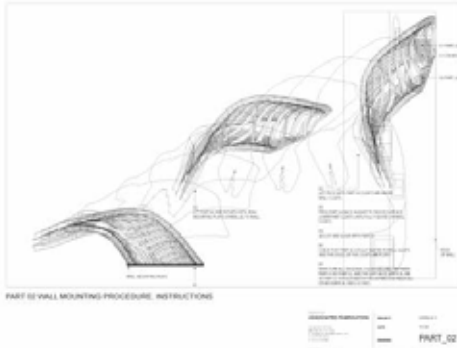
TEMPLATE

SECTION / PAGE NUMBER. 2.06

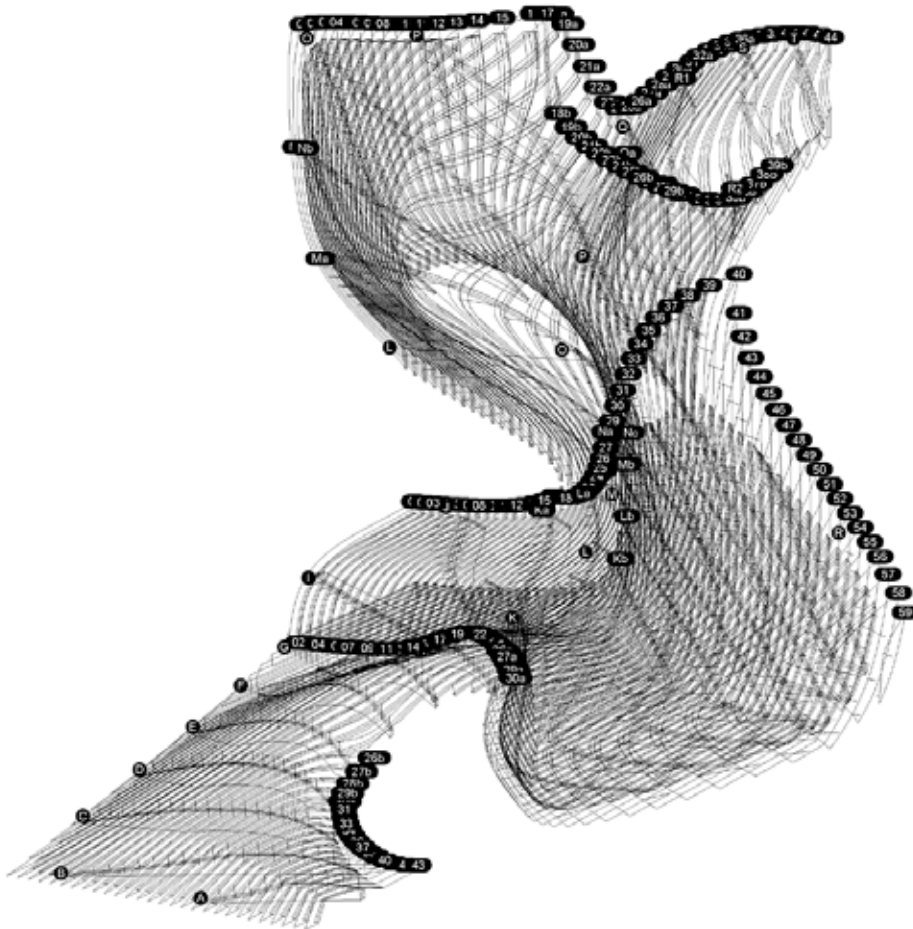


Part 01 - Wall Mounting Procedure

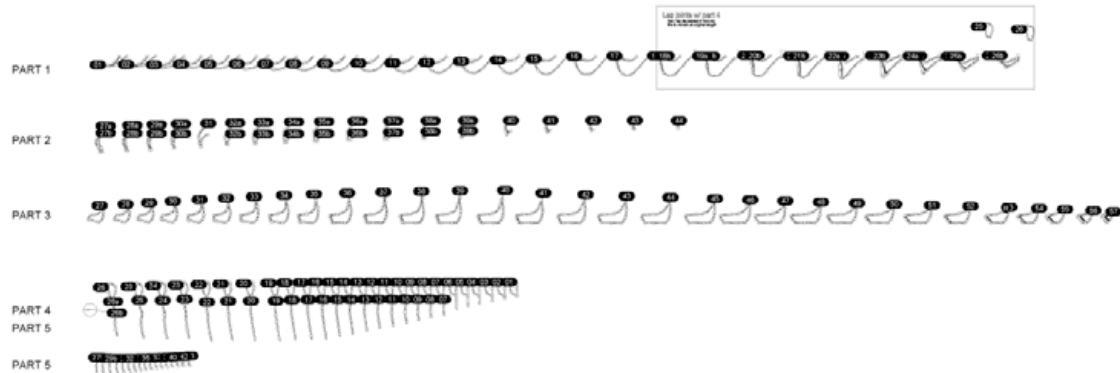
Each component required a precise set of steps to insure successful installation and alignment. The joints between each part were handled by 3" - 6" lap joints build into the parts during fabrication. High strength magnets were nested into each side of the lap joint to help guide and hold the fins together.



We engineered the structure and assembly mechanisms to construct four total Cirrus sculptures now displayed around the world. Each cirrus is constructed with high gloss Formica laminate of split cores of high density ranger board. Every unique fin uses digitally aligned dowels and magnets to hold the crossing internal and external ribs together.

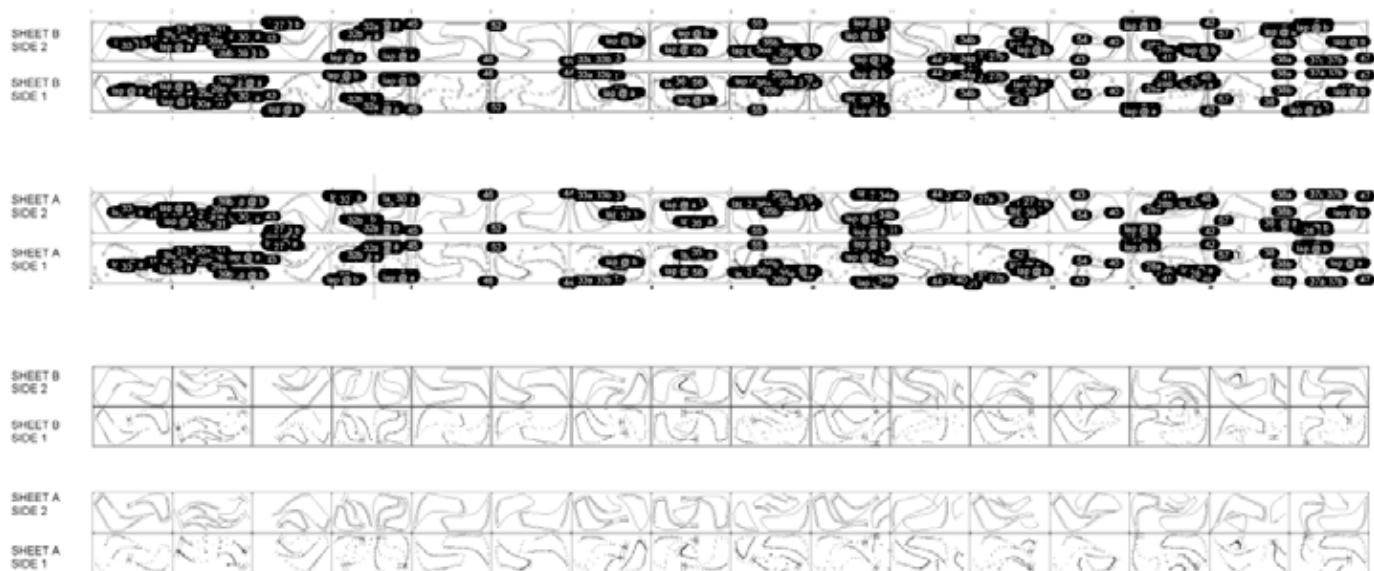


Overall interior and exterior fin index for fabrication breakdown



Elevation view of all the fins.

CNC cut sheet for one part, each fin has two halves, which must be cut from both sides to account for changing curvature.



Cirrus | Zaha Hadid Architects | Architects at Play

Cirrus was featured in Italian Vogue, January 2009. (Photo by Melodie Leung.)





FORM:

Contemporary Architecture of Place
The architecture of place is a concept that has been developed by architects and theorists in response to the need for a more holistic and context-sensitive approach to design. It emphasizes the relationship between a building and its surrounding environment, including the social, cultural, and historical context. This approach seeks to create spaces that are not only functional and aesthetically pleasing but also deeply rooted in the local community and its values. The architecture of place is a key concept in contemporary architectural theory and practice, and it has led to a renewed interest in traditional building techniques and materials. This approach is often used in the design of public spaces, cultural institutions, and residential developments. The architecture of place is a key concept in contemporary architectural theory and practice, and it has led to a renewed interest in traditional building techniques and materials. This approach is often used in the design of public spaces, cultural institutions, and residential developments.



My friend Ariel approached me to create a unique jewelry display case for his girlfriend Patty. She makes custom jewelry designs and needed a special and personal way to display them.

I had been looking for a good project to experiment with combining some extra walnut with a solid surface material. With the jewelry case I was able to incorporate burgundy Richlite nested into the walnut surface with delicate white Corian shelving the interior.

Visage | Jewelry Case

In the early design process I was looking into the morphologies of skulls and carried over some of the base geometry to the Richlite strapping. By folding the straps around the case the face or visage distorts as the angle between each half changes. These mutations resulted in a reflection of the face geometry to form feet and handles for the case.



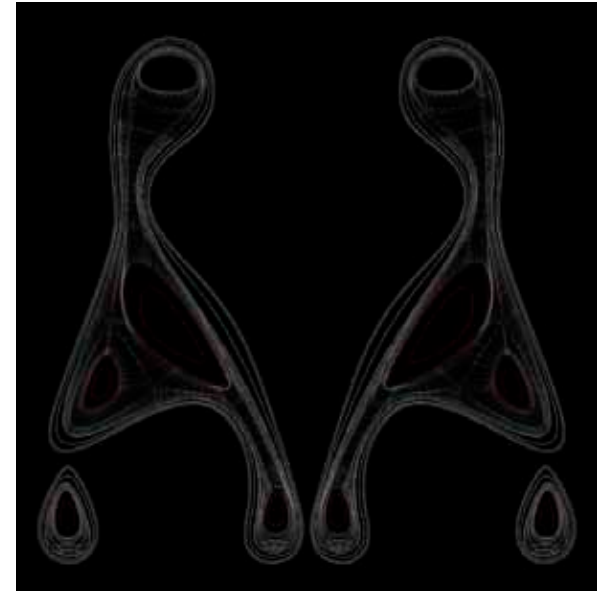


Raw Richlite straps fresh off the CNC Router.

Visage | Walnut Jewelry Case



The walnut and Richlite take an exquisite finish with natural linseed oils and a hand applied layer of protective waxes.

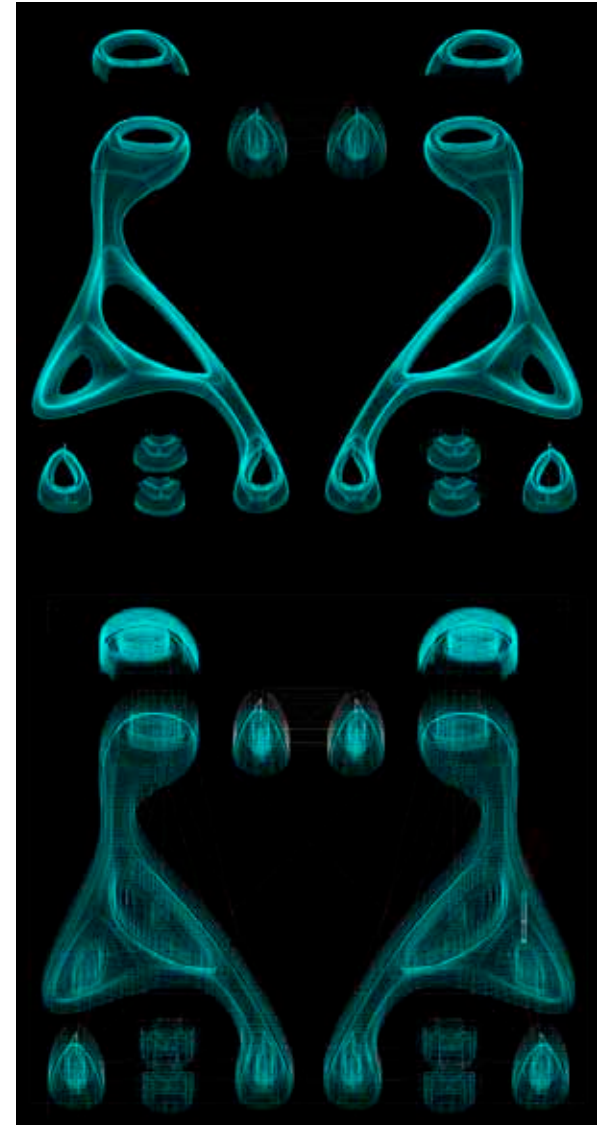




The organic Richlite strap uses a simple geometry structure with stretched points and curves. With the added layer of controlled tooling the surfaces gain a life of their own, reflecting material resistance, tooling speed, digital geometry and hand finishing.

