

COLUMBIA UNIVERSITY GSAPP

JASON IVALIOTIS
BEYOND PROTOTYPE
FABRICATION OF HYBRIDIZED FOLDED MESHES

SPRING 2014

THURSDAY 7-9PM

WARE LOUNGE

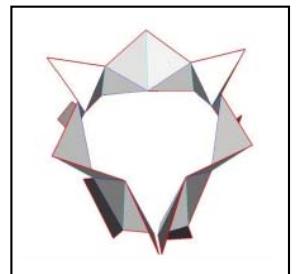
SESSION B

COURSE OBJECTIVES:

1. Translate a **complex surface or geometric pattern** into a fabrication-ready component system.
2. Design a system which uses connective geometry to make a **hybridized mesh that simultaneously performs as both skin and structure**.
3. Use fabrication tools to generate forms from **FLAT SHEET STOCK** that can be transformed using cutting, bending and folding.
4. **RHINO** will be used as a generative software platform during the design and fabrication process. Instruction will then focus on using **GRASSHOPPER FOR RHINO** to streamline the generation and **PARAMETRIC MANIPULATION** of complex cellular networks and surface tessellations. Students will be operating across these platforms to devise a completely **AUTOMATED DESIGN AND FABRICATION PROCESS**.

The research objectives of this course encourage students to devise functional design applications, establish contextual relevance for their component systems and propose realistic fabrication scenarios based on quantifiable material and mechanical constraints. **Components are extracted from the digital realm, built at full scale, tested and reevaluated, effectively taking us beyond prototype.**

5. This workshop will cover advanced fabrication techniques. **NO previous experience in fabrication is required.**

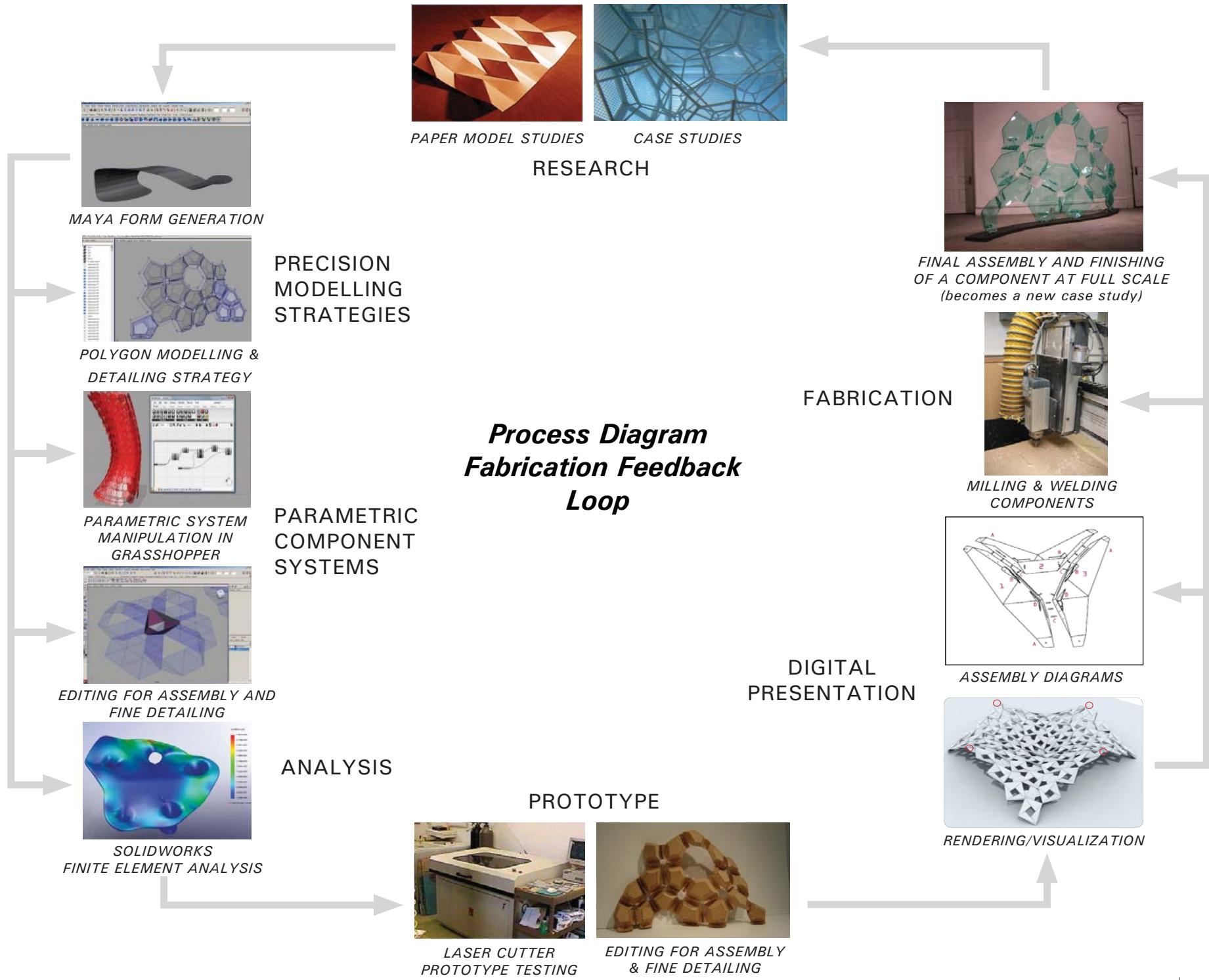


DIGITAL SOFTWARE:

RHINO
GRASSHOPPER
MASTERCAM
AUTOCAD
SOLIDWORKS

FABRICATION TOOLS:

Laser Cutter
CNC Mill
Plastic Bender
MIG Welder





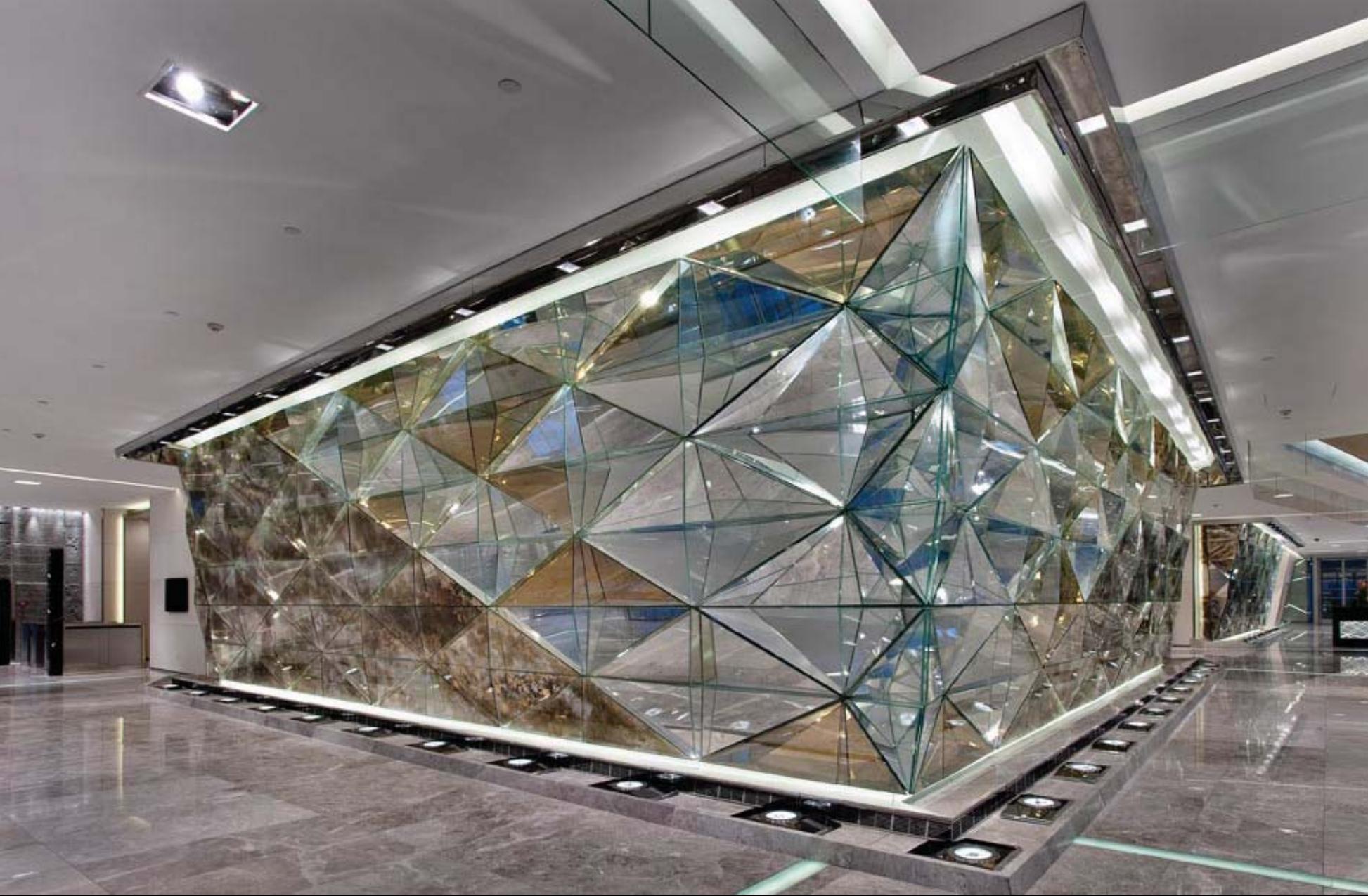
CASE STUDIES
COMPLEX SURFACE GENERATION



REPETITIVE SYSTEM ON SINGLE LAYER GRID
OLAFUR ELIASSON



SINGLE SHEET SYSTEMS WITH PATTERN VARIATION
SUPER SURFACES



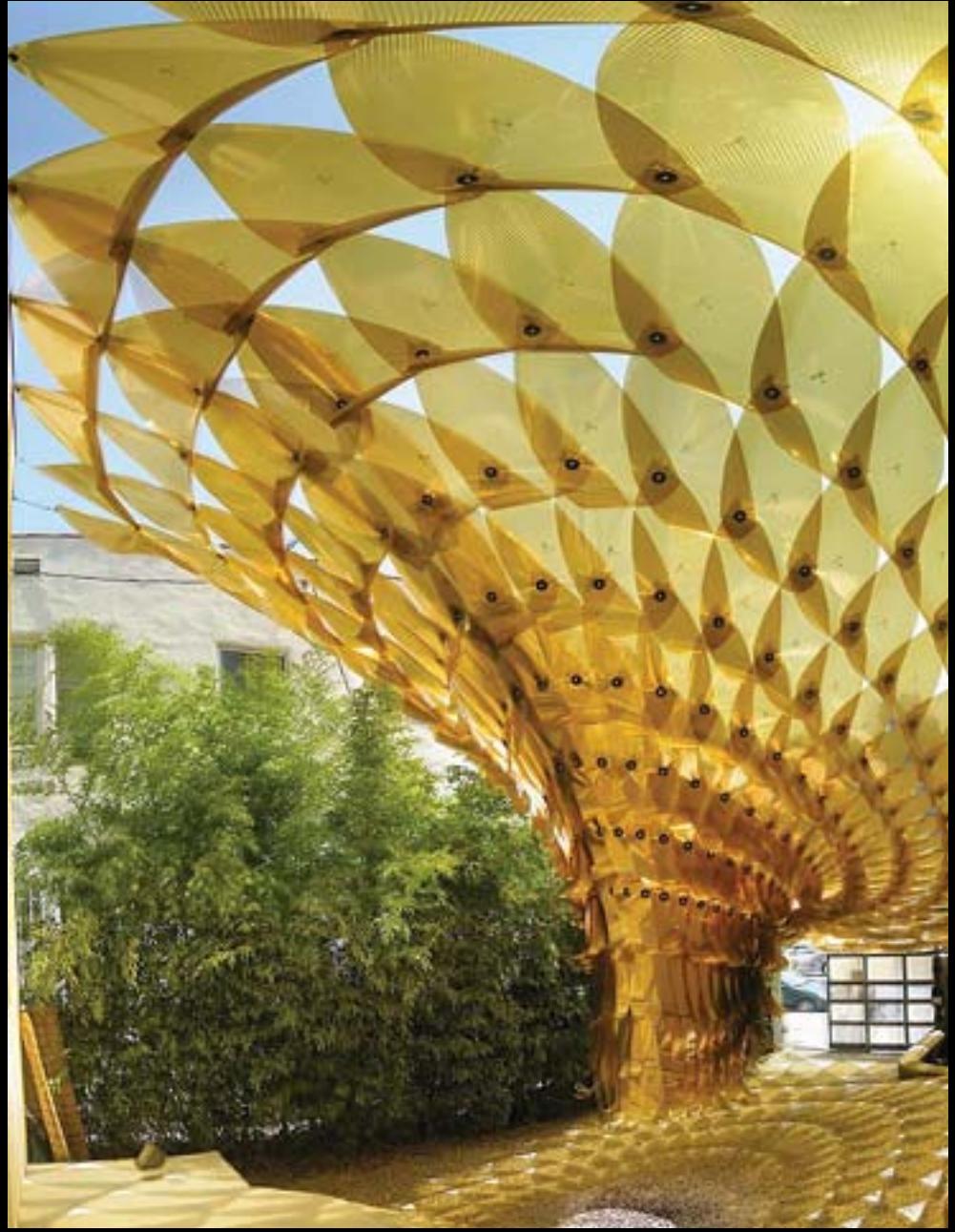
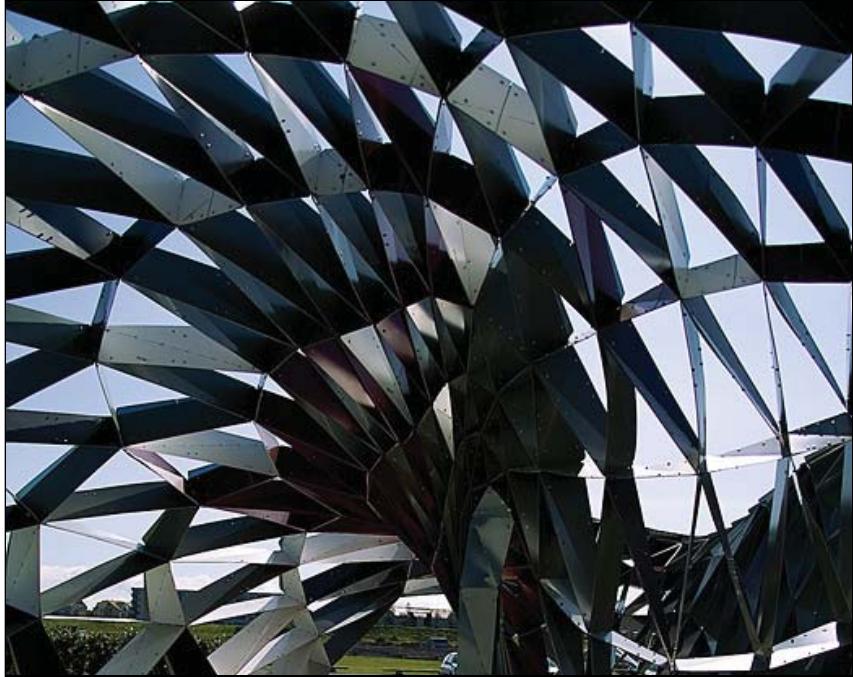
REPETITIVE SYSTEM ON DOUBLE LAYER GRID
MICHAEL HAMMERS

CASE STUDIES IN MATERIAL FABRICATION



MULTI SHEET SYSTEMS WITH VARIABLE PATTERNS
CORE FAB

CASE STUDIES IN MATERIAL FABRICATION



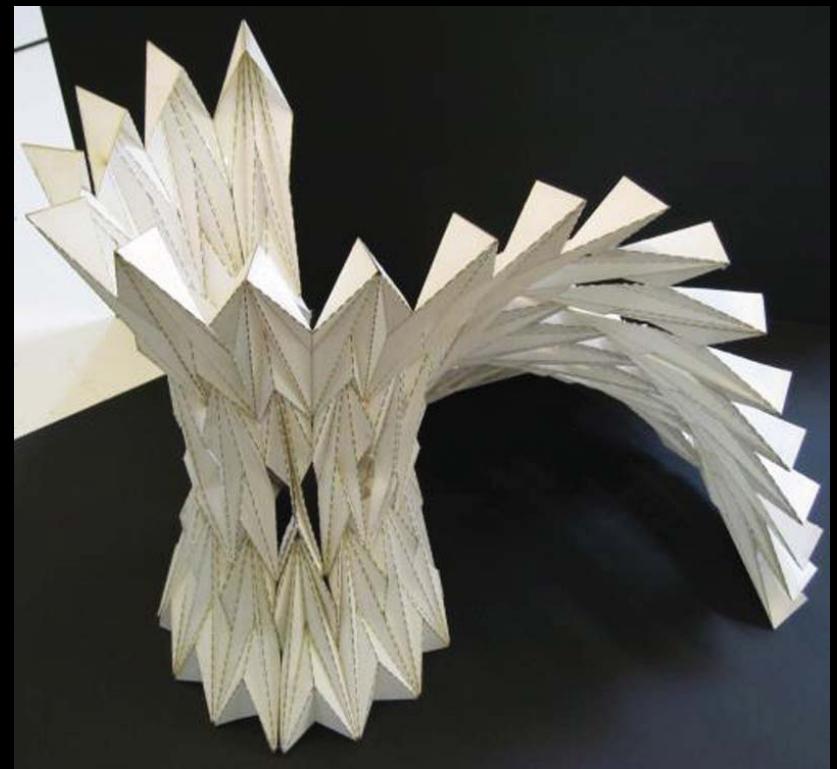
PAVILION SYSTEMS WITH SCALAR DIFFERENTIATION
R:SHIFT L:BALL NOGUES STUDIO



REPETITIVE SYSTEMS WITH STRUCTURAL FOLD
IMWATO SCOTT



SURFACE TESSELLATIONS WITH STRUCTURAL FOLD
SKYLAR TIBBITS



MULTI SHEET SYSTEMS WITH FLEXIBILITY



FABRICATION LABS

FABRICATION MATERIALS



METALS: ALUMINUM



PLASTICS: ACRYLIC

FABRICATION LABS



AVERY DIGITAL FABRICATION LAB
COLUMBIA GRADUATE SCHOOL OF ARCHITECTURE

CAPABILITIES:
CNC Milling
Metal Milling
Plastic Bending

FABRICATION LABS



PRENTIS HALL METAL FABRICATION LAB
COLUMBIA GSAPP + COLUMBIA VISUAL ARTS DIVISION

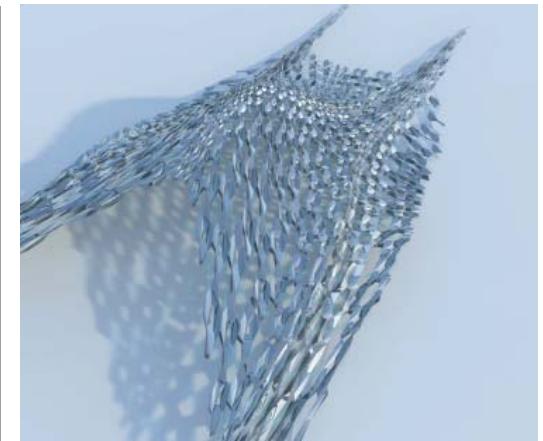
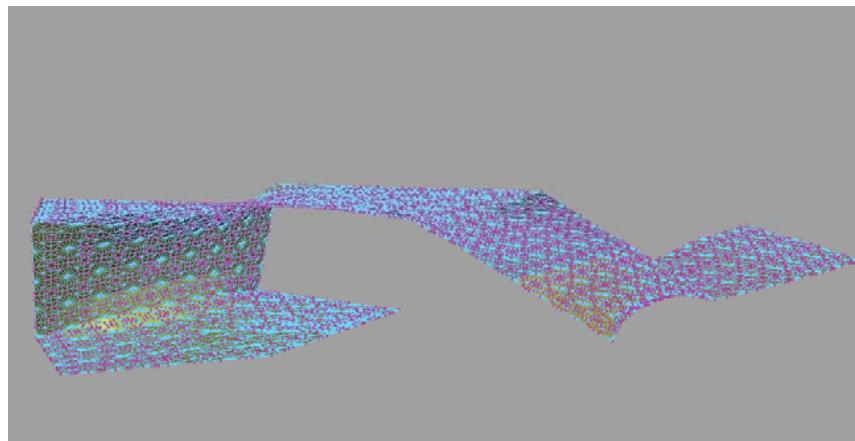
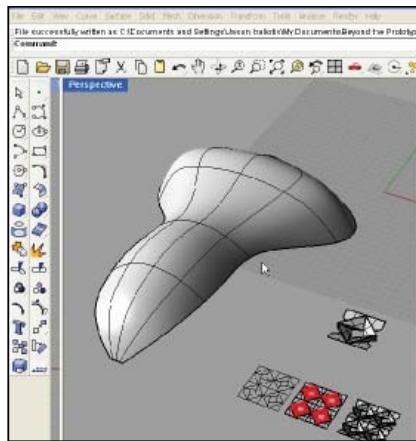
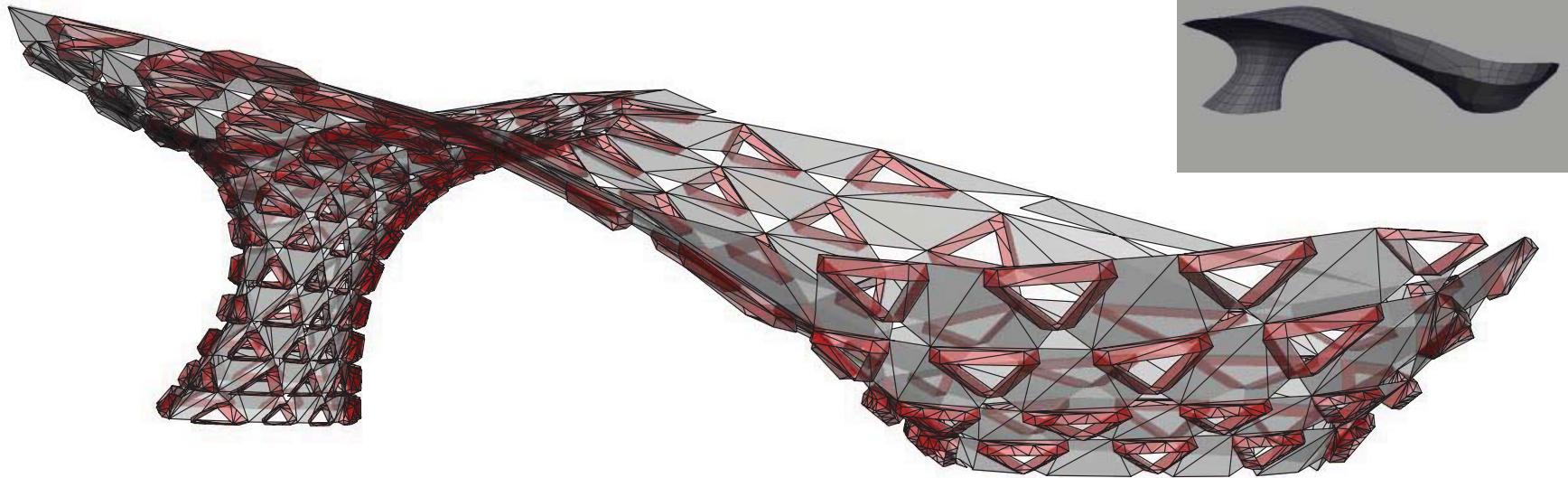


ADVANCED METAL FABRICATION:
MIG Welding
Cutting & Grinding
Bending & Punching



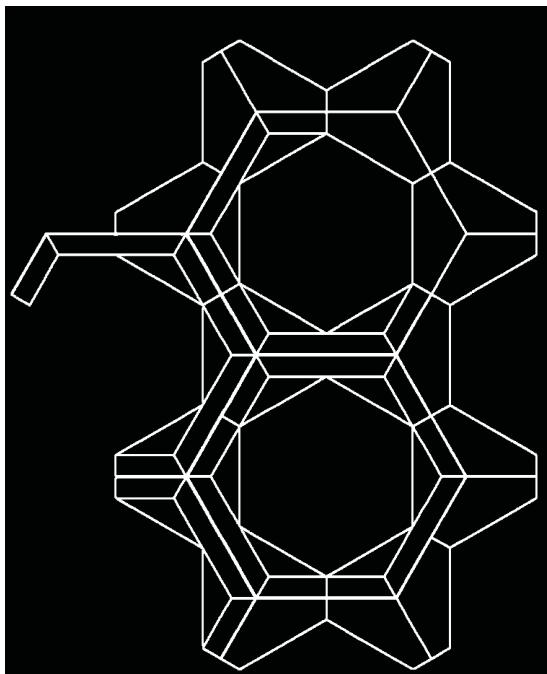
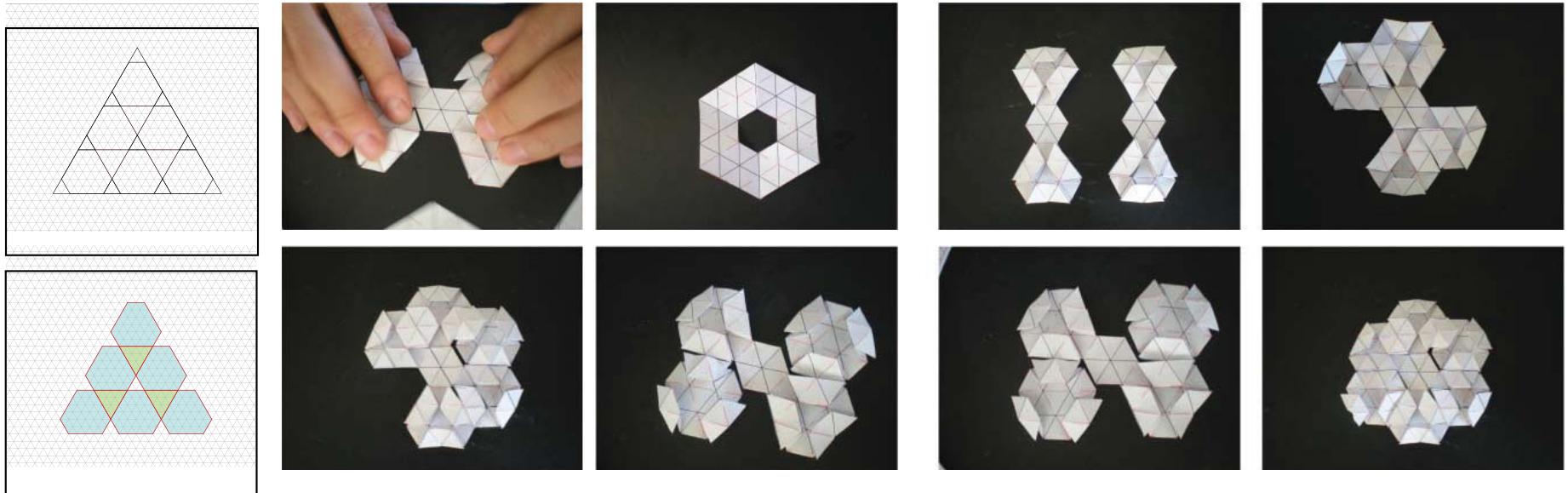
SOFTWARE & FABRICATION
TUTORIALS

TUTORIAL - DIGITAL FORM GENERATION

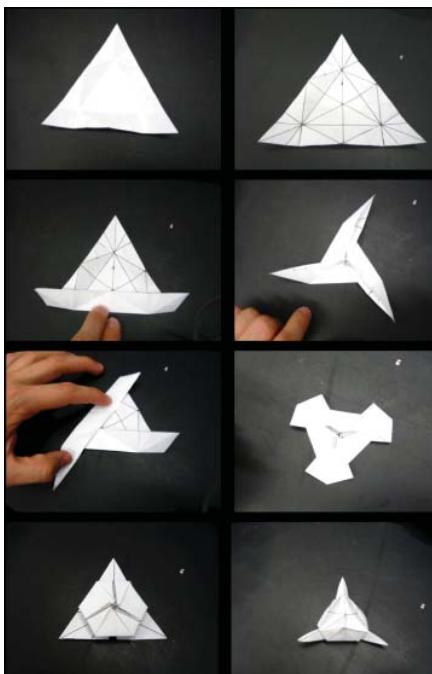


GENERATING NON UNIFORM SURFACES AND COMPLEX TESSELLATIONS USING RHINO

FORM GENERATION - FROM SURFACE GRID TO CELLULAR STRUCTURE

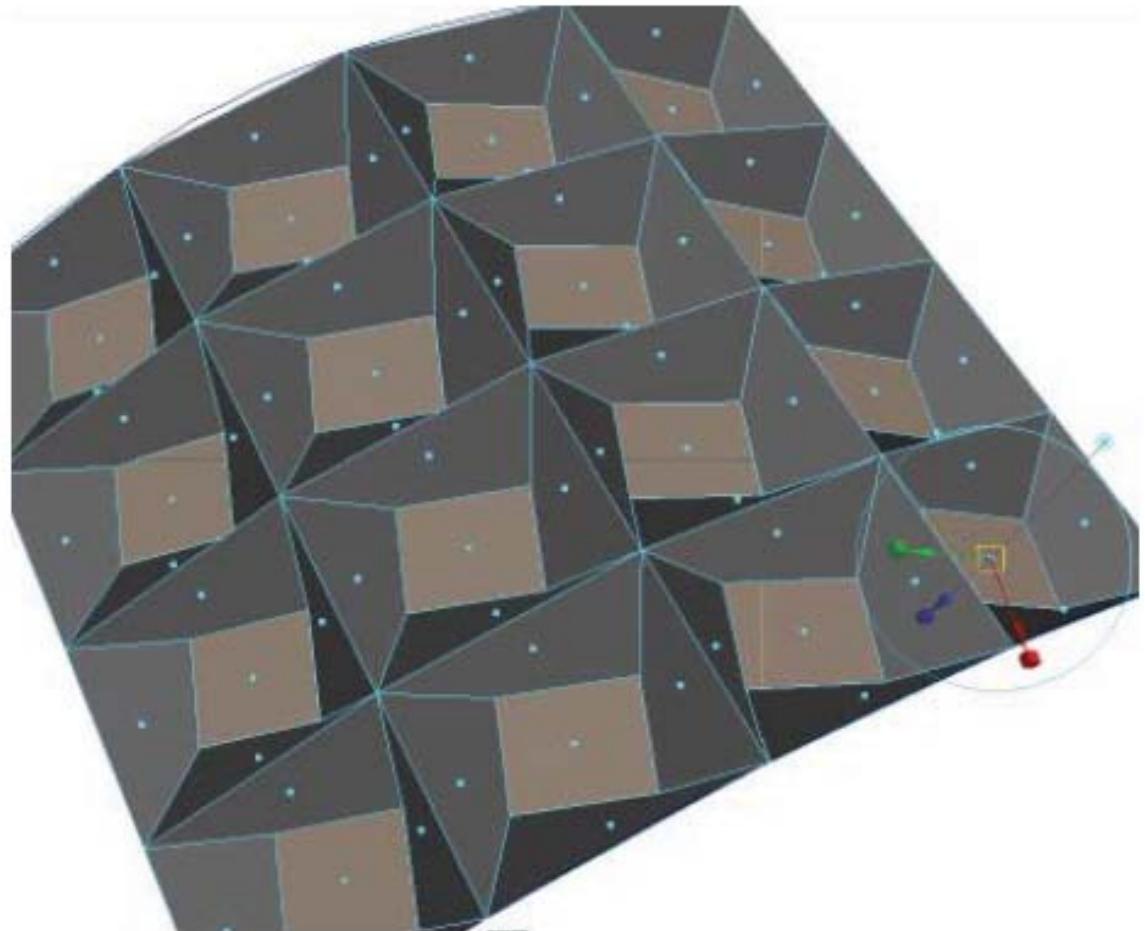
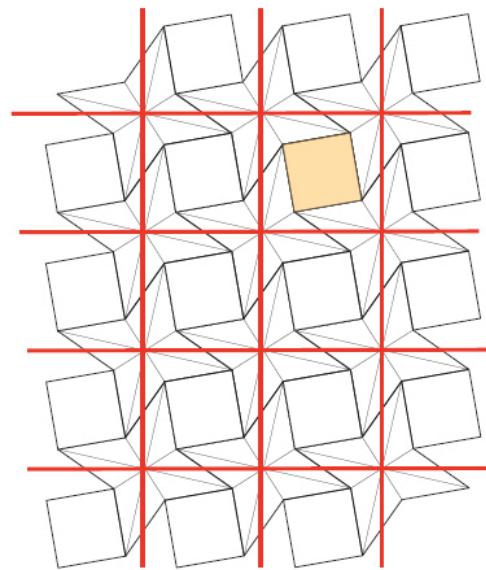