The digital model went through a multi-phase process of translation from a simple polygon structure, to a simple organic subDiv surface, and finally to precisely controlled nurbs offering complete control and modulation of the CNC tool paths.

Visage | Jewelry Case





In contrast to the deep rich reds and browns of the exterior, the interior introduces delicately clean white corian shelves custom designed for displaying jewelry.

The case is held shut by six powerful magnets. The surface remains clear of obtrusive hardware.

Visage | Jewelry Case



Selected Written Works

The following are a collection of essays published through the Tutorspree (www.tutorspree.com) blog related to architecture, design, 3D modeling and digital fabrication.

When I am not teaching in a classroom I offer tutoring service on a wide variety of technical and conceptual projects. I have developed some great working relationships with talented and motivated students.

Cultivating Technical Skills into Creative Assets

Part 1 : Mentors

<http://blog.tutorspree.com/post/8216603009/cultivating-technical-skills-into-creative-assets-part>

Part 2 : Mentors : Instructors

<http://blog.tutorspree.com/post/8216600437/instructors>

Part 3 : Mentors : Critics

future publication.

Digital Fabrication: Designers Should Make Things

<http://blog.tutorspree.com/post/8950994223/designers-should-make-things-digital-fabrication>

There are still no substitutes for practice, no shortcuts, no 30 minute DVDs, no magic pills and no direct cortical downloads to build new neural pathways for a new skill. Fortunately our brain, nervous system, and muscles are suited for just such a task, but like any good system, there are considerable levels of resistance. This resistance does not exist merely to slow down the learning process, but instead it encourages adaptability in forming creative solutions to complex problems. Thus, the journey (and frustration) of learning techniques is more a part of any skill than all the tools and processes involved. Finding good mentors is a thoroughly tested method for reducing the time to learn new technical skills and form them into creative assets.

A mentor can take many forms; an instructor providing a survey of material, while managing a group learning dynamic; a critic focusing on conceptual feedback, setting the context of a greater discussion; a personal tutor guiding a student through specific technical skills, offering direct assistance to correct missteps, and providing personal challenges connecting the skill to a greater whole. My experience as a professor, critic, and personal tutor has exposed the value that each role holds in the quest for mastering design.

My primary technical focus as a mentor concerns CAD or Computer Aided Design, a term I find a bit silly, kind of like saying Pencil Aided Design (though PAD is a good acronym), but it is an industry term for frame of reference. The 'technical skills' section of my CV has grown into a rather ridiculous list of computer programs ranging from simple drawing tools to programming robots, but the point is not the range of different skills I can use, it is a transparent understanding of the techniques those programs build upon to aide in the design process.

I started developing that understanding through many years of chaotically trying to learn the newest most beneficial program that would make me a better designer, or scrambling

Part 1 - Mentors

to brute force my way through a school project. Then, I began teaching others how to use these programs and quickly realized that what I had really gained from the extensive trial and error skill absorption process was a more fluid and flexible approach to creatively employing techniques. The specific skills were only important until they had dissolved into a larger pool of concepts ready to be poured into any project.

I now have a much deeper appreciation for the, often quiet, mentors who have shaped my journey so far. Masters who balance technical instruction and development with critical thinking and, most challenging for me, the elusive skill of self editing. These mentors were not only classroom instructors, but personal guides (tutors), encouraging exploration while maintaining focus. I worked with them on a personal level and now appreciate the challenges they provided from their own endeavors with the creative learning process. Without a guide, a mentor, or a tutor it is easy to lose perspective, becoming absorbed by technique without incorporating it into your design process. It is greatly beneficial to have a little help making the 99% perspiration part smoother to better engage our search for that 1% inspiration.

Previously I introduced three roles of the mentor: the instructor, the critic, and the tutor. Initially, I was focused on the role of the tutor, but I feel that there is more to explore in the subtle distinction between these roles. A mentor should be familiar with many forms of instruction, and fluidly shift between each role as the situation demands. The second and third part of this series will explore the roles of instructor and critic respectively as guides along the path to cultivating technical skills into creative assets.

Beyond sheer self motivation and driven curiosity it is the instructor who weaves the web of a curiously evolving story, engaging the creativity and critical thinking of an audience. Instructors present the vanguard of learning, offering a survey of possible starting points, a taxonomy of available techniques and an organized framework for exploration. The instructor must have an almost dubious understanding of the necessity for the patience and practice each student requires as they cultivate their new skills. Timing is crucial, there is a subtle rhythm to revealing information and establishing relationships between concepts and technical skills, while guiding students' absorption to establish a smooth flow of knowledge and learning. In my experience as an instructor, teaching seminars on design practices and work flow, the greatest challenge is finding the balance between lecturing and individual instruction.

Lectures have a reputation for being exhausting (if not boring) and when understood individually appear as a intensive mental drain with minor returns. They are the human equivalent to a direct data transfer from the mind of the instructor to the mind of the students, with a bit of added redundancy to encourage the most important points to stick. Since our memory (at least for most of us) does not behave like its digital counterpart it is not wonder that students come away confused and even irritated by lectures. I remember wondering; How will I remember all of this? What do they want me to know? What do they want me to do? Why can't they just skip to the really important stuff? Now that I am on the other side of the equation, I understand that

Part 2 - Instructors

these questions, in a somewhat perverse way, are exactly what an instructor wants. Clever teachers orchestrate the emergence of these questions, not through confusing material and information overload, but with a carefully and patiently unfolding story line. It is the art of the instructor to develop often seemingly unrelated characters in parallel, slowly merging vast layers of information, forming a complex lattice of skills, theories, and personal experience. Most essential to the process is a good sense of humor and near endless patience.

While engaging multiple students, each viewing the unfolding drama with a unique perspective, it is necessary to leave the podium and walk the space between the seats. Each individual's understanding and challenges weave into the evolving story line. I believe that this makes it possible to teach the same general subject for many years and never experience the same story, never fail to discover new insights and never stop challenging my understanding of the material. There is, however, a balance that must be struck between the instructor and the students. While I am almost compelled to spend enough time with each student to ensure that the knowledge is well seeded into their consciousness, the equation is limited by time. Even more importantly, it is the role of an instructor to present information with just enough guidance to ignite personal initiative in each student without developing a relationship of reliance. My goal is not to transfer personal knowledge, my neural network, to the students, but to pollinate the flowers of curiosity so that they may produce the endless fruits of creativity.

As a tutor and instructor I find stepping into the role of the critic the crucial motivator that expands learning beyond the classroom. By stepping into this role I take a step back from the intense focus of instruction and help the student(s) relate their work to a larger context. In design and artistic fields the studio / critic culture takes the forefront as everything is about concisely presenting an internalized process. Projects involve high levels of research and exploration into very localized subject matter. I remember being so fully absorbed into learning and doing that it was hard to take a deep breath and see the proverbial forest through the trees, to grasp the context of my work and question my position within that context. The critic is your guide along the toughest part of the journey to building a strong collection of creative assets, the voyage through the space of critical self analysis.

Stepping back from ones work is challenging in any field of study, and something I feel often doesn't receive enough attention. Probably the main reason that critical self analysis lags behind technical instruction is that it is really difficult, both to learn and to teach. There are no clear cut rules or step by step instructions to follow and everything is relative to your own perspective. It is a process deeply linked to the individual, slowly evolving over time to match new sensibilities, new creative pursuits, and new scales of work.

So how do we develop this skill? The first step is to consider it as a skill, not some innate ability or position reserved for experienced professors, but a simple technical skill that must be practiced, cultivated. Critical self analysis will challenge the foundations of your work, provide the harshest criticism you will ever face. It will tear at your self confidence, devour your inspiration, and yes, it will build character. Fortunately, you can reclaim your confidence with a thicker and wiser skin, derive more focused inspiration from unforeseen opportunities, and, well, keep building character, but first your personal critic needs a voice.

Part 3 - Critics

Like any skill, technical or otherwise, the paths to adept levels of proficiency are paved by the successes and failures of life's many mentors. Sharp minded, creative individuals able to dig deep into the gritty flesh of your project, and more importantly your mind, helping you to flush out the roots of the problems integral to your work. Their barrage of criticisms discipline your mind into a critical thinking creativity engine. Through their observation and analysis you develop your internal critical voice.

The relationship between student and critic is often a tenuous one, and like any dynamic pairing requires commitment, patience, and trust to fully develop. Criticism, no matter how constructive, is never an easy thing to accept, and from my experience, as the criticism and work gets better & more focused, it becomes harder to take. It reaches in, beyond the project, deep into your being. Student and critic are entwined at an emotional level no matter how objective the critique may be. Criticism reflects the personal sensibilities, understanding, and skills of the critic even more than the student and reveals possibility in the vulnerability of both sides.

Therefore, as nerve racking as presenting and defending your work may seem, keep in mind that this is a chance to see deeper into the mind of your critics. Listen carefully, and sharpen your critical sense on their words. The feelings of defeat are a byproduct of an unavoidable power gap between student and critic primarily based on time. This is your chance to absorb countless years of experience from passionate (it requires an immense amount of passion and caring to truly listen and offer criticism) peers. These mentors will not be with you all the time, they may be friends or just fleeting acquaintance, you probably will not like most of them (at first), but they are there to help explore the most exciting subject of all, understanding yourself. Listen carefully, be critical, and remember; you can't know everything, but right now you know something.

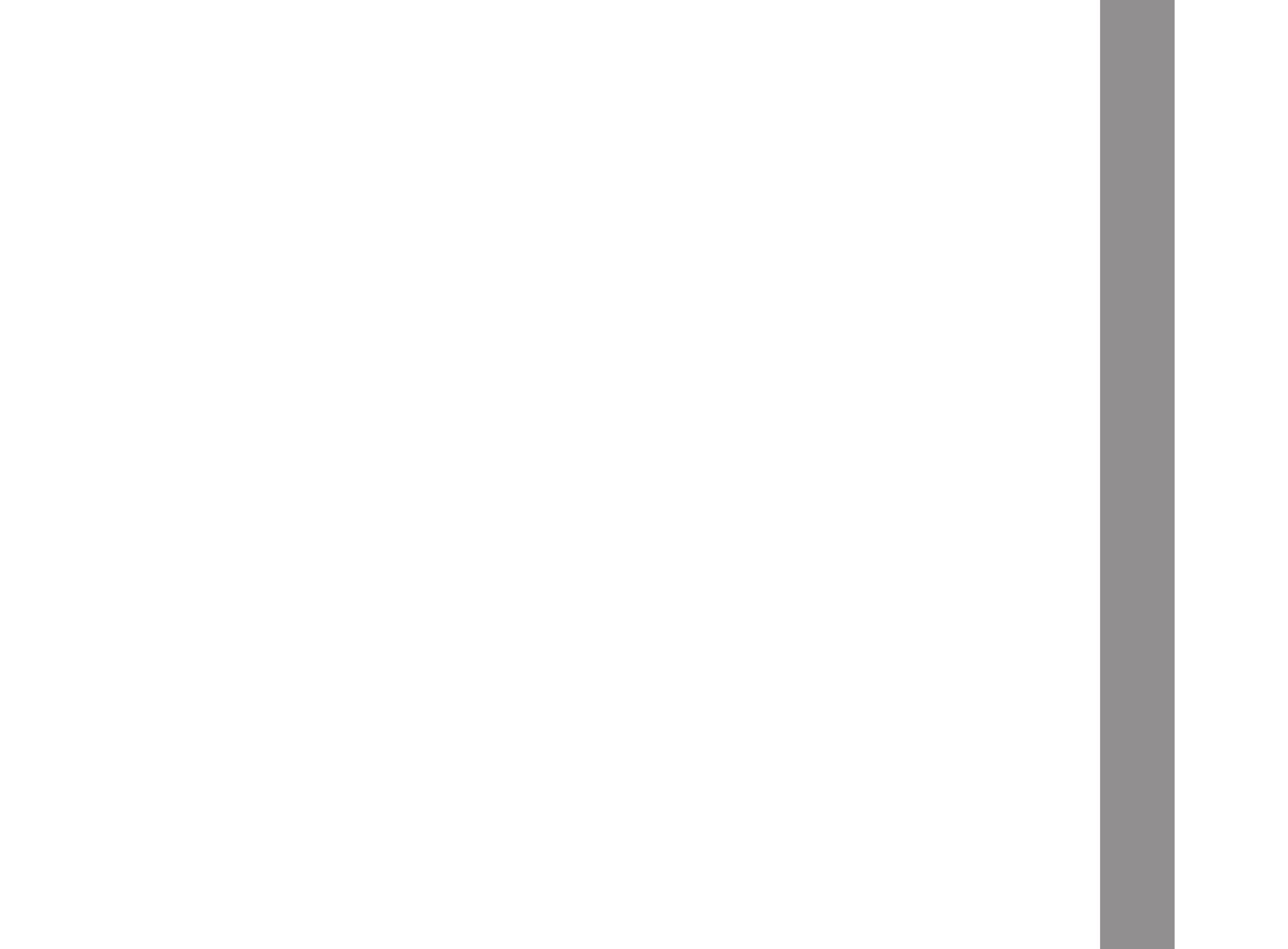
Computer controlled robotic manufacturing technology has existed for several decades in domains such as automotive, aerospace, and food processing, just to name a few. It automates repetitive tasks with a high degree of precision and minimal human oversight. As the technology advances and becomes smaller, cheaper, faster and generally more accessible it trickles down into other industries, probably just about anything you can think of from furniture and textiles to jewelry and table wear. As a designer I see digital fabrication technologies as powerful tools for increasing the feedback between virtual design and material form. Rather than employing the technology for mass production and automation, designers can utilize the agility of rapid prototyping and custom fabrication to offer better design solutions.

Digital fabrication can cover a pretty wide range of technologies. I personally have experience with high powered laser cutters, high precision 3D printers, pressurized water jet cutters, CNC pipe benders, and most extensively, 3-axis CNC routers. These are just a small sampling of tools available, and while I am not an expert with all of them, I do have several thousand hours working intimately with large 3-axis CNC routers while completing my Masters degree at Columbia University and as the Production Manager for Associated Fabrication (www.associatedfabrication.com) in Brooklyn. Understanding the machine processes helps me maintain design consistency and production efficiency.

When asked about digital fabrication I find myself referencing the acronym CNC all the time, quickly following it with “Computer Numerically Controlled” in an attempt to clarify. I cringe slightly every time I say this, on one hand the description is very literal, almost redundant, but on the other, it is nearly as inaccessible in every day conversation as simply saying “CNC”. I often end up quickly explaining it as, “a large computer controlled robot that cuts things”. Brilliant it is not, much too simple. While a CNC Router is a big (or small) robot, and it does cut things (nearly infinite material

applications) the sentence doesn't convey the most important aspect of the machine. It is a tool, and extension of the user's hand, and in turn, the user's creative mind. The robot doesn't really do anything itself, instead it relies on the user's intimate understanding of the material, virtual modeling, programming, and knowledge of the machine to provide instructions to be translated through a computer. It is much more than pressing a few buttons, just like print production is far more complex than pressing "Print". The designers hand flows through the digital process into the final product, crafting unique material objects with human character.

I believe designers, in any field, should have at least a basic understanding of the underlying processes involved in outputting their work. I offer my expertise to designers who want to understand the translation of their work and encourage students to take courses in digital fabrication, especially options focused on fundamental principles of making. Students should get into the laser cutting and CNC labs and navigate the machine's settings. Sure it is completely inefficient at first, and any number of things can go wrong (we are talking about robots and lasers here), but the connection between the virtual space of designing and the reactive feedback of the material is crucial to creating physical objects. The more control a designer has with tools and materials, the more she/he can focus on creating beautiful, intriguing and functional works. Plus, playing with robots is fun, schools are investing in the technology, and the distinction between designer and fabricator is fading, now is a great time to explore digital fabrication as a powerful creative asset.



Laser Cutter Setup

Digital Media Lab Equipment Tutorial 2004 - 2005

The laser cutter should be thought of as a plotter. Any application that prints can be cut on the laser cutter. It cuts two ways: **Vector** or **Raster** cutting. Vector based cutting follows lines, circles, etc. Raster based cutting is used with digital images.

M-300: 24"x12" Small Laser Cutter

X-600, X-660: 32"x18" Large Laser Cutter

The laser cutter cartridge should be set to 4 inches above your cutting material.

The height of the cutting bed and cartridge can be adjusted on the control panel on the front display of the laser cutter. Instructions on setting the height are posted above each of the laser cutters.

General Instructions For Plotting To The Laser Cutter

See next page for specific instructions on plotting from AutoCAD 2004.

Step 1: Open your file to plot. Select **Print Setup** from the **File** menu. Select the **Properties** button to display the following window:

Step 2: Click on a line color to adjust the power of the laser and the speed of the cartridge.

High Power and Low Speed = Deeper cuts

Low Power and High Speed = Lighter cuts

The colors coordinate with the line colors in Vector based programs such as AutoCAD.

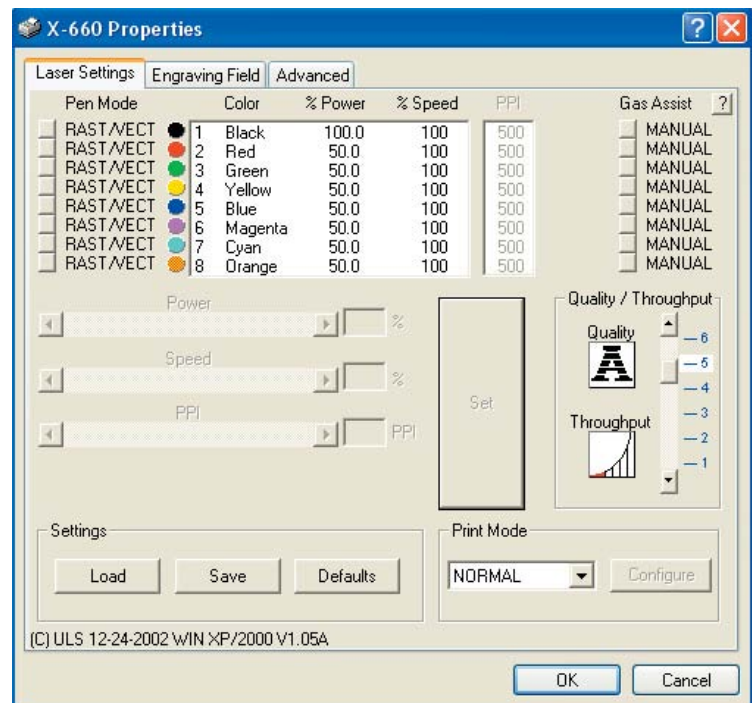
Step 3: Click the small boxes to the left of the color to select **VECT**, **SKIP**, **RAST**, or **RAST/VECT**.

-Select **VECT** for line colors to plot from vector based programs (AutoCAD)

-Select **SKIP** for line colors in the file the laser cutter should ignore and not plot.

-Select **RAST** to plot rasterized images of that color.

-Leave **RAST/VECT** for digital images with no vector information.



Each line color should be adjusted separately, one at a time. Once the Power and Speed settings are configured for the line color, click on the Set button to lock in the settings, then configure the next line color, etc.

Rasterized Images will be plotted as grayscale. The power is automatically adjusted by the gray scale information in the image.

Step 4: Click **OK** to send the file to the laser cutter, it will be visible on the control panel display (rasterized images take longer to spool and may take up to 2 minutes to appear on the display of the laser cutter).

Step 5: Press the green **Start** button on the laser cutter to start the plot. When complete, the laser cutter will beep. You can open the cover and remove the media.

If the cover is opened during cutting, the laser cutter will stop and the cutting head will move over the plot to trace out the lines. You should start the job over by pressing the Start button again.

Step 6: Turn OFF the laser cutter, this allows the laser to re-ionize and re-charge.

*** For troubleshooting tips, go to the last page of this tutorial for possible reasons for certain errors and what you can do to avoid them.

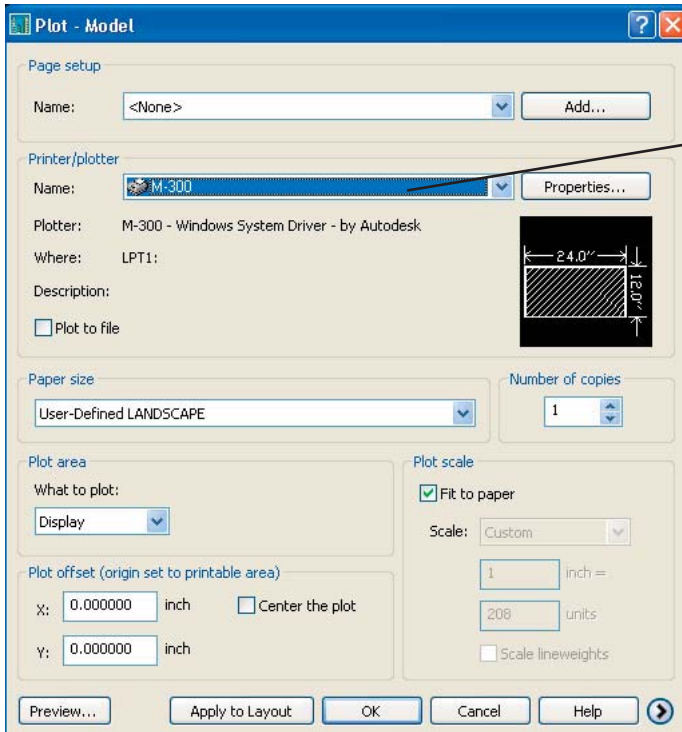
AutoCAD 2005: Plotting to the Laser Cutters

NOTE:

- All colors used in your AutoCAD file must be of the 8 main colors (black/white, red, green, yellow, blue, magenta, cyan, orange). Custom colors will not match up with the laser cutter plot settings.

- When selecting plot settings for speed and power of the laser, the color black refers to the white line in the AutoCAD file. It should be set to VECT only. Leaving it on RAST/VECT will digitize the image; the laser cutter will try to plot the entire background of the file.

STEP 1: Open your file to plot. Select **File - Plot**. The Plot window will appear:



STEP 2: Select the correct plotter driver for the laser cutter.