SURFACE GRID GENERATION



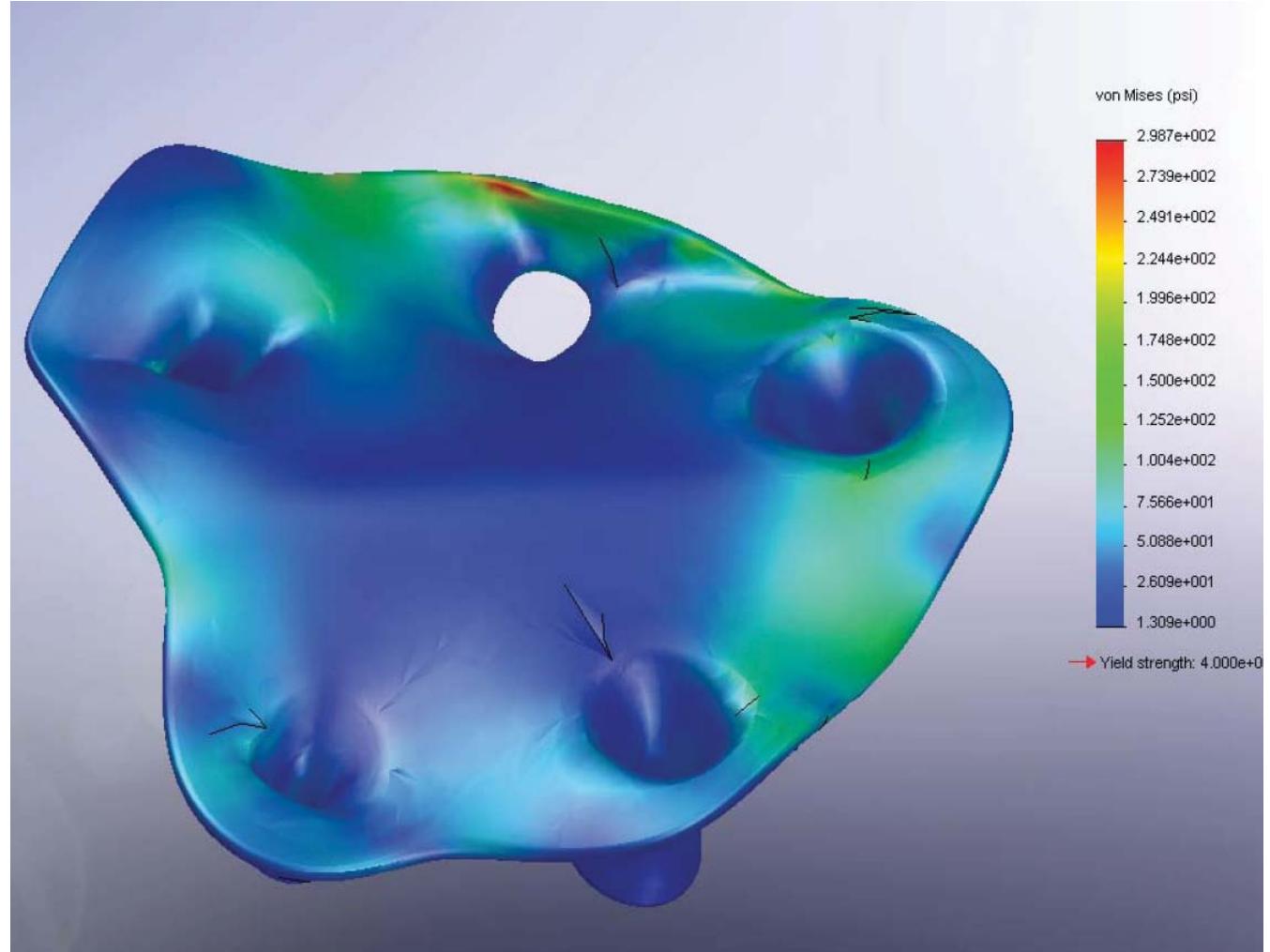
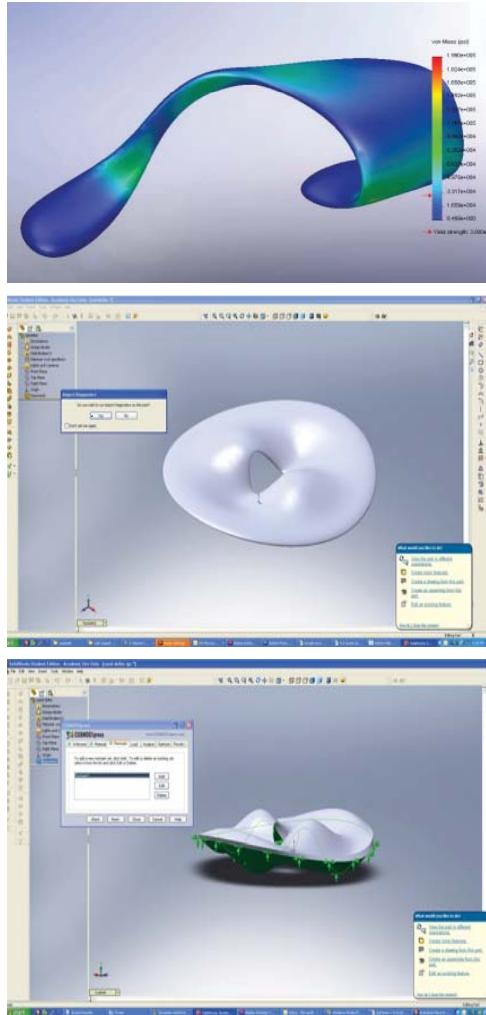
PHYSICAL MODELLING IN PAPER: FOLDED STRUCTURES





SETTING UP A MULTI-LAYERED GRID TO MODEL A FOLDED SHEET SYSTEM

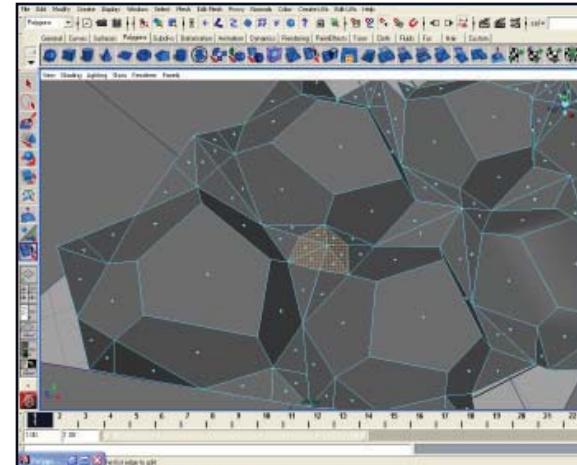
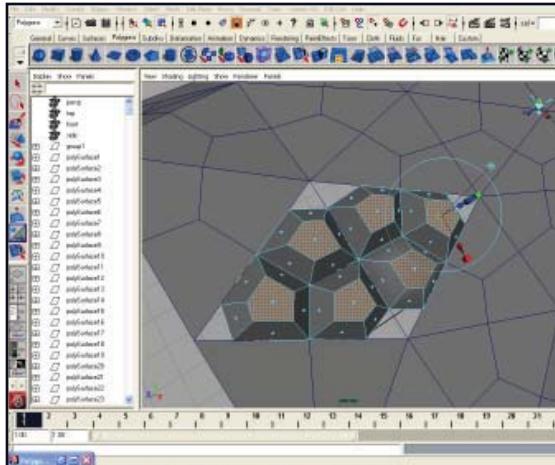
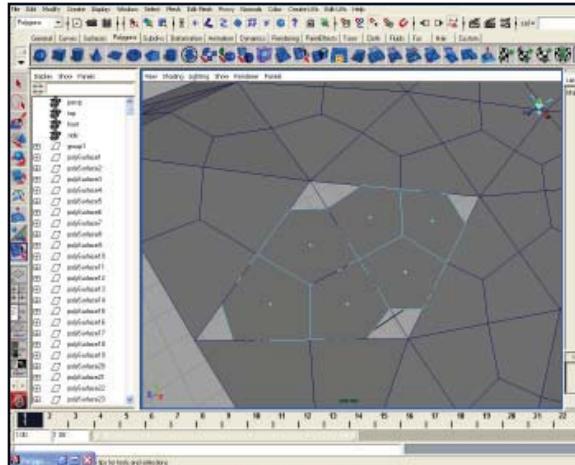
SOLID WORKS TUTORIAL - SURFACE FINITE ELEMENT ANALYSIS



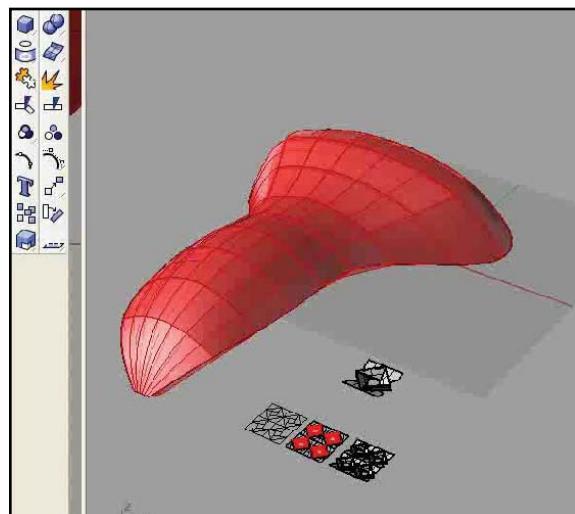
FINITE ELEMENT ANALYSIS OF BASE SURFACE AS A BASIS FOR CELLULAR VARIATION FOR STRUCTURAL STABILITY

TUTORIAL - FROM GENERATIVE FORM TO PARAMETRIC COMPONENT SYSTEM PART 1

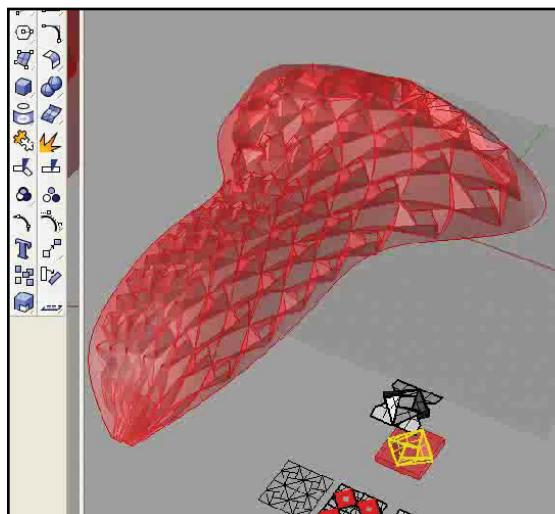
CELLULAR REFINEMENT: ESTABLISHING PRIMARY SYSTEMS AND SECONDARY CONNECTIVE GEOMETRY



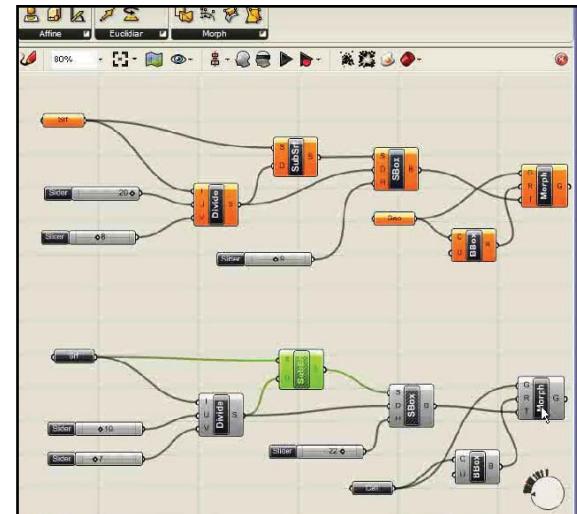
TRANSFORMING NON UNIFORM SURFACE GEOMETRY AND COMPLEX TESSELLATIONS GENERATED IN RHINO INTO PARAMETRIC COMPONENT SYSTEMS USING GRASSHOPPER



PARAMETRIC UV DIVISION OF SURFACE USING GRASSHOPPER

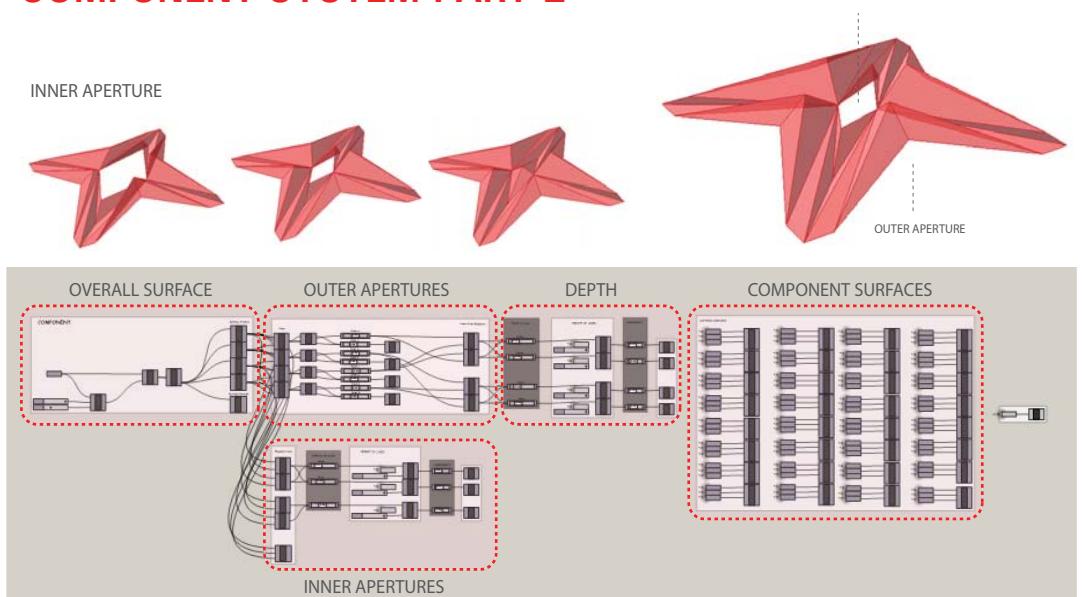
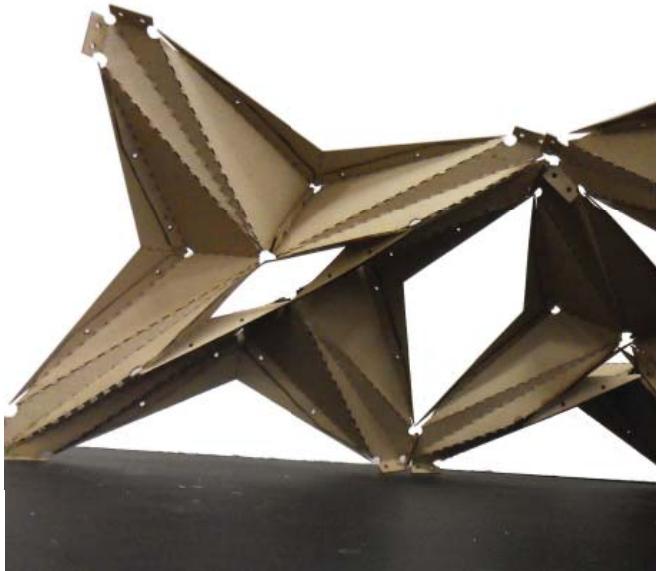


PARAMETRIC COMPONENT MAPPING (CELL ONTO SURFACE) WITH GRASSHOPPER

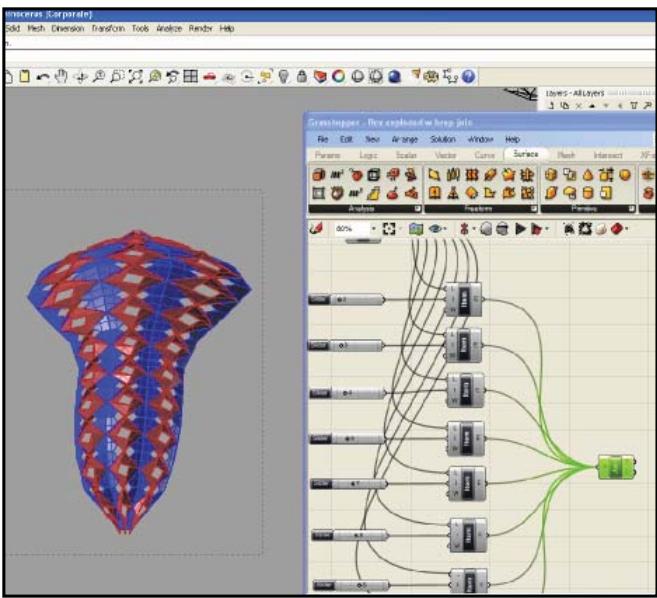


PARAMETRIC COMPONENT MAPPING: GRASSHOPPER DEFINITION

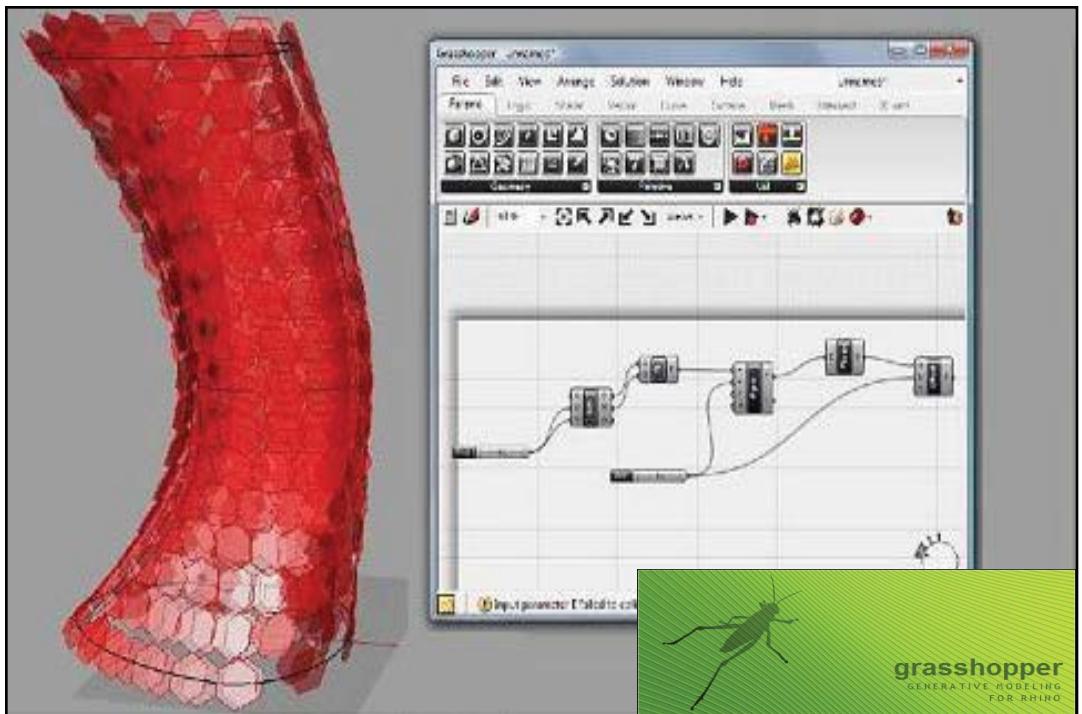
TUTORIAL - FROM GENERATIVE FORM TO COMPONENT SYSTEM PART 2



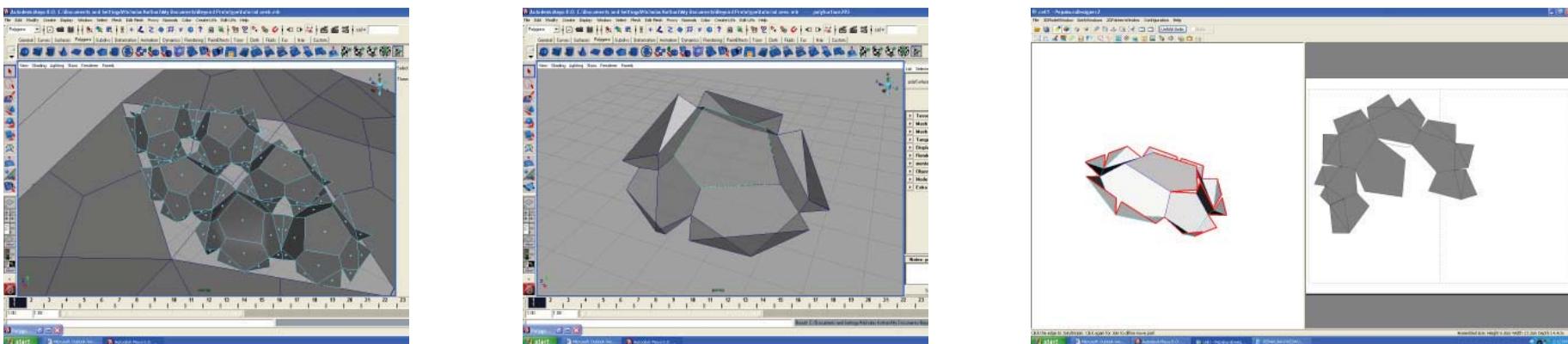
USING GRASSHOPPER TO CONTROL INDIVIDUAL CELL ATTRIBUTES



SUBDIVIDING A CELLULAR MESH INTO COMPONENTS WHICH CAN BE FABRICATED USING THE CNC MILL



DRAWING FOR THE MACHINE - FROM DIGITAL TO PHYSICAL



UNROLLING AND FLATTENING COMPLEX GEOMETRY IN GRASSHOPPER/RHINO FOR FABRICATION

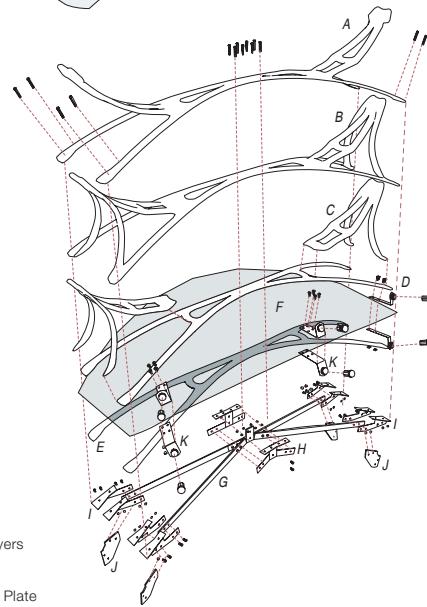
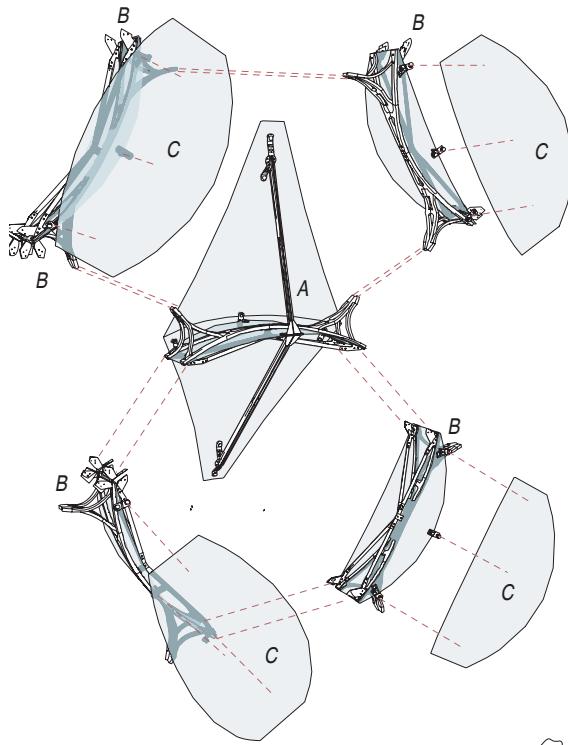


TOOLPATHING IN MASTERCAM AND CNC MILLING INSTRUCTION FOR FULL SCALE FABRICATION



PLASTIC BENDING INSTRUCTION: USING **DYNAMIC AND STATIC JIGS** FOR RAPID ASSEMBLY

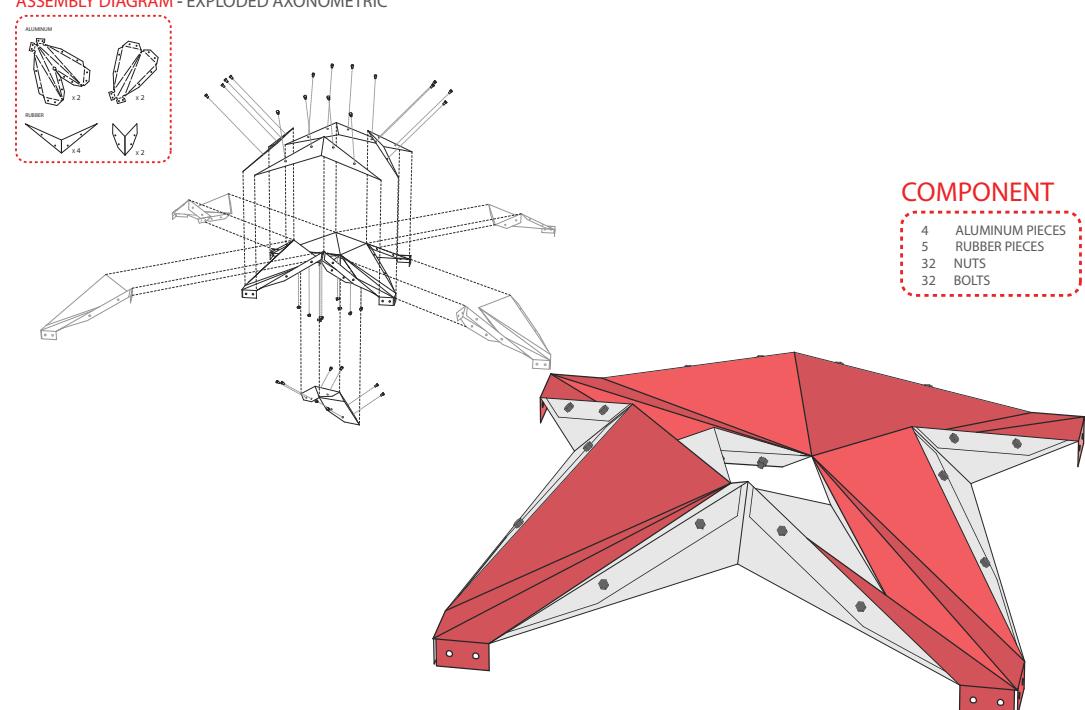
DRAWING FOR THE FABRICATOR - GENERATION OF ASSEMBLY DIAGRAMS & RENDERINGS



Laminated Rib

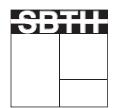
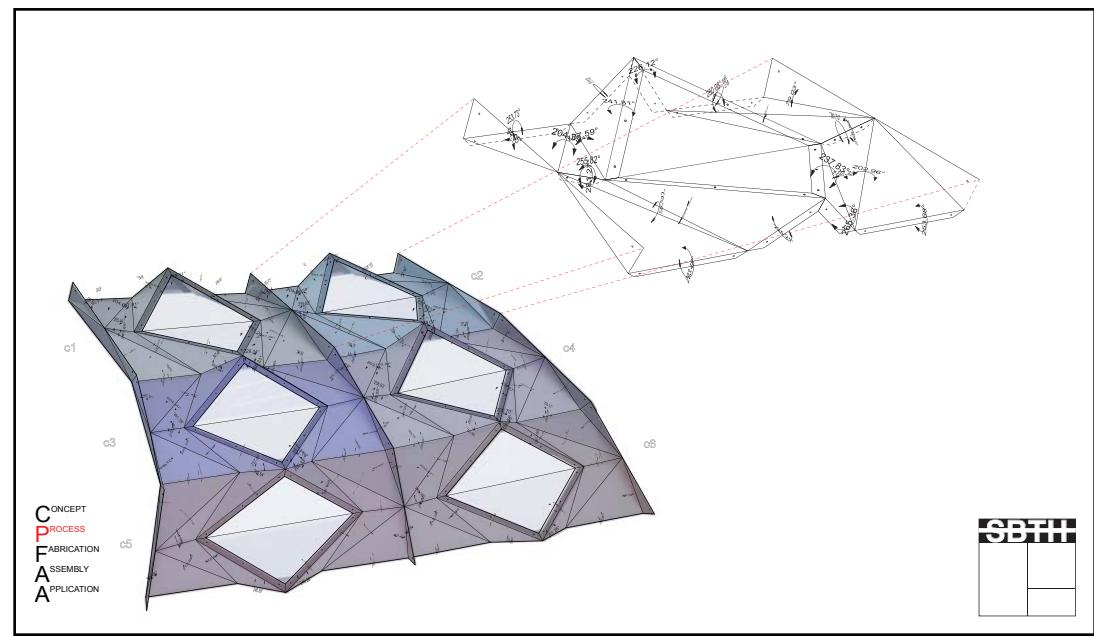
A - E. Laminated Sintra Layers
F. Laminated Acrylic Panel
G. Aluminum Tension Strut
H. Central Strut Connector Plate
I. Strut to Sintra Connector Plate
J. Web to Web Connector Plate

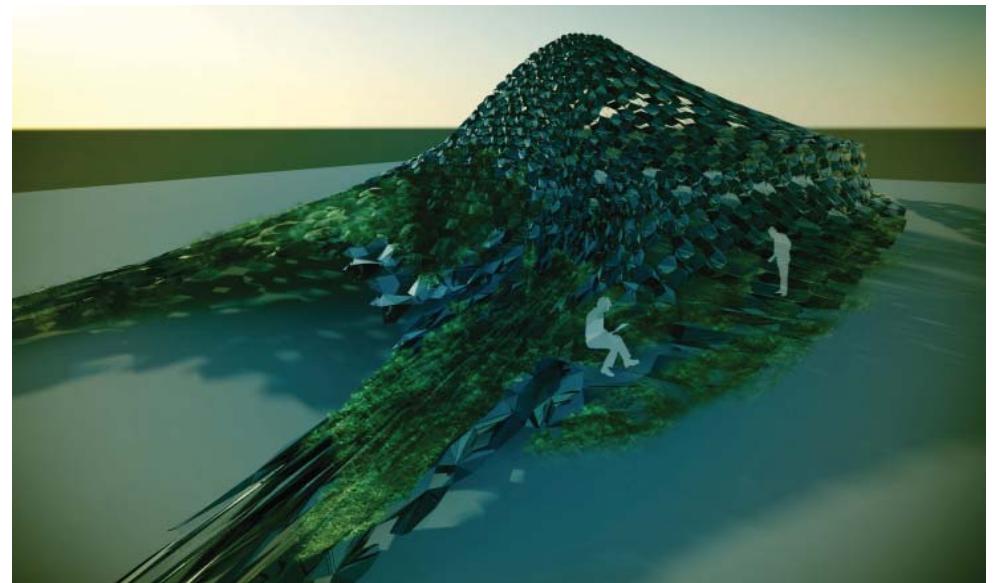
ASSEMBLY DIAGRAM - EXPLODED AXONOMETRIC



COMPONENT

4	ALUMINUM PIECES
5	RUBBER PIECES
32	NUTS
32	BOLTS



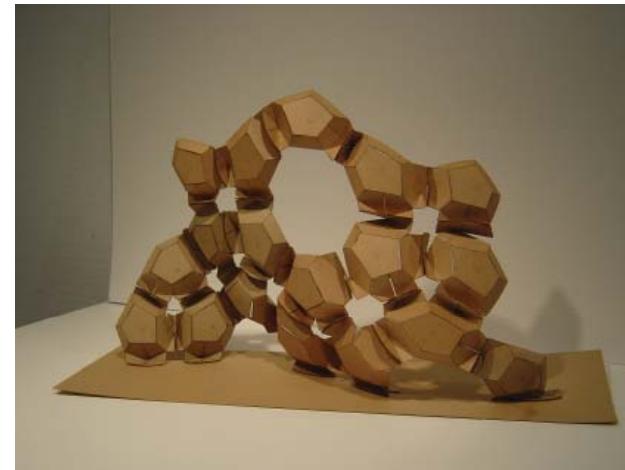




INSTRUCTION IN **MIG WELDING** AND ADVANCED METAL WORKING

Phase I - Analogue Modelling

The first component of **Beyond Prototype** focuses on the generation of a tessellated surface by employing analogue modeling techniques. Each design team creates a **two dimensional grid of polygonal patterns** to organize their cellular network. The base grid is printed on a single sheet of paper and through experimentation with techniques of cutting and folding, they formulate a strategy for bending this single surface into a rigid three dimensional mesh.



Phase II - Parametric Modelling

Using **Rhino** as a generative platform, each design team creates a NURBS surface or object that will serve as the overall form for the final project. Students are required to propose a practical application for this surface which will help drive its form, such as a pavilion design, shell system or building façade.

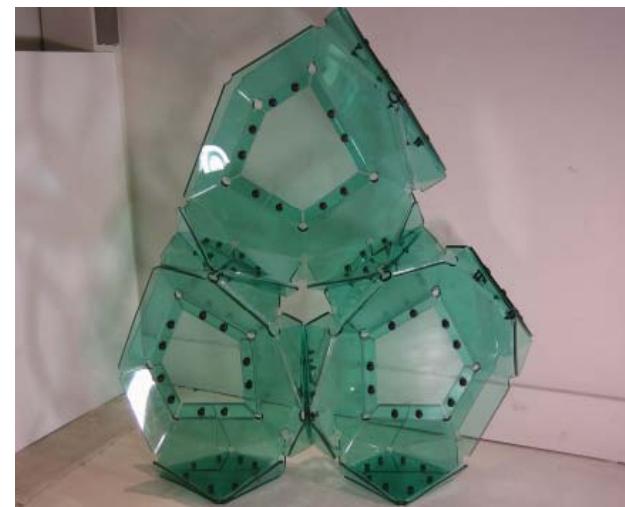
Using **Solid Works** each team performs a finite element analysis on the surface to analyze structural deficiencies within the overall form to ascertain where cellular variation will be needed for rigidity. The folded cell developed within the analogue models is recreated within the digital environment.

Using the parametric tools of **Grasshopper**, each team formulates a strategy for superimposing their 2D base grid onto the 3D surface model and mapping the folded cell onto the overall surface, thereby creating a **parametric component system**. Using Grasshopper, each team will be required to develop a digitally performative or parametric procedure for manipulating the surface tessellation into an activated mesh and propose a realistic application scenario. The objective is to create a skin/structural hybrid where the cellular surface is variable and is able to achieve structural rigidity through tessellation, a folding strategy and a three dimensional system of connections.

Phase III - Prototyping and Fabrication

Each team chooses a significant formal or structural moment within their cellular network. Using the laser cutter, **CNC Mill**, **welder and plastic bender** to extract the system from the virtual realm, students **construct a full scale, physical counterpart, (minimum size 3'x3')** in folded acrylic or metal, that physically demonstrates the underlying design principles of the system.

Each team will present their surface generation and assembly process, create assembly diagrams for fabrication and produce renderings for presentation of the overall vision.





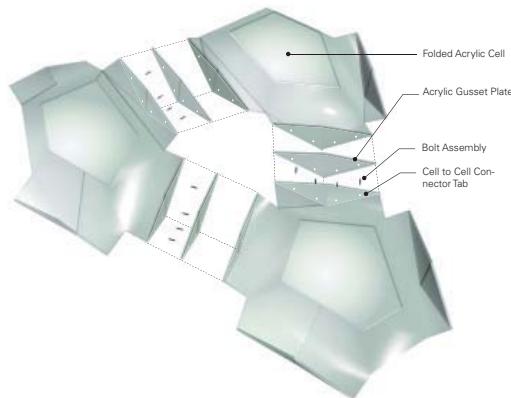
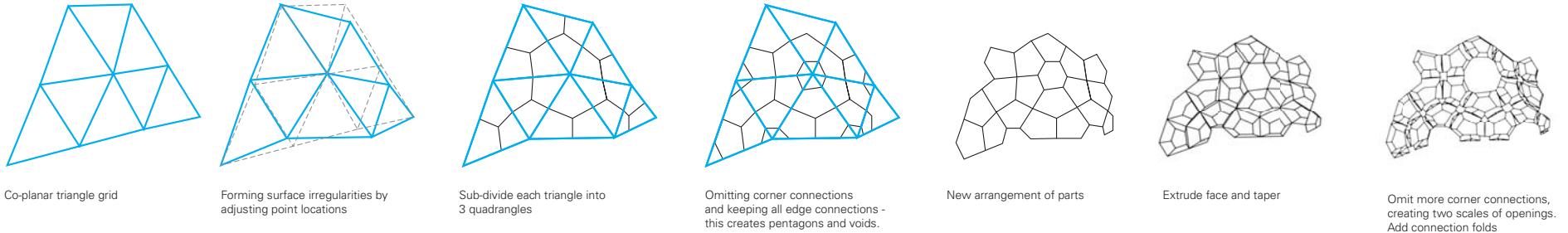
RESEARCH DATE: SPRING/FALL 2007

PENTAGONAL WALL SYSTEM

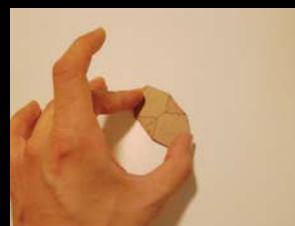
Green Tinted Acrylic
Hex Bolt Fasteners

Team:
Jason Ivaliotis
Nicholas Kothari

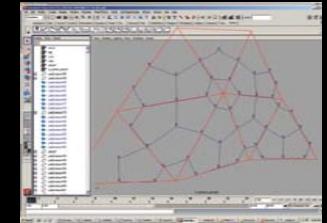
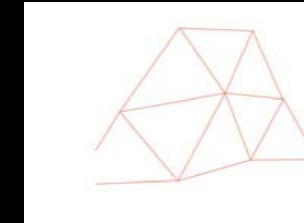
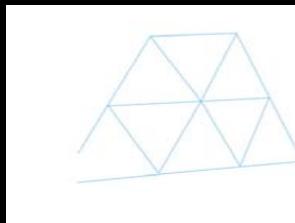
FORM GENERATION



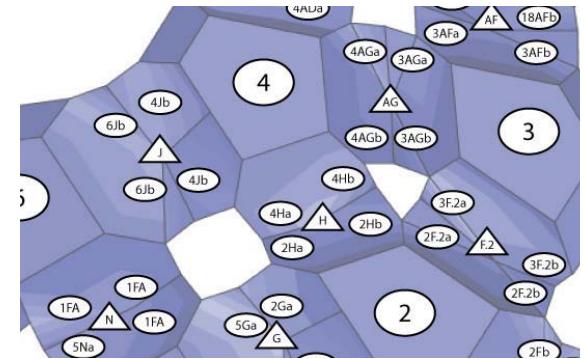
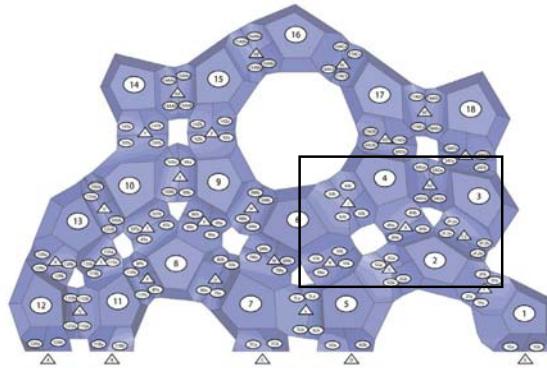
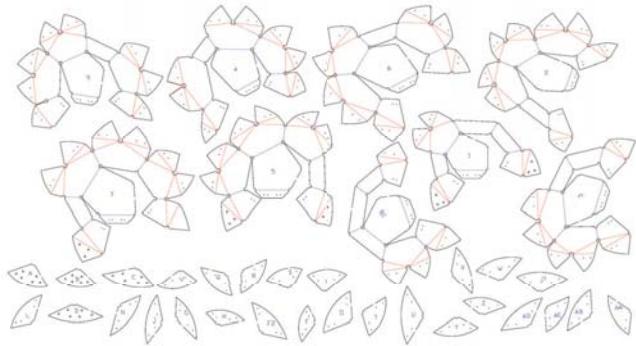
STUDY MODEL PROCESS:
Connection details are based on this study of an adjustable angle which is produced by 7 folds in this surface.



DIGITAL GENERATION:
The overall form of the wall is determined in the triangular grid. Points are pushed and pulled to create an S-Shaped base promotes structural stability and proper balance of the system. Then, the triangles are subdivided and articulated into pentagonal cells.



PROTOTYPING & FABRICATION

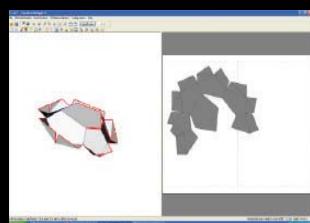
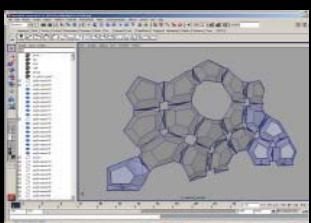
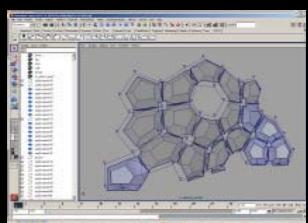
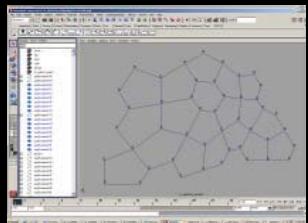


Unique angle bend tags and part catalog



Maintaining coplanar geometry in non-triangulated surfaces is one of the many challenges students face when modelling a fabrication-ready surface. Triangulated faces are a common solution to achieving coplanarity; however this limits the patterns and forms that can be developed. The major innovation in this project is the **subdivision of giant triangular planes into three pentagons**.

Each pentagonal cell has a unique flap detail which allows easy edge-to-edge connections.

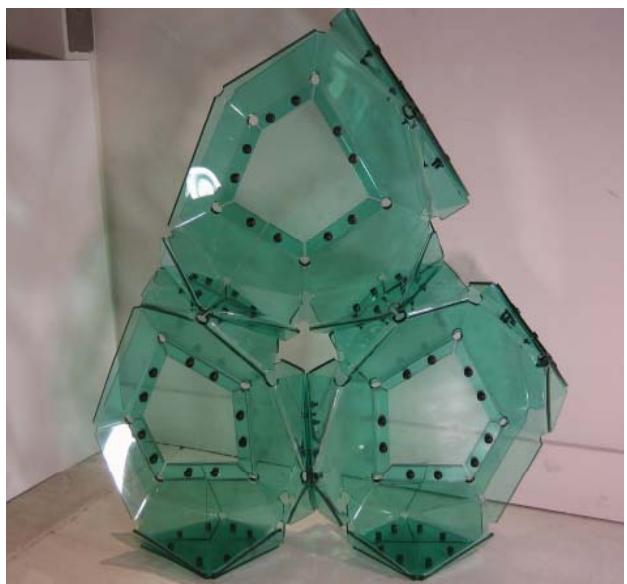
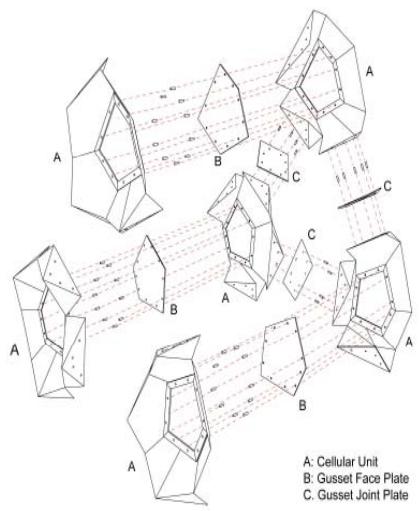


FABRICATION / ASSEMBLY



INSTRUCTION IN CNC milling: **CONTOUR CUTTING**

FABRICATION/ASSEMBLY

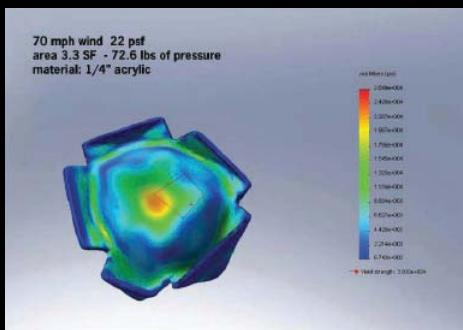




Hardware on the front side.



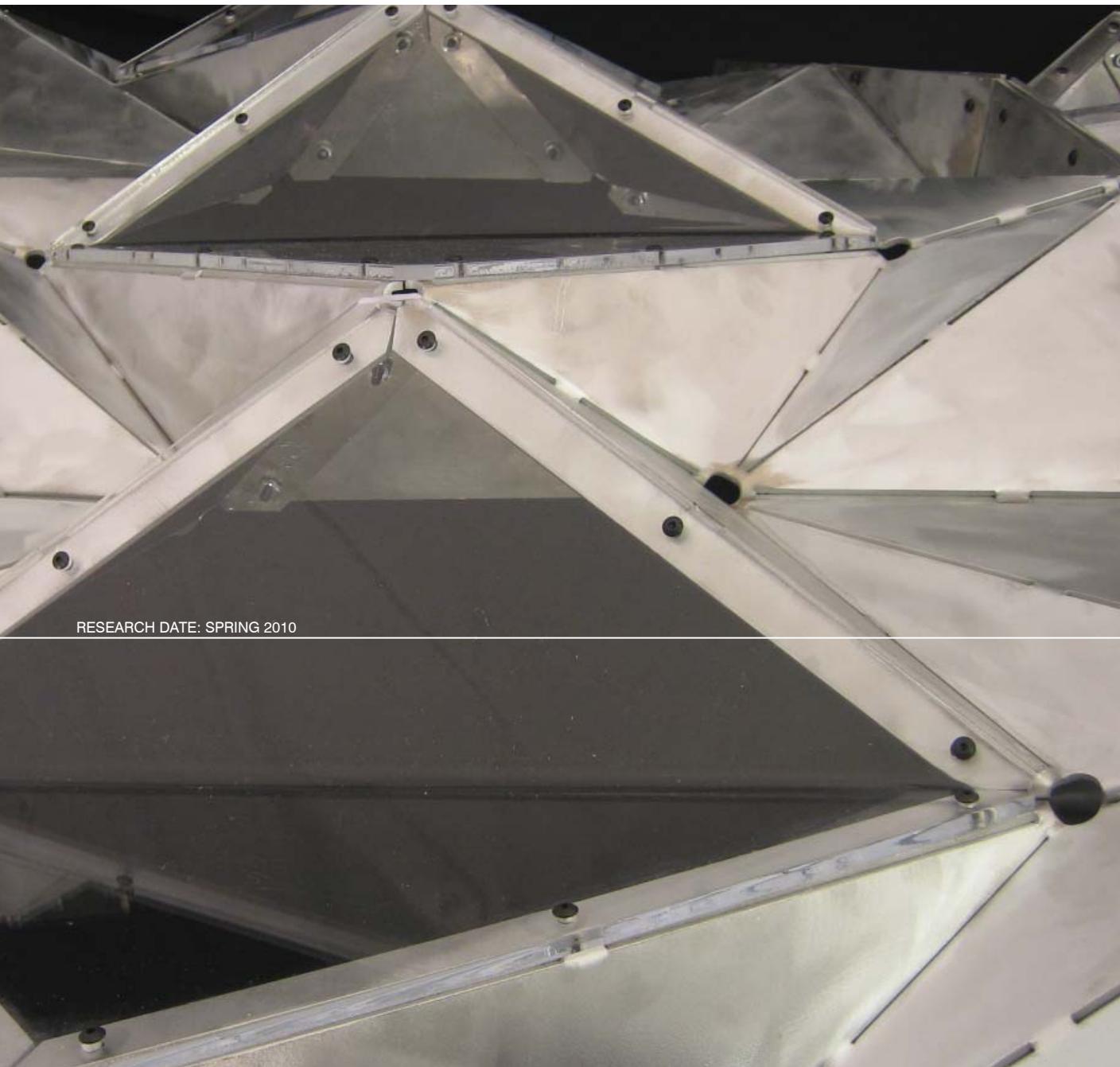
Flap connection from the backside.



Finite Element Analysis



FINAL ASSEMBLY: 18-cell wall mounted on MDF base.



RESEARCH DATE: SPRING 2010

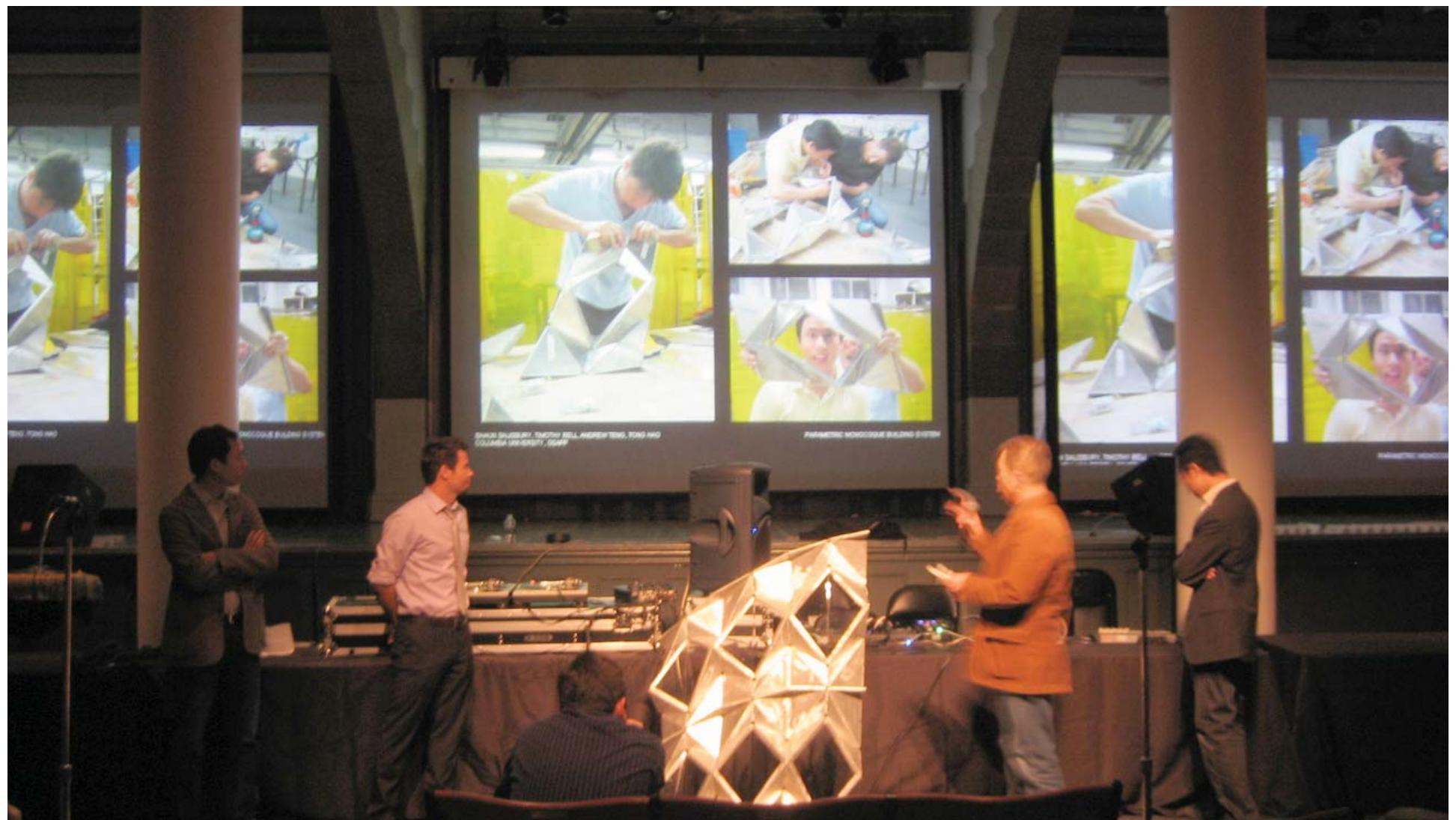
FABRIC TESSELLATION

Clear Acrylic
Aluminum

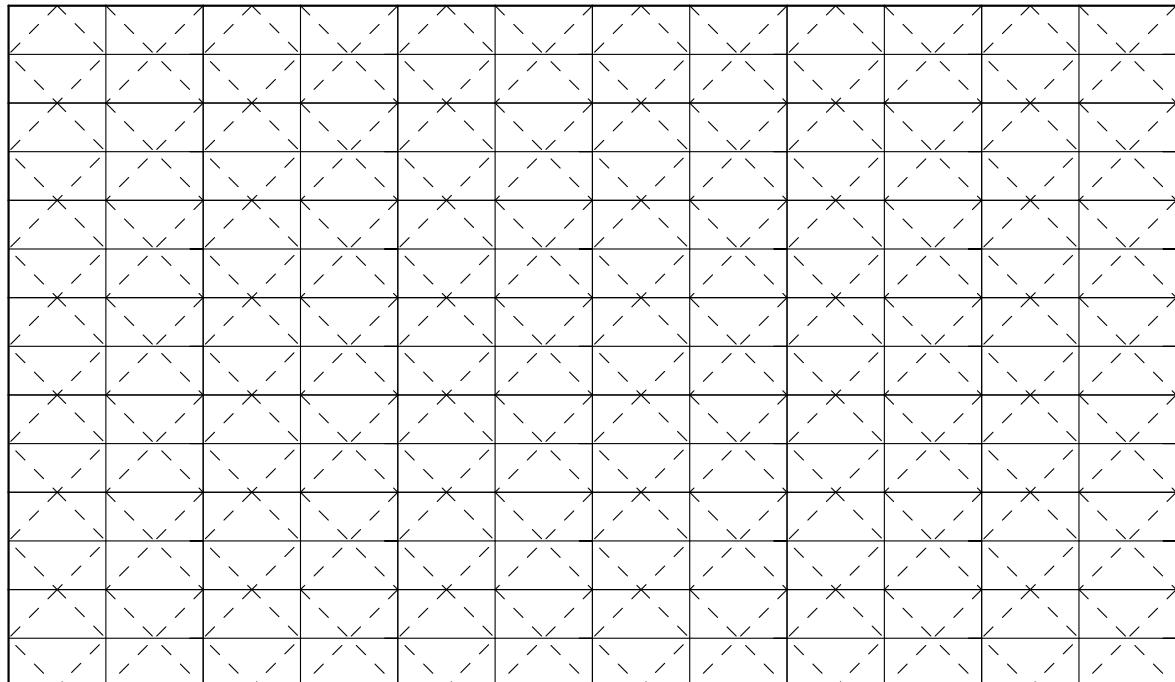
Team:
Timothy Bell
Tong Hao
Shaun Salisbury
Andrew Teng

BEYOND PROTOTYPE STUDENTS PRESENT: FABRIC TESSELLATION

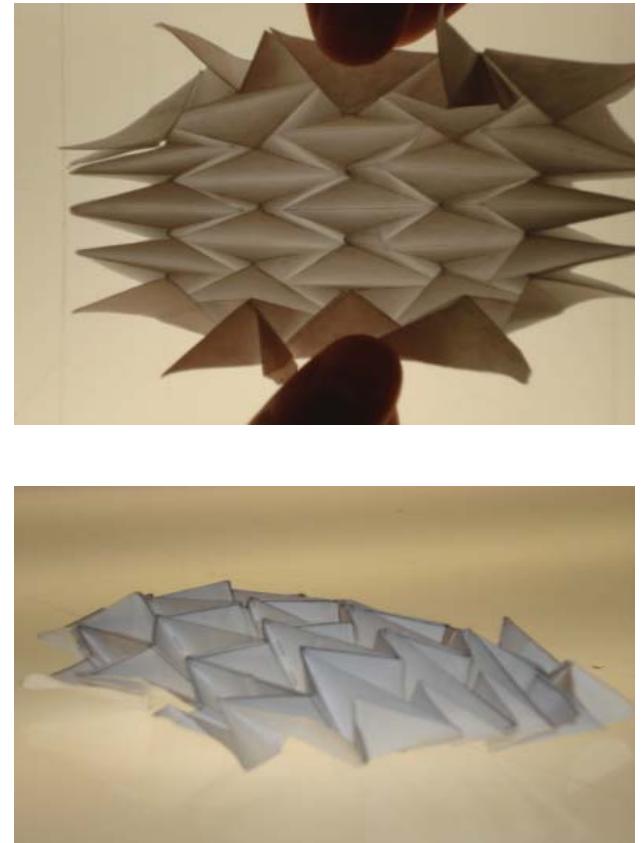
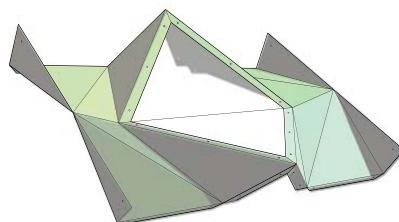
ACADIA 2010 LIFE IN:FORMATION



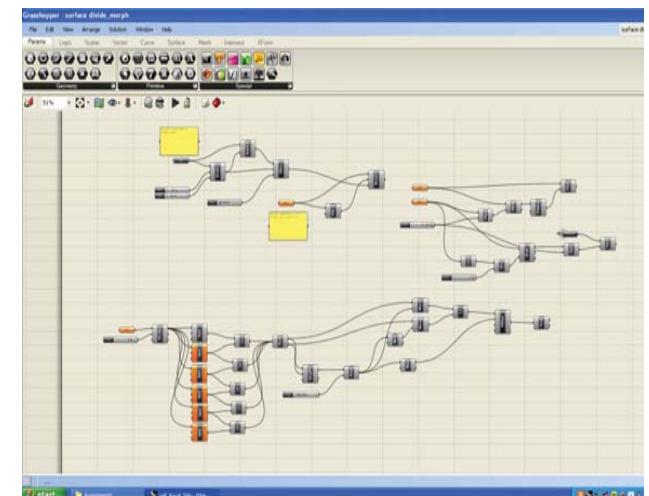
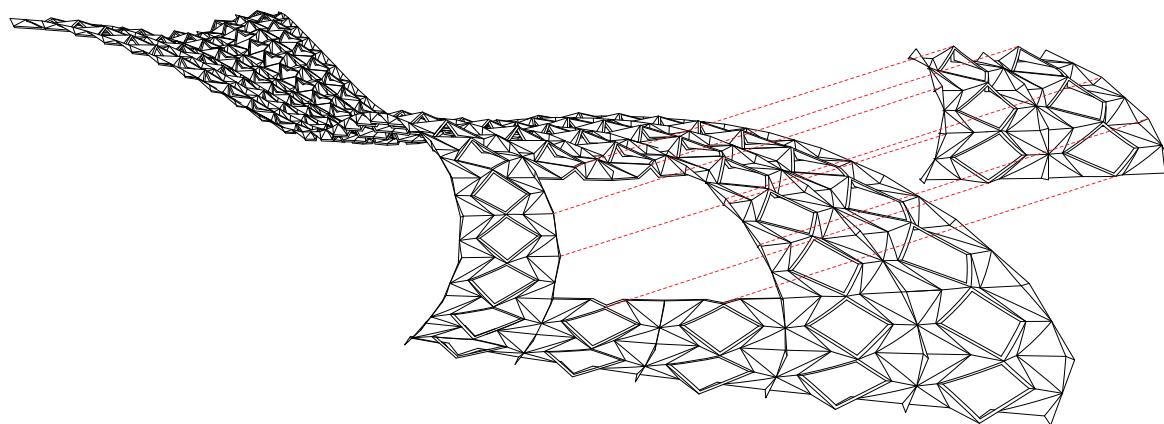
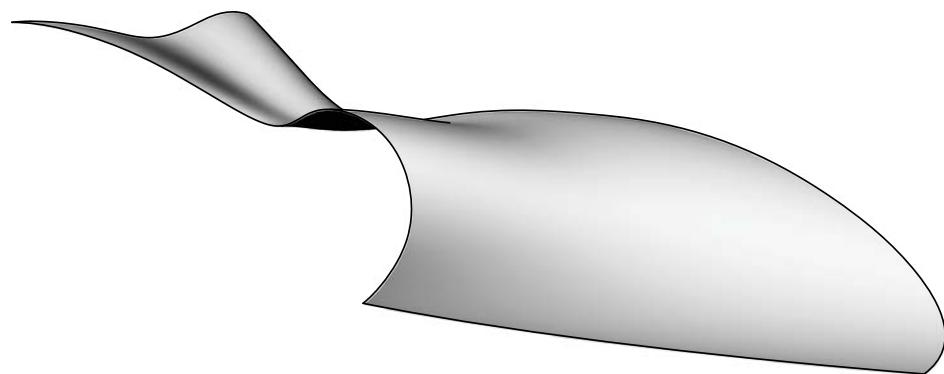
MESH GENERATION



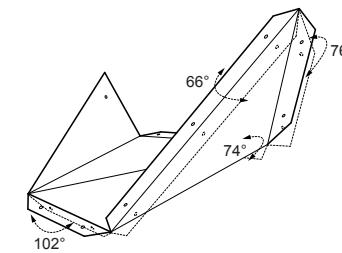
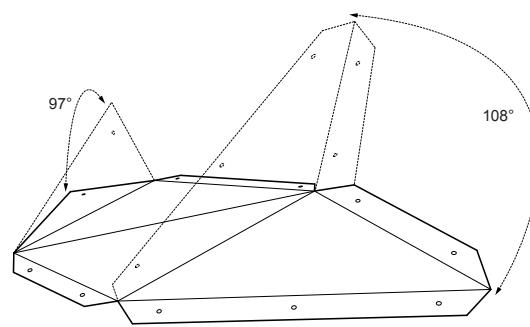
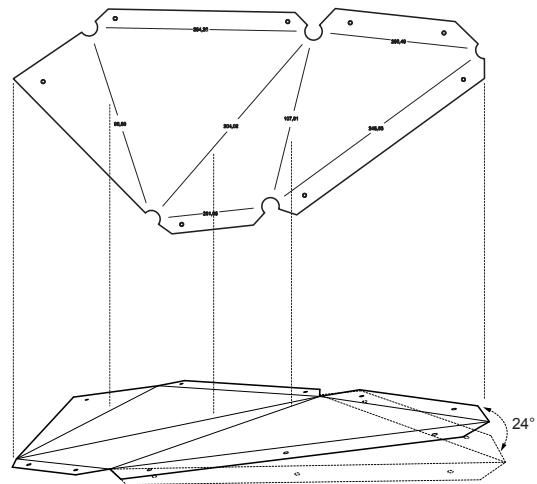
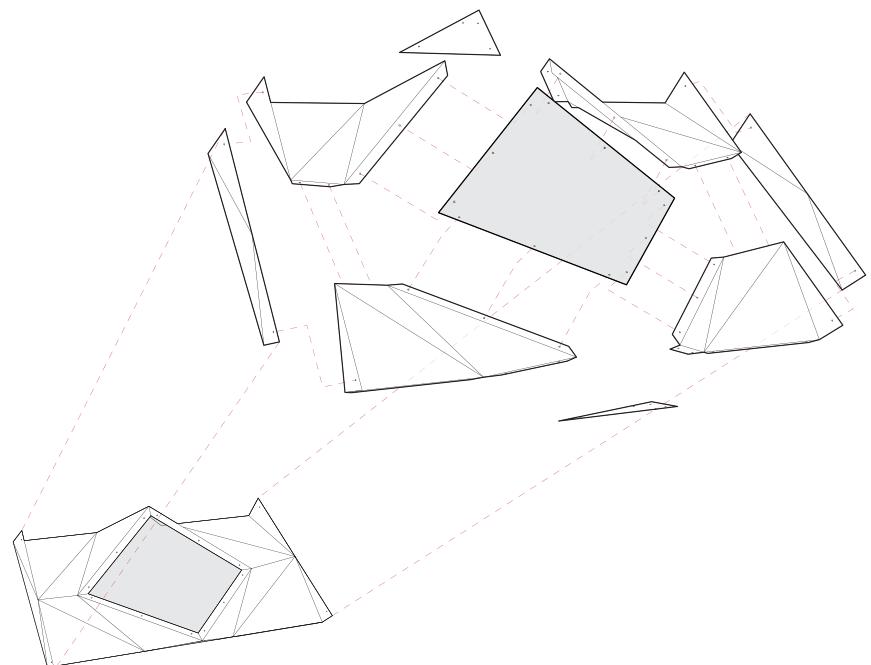
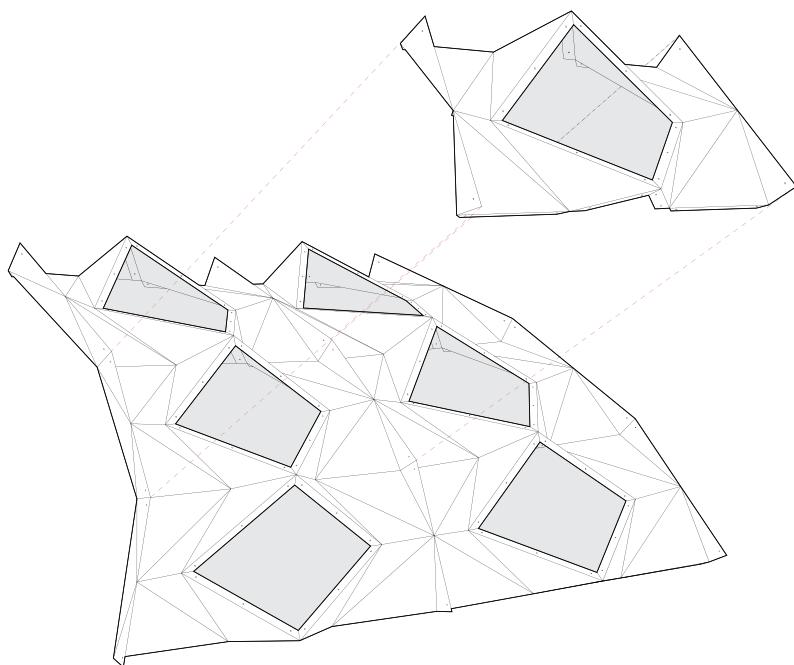
C
P
F
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A
ONCEPT
ROCESS
ABRICATION
SSEMBLY
PLICATION



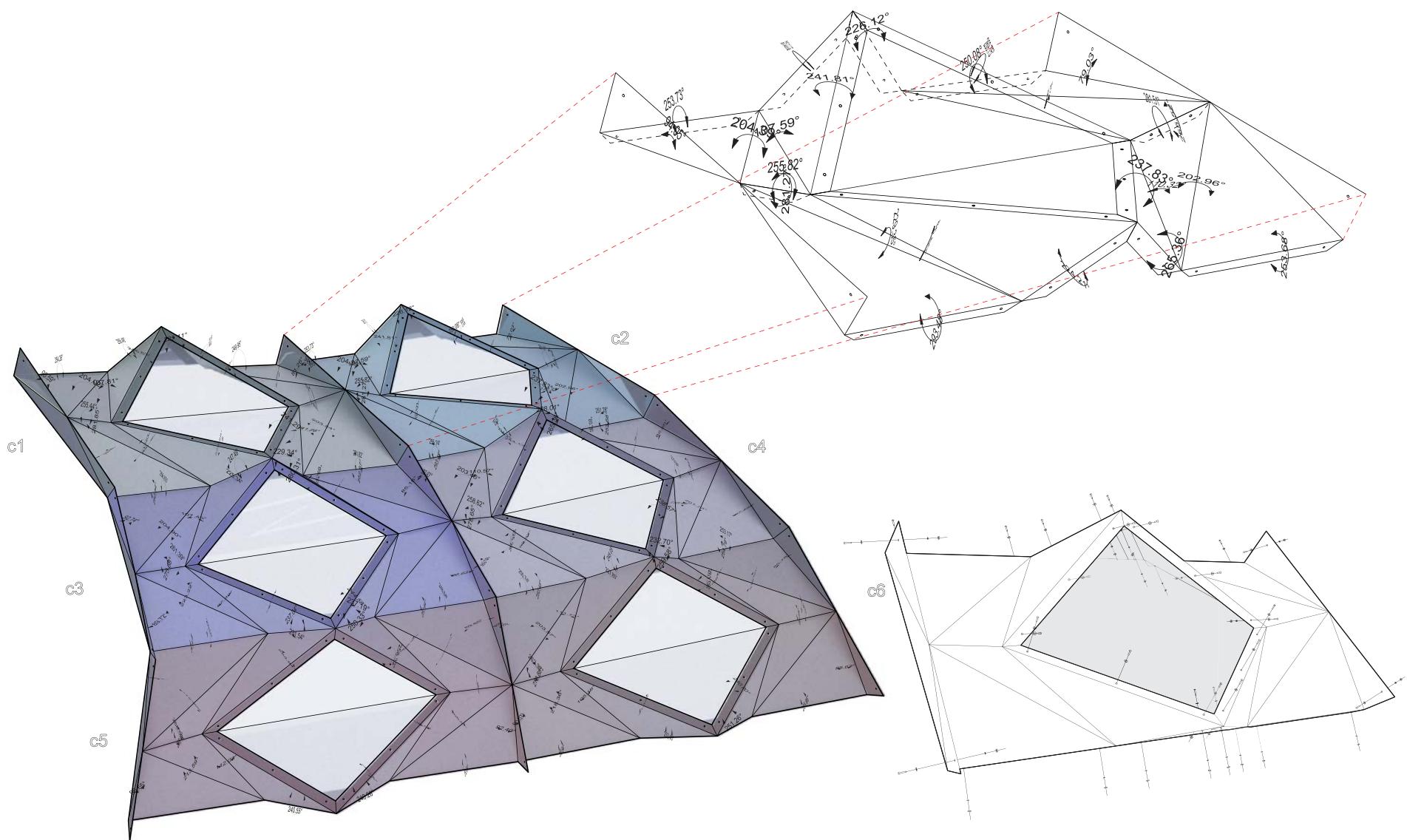
PARAMETRIC COMPONENT GENERATION



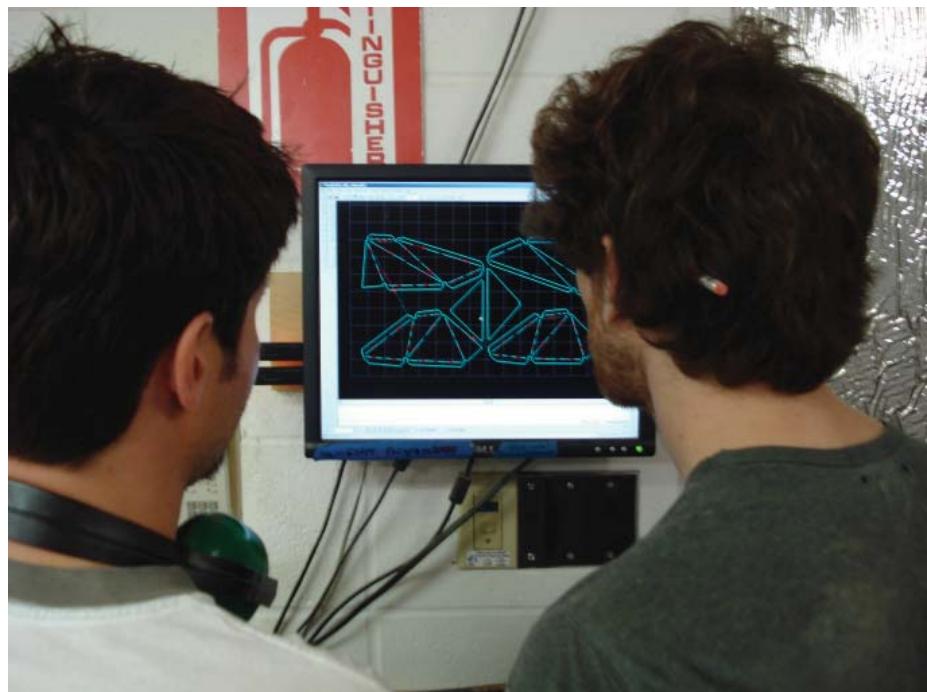
COMPONENT ASSEMBLY / FABRICATION DRAWINGS