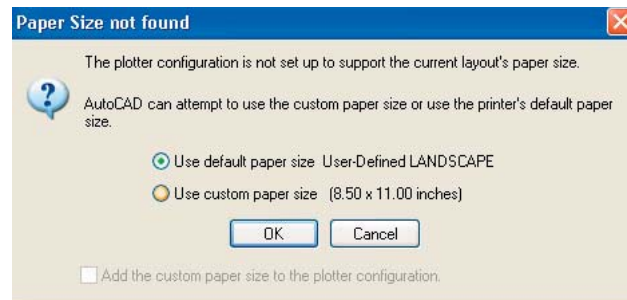
M-300: Small (24" x 12")

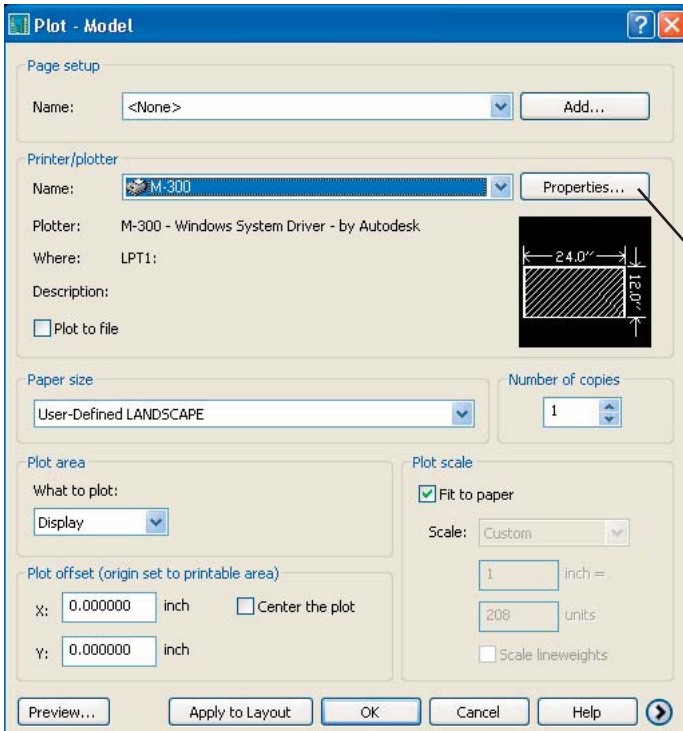
X-600: Large (32" x 18")

X-660: Large (32" x 18")

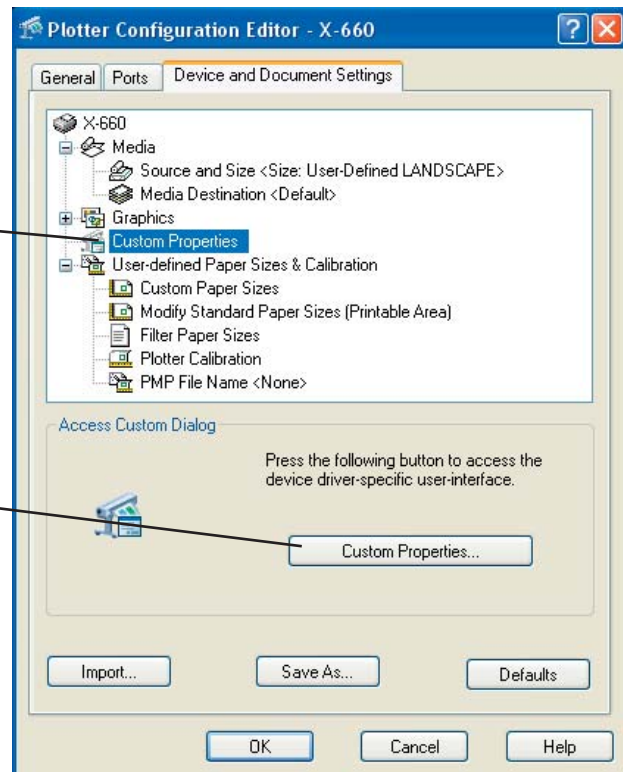
Important: It is recommended to select the main driver (name of laser cutter without .pc3 extension) rather than an existing .pc3 driver, which may cause errors in your plot.

Click OK at this window.





STEP 3: Click on the **Properties** button. The following window will appear:



STEP 4: Activate the Device and Documents Settings tab, and click to highlight **Custom Properties**.

STEP 5: Click the **Custom Properties** button to open the speed and power settings window.

STEP 6: Set the speed and power settings as required, or load preset settings.

In the **Pen Mode** column, click the small box to VECT for each color to plot in your file.

Each color's settings must be entered separately. Click on the color name to highlight the line (only 1 line should be highlighted at a time) and change the power and speed setting accordingly.

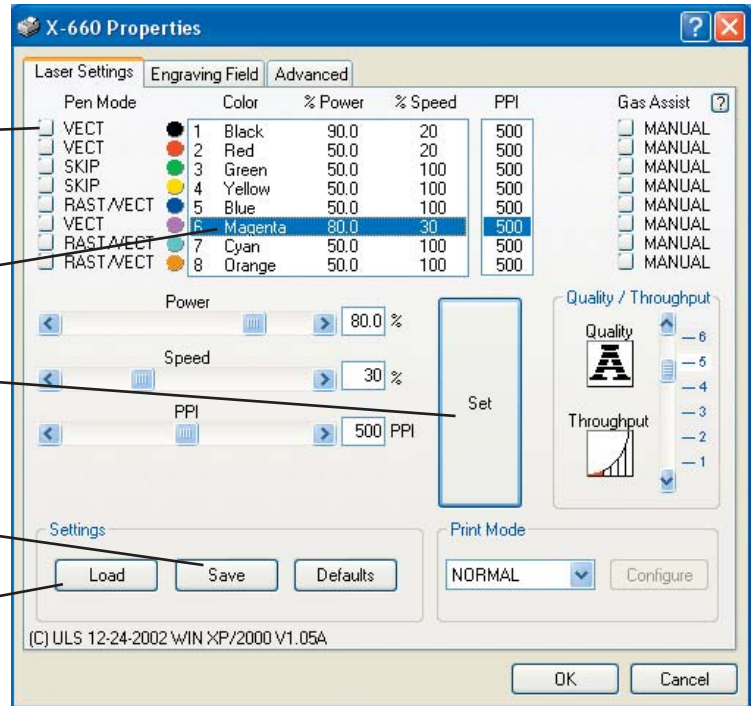
Click **Set** to establish the settings for the color.

Do this for each color you wish to plot in your file.

You can save the above Power and Speed settings for use in another file by selecting the **Save** button.

You can load Power and Speed settings you have already saved by selecting the **Load** button.

Click **OK** when done to load the settings for your file.

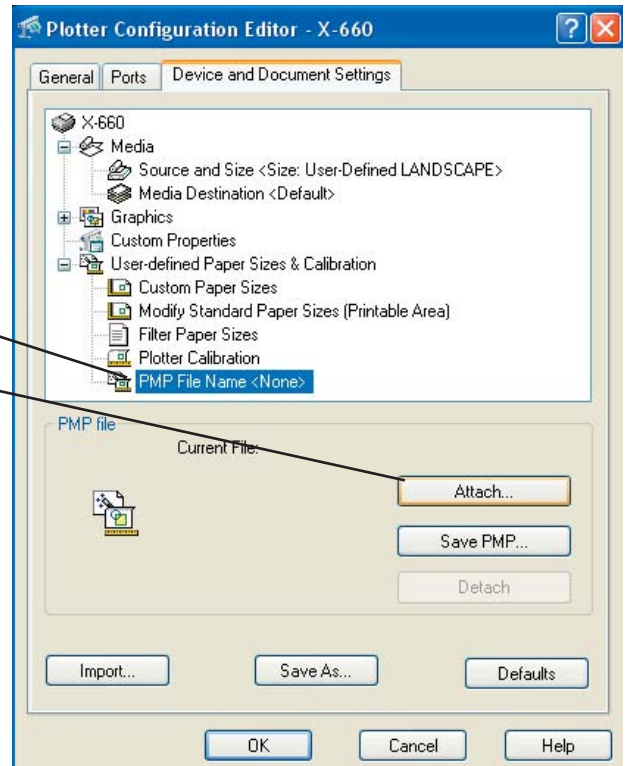


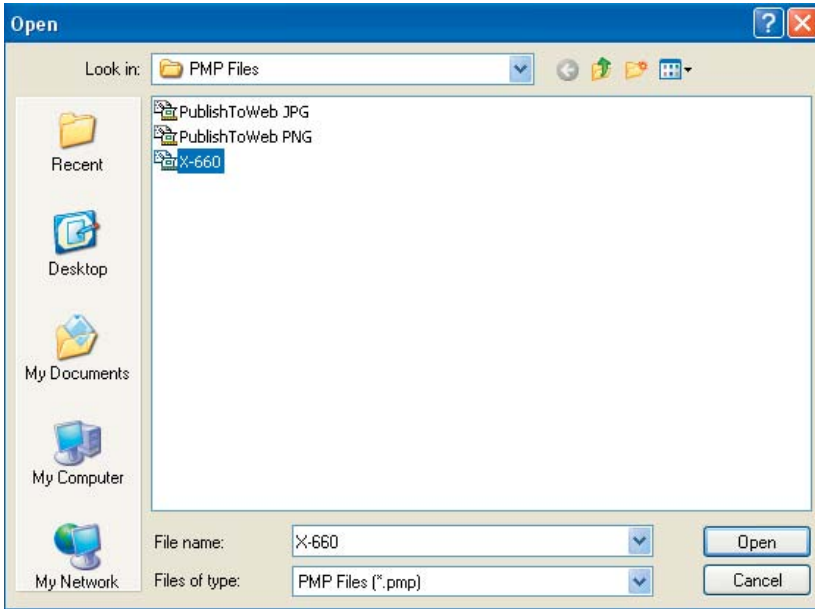
STEP 7: In the Device and Documents Settings tab, click to highlight **PMP File Name <None>**.

Click the **Attach** button.

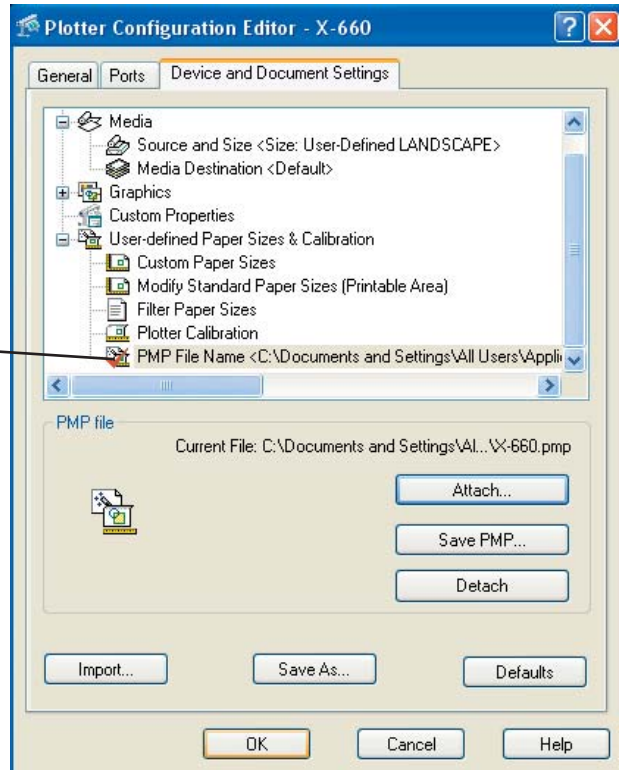
The .pmp file sets the printable area to the exact sizes of the laser cutter bed without any margins.

If the .pmp file is not loaded, the file will be slightly scaled down to accommodate a 1/2" margin in the laser cutter. This makes your file slightly smaller. Using the .pmp file will avoid this.



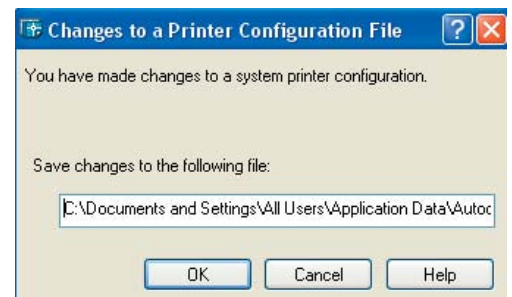


STEP 8: Select the correct .pmp file for the corresponding laser cutter. Click **Open**.