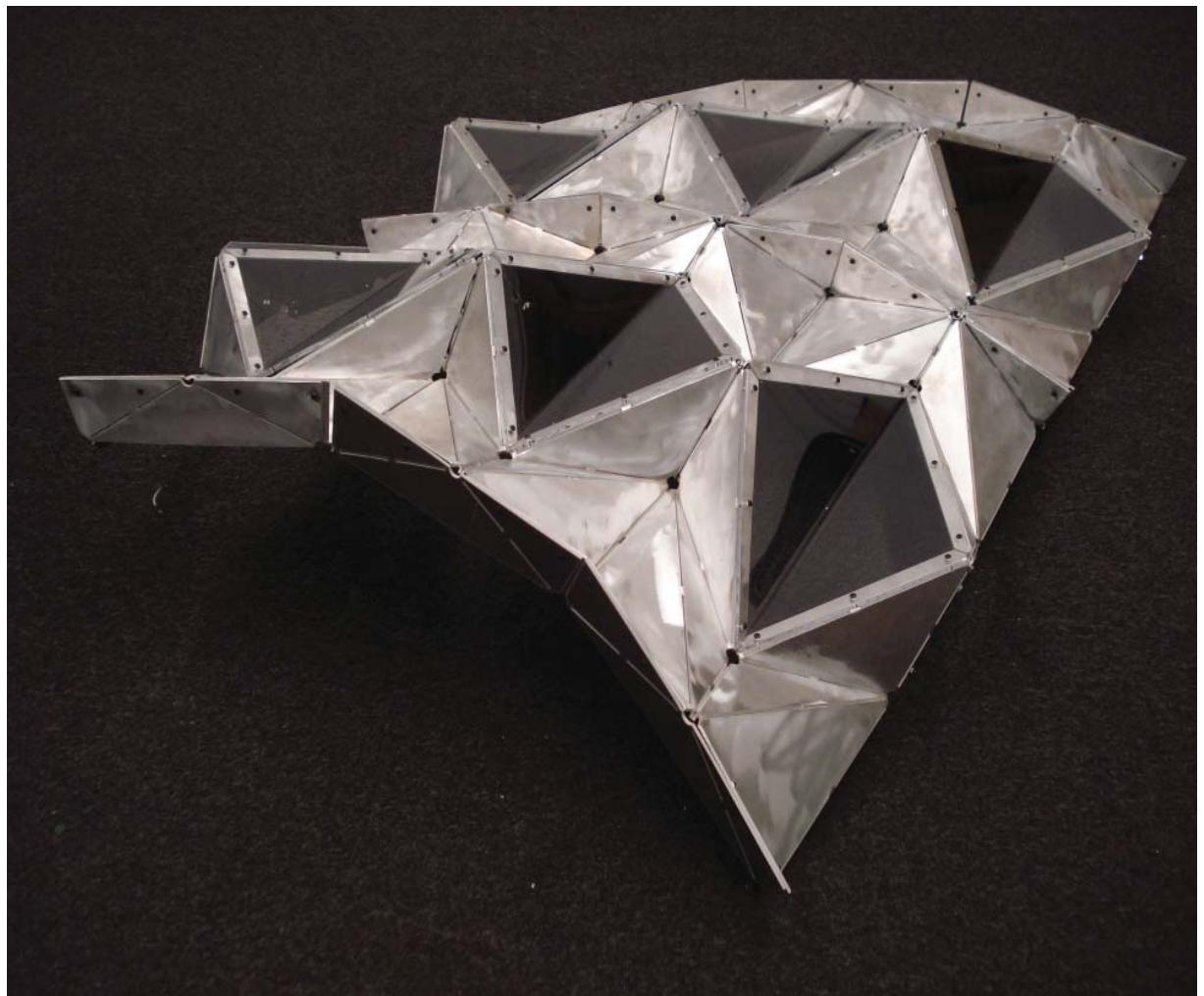
COMPONENT ASSEMBLY



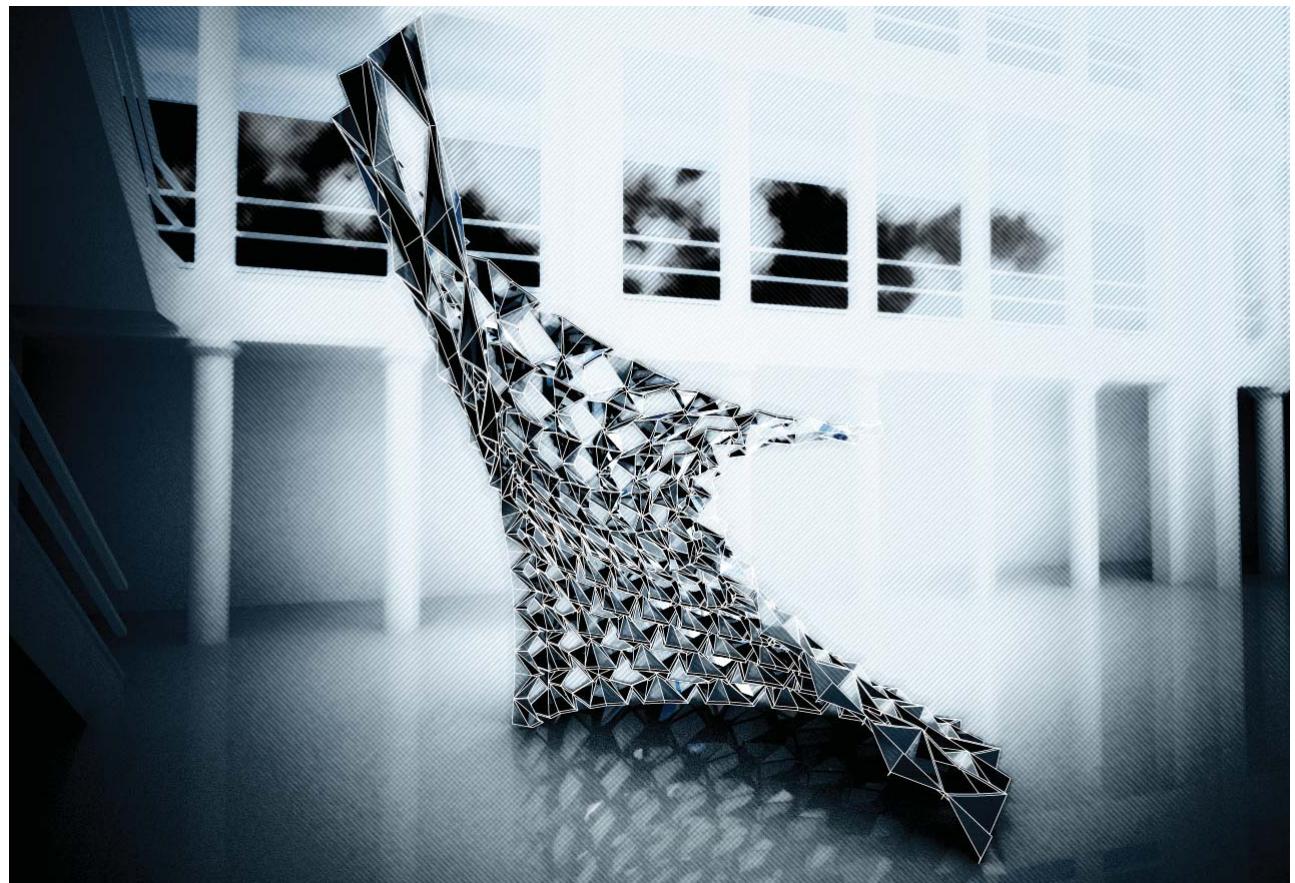
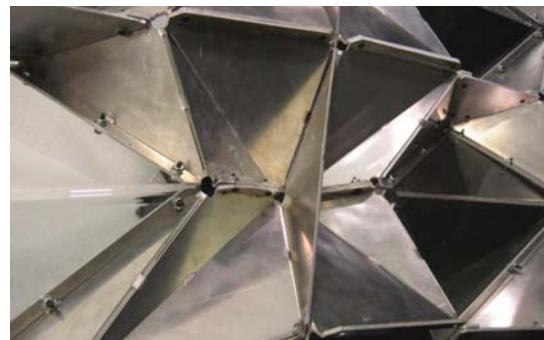
FABRICATION / ASSEMBLY

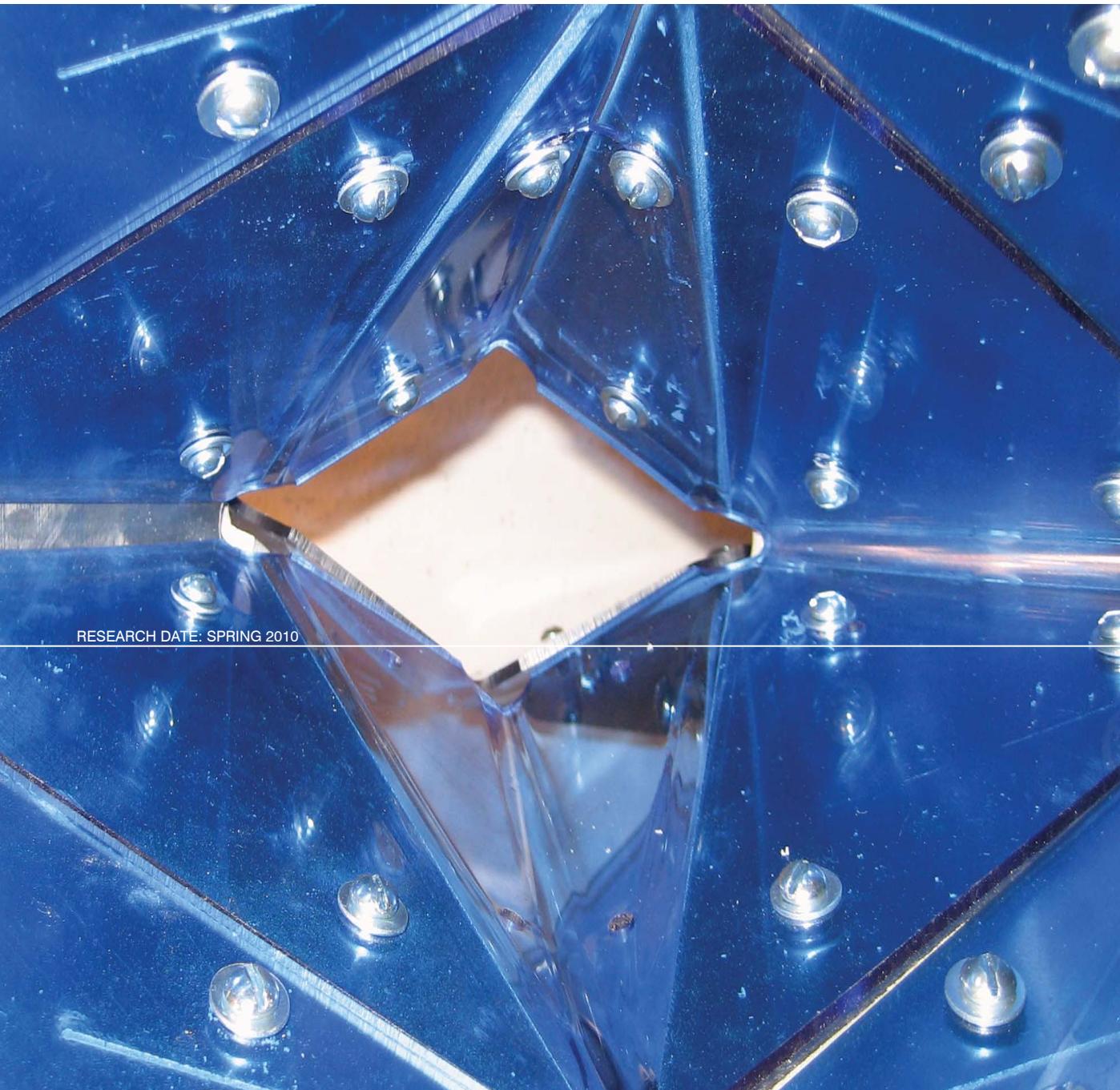


FABRICATION / ASSEMBLY



FABRICATION / VISUALIZATION





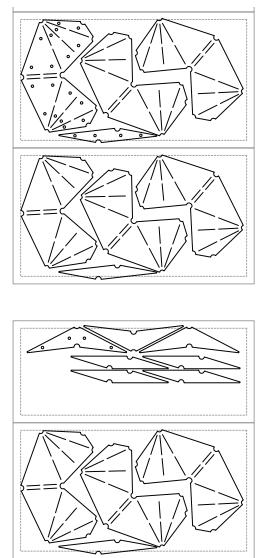
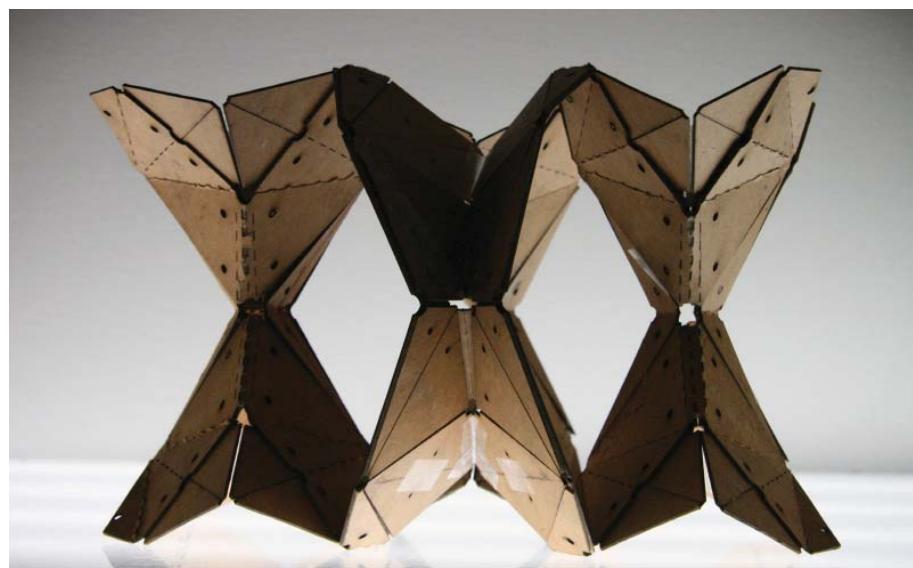
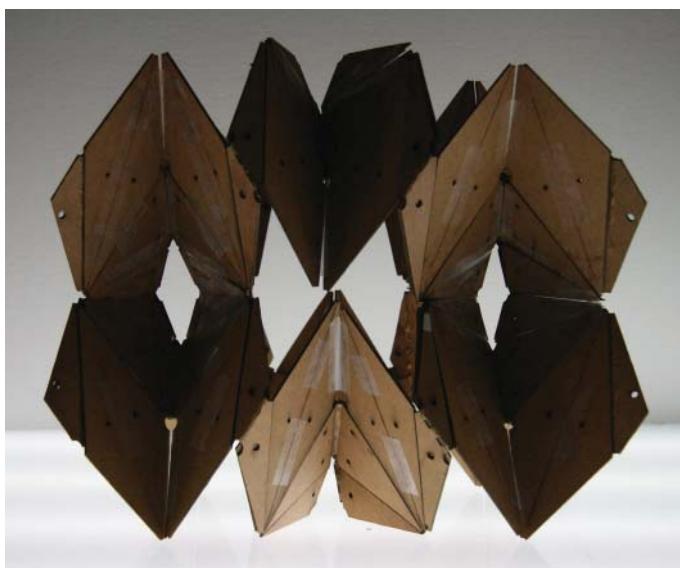
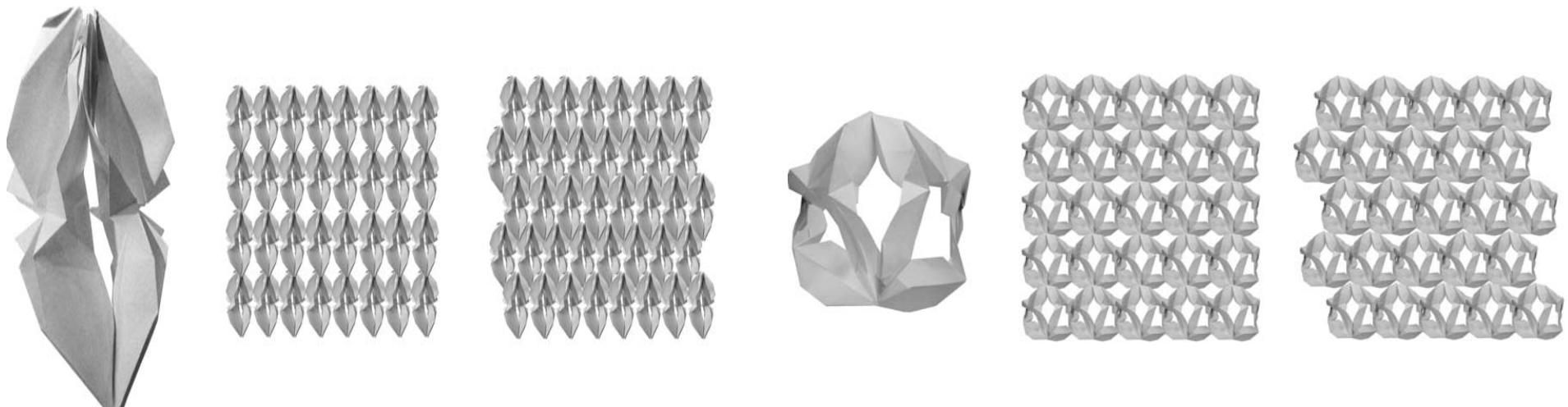
RESEARCH DATE: SPRING 2010

NATURE CULTIVATOR

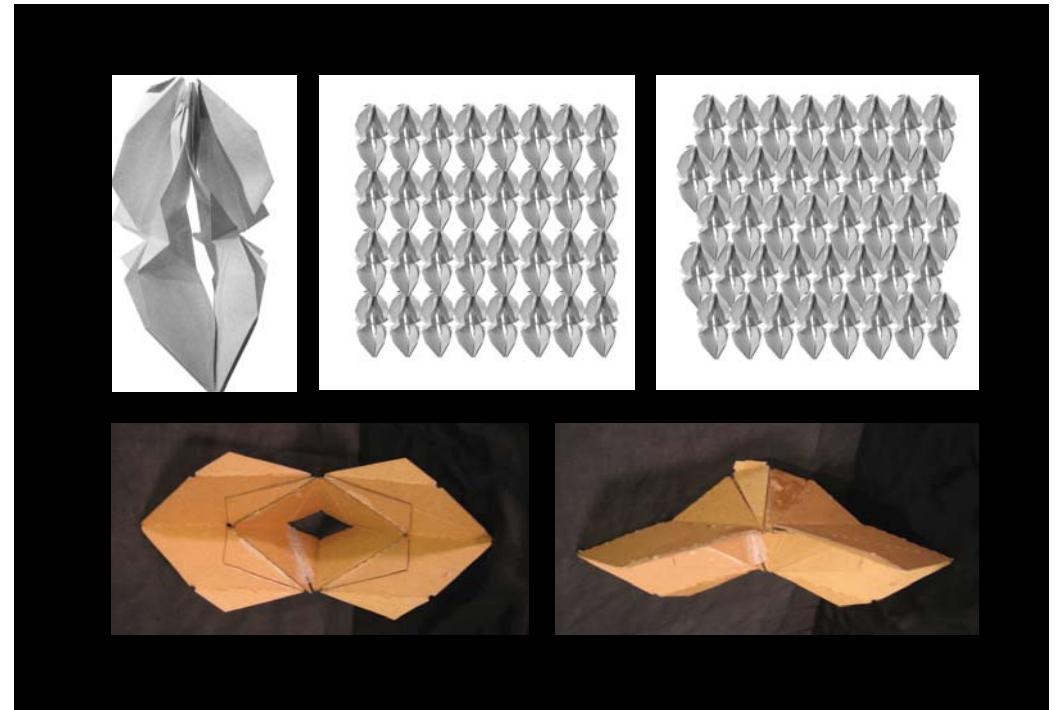
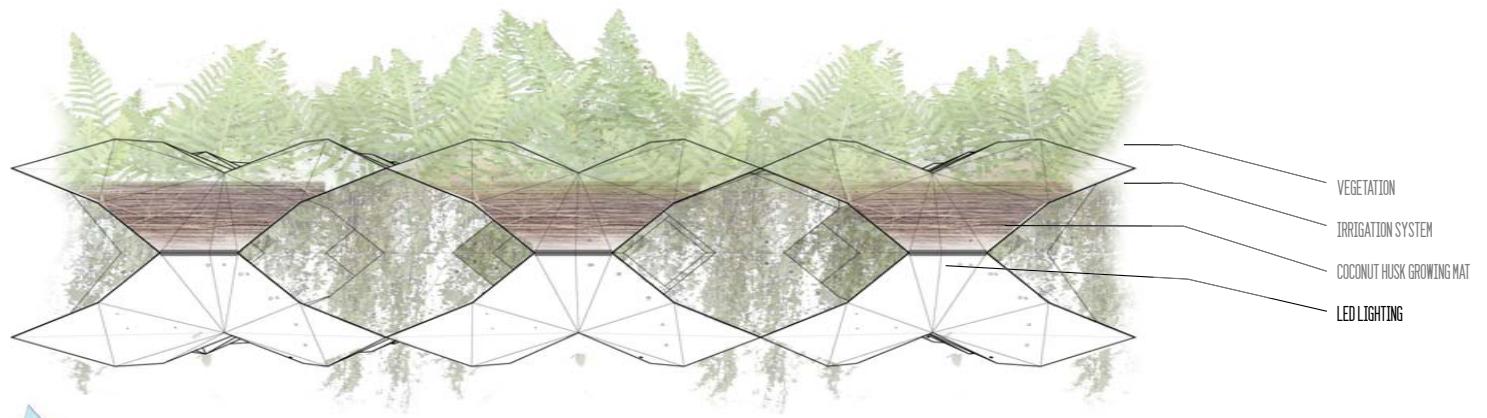
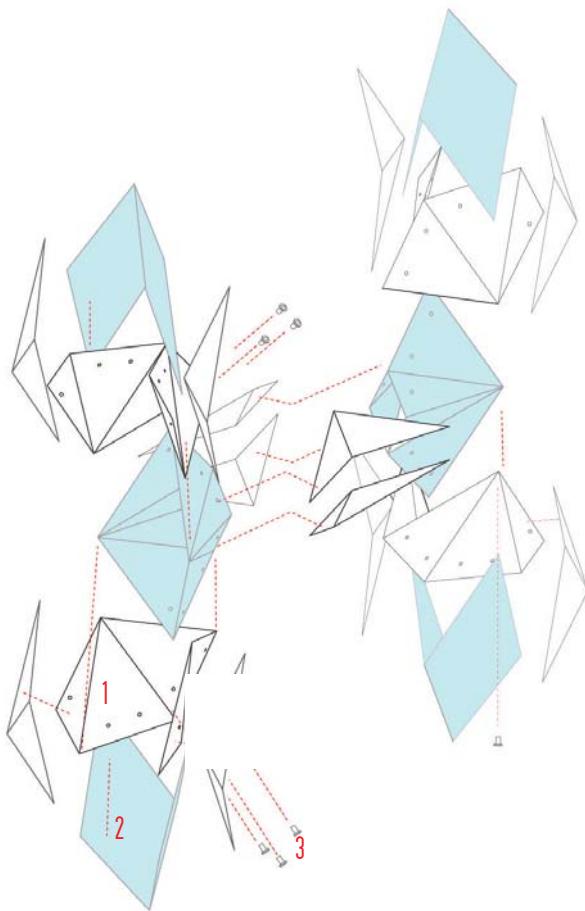
Blue Tinted Acrylic
Aluminum

Team:
Trevor Hollyn Taub
Ethan Hatton Taylor
George Valdes

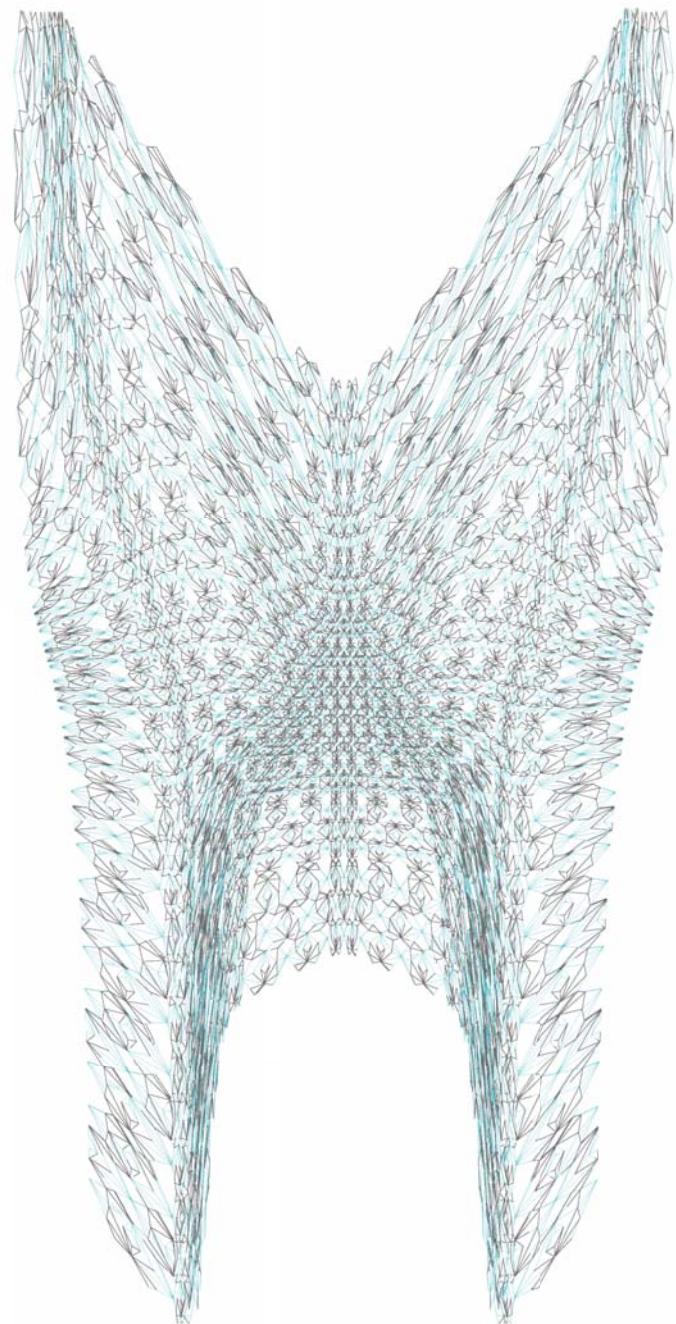
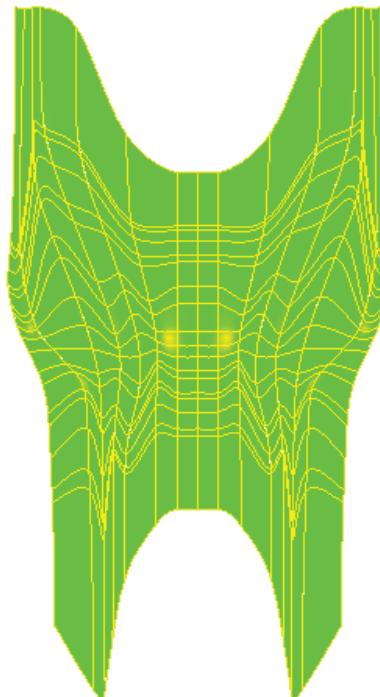
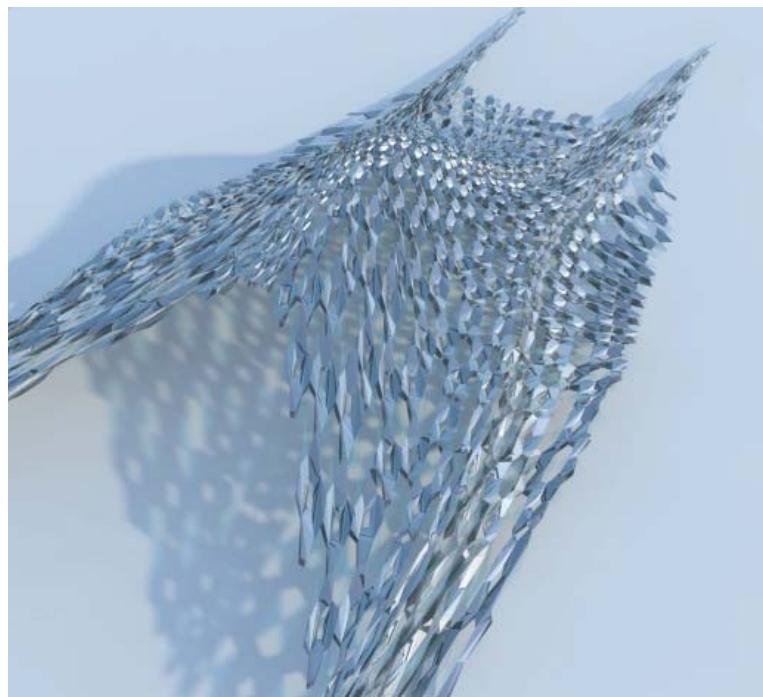
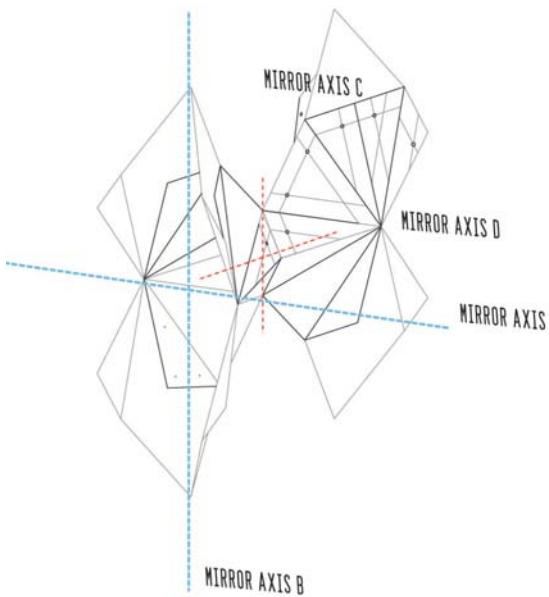
MESH GENERATION



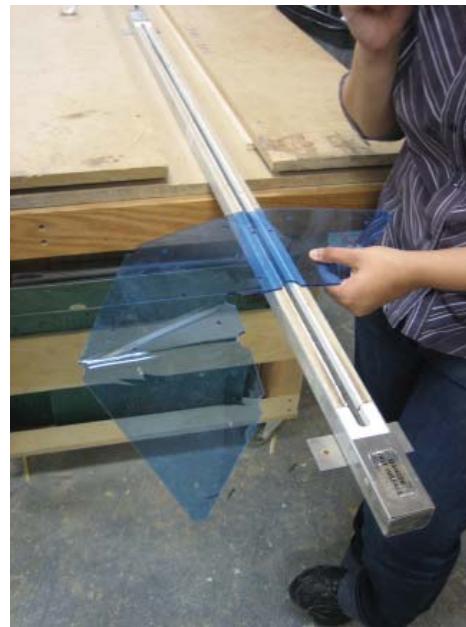
PROGRAMMING / ASSEMBLY



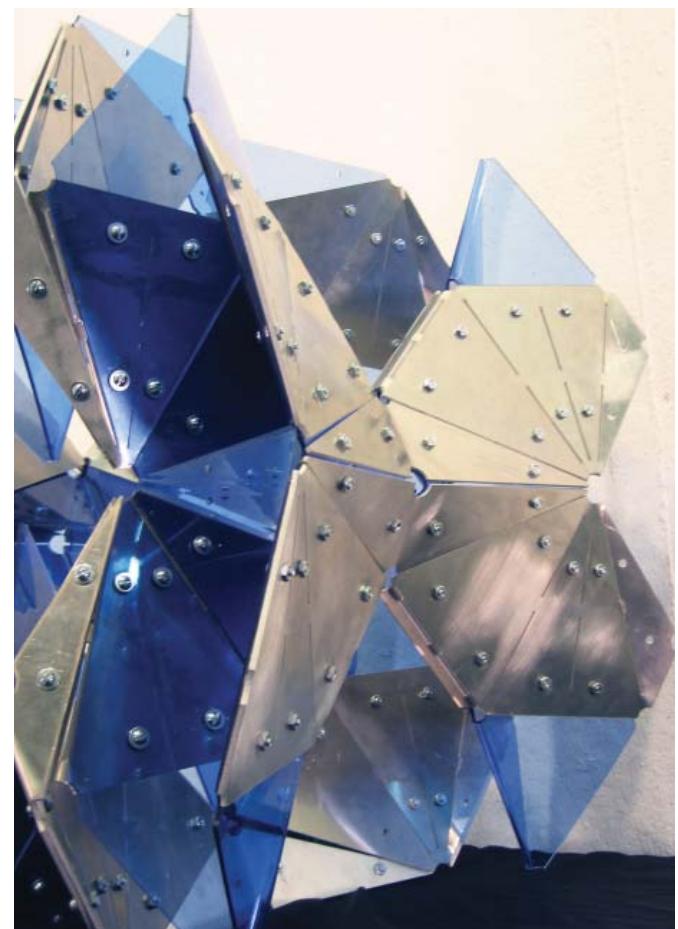
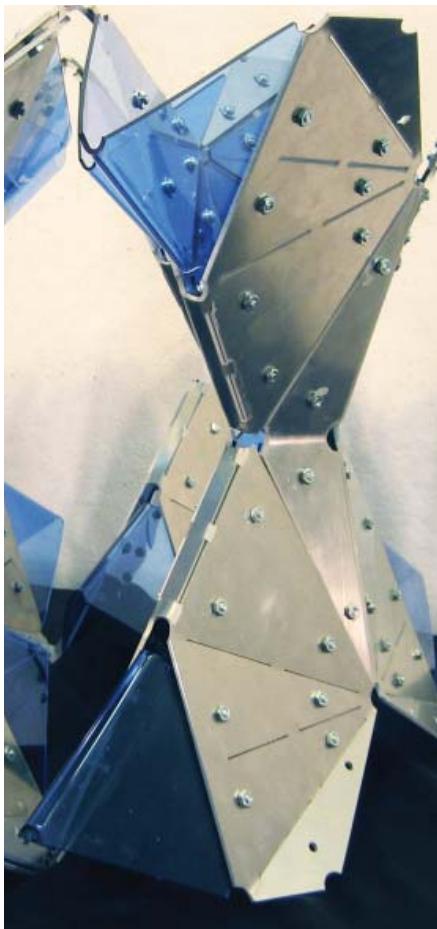
PARAMETRIC COMPONENT SYSTEM GENERATION