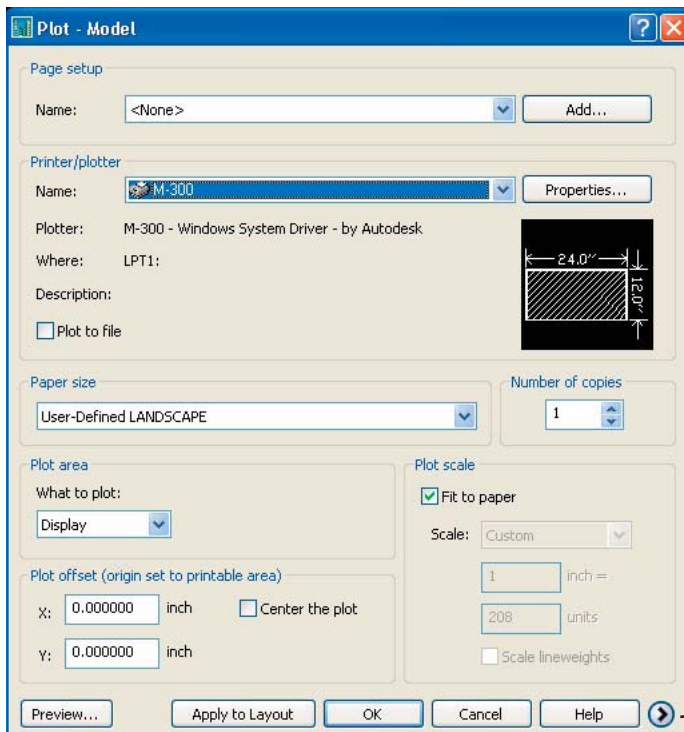


STEP 9: Verify the .pmp file is loaded.

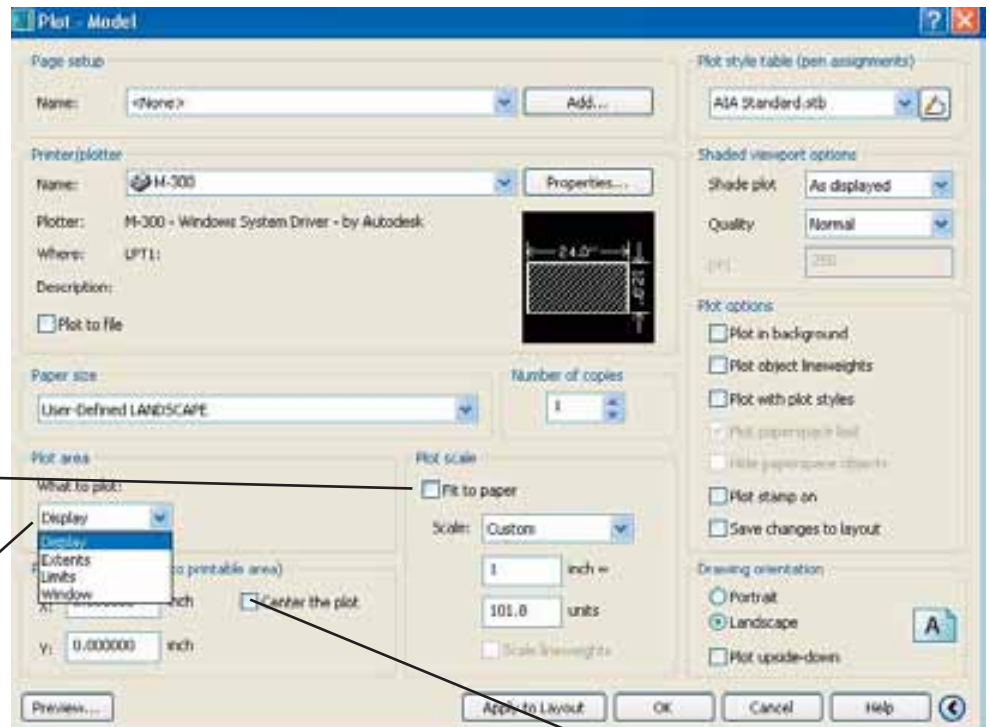
Click **OK** to save your settings.



STEP 10: The following window will appear. Click **OK** to save your changes.



STEP 11: Click on the arrow button to expand the settings window.



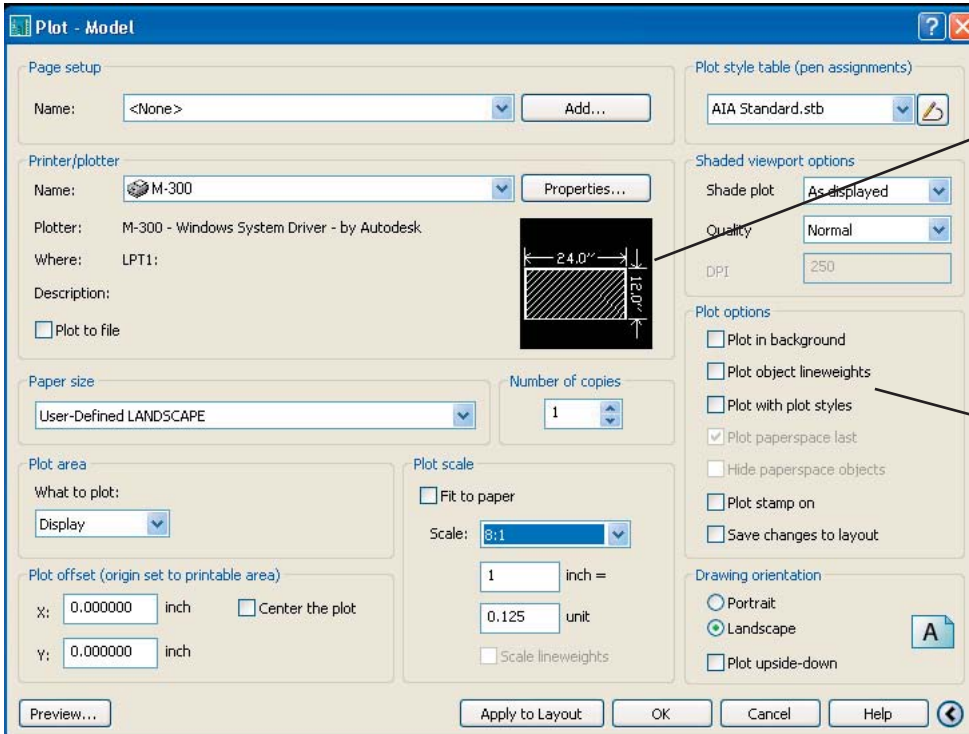
STEP 12: Select the plot area based on how your file is set up.

- Adjust the **Plot Scale** if necessary.

- Click **Window** if you want to draw a box around the area to plot.

STEP 13: Adjust the Plot Offset settings. Uncheck **Center the plot** if needed.

STEP 14: Verify that your settings are correct:



The correct dimensions should appear for the Laser Cutter being used:

M-300: 24" x 12"
X-600: 32" x 18"
X-660: 32" x 18"

Both "Plot object lineweights" and "Plot with plot styles" need to be unchecked.

Step 15: Click **Full Preview** to view a preview of the plot. In the preview, check the scale and positioning of the file.

If the preview is incorrect, the plot will also be incorrect!

Step 16: Click **OK** to send the file to the laser cutter.

Laser Cutter Guidelines and Troubleshooting Tips

General Laser Cutter Guidelines:

- The laser cutter glass cover must be completely closed on all sides for the laser cutter to plot.
- The laser cutter must be on and the display should read "Ready" when sending your file.
- Only one file can be sent at a time. The laser cutter does not have a print queue of files. The laser cutter will plot the last file sent.
- If the laser cutter is plotting thick lines, or uneven lines across the cutting bed (i.e. the upper left side's lines are thicker) the lens needs to be properly cleaned. See a DM Staff member to clean the lens.
- Files plotted from Photoshop should be saved as .jpg images to reduce file size and flatten layers.

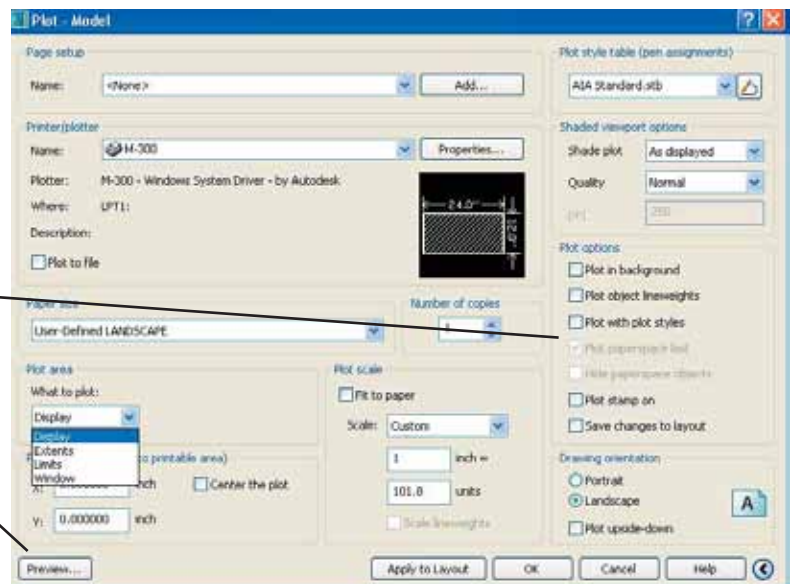
AutoCAD Troubleshooting Tips:

- Line colors must be limited to the 8 main colors in AutoCAD (black/white, red, green, yellow, blue, magenta, cyan, orange). Custom colors will not plot to the laser cutters.

- **Plot object lineweights** and **Plot with plot styles** should be **unchecked**.

- Click the **Full Preview** button to verify the following are correct:

- orientation
- scale
- lines



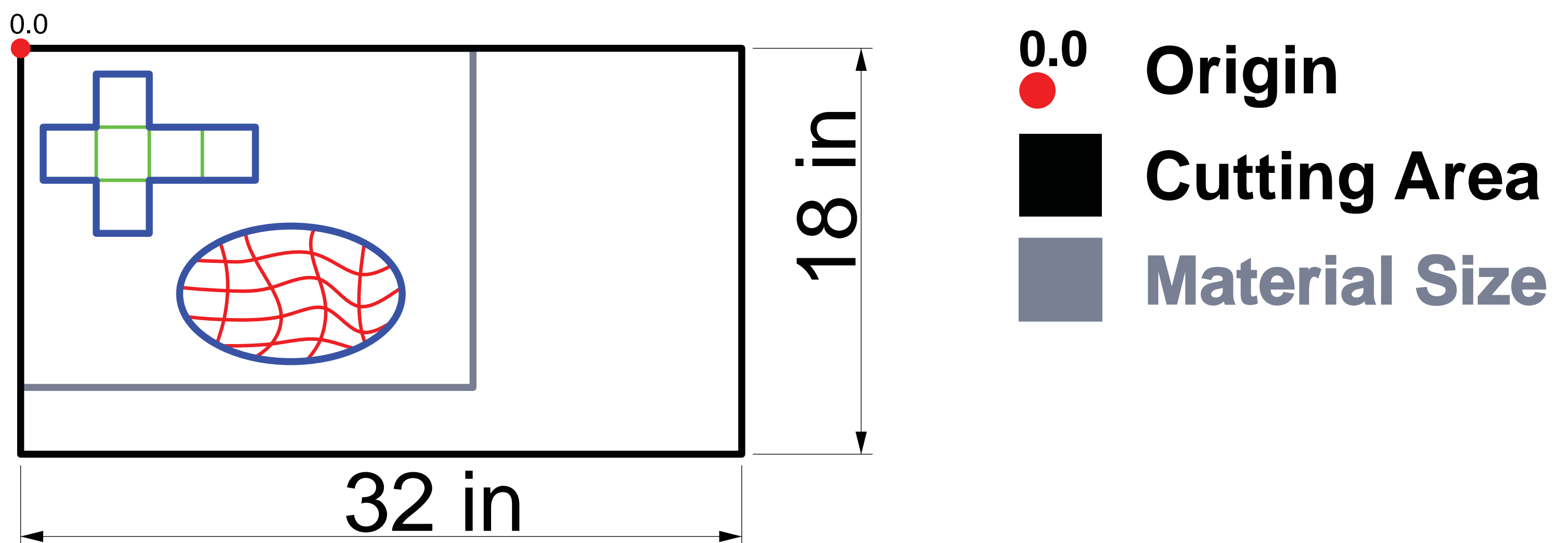
NYCCTfab

LASER CUTTING

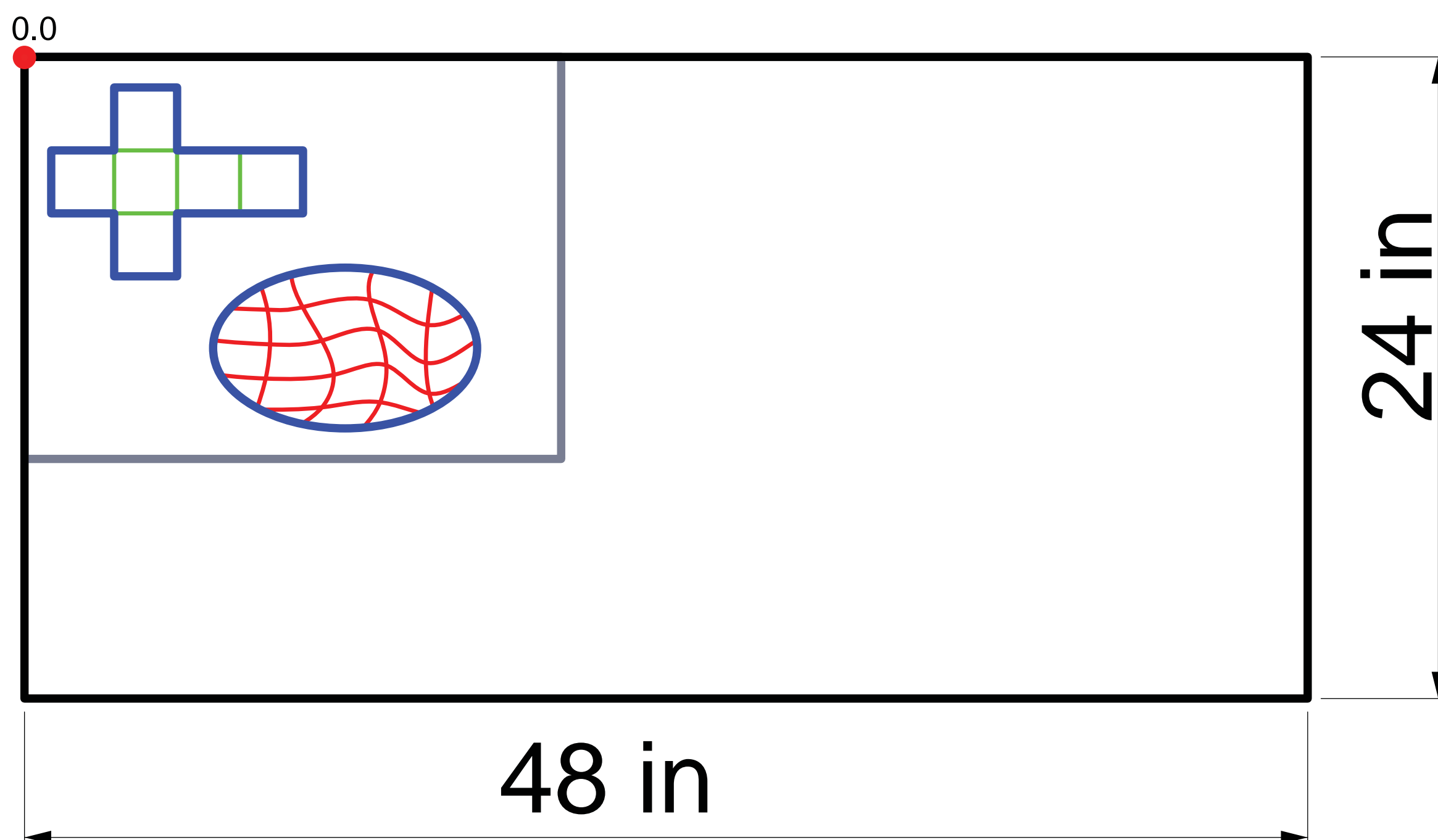
Sheet Layout

Students should use the laser cutting templates provided by the department to layout and prepare the sheets for laser cutting. The Cutting Area and all layer color settings for laser cutting operations have been set up properly in the templates. All laser cutting geometry should be properly scaled to the size of the laser cut parts in model space and fit inside the material boundary as shown below. Align material boundary with origin and plot from paper space at 1:1 scale.

X-660 & PLS Laser Cutter



ILS Laser Cutter



NYCCTfab

LASER CUTTING

Colors & Templates

Students are required to use the laser cutting templates posted on NYCCTfab.com.

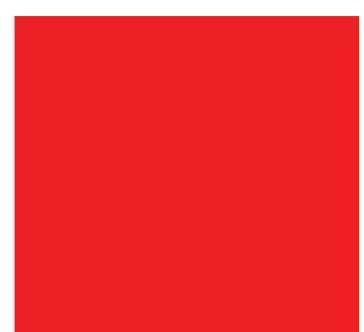
The templates have the necessary layers and layer colors for various laser cutting operations. The templates are preset to the correct sizes of the laser cutter beds. All geometry should be scaled 1:1 in model space and aligned correctly relative to the material outline and cutting bed perimeter.



CUT



SCORE (FOR FOLDING)



ETCH



RASTER ENGRAVE

Templates are available for Rhino 4.0, Rhino 5.0, Adobe Illustrator and AutoCAD 2013 from NYCCTfab.com at the following location:

NYCCTfab.com > [equipment](#) > [machines](#)
> [laser cutting](#)



NYCCTfab_AutoCAD2013_laser.dwg



NYCCTfab_Rhino4_laser.3dm



NYCCTfab_IllustratorCS6_laser.ai

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LASER CUTTING

Maintenance Schedule

- 1. Clean #2 mirror, #3 mirror and the focus lens at the beginning of the shift.**
- 2. Clean the focus lens and #3 mirror for every 30 minutes of laser cutting operation.**
- 3. Remove the staples and put them back to the storage box at the end of the shift.**
- 4. Clean the laser cutter bed at the end of the shift.**

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LASER CUTTING

Geometry Preparation

1. Clean up the file. Leave only the geometries needed to be laser cut.
2. Purge any duplicate objects.
3. All linework must be assigned to the proper layer. **Cut (Blue)**, **Score (Green)**, **Etch (Red)**, **Raster Engrave (Orange)**.
4. All vector linework to be laser cut must be continuous. (“joined”)
5. Keep linework at least 0.25” away from the edges of your material and 0.125” away from other linework.
6. All laser cutting geometry should be properly scaled to the size of the laser cut parts in model space and plotted from paper space at 1:1.

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LASER CUTTING

Pre-Cut Checklist

- 1. Is the water bottle nearby?**
- 2. Have the optics been cleaned?**
- 3. Have the staples been laid down?**
- 4. Has the Purex Filtration machine been turned on?**
- 5. Has the air compressor been turned on?**
- 6. Has the focal distance (“Z”) been set to the correct distance?**
- 7. Have the hood and front panel been closed?**

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LASER CUTTING

Material Data Files

Operators should load the according laser setting for a certain material from the path shown below:

**Desktop > Fall2012 > xxx Laser Settings
(xxx will be the model of the laser cutter)**

**** If there is no such laser setting for the material, please consult Brian before running the laser cut.**

**** If the laser cutter encounter situations that the material does not cut through using the normal laser setting for the material, first check if the optics are cleaned as schedule or the focal distance is set properly. If the situation continues to happen, please consult Brian before changing the laser setting.**

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LASER CUTTING

Typical Hours of Operation**



Mon - Fri: 9:00 am - 9:00 pm

Sat / Sun: 9:00 am - 4:00 pm

** Hours subject to CLT availability. Students are prohibited from using the equipment without CLT supervision.



** Each laser cutting appointment is 30 minutes. Students may register for up to two 30-minute appointments per day.

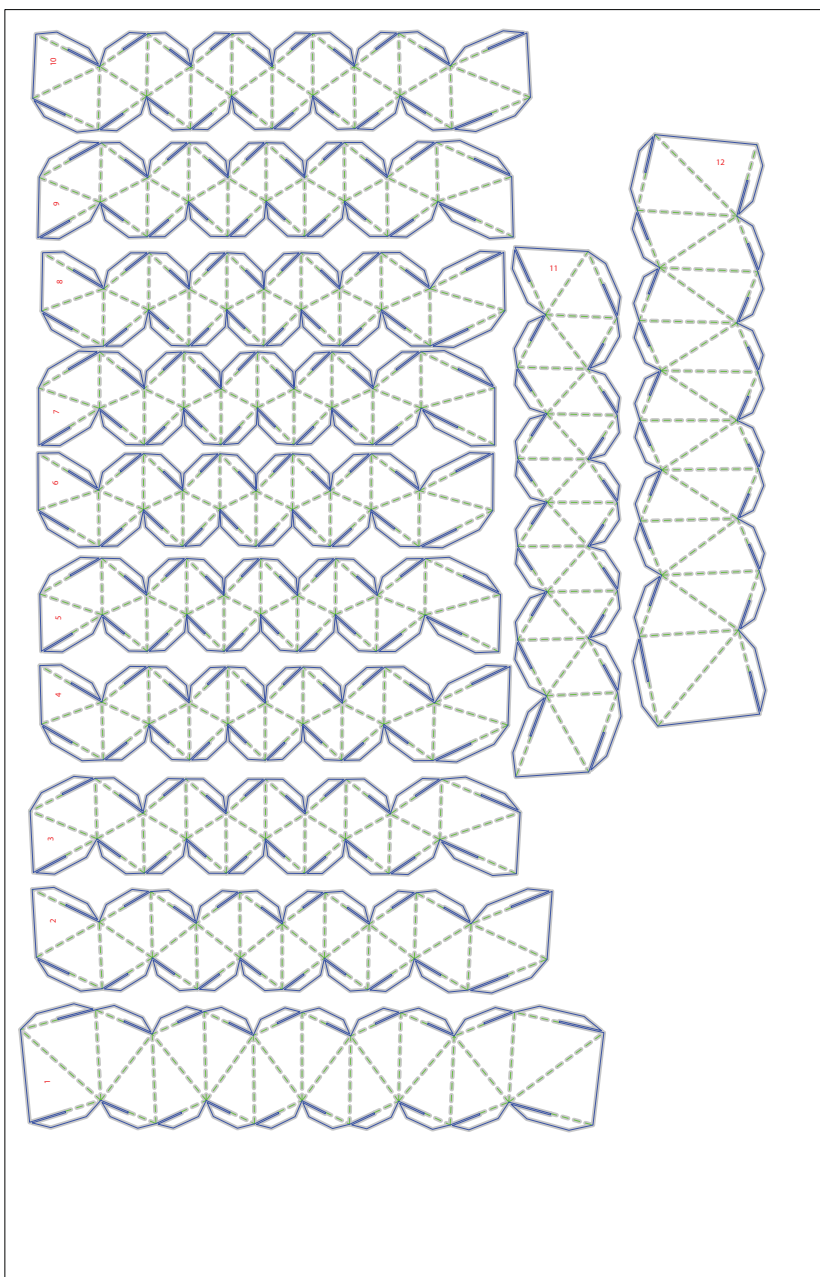
** If your file is not prepared ***at the start*** of your appointment then you will lose your spot to a student that ***is*** prepared to cut.