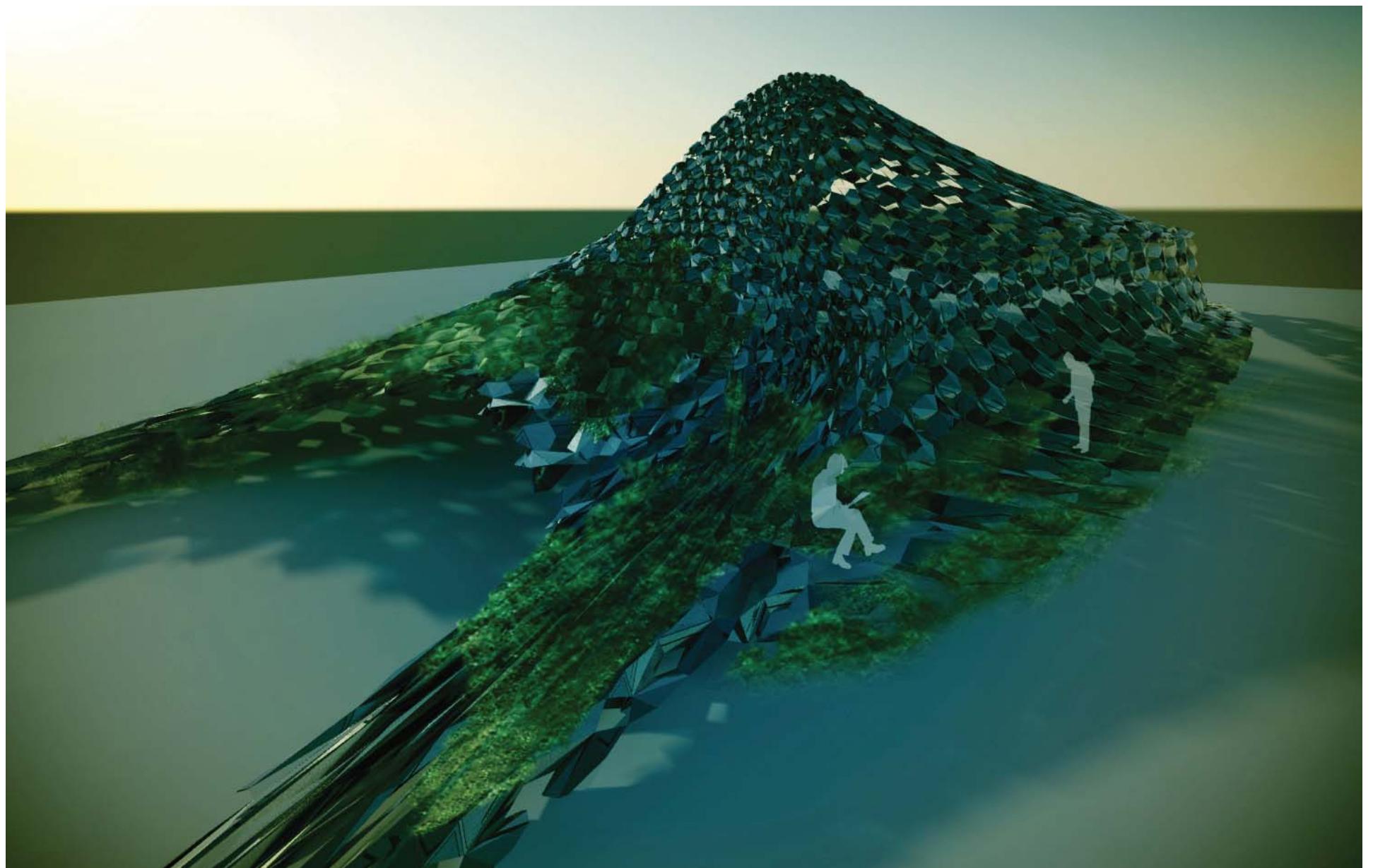
FABRICATION / ASSEMBLY

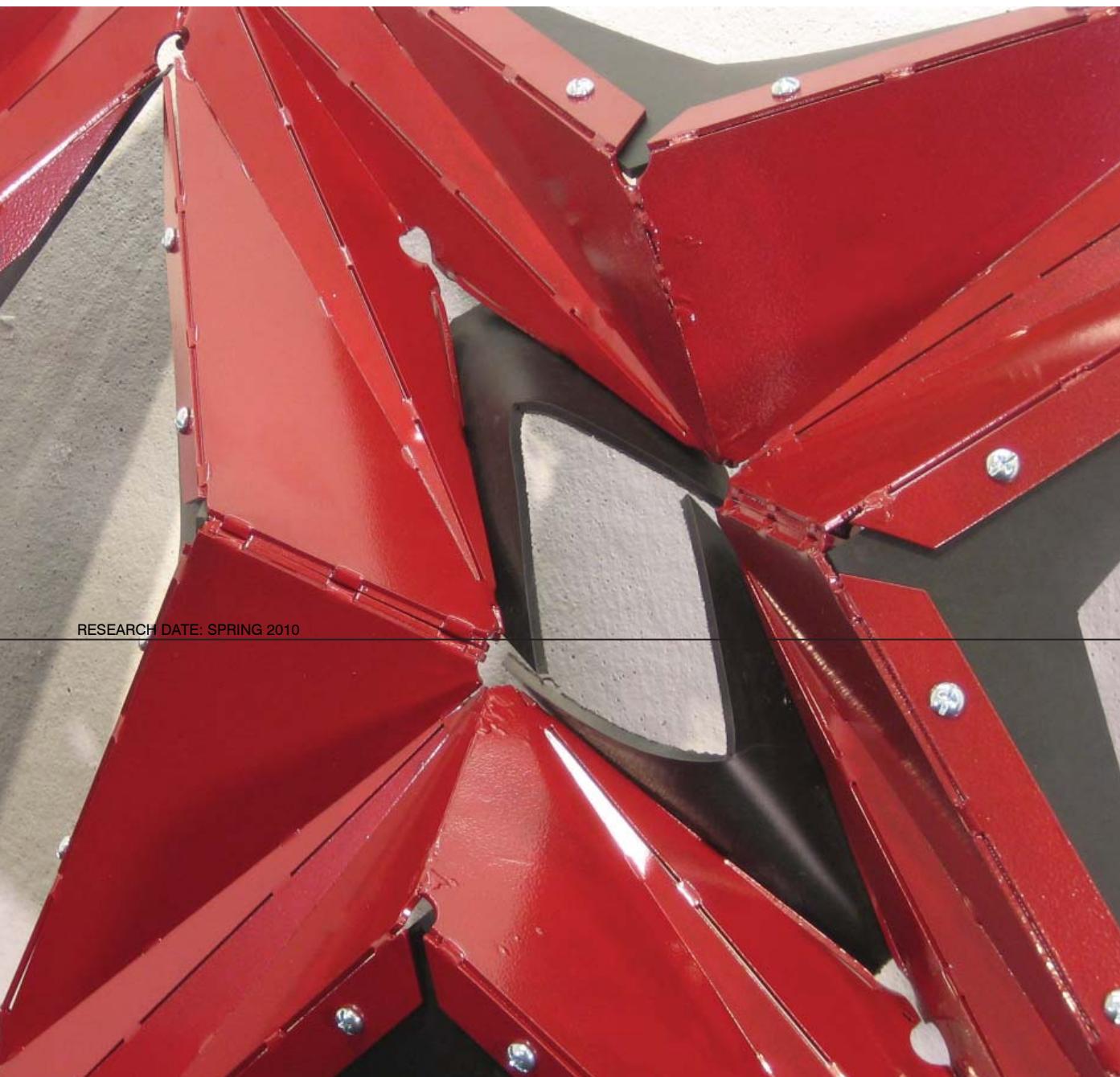


FABRICATION / ASSEMBLY



VISUALIZATION / PAVILION DESIGN





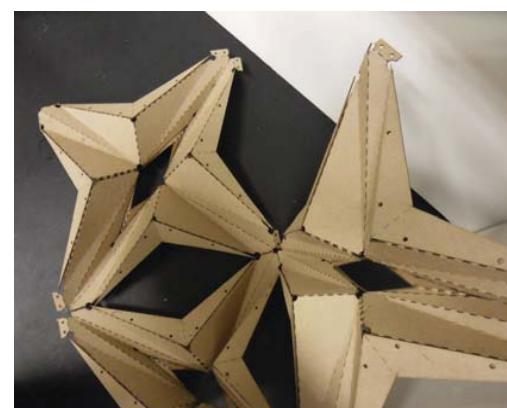
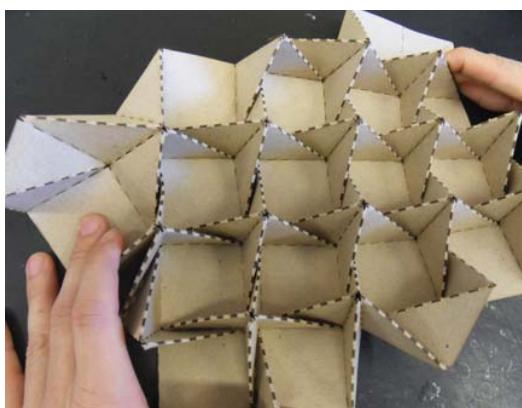
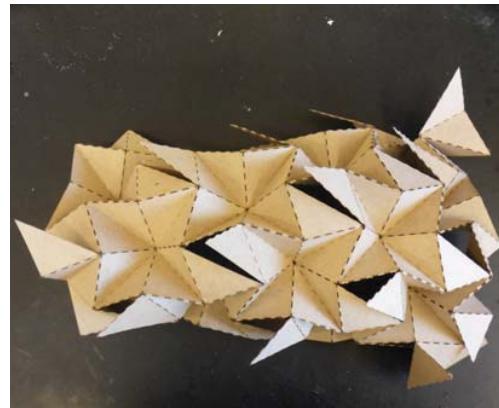
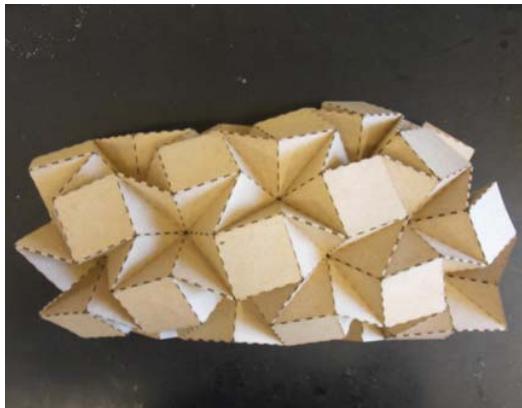
RESEARCH DATE: SPRING 2010

STAR APERTURE

Aluminum
Rubber

Team:
Kerri Henderson
Lior Shlomo
Diego Urrego

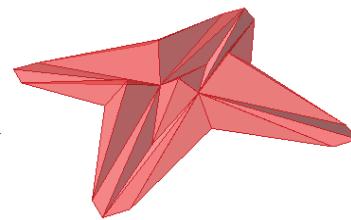
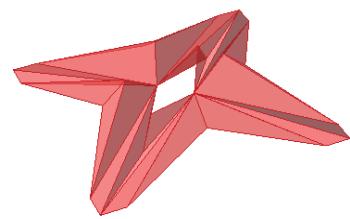
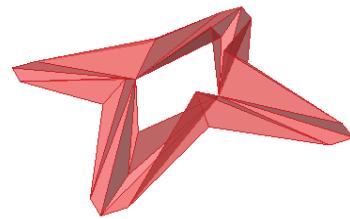
MESH GENERATION



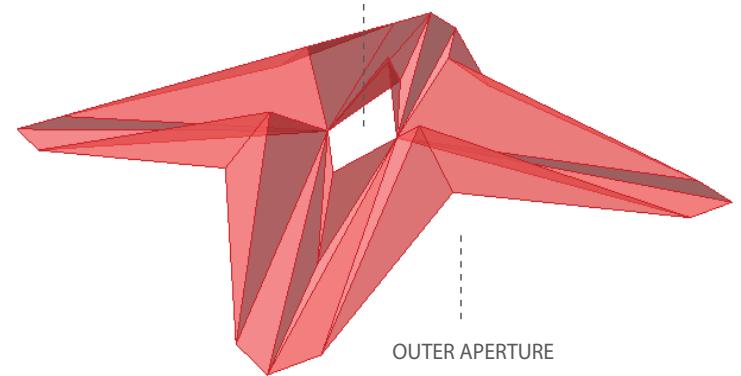
PARAMETRIC CELL

MAIN COMPONENT - Grasshopper Definition

INNER APERTURE

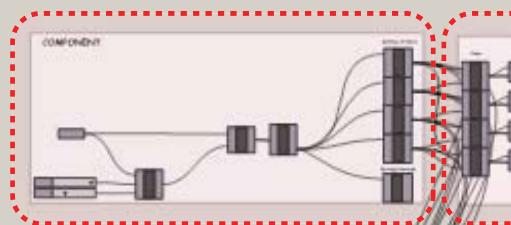


INNER APERTURE

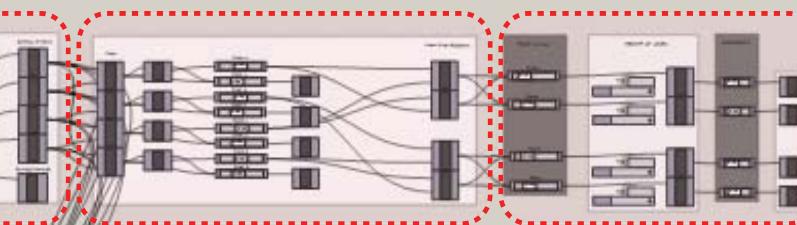


OUTER APERTURE

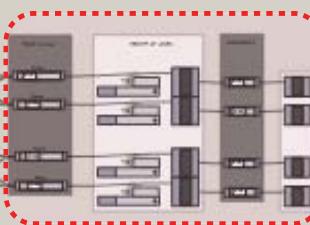
OVERALL SURFACE



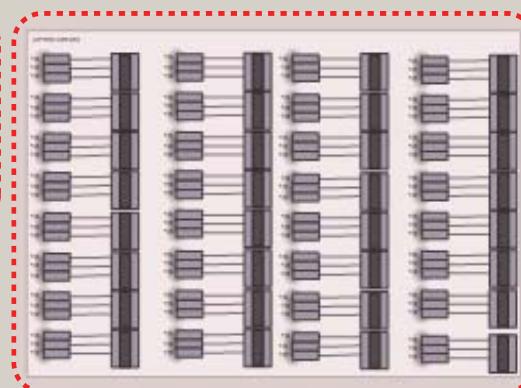
OUTER APERTURES



DEPTH



COMPONENT SURFACES

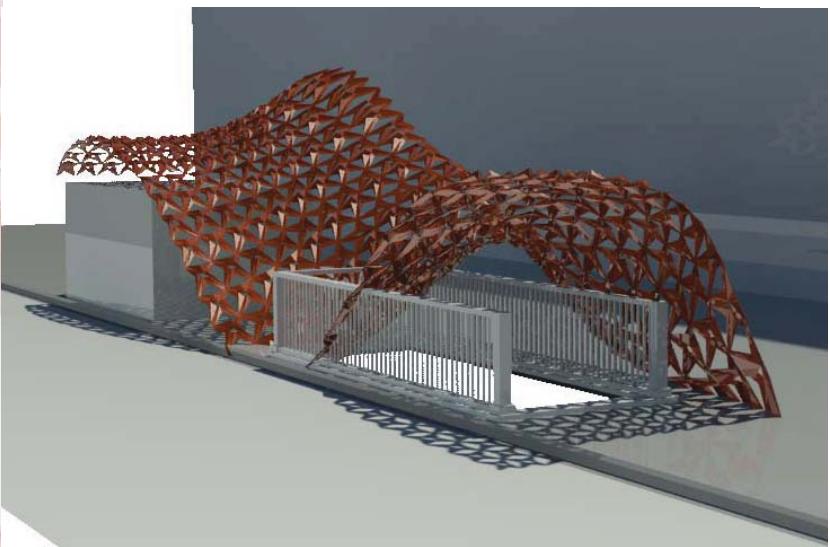
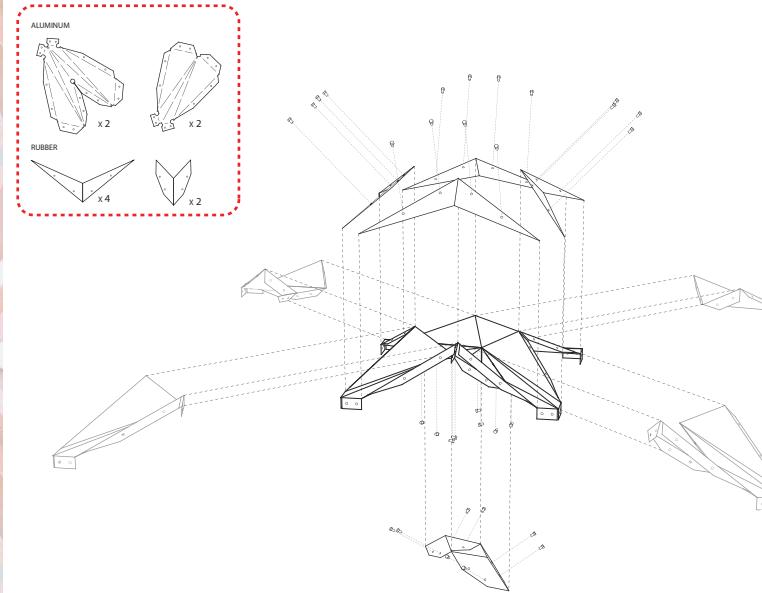


INNER APERTURES

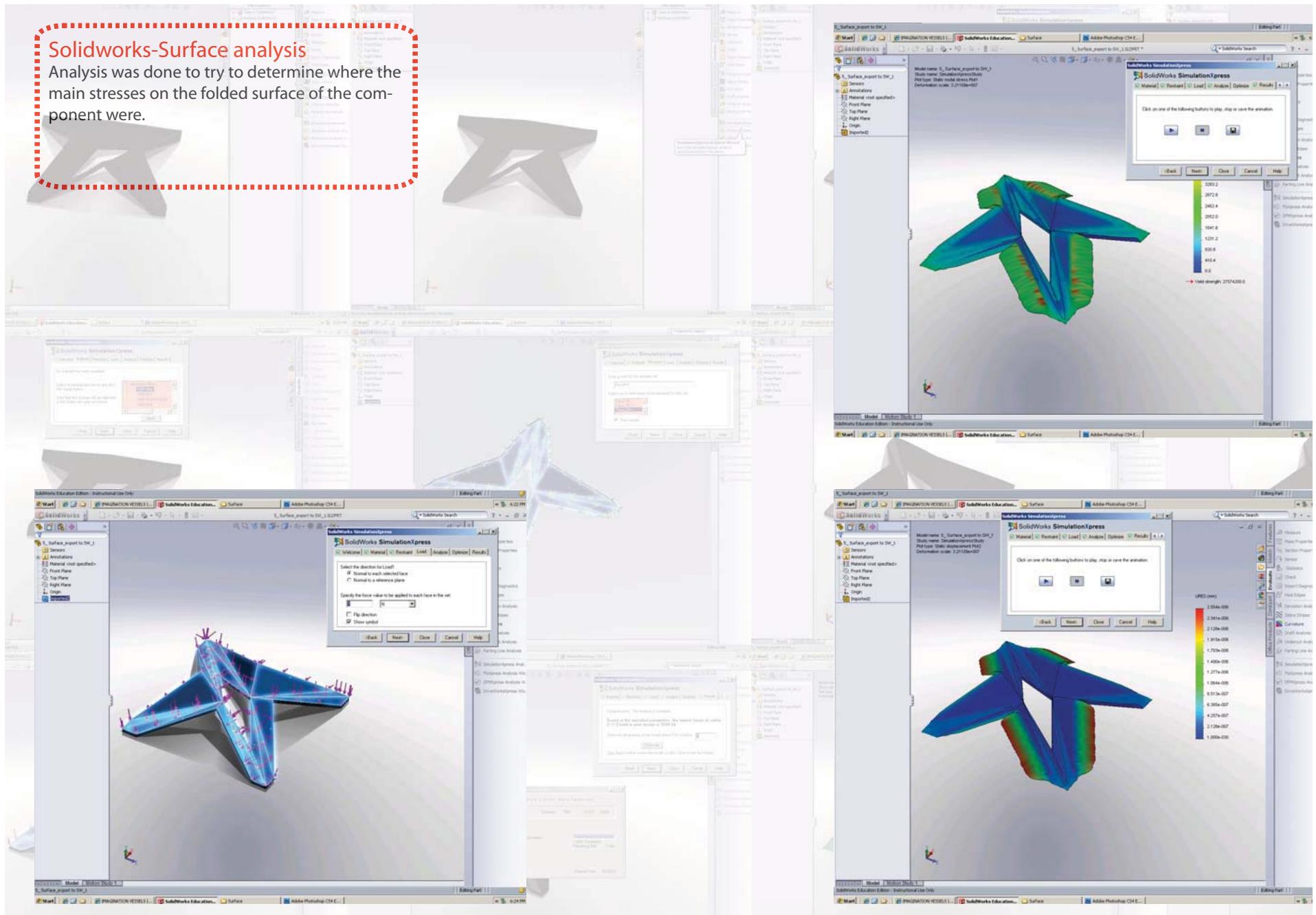
PARAMETRIC SKIN SYSTEM



ASSEMBLY DIAGRAM - EXPLODED AXONOMETRIC



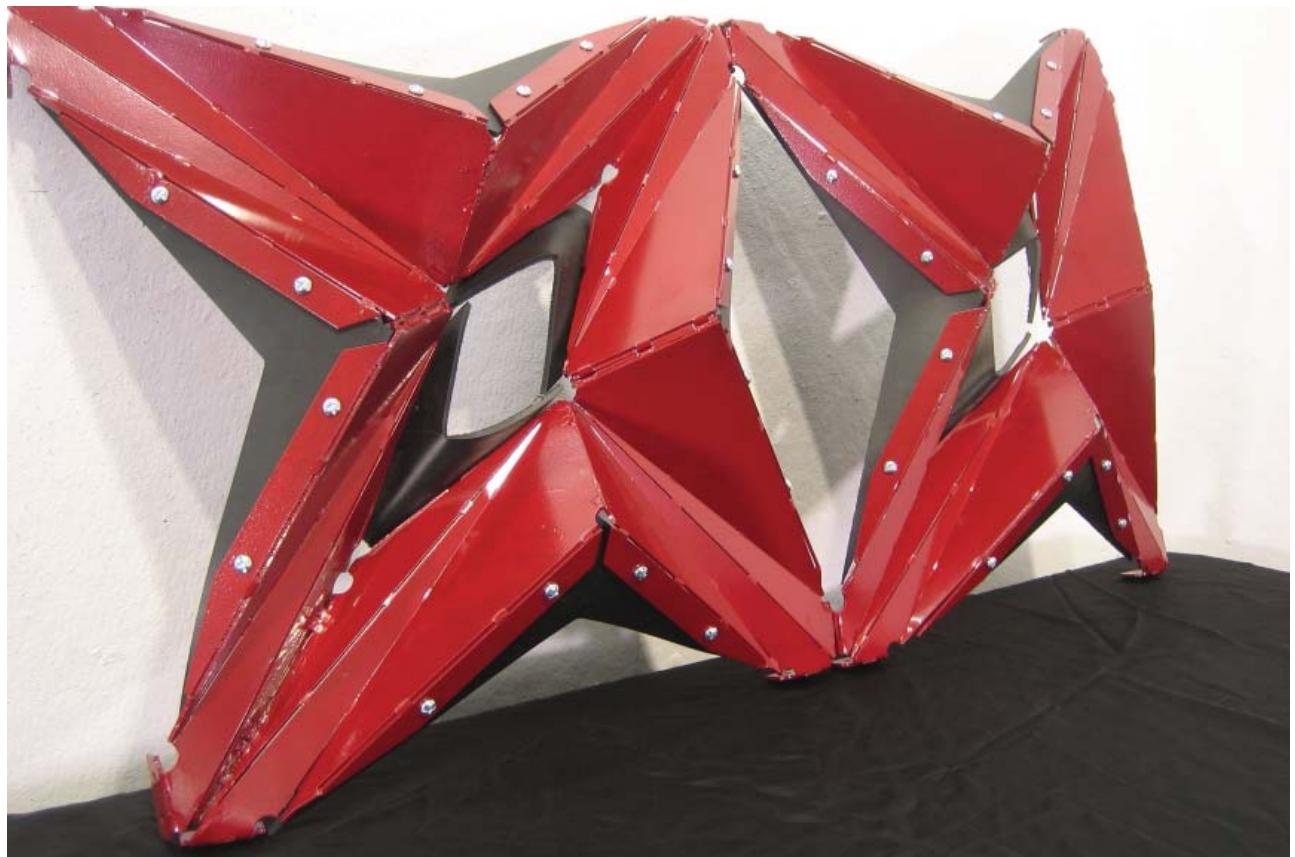
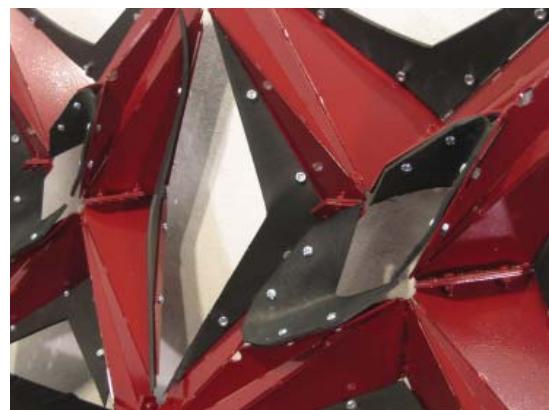
CELLULAR FINITE ELEMENT ANALYSIS

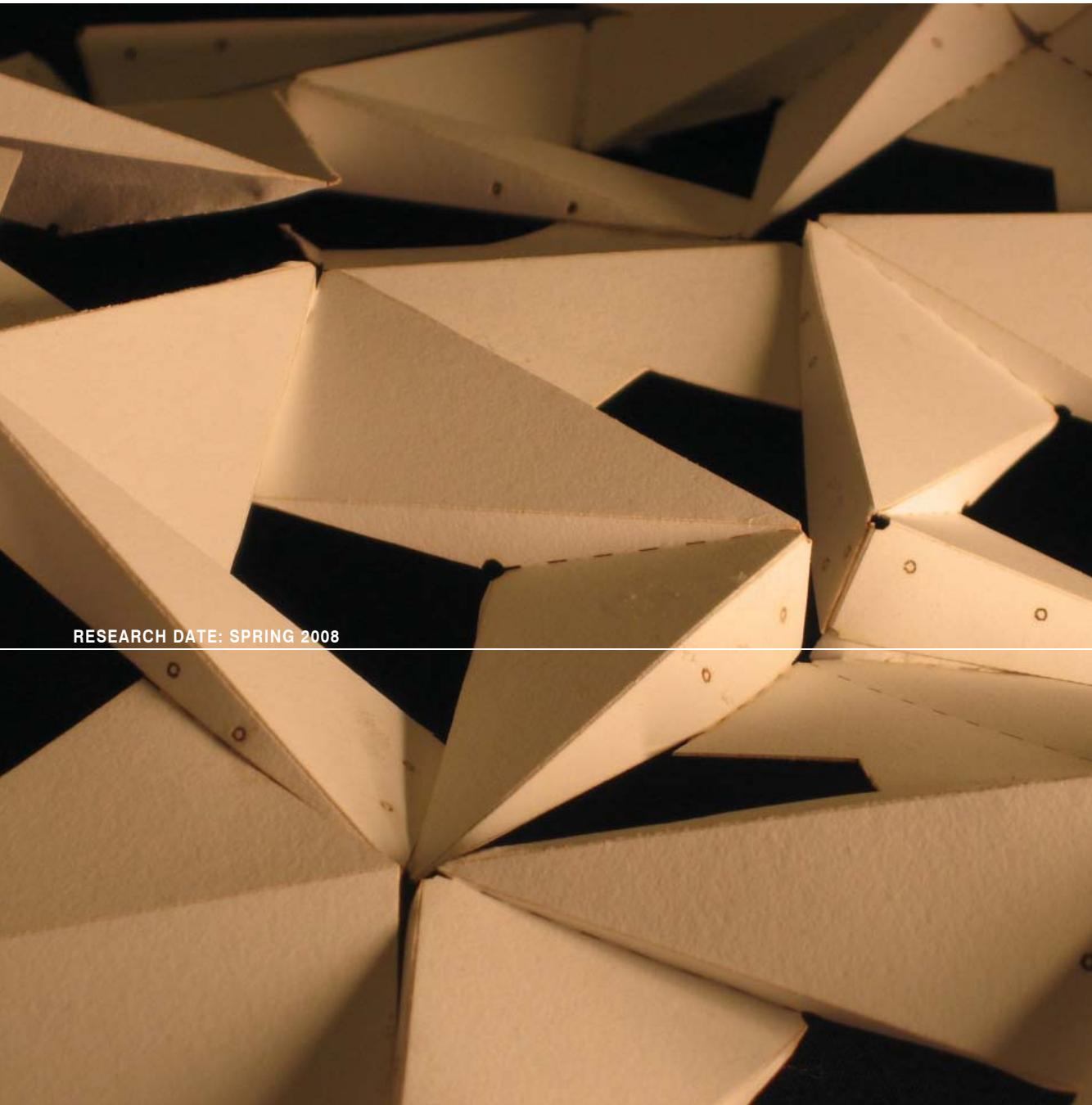


FABRICATION / ASSEMBLY



FABRICATION / ASSEMBLY





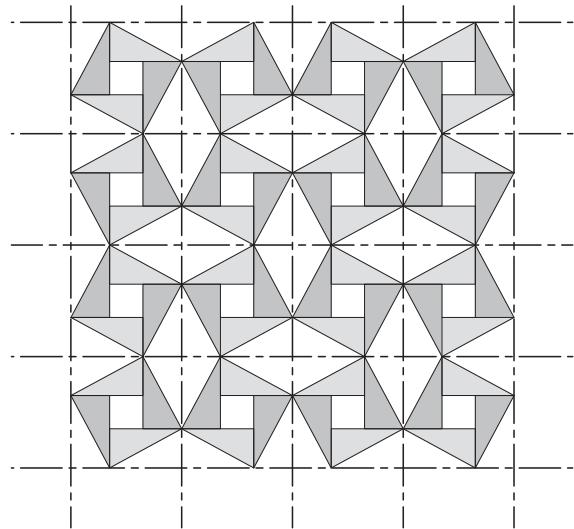
RESEARCH DATE: SPRING 2008

PAVILION SKIN SYSTEM 01

Red Tinted Acrylic
Flathead Steel Fasteners

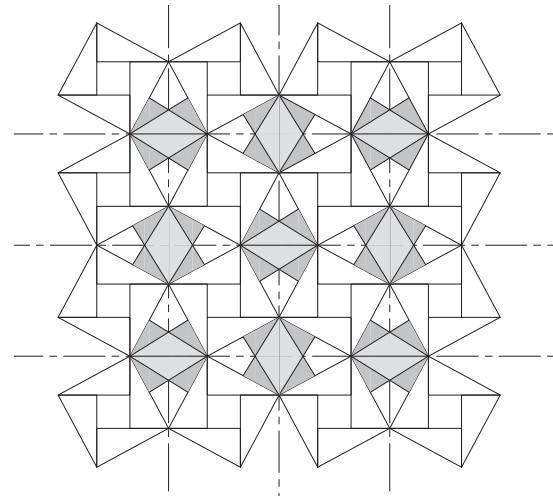
Team:
Jose Luis Perez-Griffo
Ingrid Campo Ruiz

MESH GENERATION



a . Center Cells

+



b . Intermediate Cells

- All the System is created by triangles in the three dimensions in order to allow more flexibility and Rigidity as well

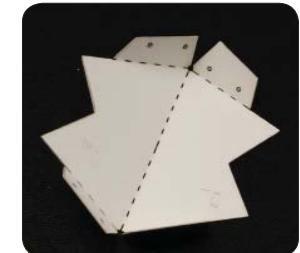
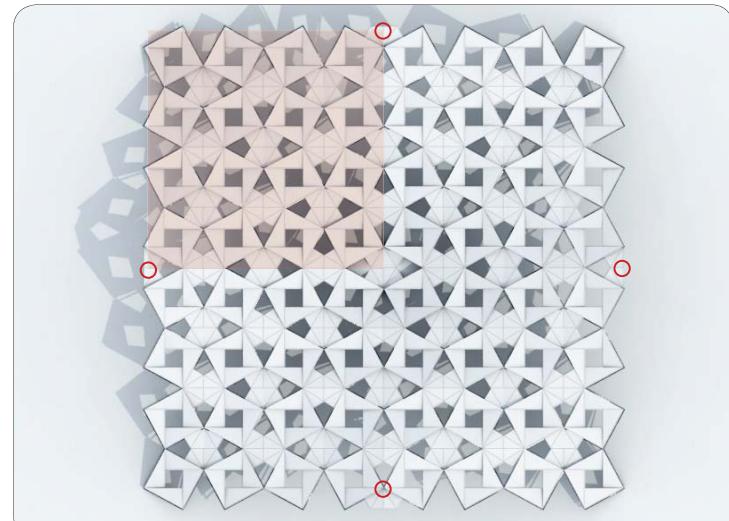


- . Six Cells

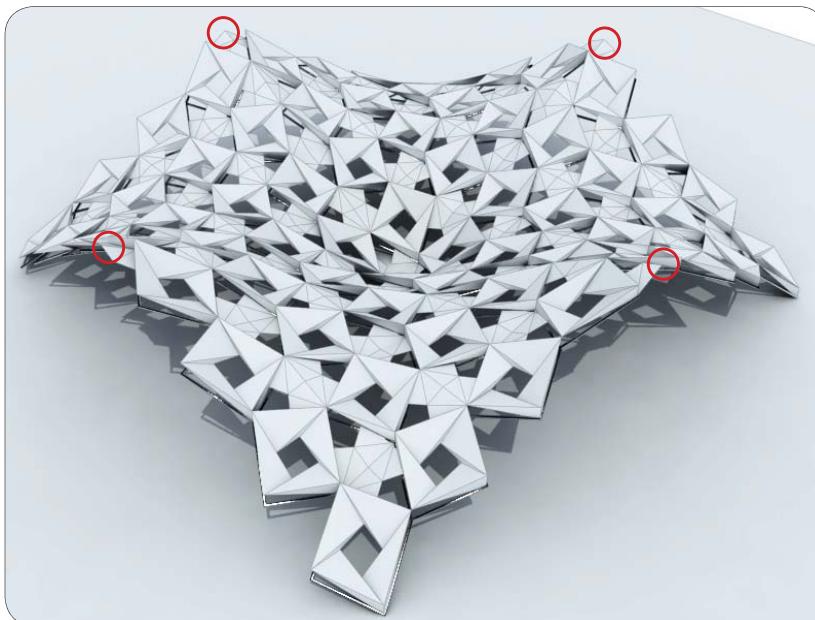


- . Sixteen Cells

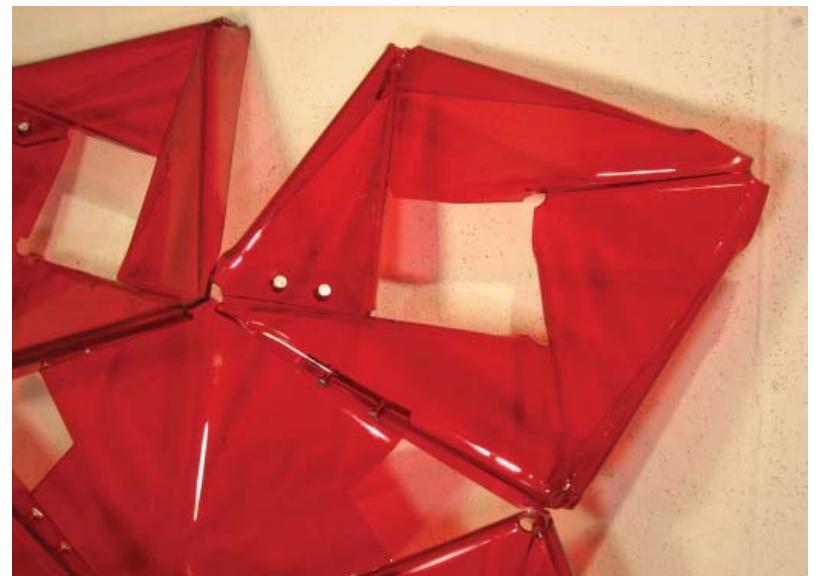
MESH GENERATION



- . Exterior view



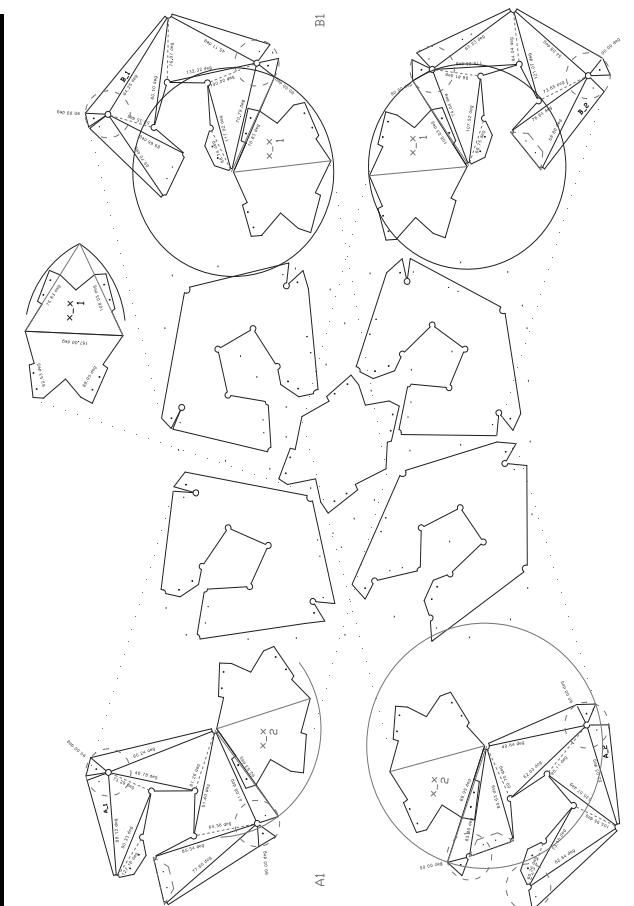
FABRICATION / ASSEMBLY

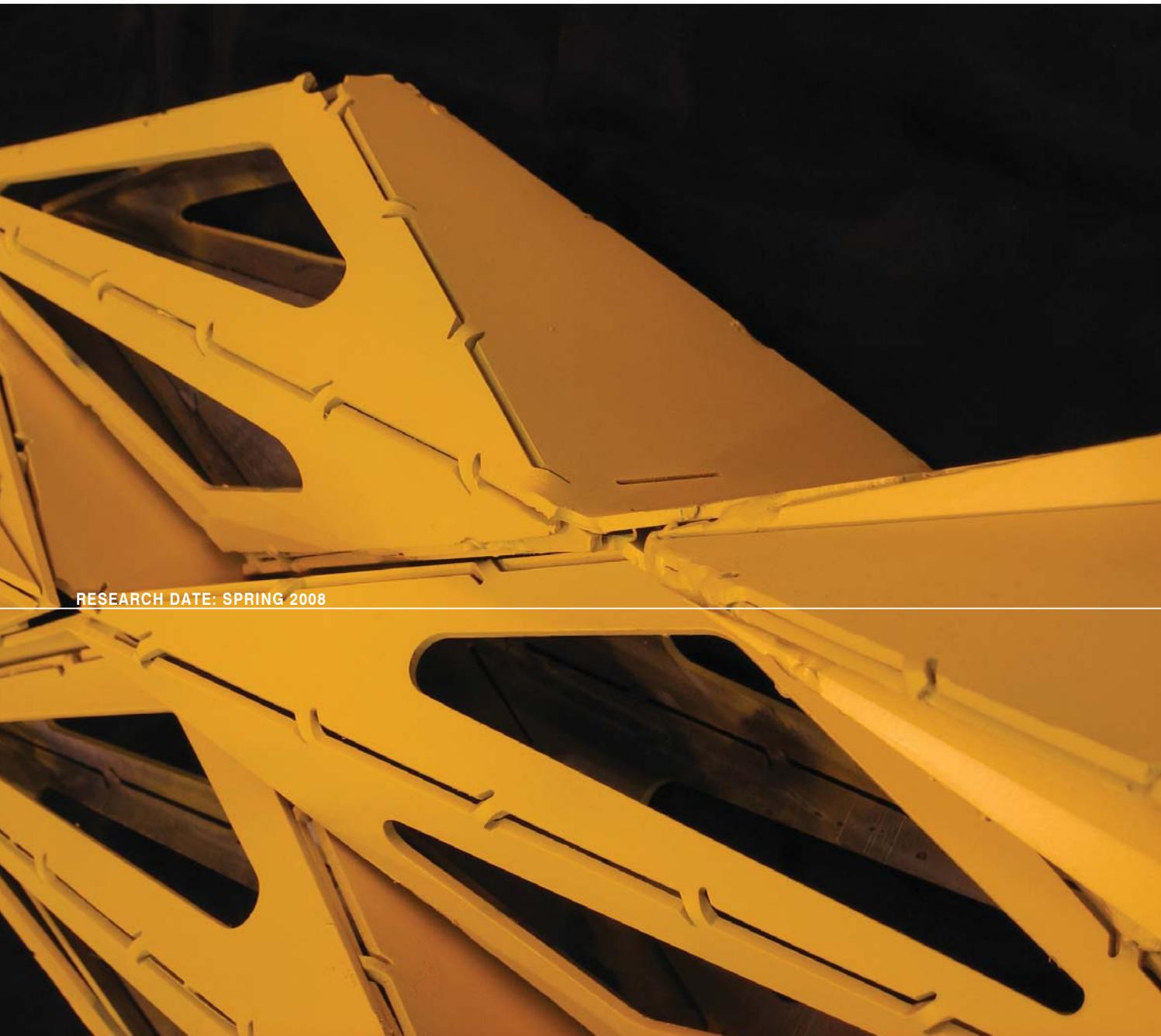


FABRICATION / ASSEMBLY



ASSEMBLY PROCESS: Highly detailed fabrication requires a correct sequence of folds in order to use the flatbed hot-bender. Accuracy becomes challenging with smaller folds.