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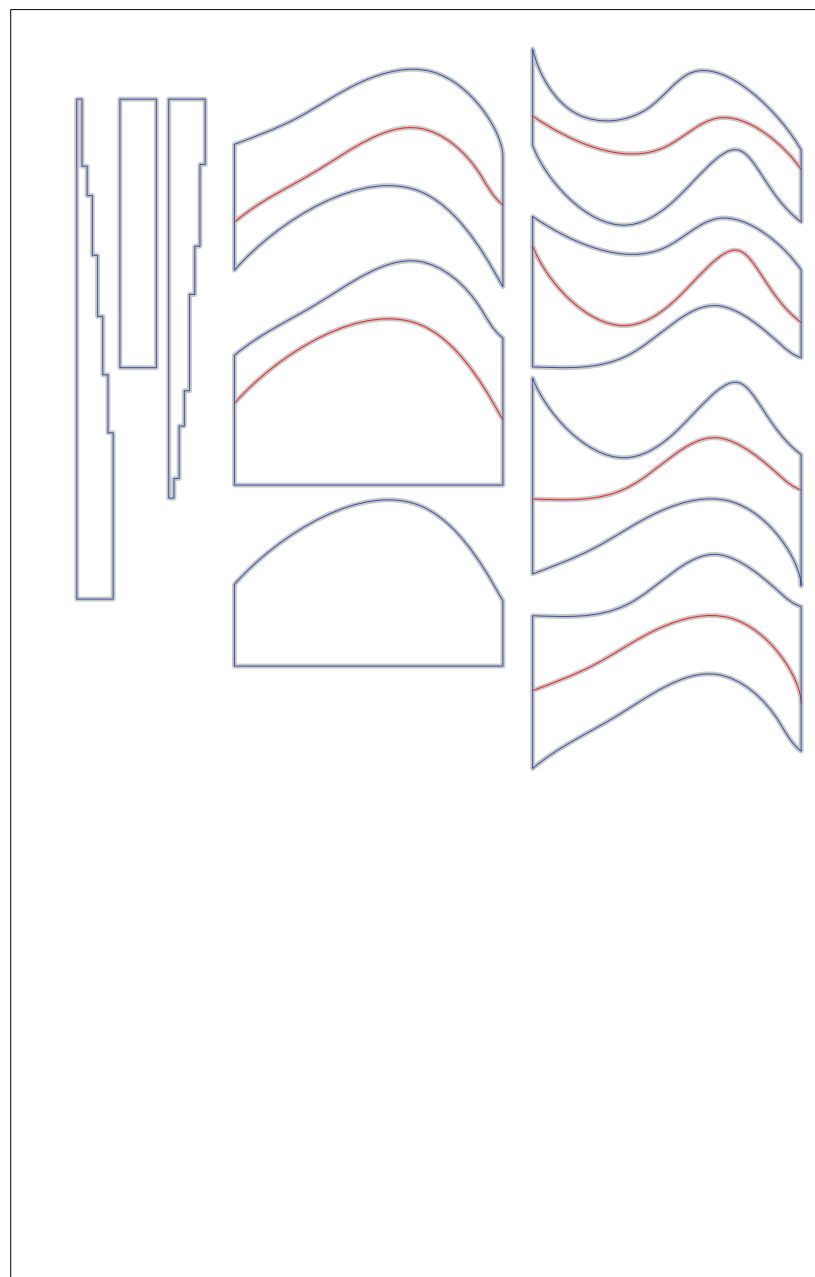
LASER CUTTING