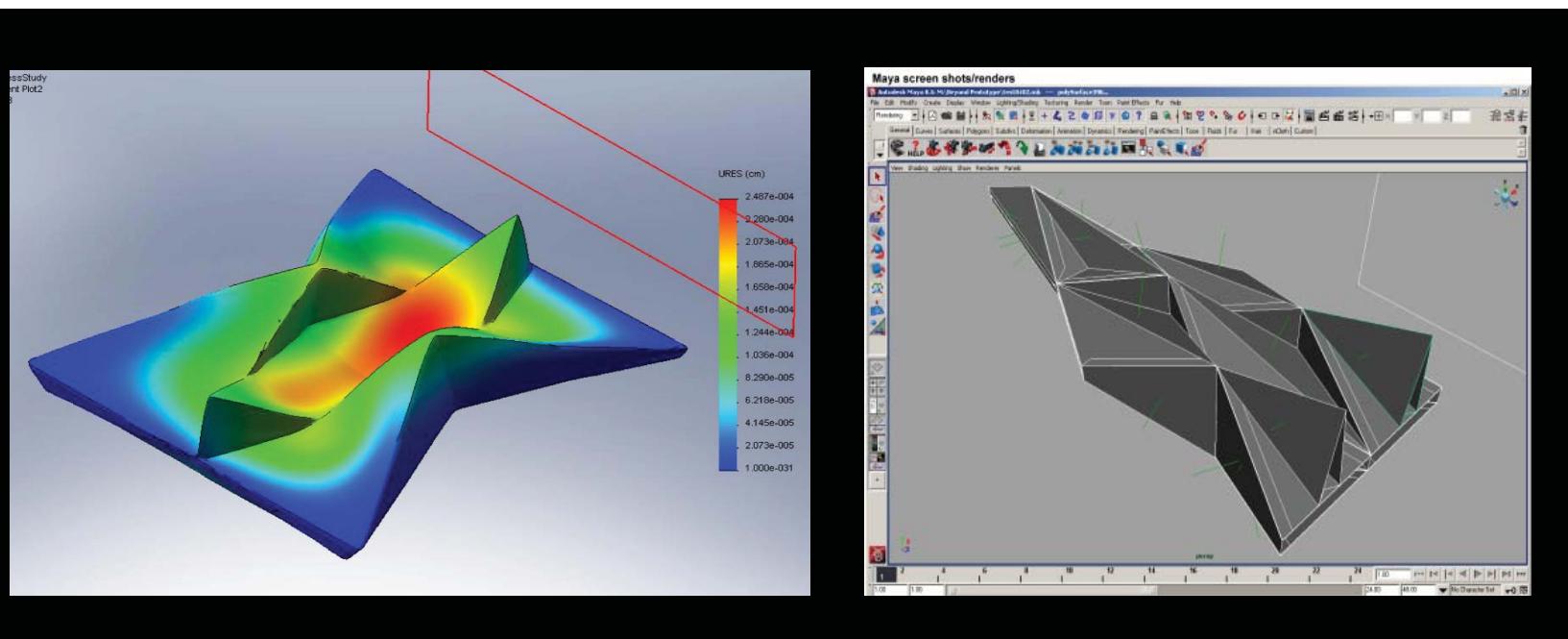
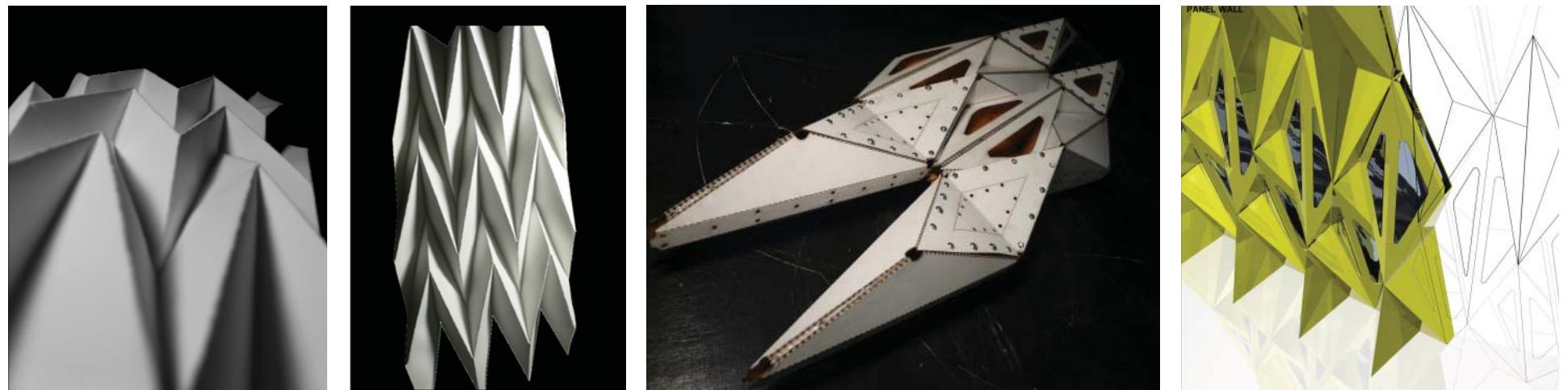
RESEARCH DATE: SPRING 2008

FACADE SYSTEM 01

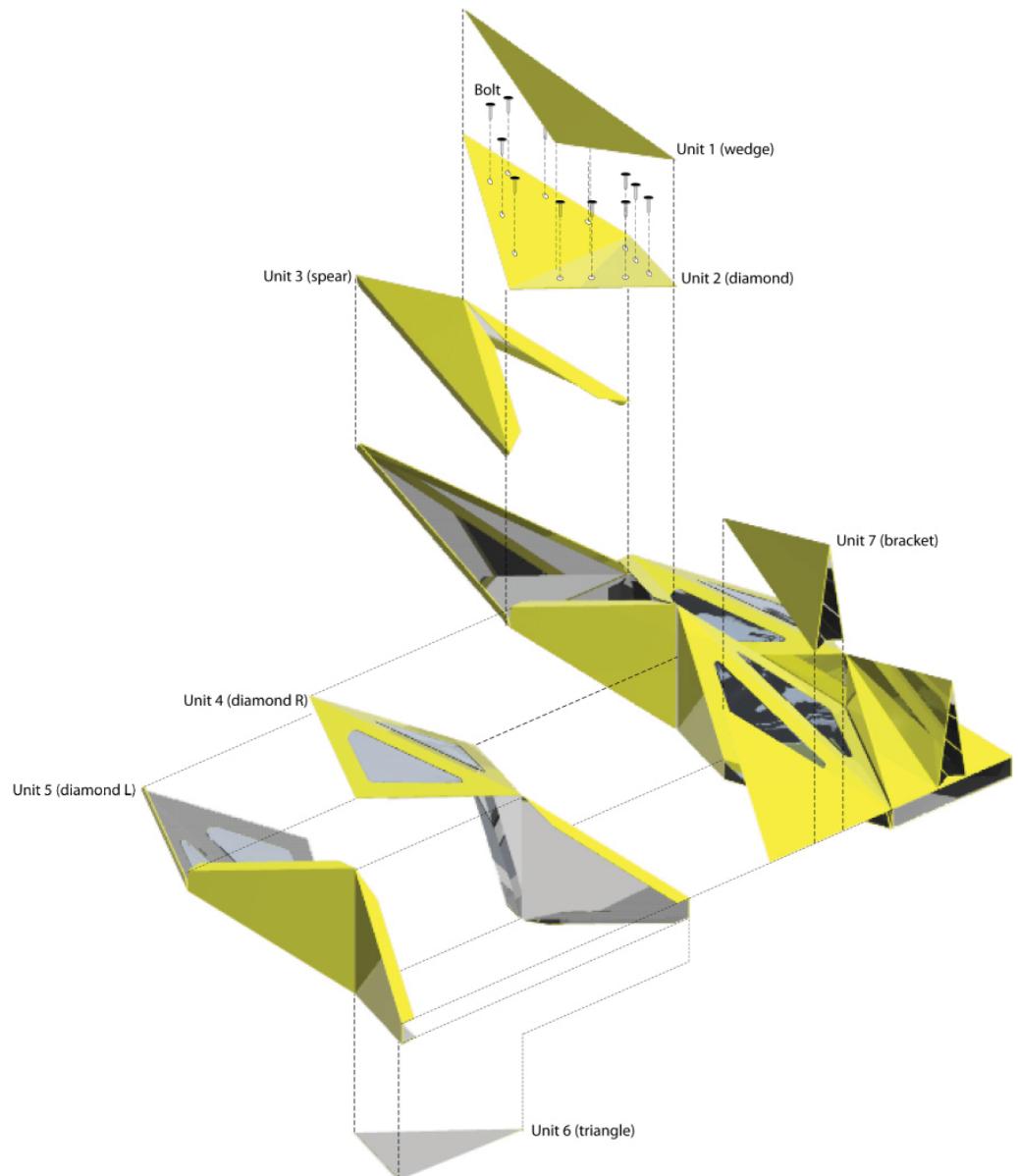
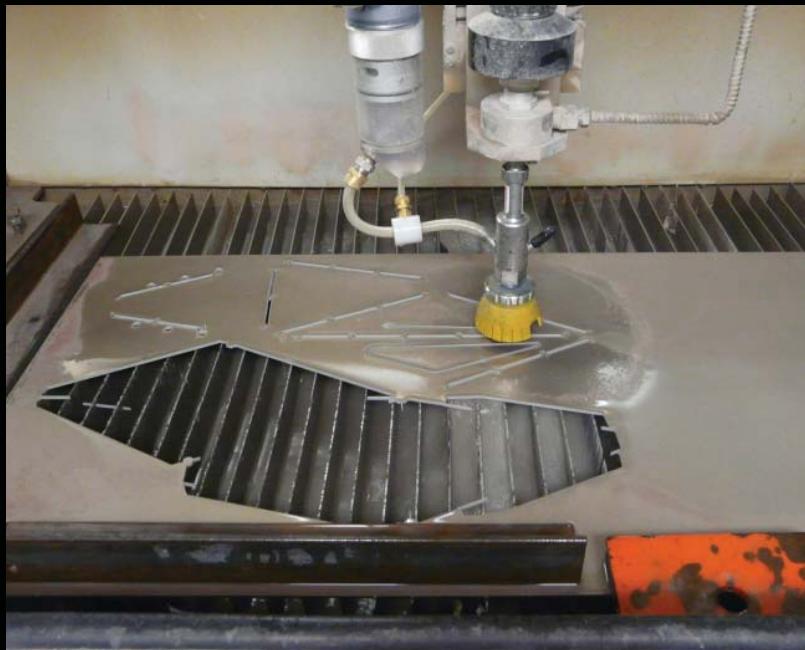
Welded Aluminum

Team:
Leuyu Chen
Siddharth Jadhav
Jugal Mistri

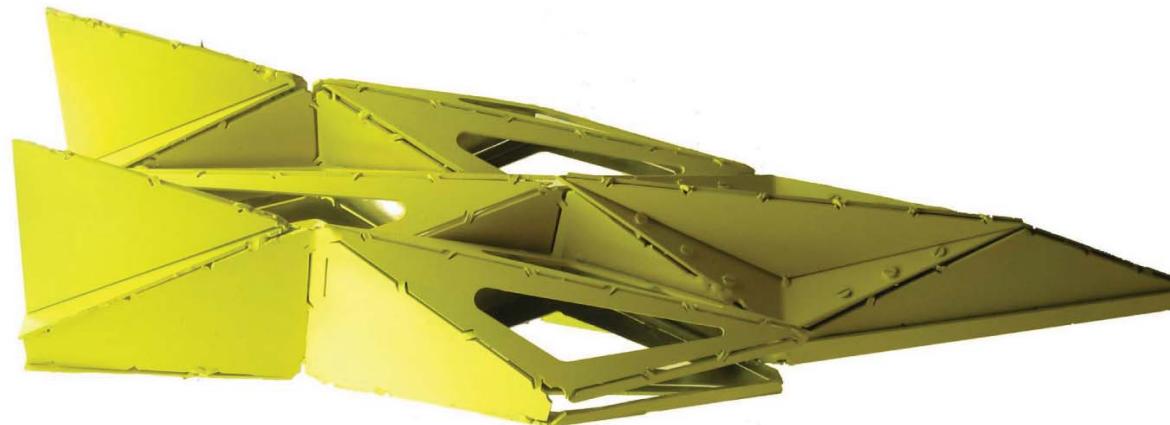
MESH GENERATION

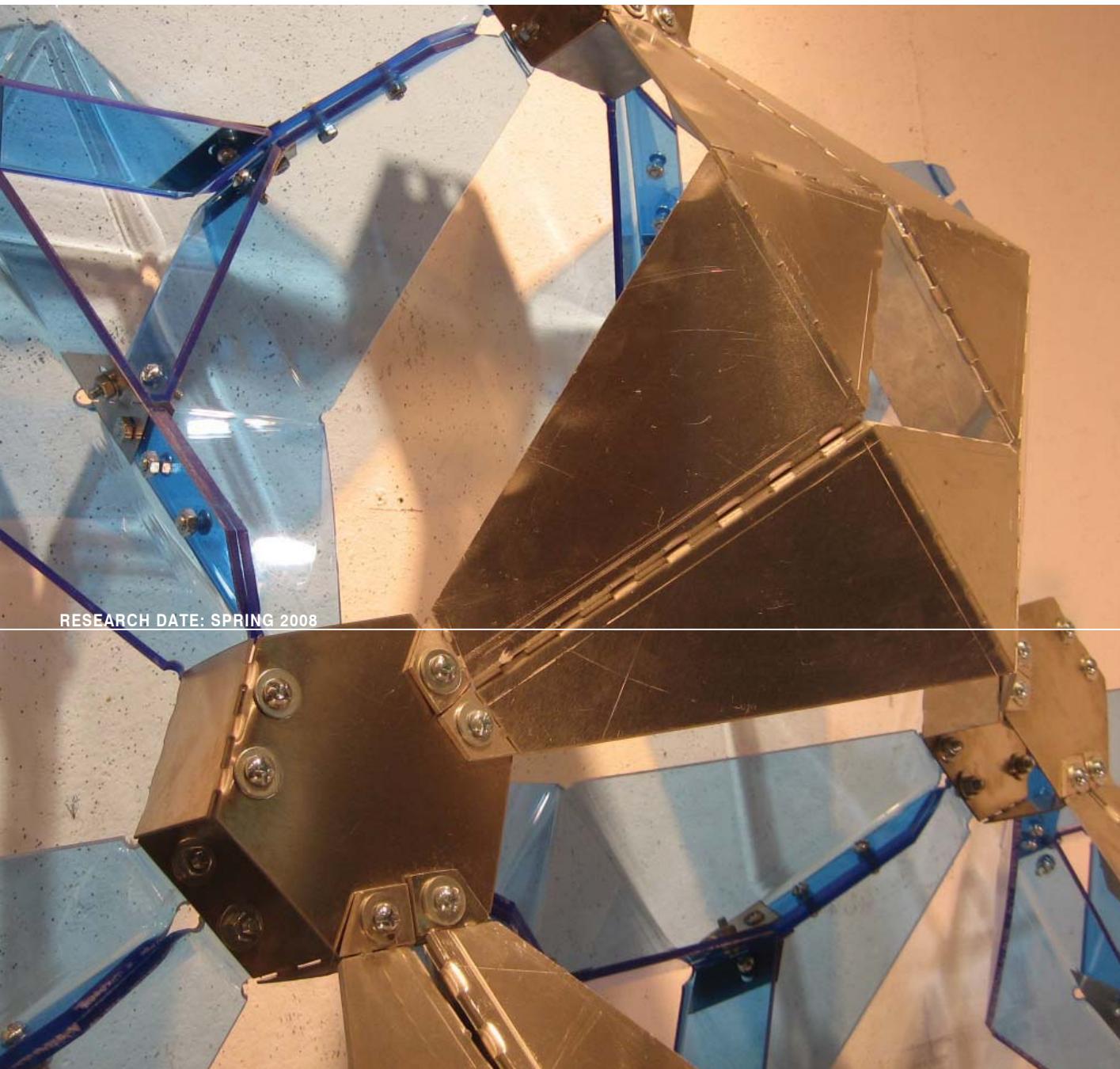


FABRICATION / ASSEMBLY



FABRICATION / ASSEMBLY





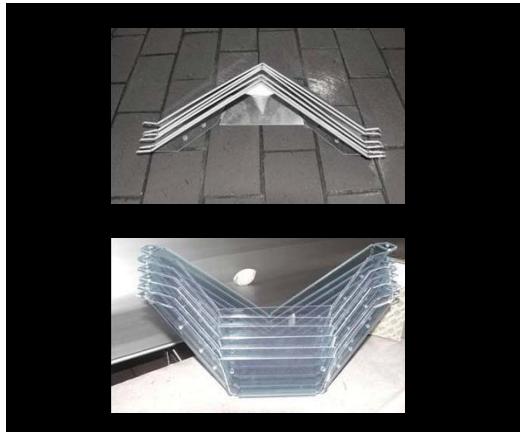
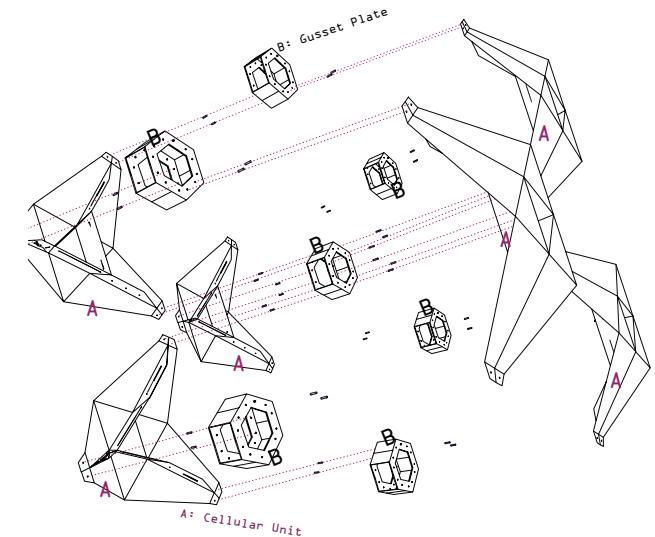
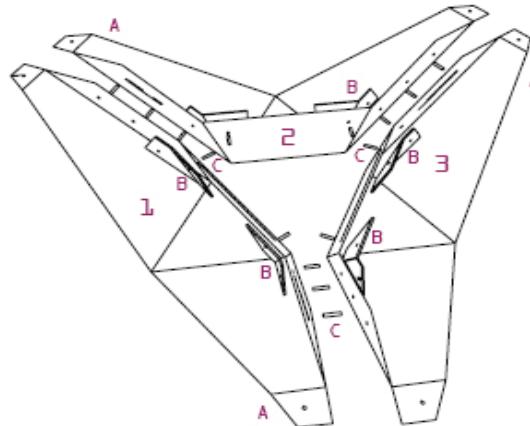
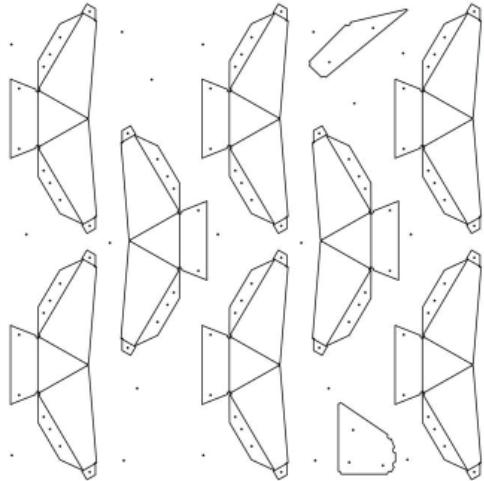
RESEARCH DATE: SPRING 2008

UNDULATED TRIANGLES

Blue Tinted Acrylic
Aluminum

Team:
Brian Manning
Fernando Pando
Iliana Kretestzi

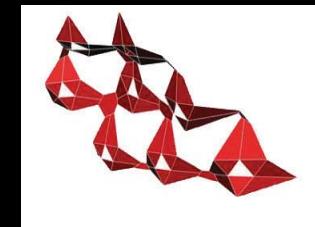
MESH GENERATION



STACKABLE UNITS

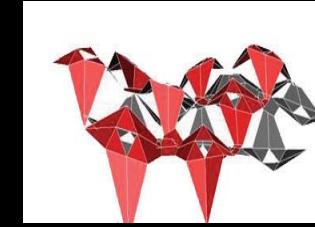
STUDY MODEL PROCESS:

The Paper study uses overlapping triangles with a lap joint detail which allows each triangle edge to lock with an adjacent triangle.

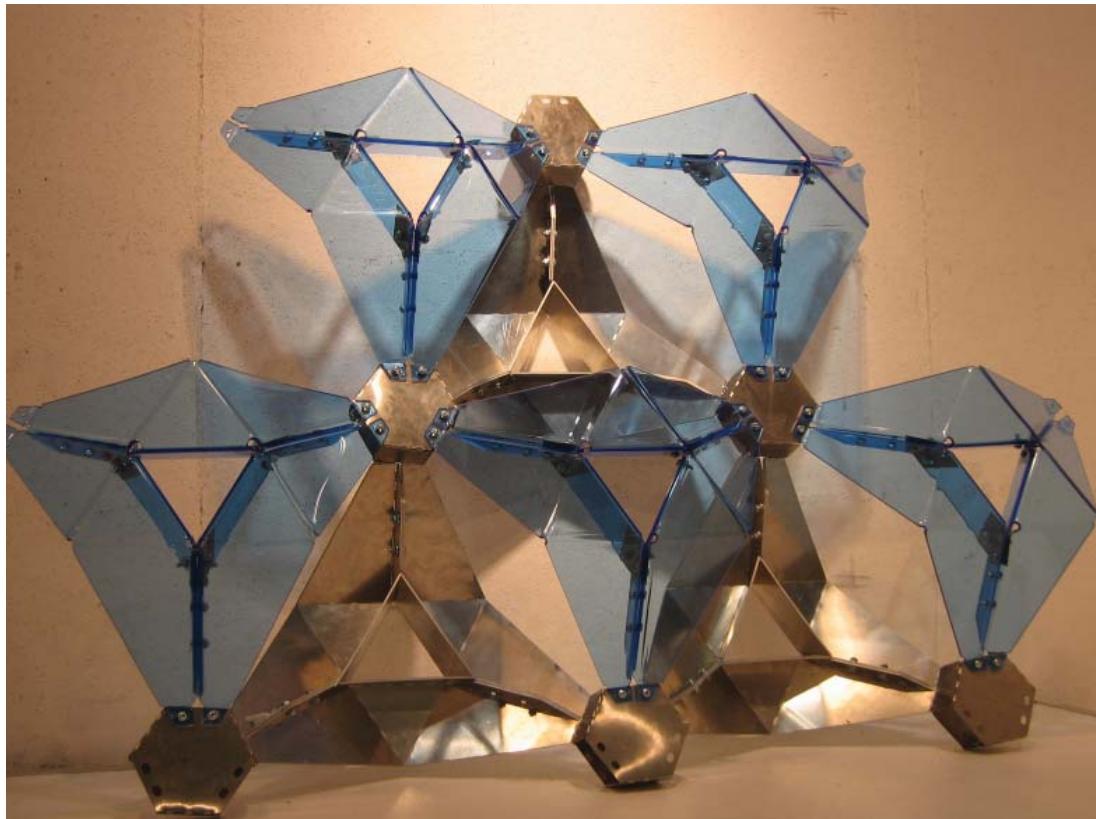
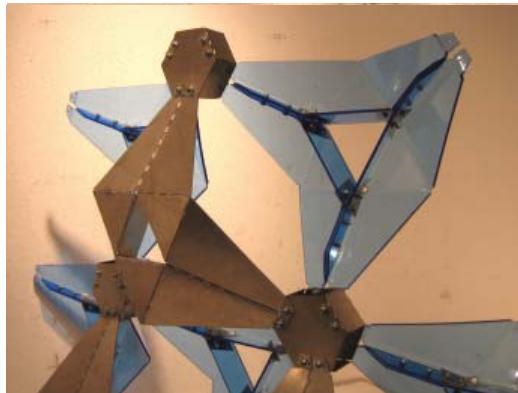


DIGITAL GENERATION:

The lap joint is substituted with a 6 way node which allows a stronger connection. Each triangle is composed of 3 units which fold into a central structural flap. This flap forms an inner rib that provided rigidity when the 3 units are combined into one cell.



FABRICATION / ASSEMBLY



This system produces a complex form from simple parts using only 2 repetitive units that are mirrored in the x and z-axis. Plastic is used as a semi-structural convex glazing detail which is identical to the concave structural aluminum triangles. The central node, made from bent stainless steel, allows the triangular units to be repositioned from back to front. The units can also be mounted to the same side of the node which would form a closed surface instead of an open mesh. The use of identical parts allows the pieces to be **stacked before assembly for efficient storage.**



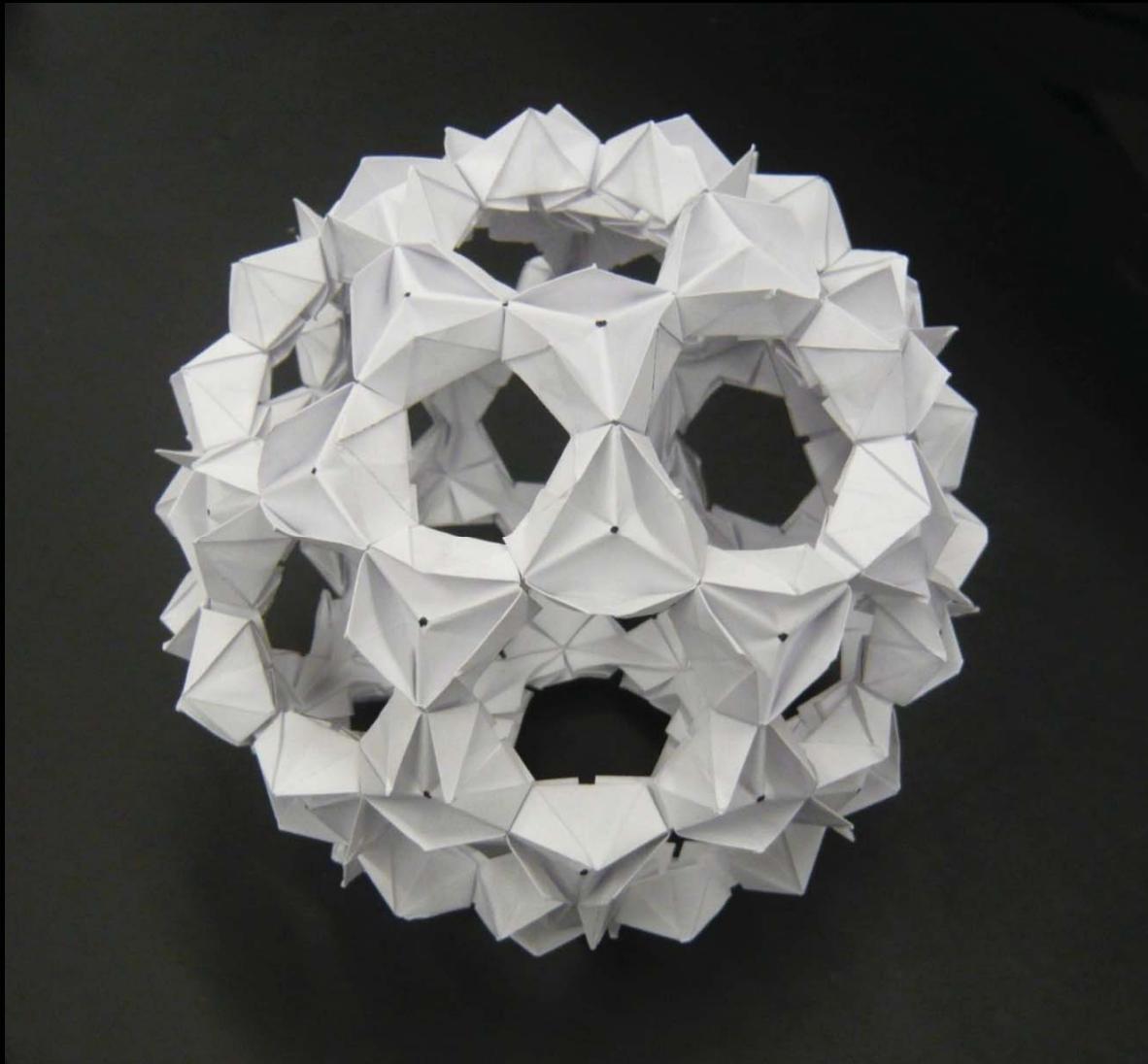
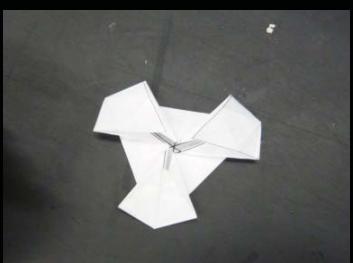
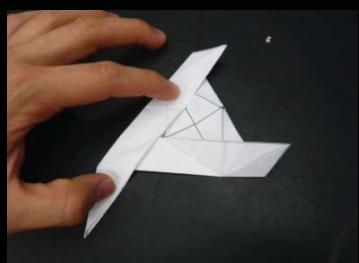
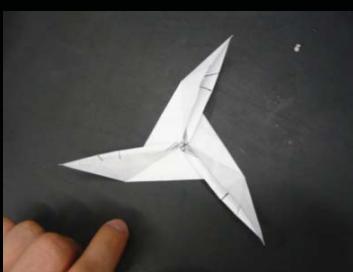
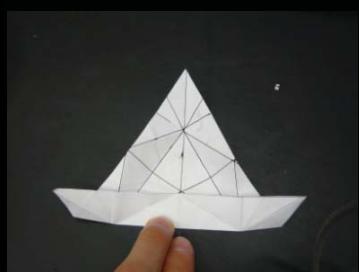
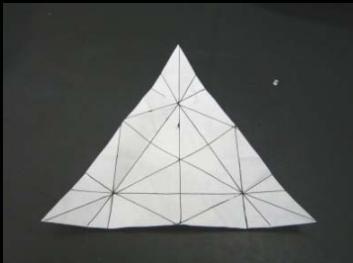
RESEARCH DATE: FALL 2008