Appropriate Use of Laser Cutters

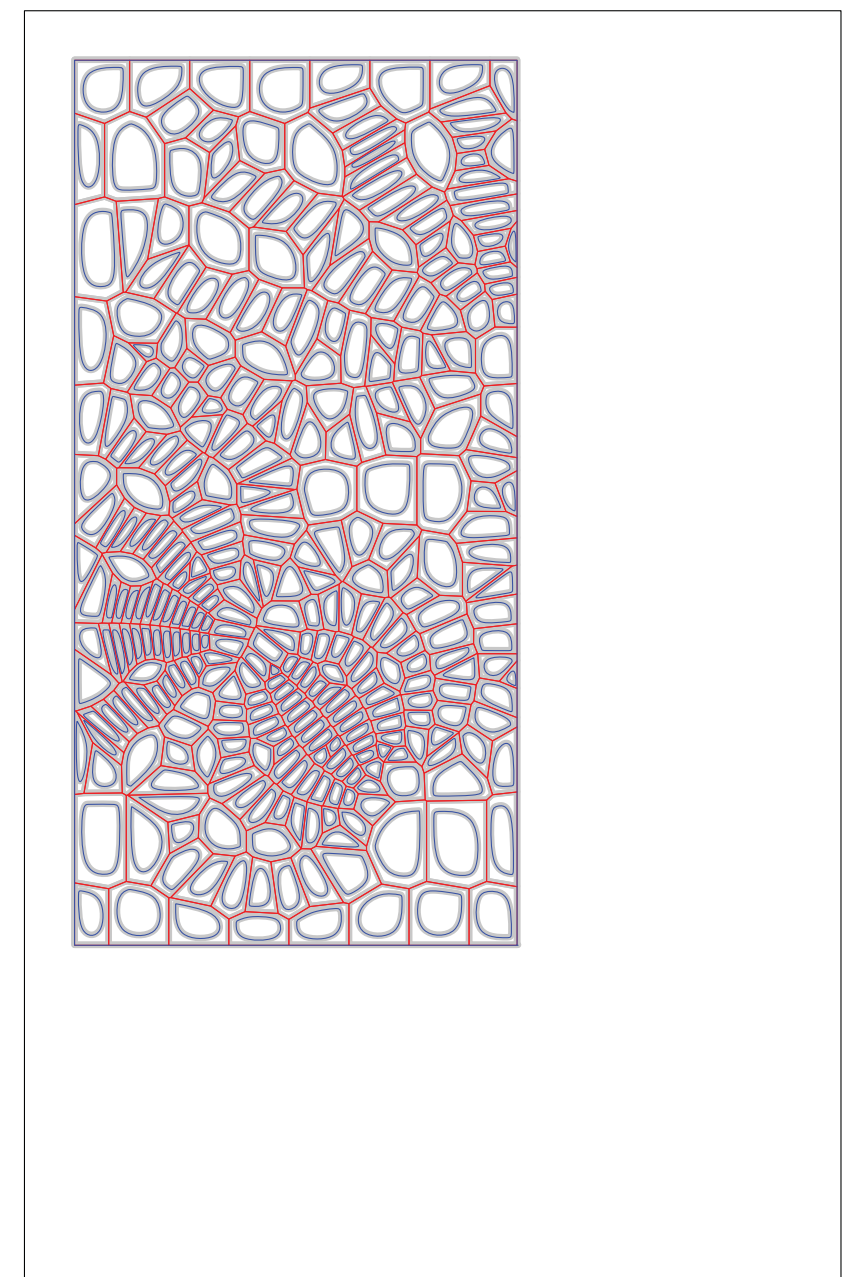
APPROPRIATE USE



Complex Geometry

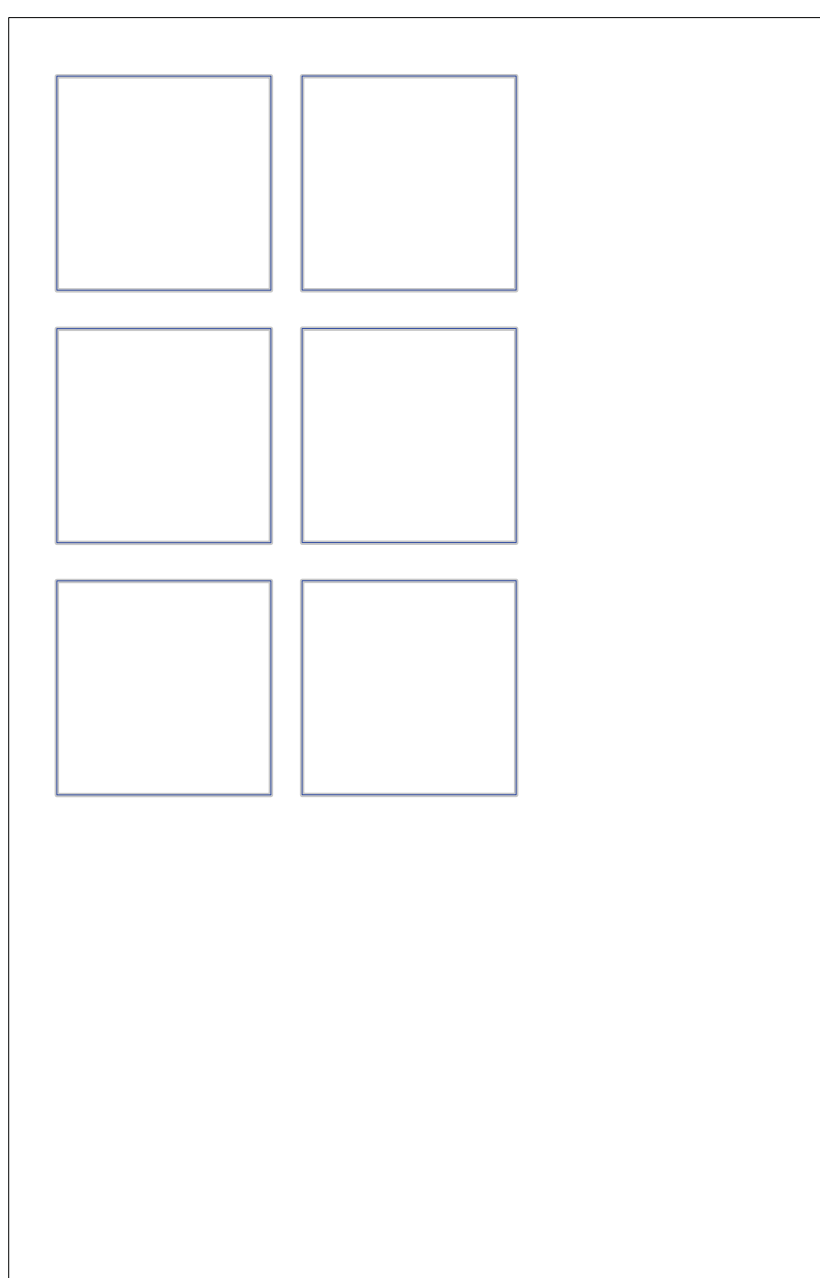


Hollow Topo Model

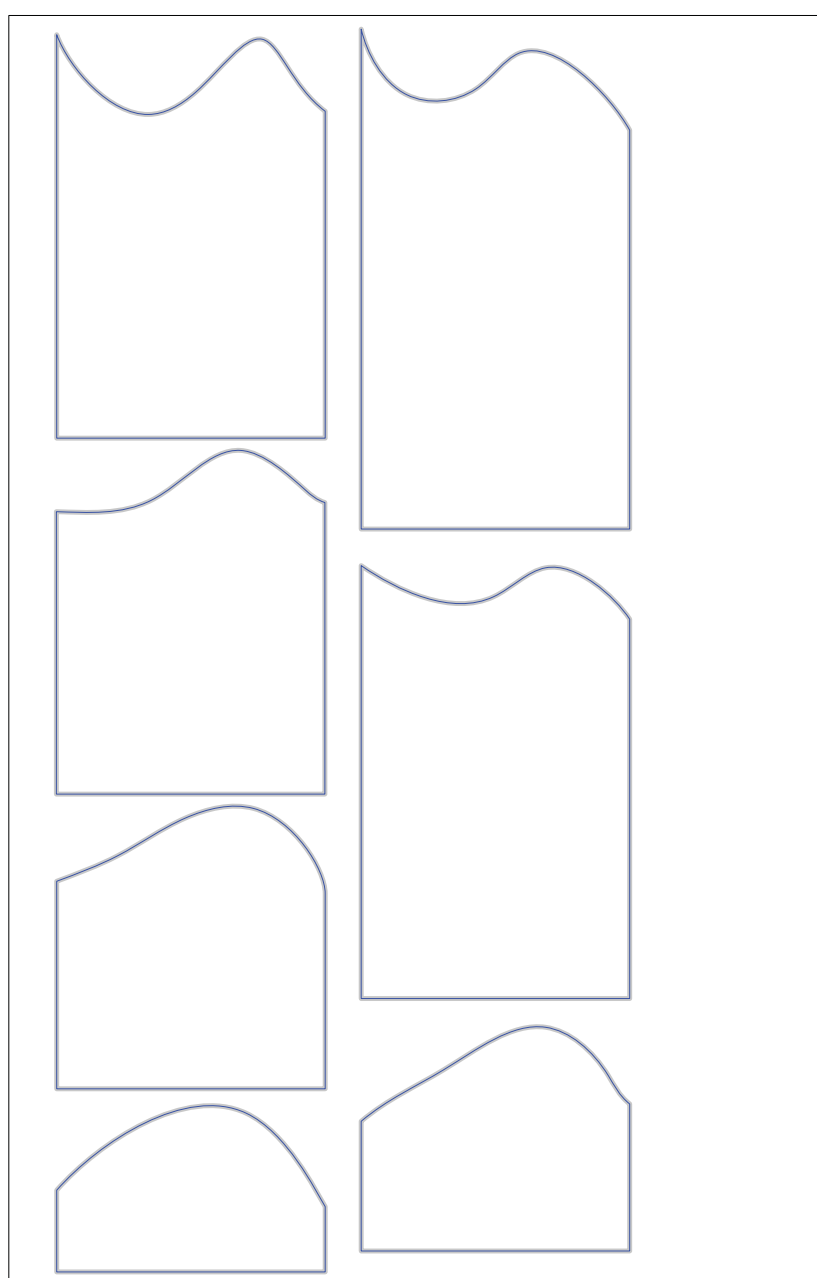


Complex Facade

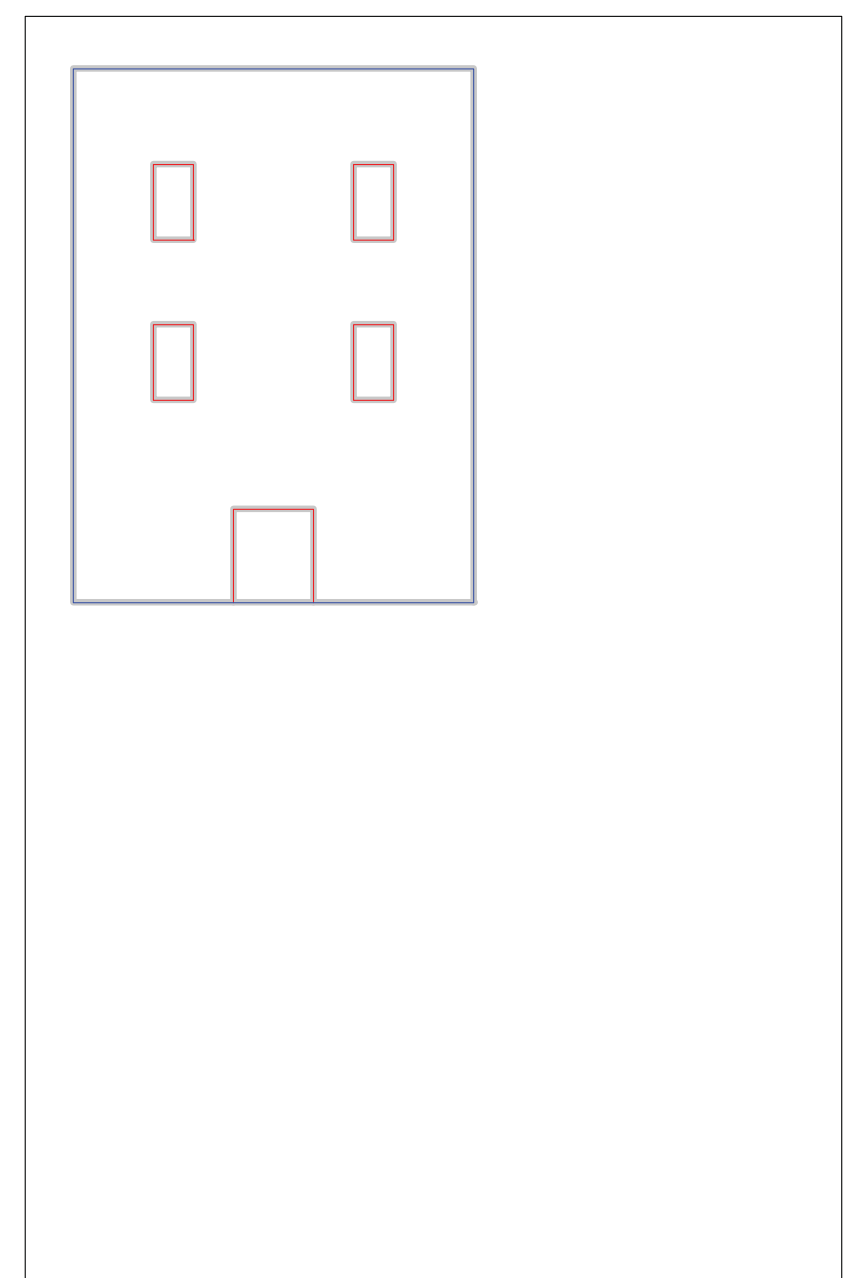
INEFFICIENT OR INAPPROPRIATE USE



Simple Geometry
Can Be Cut By Hand



Solid Topo Model

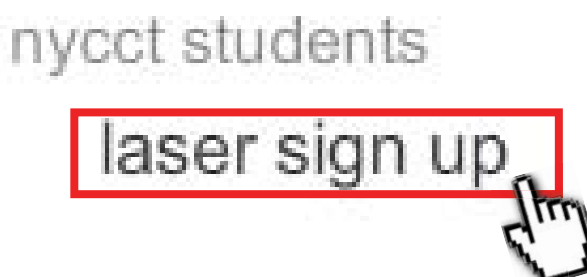


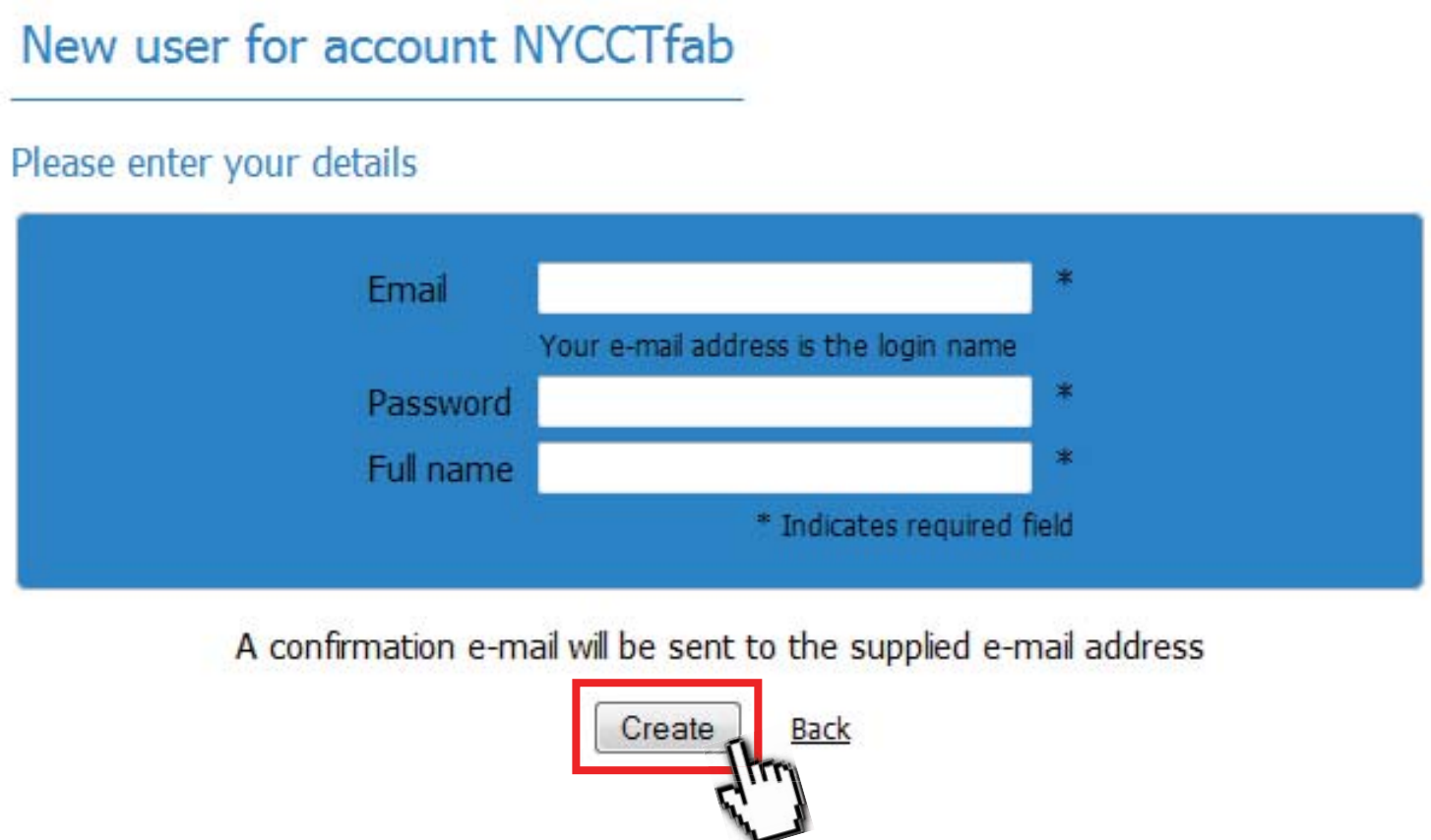


Simple Facade

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LASER CUTTING

Laser Cutter Sign-up Instructions

1. Open a web browser and go to www.NYCCTfab.com
2. Click on **laser sign up** under nycct students
(A new window tab will popup)
3. On the top right corner, click on **Sign In**
4. Click on **Create a new user account**
5. Fill out the form with your Cuny CityTech email address (first.last@mail.citytech.cuny.edu), password of your choosing (make sure you remember it) and full name (*no nicknames or screen names*), then click **Create**.
6. Check your email to confirm the account (<http://mail.citytech.cuny.edu>)
7. Once that is complete, go back to NYCCTfab > laser sign up > Sign In and input your email (first.last@mail.citytech.cuny.edu) and password.
8. If all goes well, you will be successfully logged in. You will be viewing the current week's schedule. The white boxes indicate available appointment slots (there is two columns per day, which means access to both the gray X-660 laser cutter and blue PLS laser cutter)
9. Click on an available slot with a time frame that will work for you. Make sure you are on time and ready to laser cut or else you may lose your place.

NYCCTfab

LASER CUTTING

Scale Conversion Chart

Architectural Scale x inches = 1 foot	Scale Factor 1:(12/x)	Decimal Value x/12
1' = 1'-0"	1:1	1.000000
6" = 1'-0"	1:2	0.500000
3" = 1'-0"	1:4	0.250000
1-1/2" = 1'-0"	1:8	0.125000
1" = 1'-0"	1:12	0.083333
3/4" = 1'-0"	1:16	0.062500
1/2" = 1'-0"	1:24	0.041667
3/8" = 1'-0"	1:32	0.031250
1/4" = 1'-0"	1:48	0.020833
3/16" = 1'-0"	1:64	0.015625
1/8" = 1'-0"	1:96	0.010417
3/32" = 1'-0"	1:128	0.007813
1/16" = 1'-0"	1:192	0.005208
1/32" = 1'-0"	1:384	0.002604
1/64" = 1'-0"	1:768	0.001302
1/128" = 1'-0"	1:1536	0.000651

Universal PLS, X-660 and ILS 12-150 Laser Cutters

Universal PLS and X-660 laser cutters have 32(X) x 18(Y) in work areas and Universal ILS 12-150 laser cutter have 48(x) x 24 (y) in work areas. these can be used for cutting, stitch-cutting, scoring, etching, engraving, and drilling a wide variety of paper, wood, plastic, and fabric materials.

The machines are located in Lab 813.

Basic Modeling Requirements

Files must be set up using the templates provided below in either Rhino, AutoCAD, or Illustrator.

All vector linework should be continuous and free of duplicates.

Keep linework at least 0.25 in away from the edges of your material and 0.125in away from other linework.

All laser cutting geometry should be properly scaled to the size of the laser cut parts in model space and plotted from paper space at 1:1.

File Layer Protocol

Laser Operation Layers: Cut (Blue), Score (Green), Etch (Red), Raster Engrave (Orange)

Any other geometry such as material or laser bed boundary curves should be grayscale.

Submission Guidelines

Students may use the machine

List of acceptable, non acceptable materials

Allowable materials:

Bristol, chipboard, bass wood, illustration board, acrylics (plex)

Prohibited materials:

Low-grade plywood, sheet metal, aluminum, copper, brass, glass, mirror, polycarbonate, vinyl, PVC, foamcore, SNC-3 neoprene, low density polyethylene foam, self-laminated or glued materials, wood knots or varying density, warped materials, materials of varying thickness.

Laser Cutter Sign up Instructions

Laser Cutter setups by making an appointment using the new NYCCTfab Laser Schedule.