OPERABLE ROSETTES

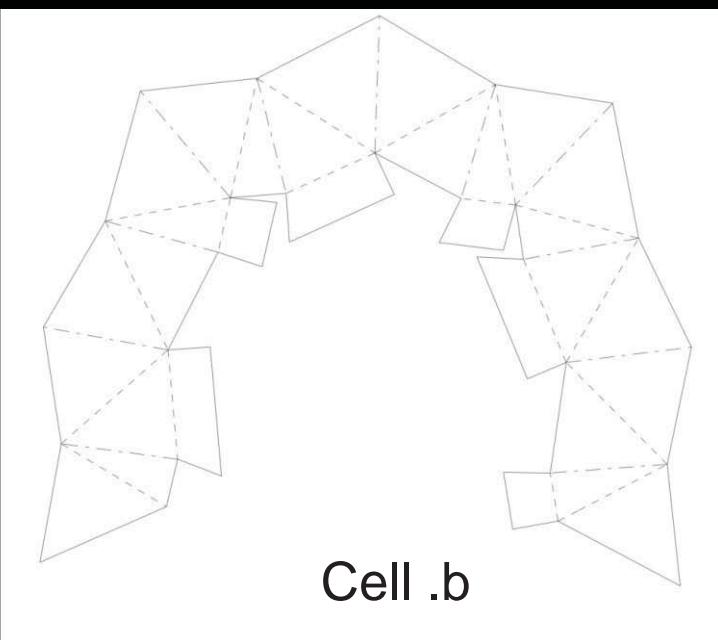
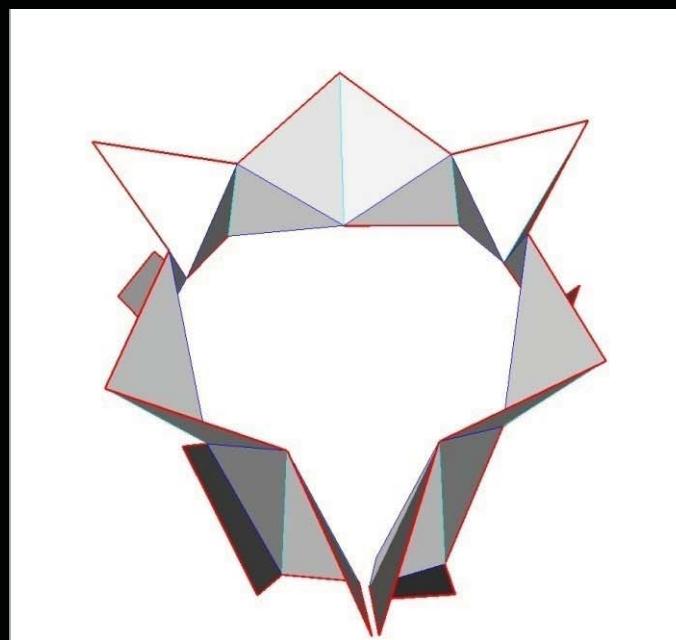
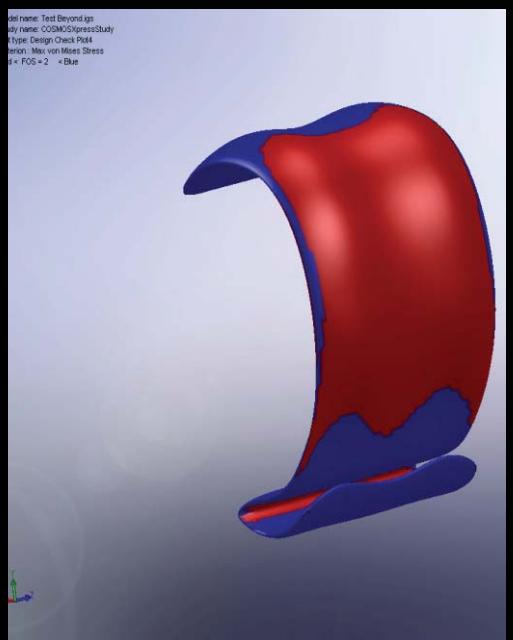
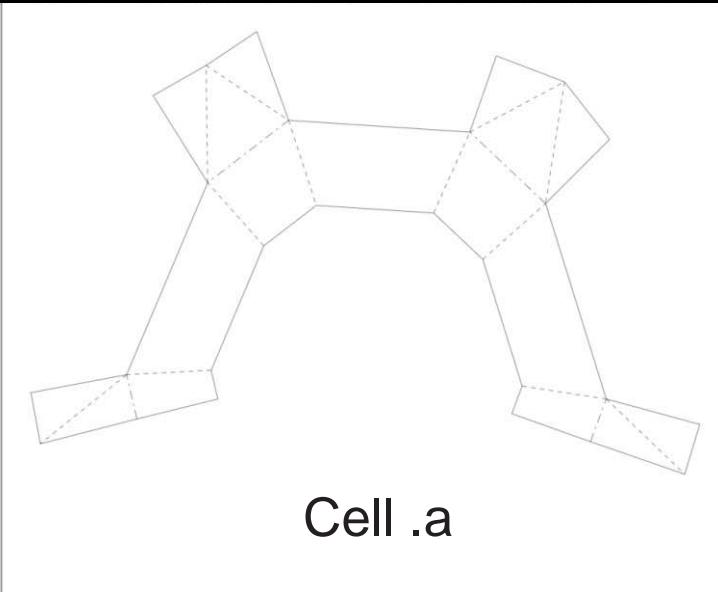
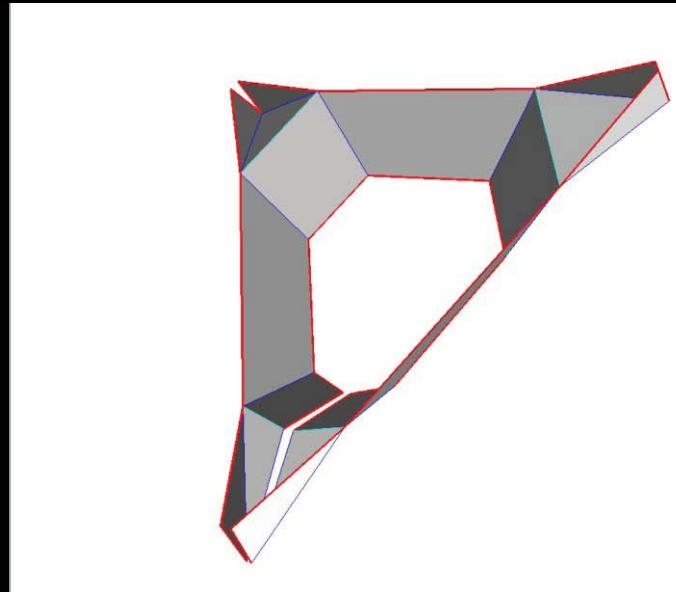
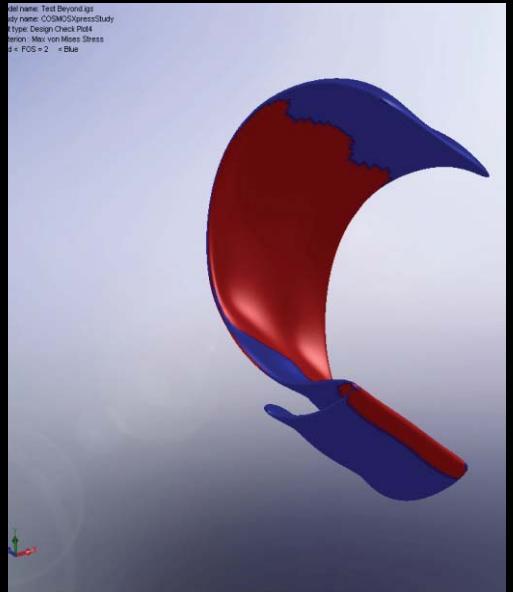
Frosted Clear Acrylic
Red Tinted Acrylic

Team:
Jorge Barragan
Sina Mesdaghi
Saskia Maria Nagel

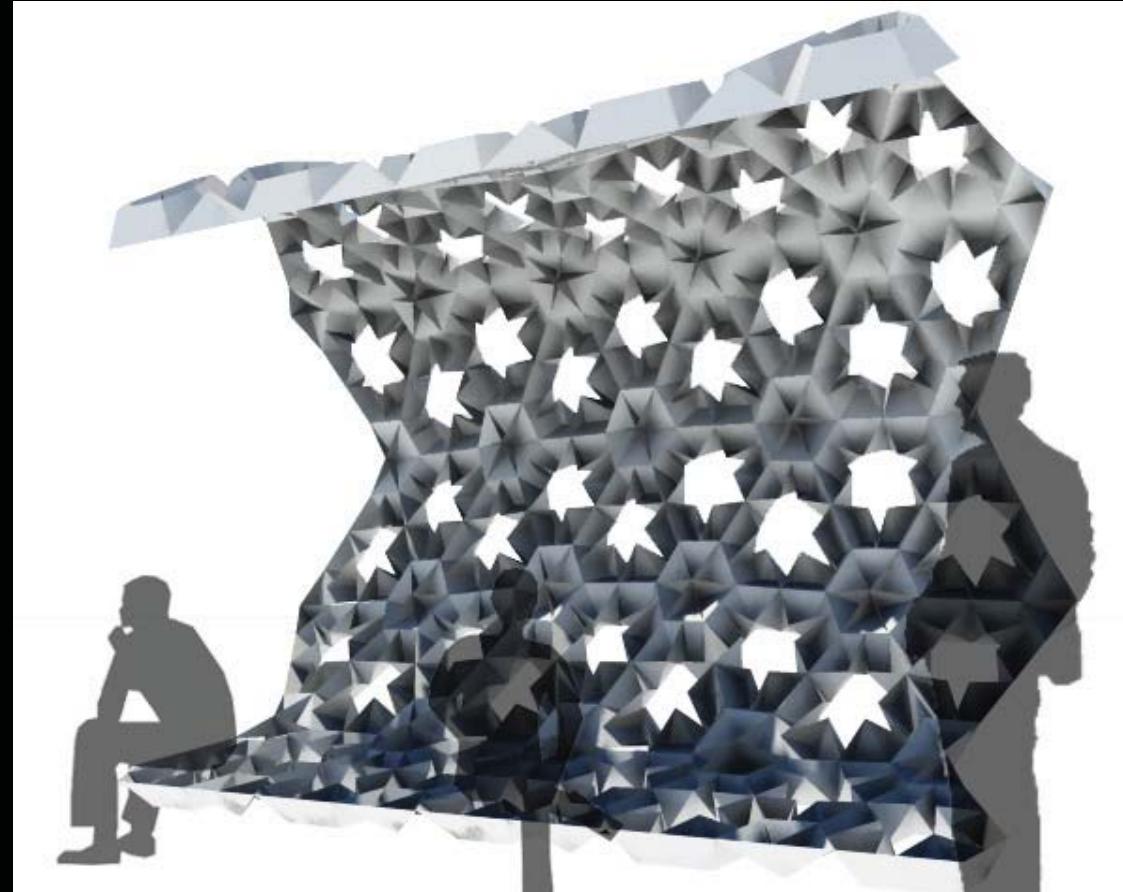
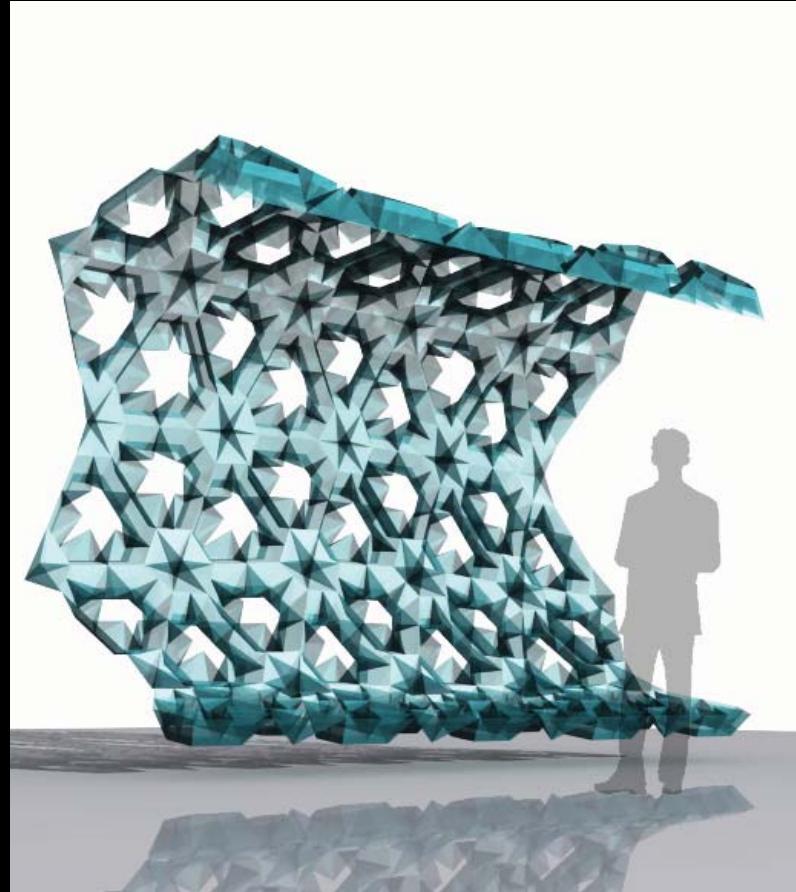
MESH GENERATION



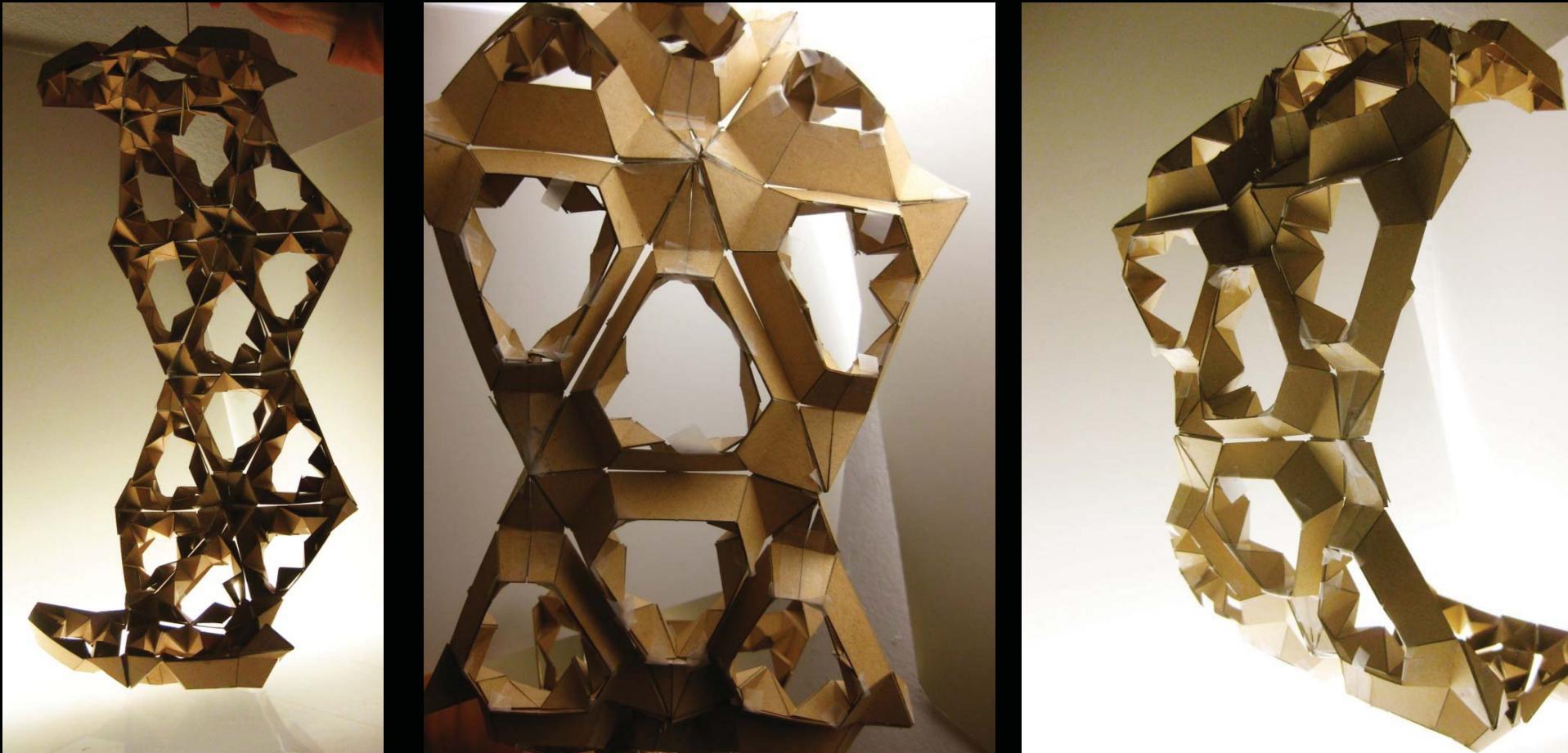
DIGITAL MODELLING / FINITE ELEMENT ANALYSIS



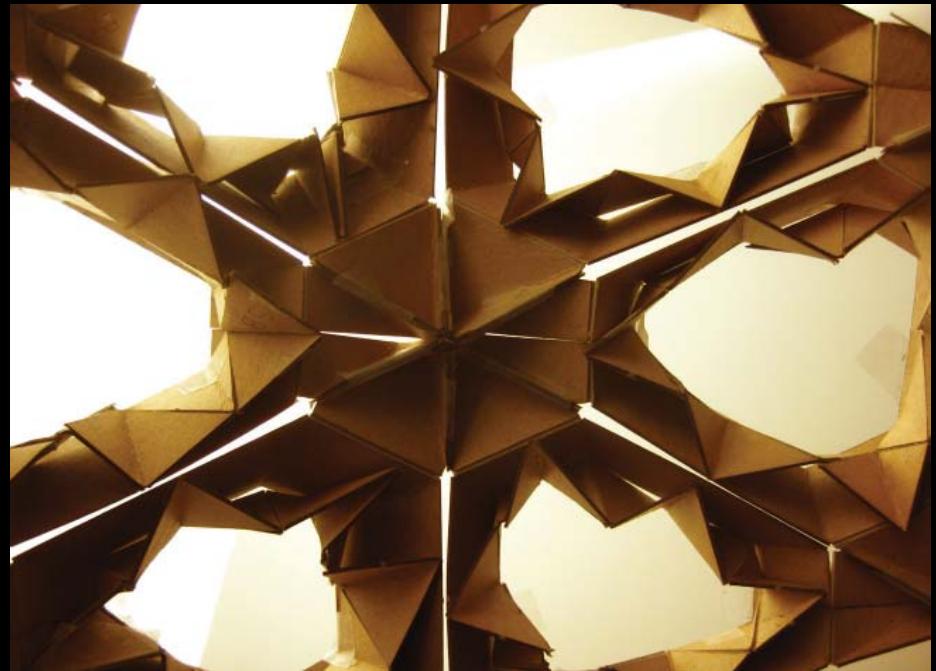
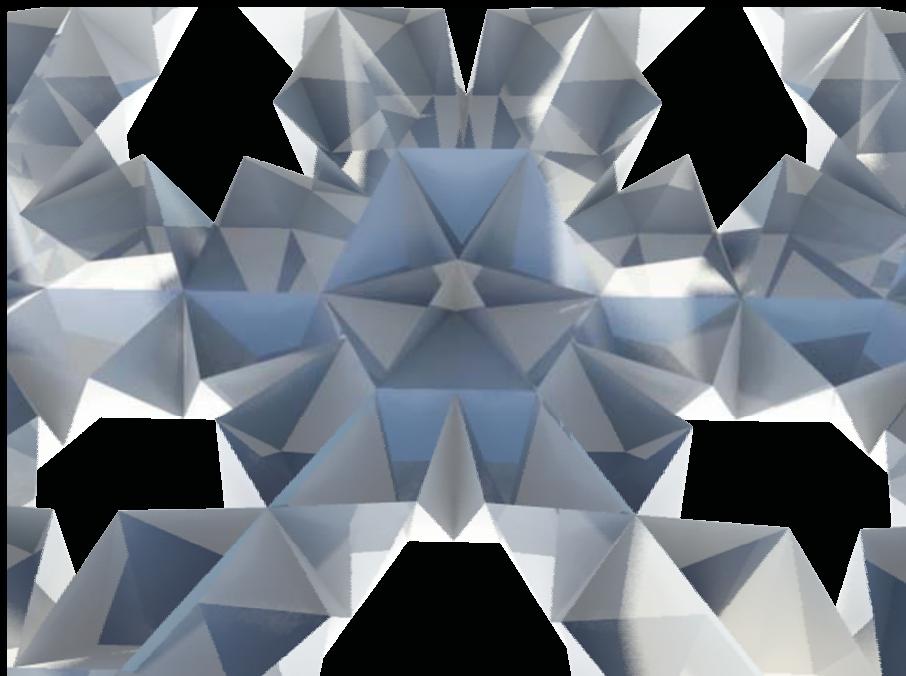
FORM GENERATION



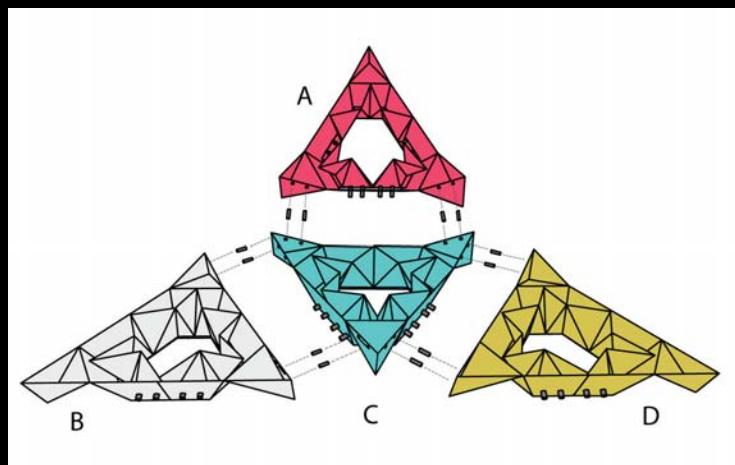
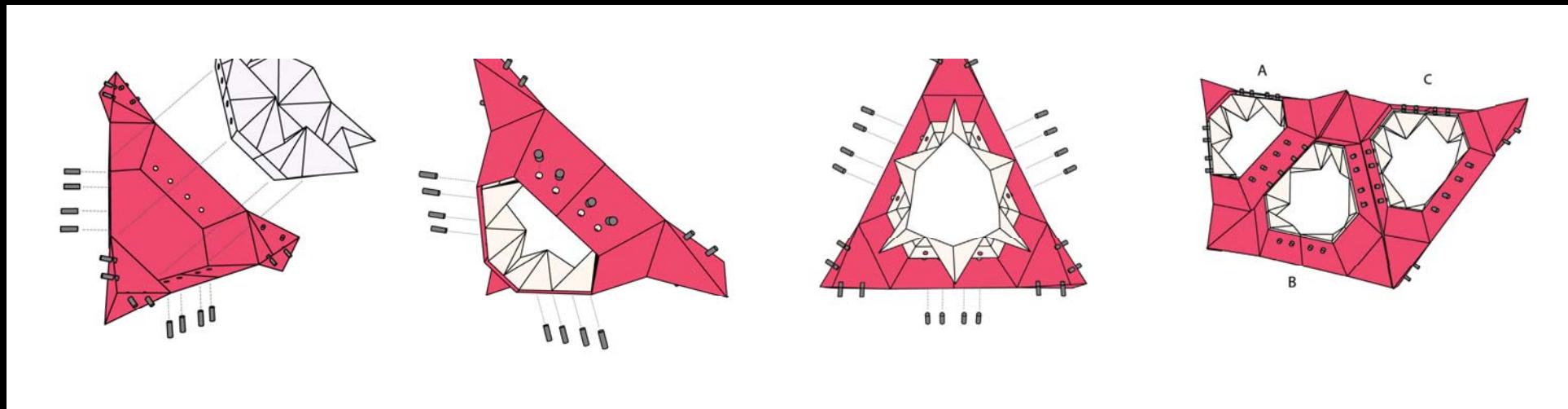
PROTOTYPING



PROTOTYPING

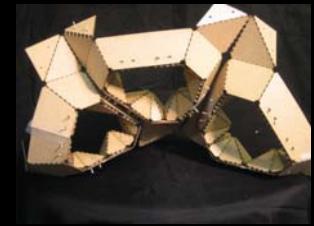
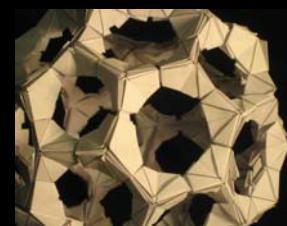


FABRICATION / ASSEMBLY



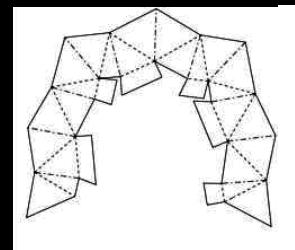
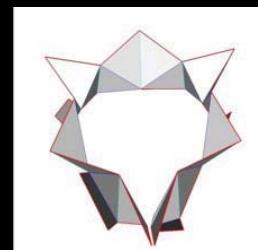
STUDY MODEL PROCESS:

The original model was a set of 6 cells which produced a closed polyhedron shape. To open the system to other forms, the geometry was reduced to a 3 cell set.



DIGITAL GENERATION:

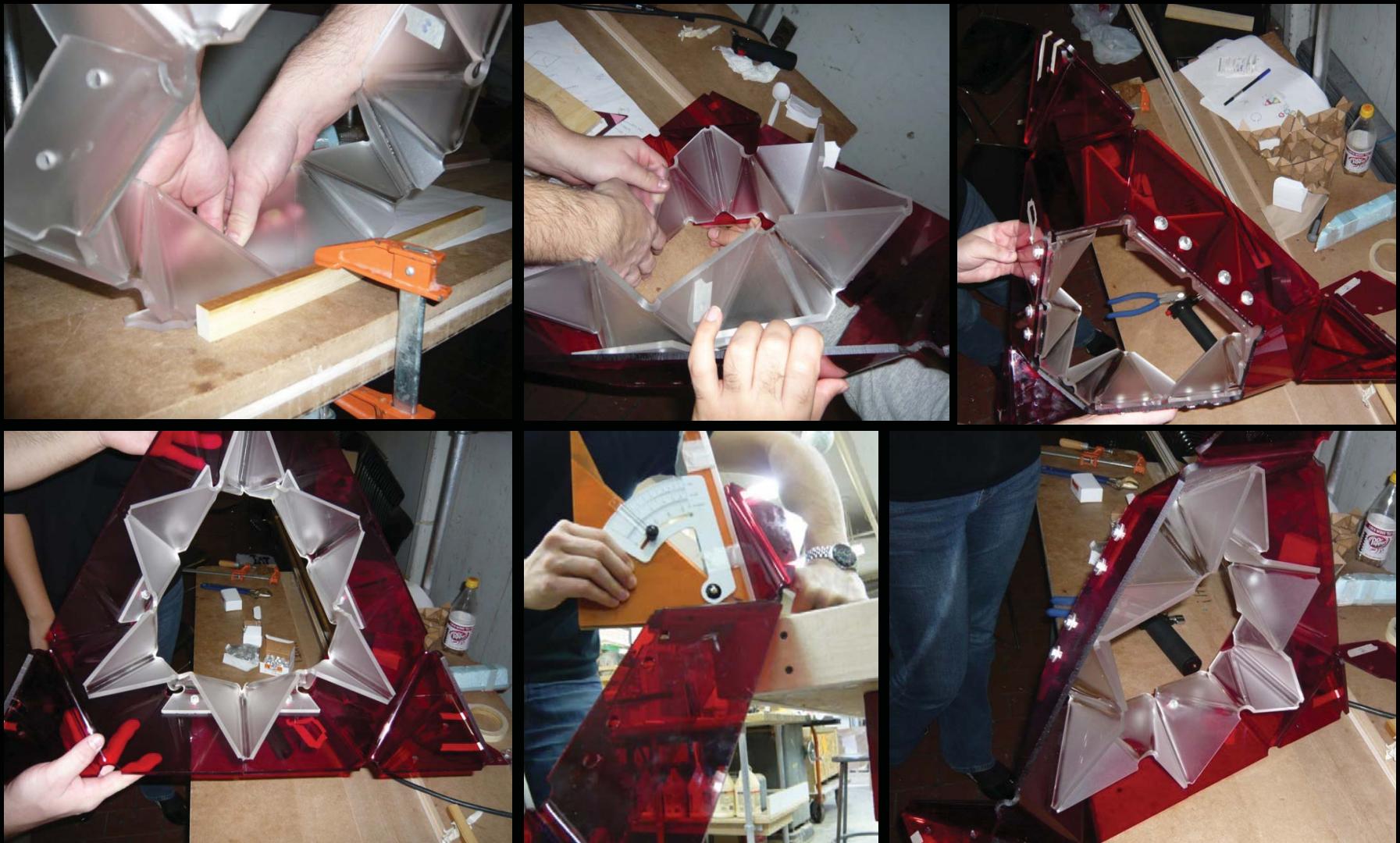
The model begins with a triangle cell which is subdivided into a hexagon and 3 triangle connectors along the outside. The rosettes unfold into a series of triangles with 6 tabs that connect into the structural geometry.



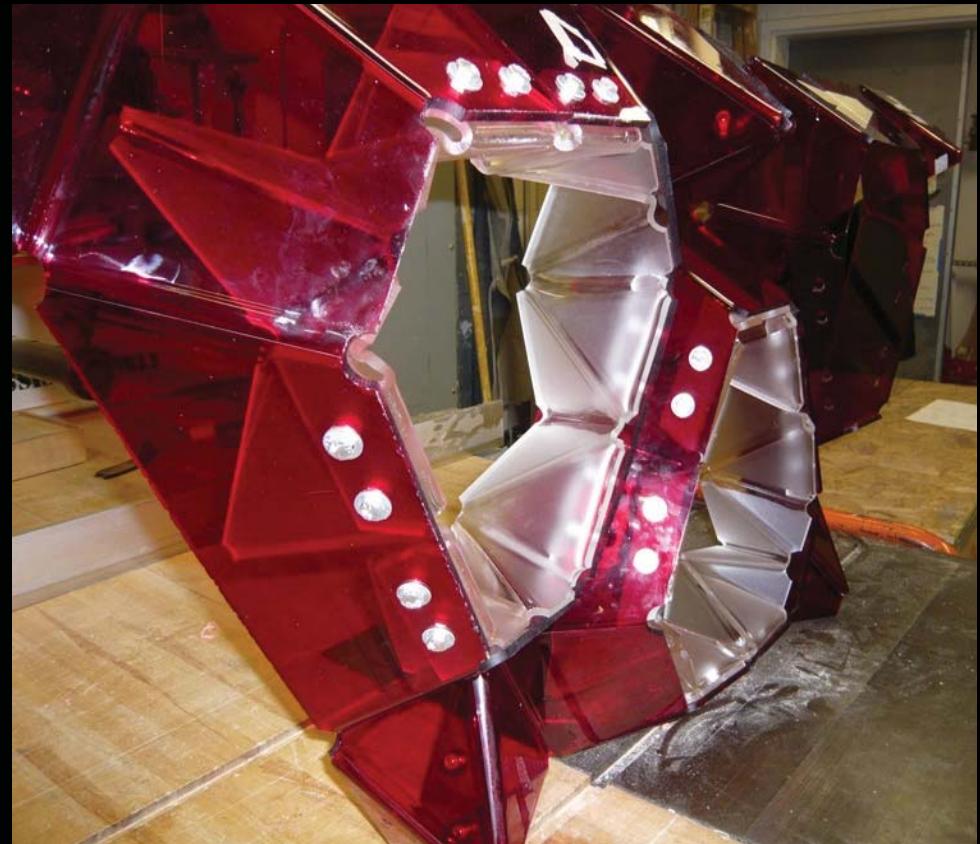
FABRICATION / ASSEMBLY



FABRICATION / ASSEMBLY



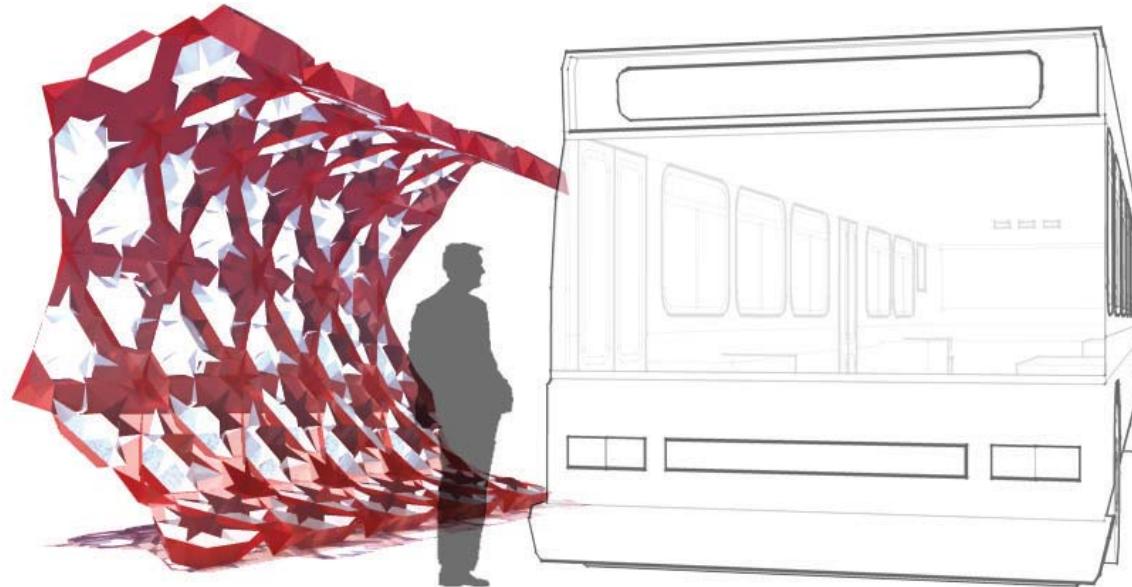
FABRICATION / ASSEMBLY



FABRICATION / ASSEMBLY



FINAL ASSEMBLY: A 3 Cell Cluster at actual size (front, back and close up views)



CONTEXT STUDY: The bus shelter can open and close its rosettes depending on the weather.



FINITE ELEMENT ANALYSIS: The vertical portion holds the most stress



FINAL ASSEMBLY: 18-cell wall mounted on MDF base.



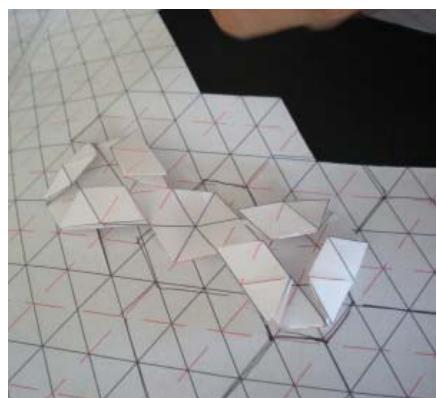
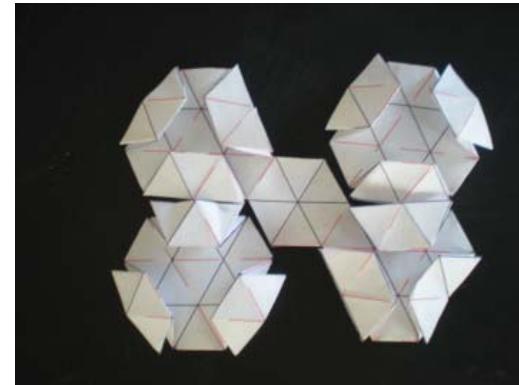
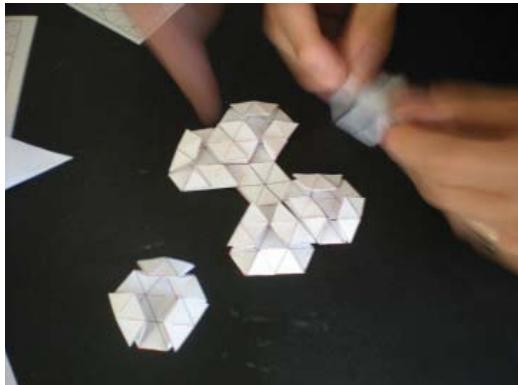
RESEARCH DATE: FALL 2008

PAVILION SKIN SYSTEM 02

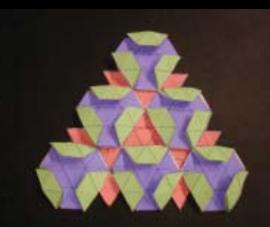
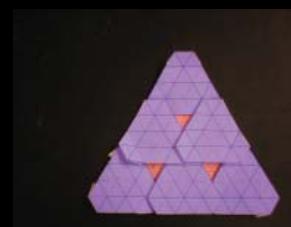
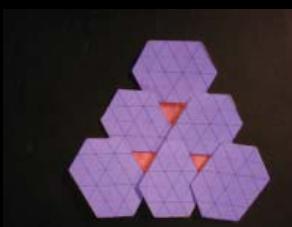
Orange Tinted Acrylic
White Opaque Acrylic
Aluminum

Team:
Nick Na
Gabriel Nichols
Jimmy Park
Koko Takahashi

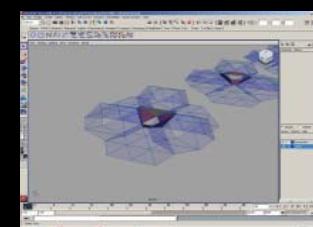
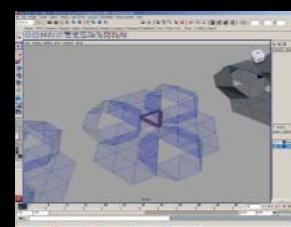
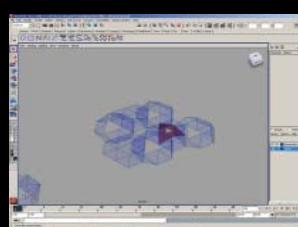
MESH GENERATION



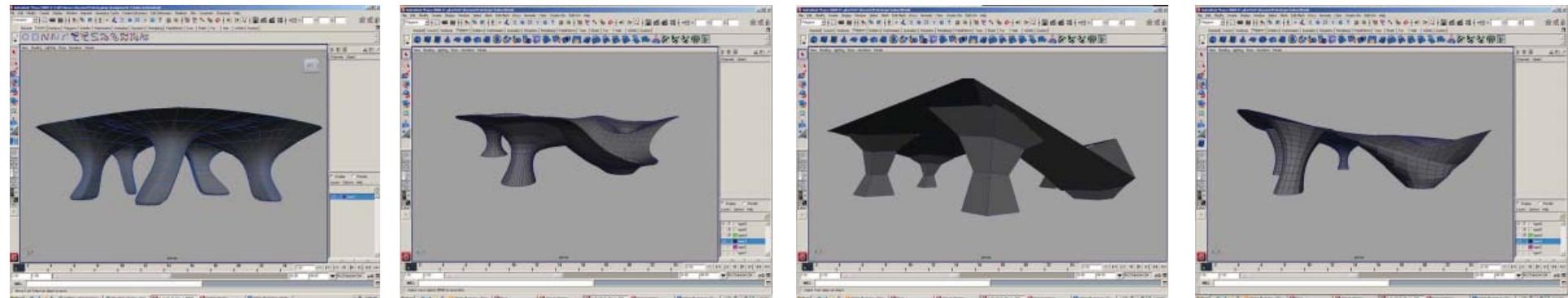
STUDY MODEL PROCESS:
Paper folds were made along a triangular grid with only a few cuts for folding connective flaps. This method reduces the number of components for each cell when the system is fabricated at full scale using the CNC mill



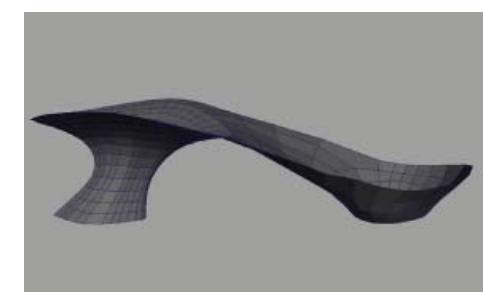
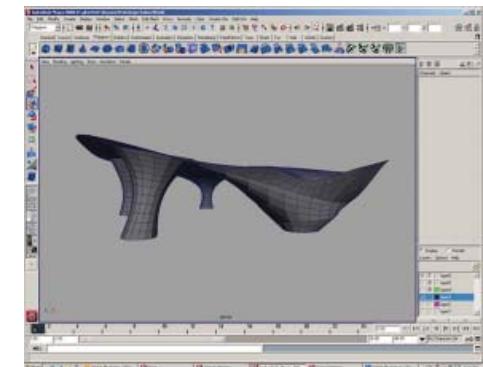
DIGITAL GENERATION:
The paper model offers clues to begin the digital model. The Maya model mimics the original triangular grid as a base for organizing the parts.



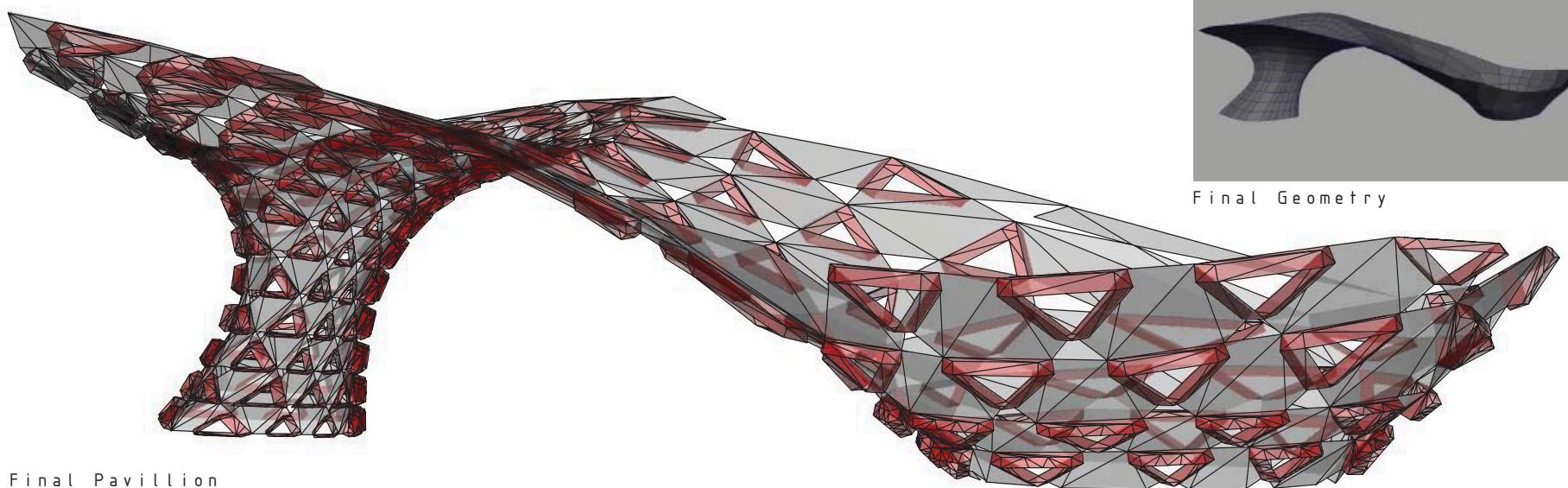
MESH GENERATION



Evolution of Pavillion Form



Final Geometry

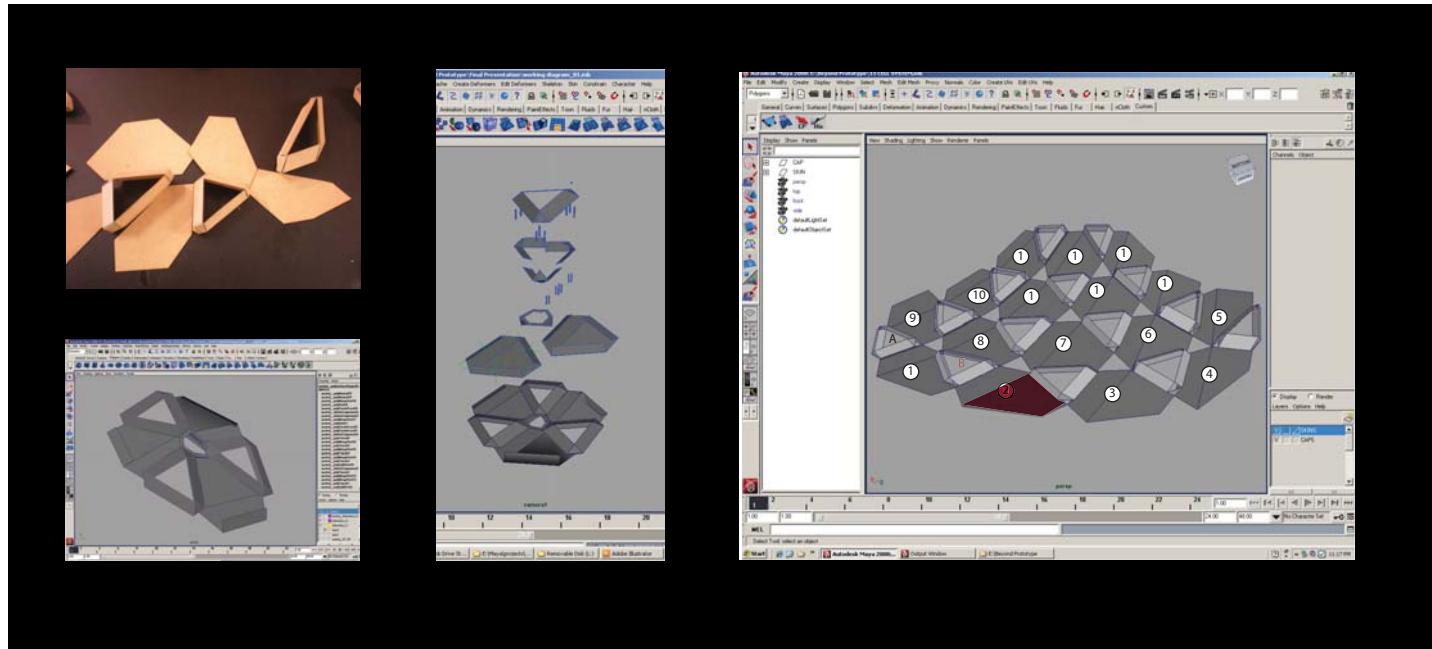


Final Pavillion

FABRICATION / ASSEMBLY

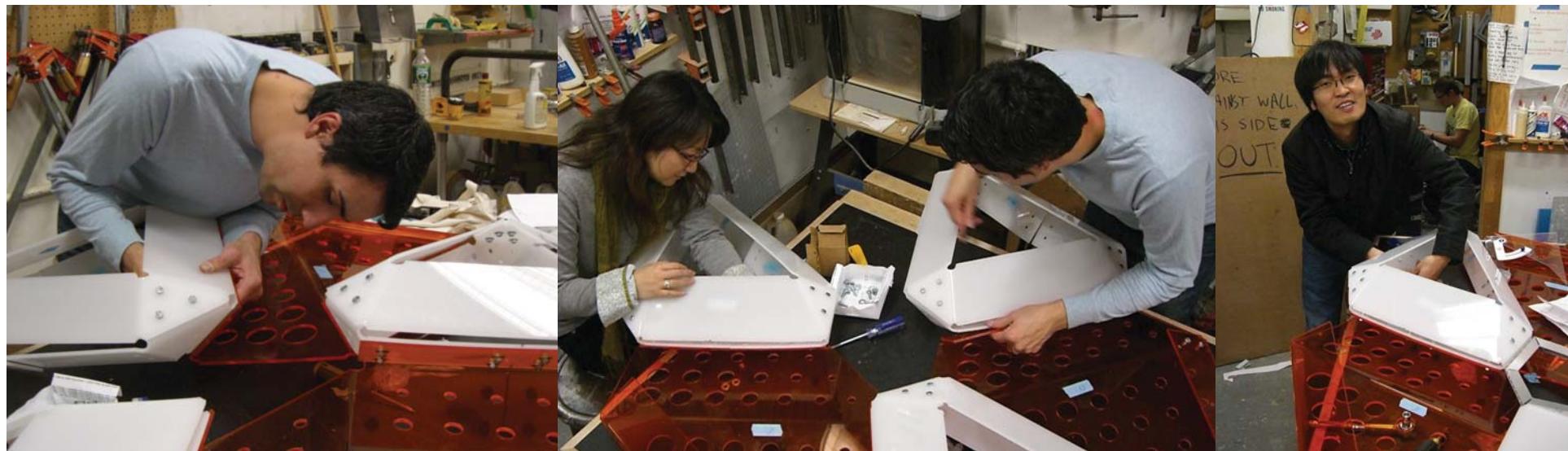


ASSEMBLY PROCESS: Many of the bolt connections are hidden inside the opaque white triangle part to keep the details clean.

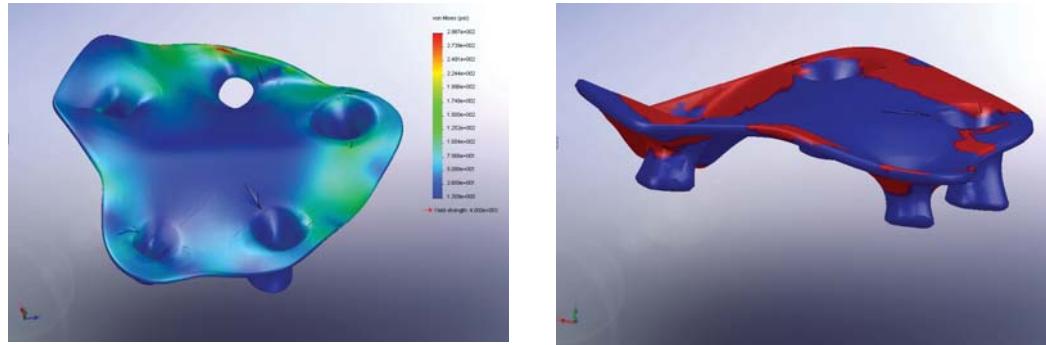


The material strategy for this project takes advantage of aluminum to produce a 6-way connection node between panels. Plastic bends become less reliable and accurate in acute angle bends. The hollow opaque white triangles allow hardware connections to be hidden while the orange transparent panels are unobstructed. In the overall system (next page), the cells imply a relatively smooth curved surface even though it is made up of smaller flat panels.

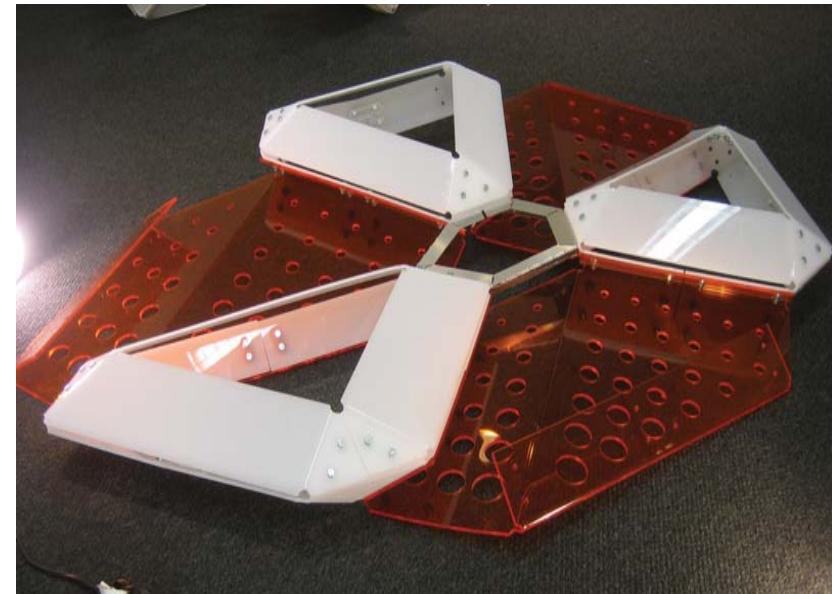
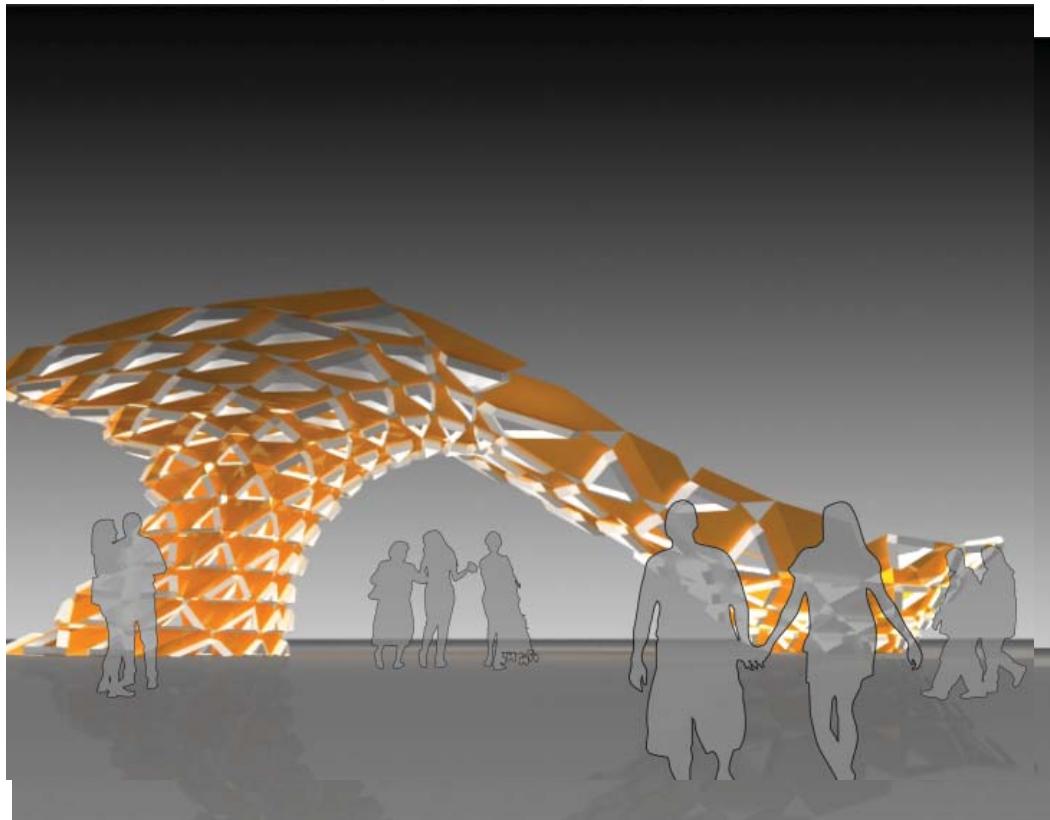
FABRICATION / ASSEMBLY



FABRICATION / ASSEMBLY

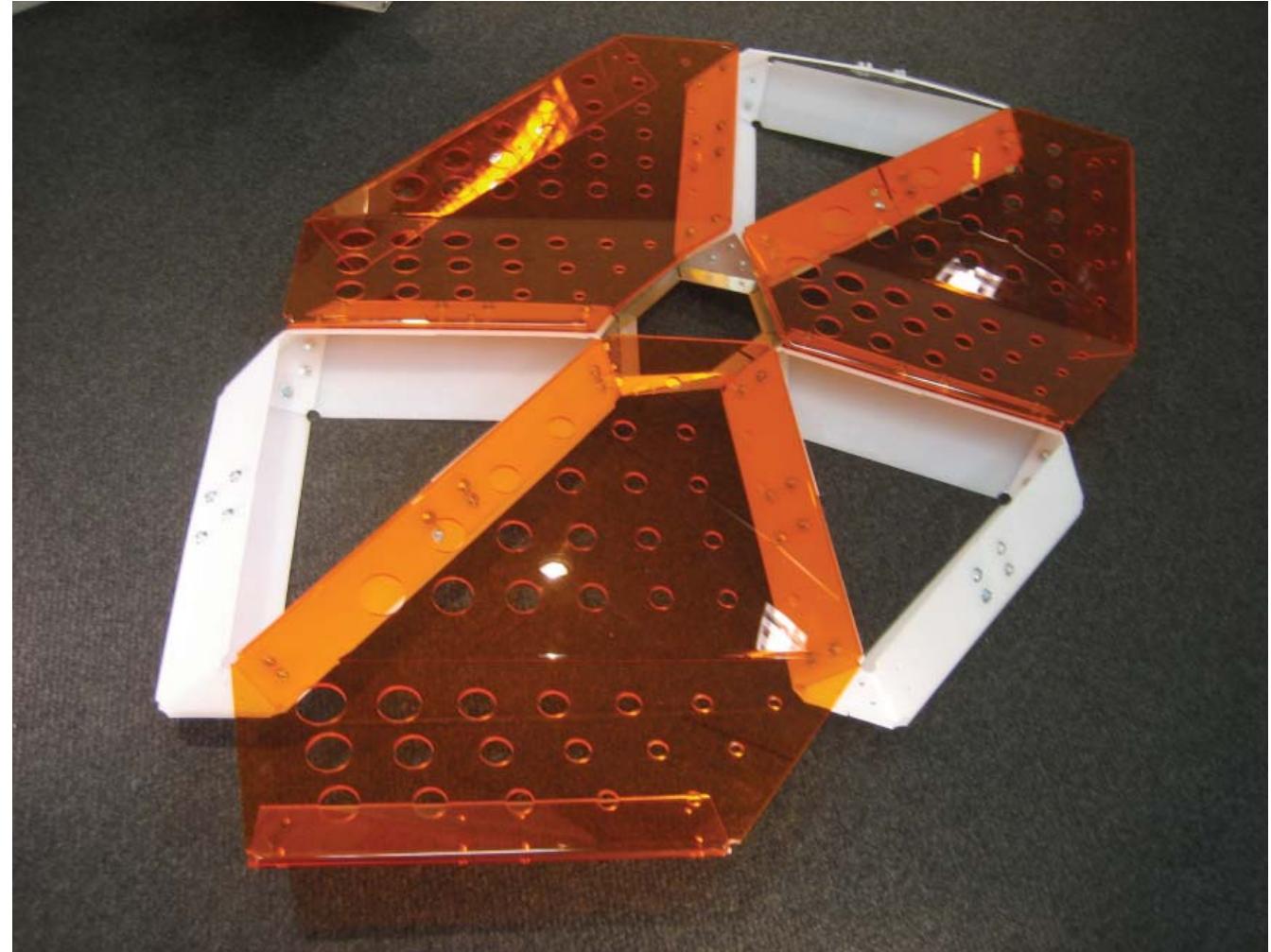
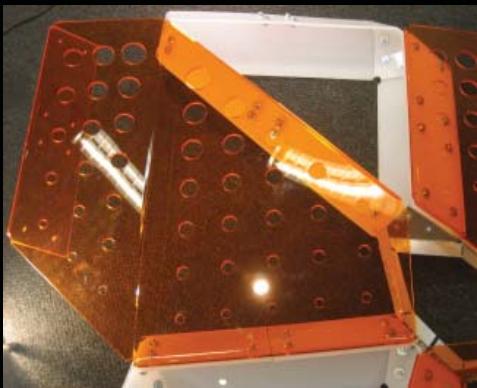


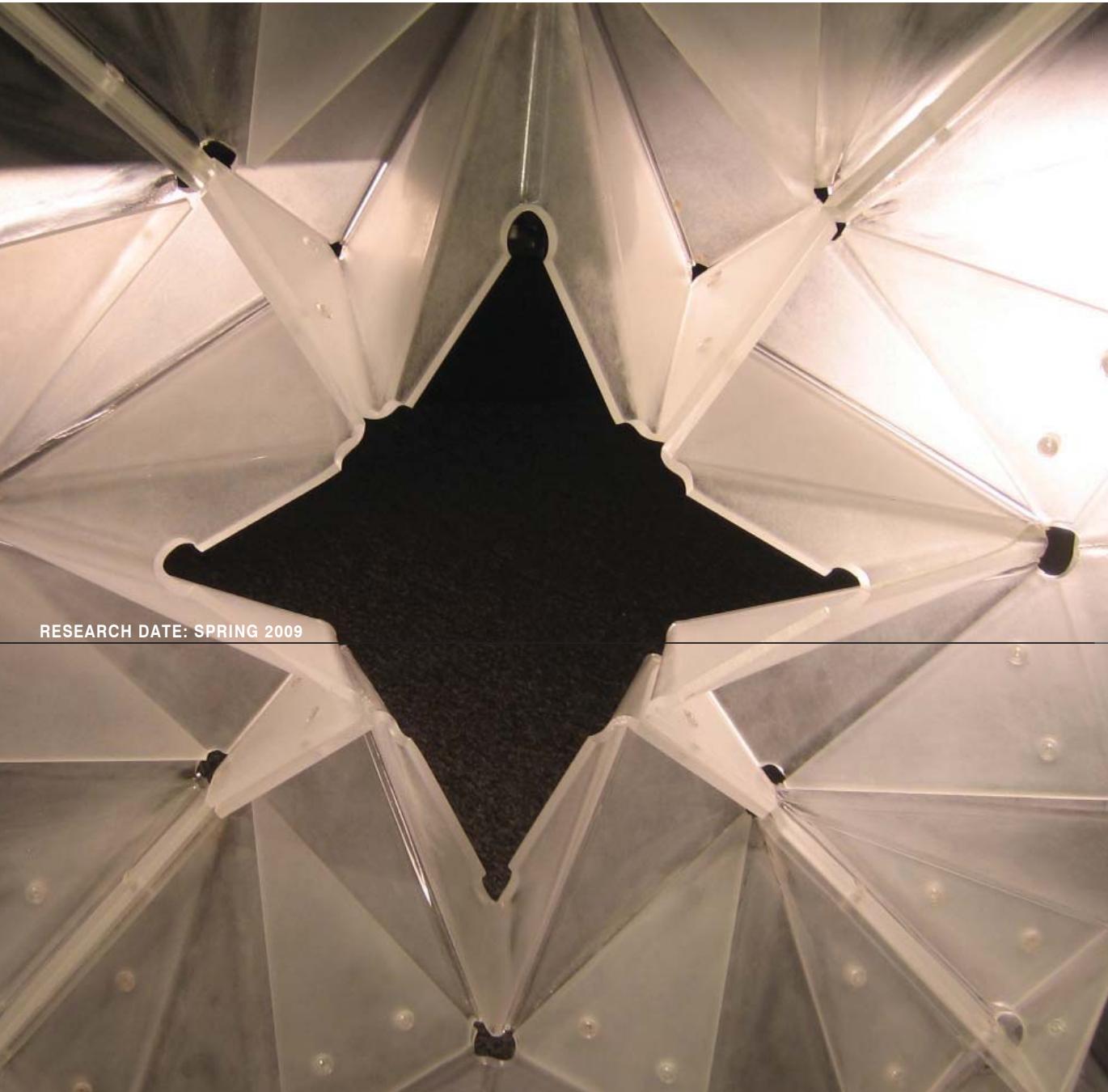
FINITE ELEMENT ANALYSIS: Graphic stress analysis is generated by a simple input of material type, stress / resistance points and load.



FINAL ASSEMBLY

PROPOSED PAVILION





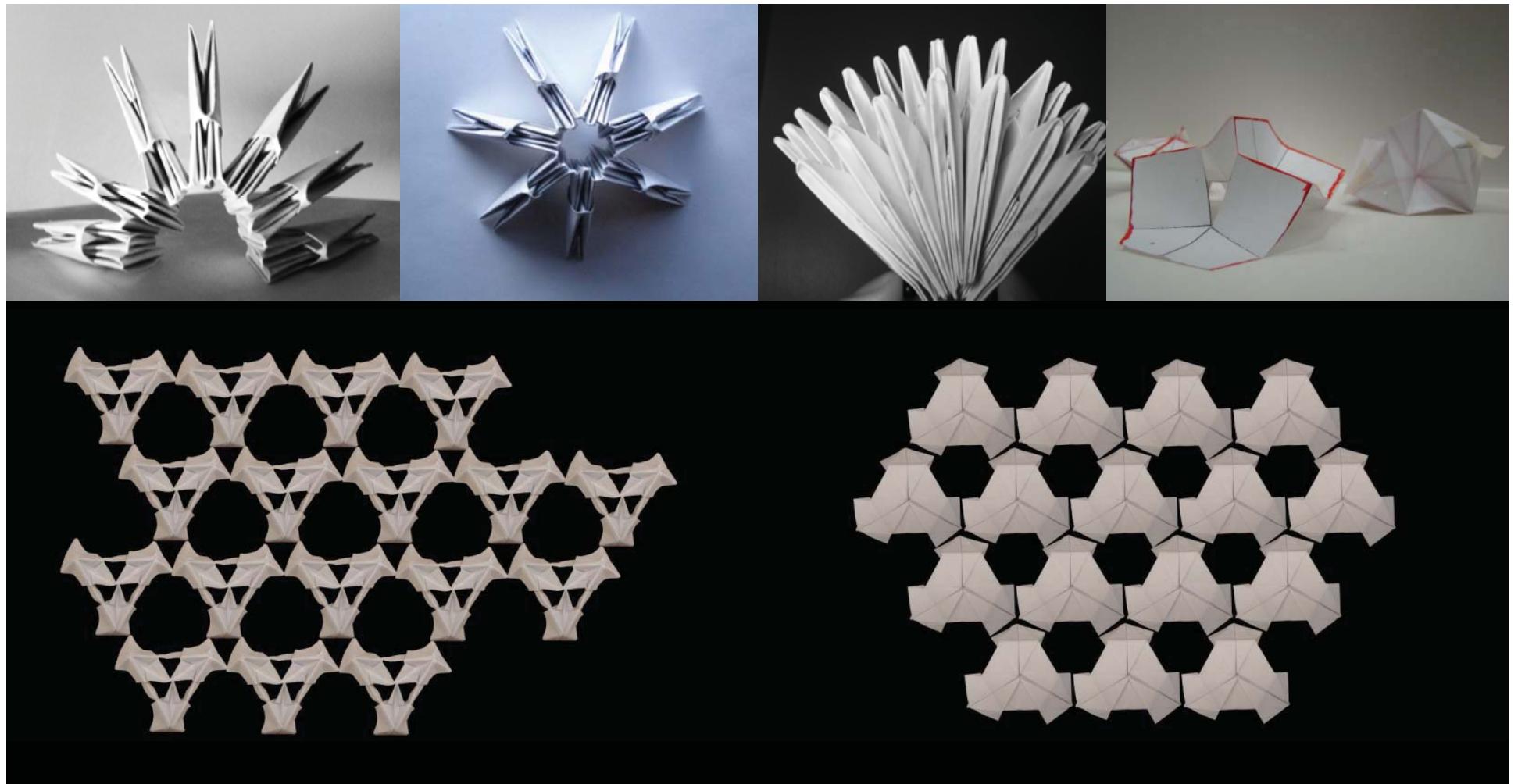
RESEARCH DATE: SPRING 2009

POCKET PAVILION SYSTEM

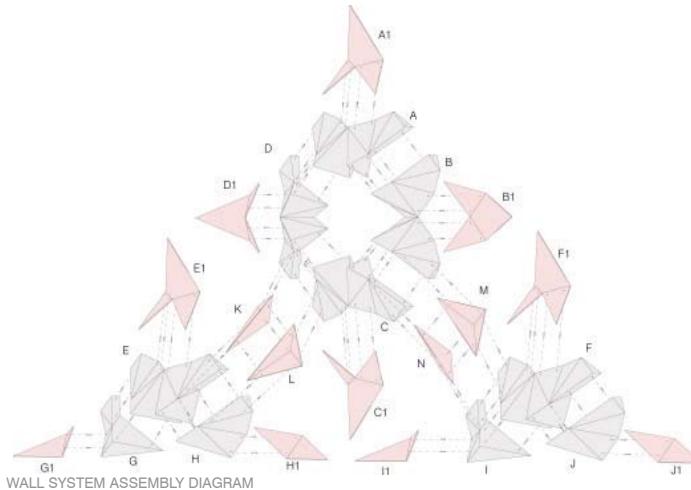
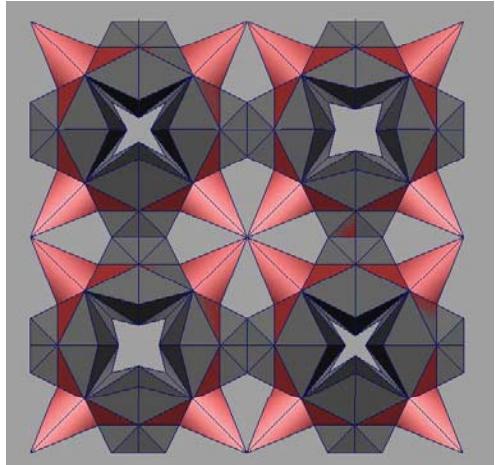
Frosted Acrylic
Clear Plastic Fasteners

Team:
Gonzalo Casis
Elia Karachalio
Masaki Morinobu
Natalia Roumelioti
ShenWei Shih

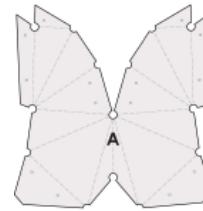
MESH GENERATION



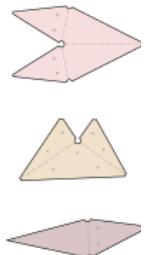
MESH GENERATION



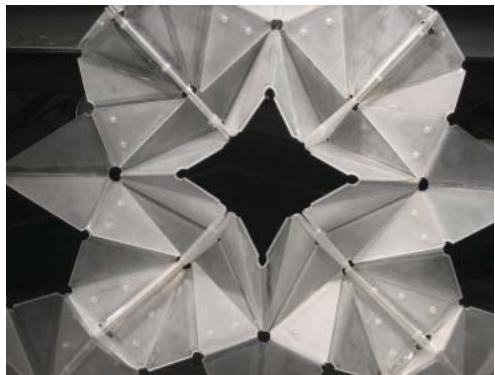
2 Main Components



3 Connectors

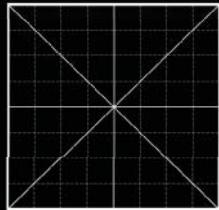


FLATTENED CELLULAR GEOMETRY: 5 UNIQUE COMPONENTS

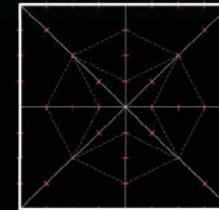


STUDY MODEL PROCESS:

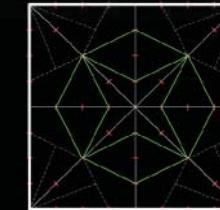
The geometry was generated from a square grid which was divided into triangles with diamonds inset at the center. Study models produced an array of folded cells with an internal pocket and a solid square disk seamlessly integrated within the overall geometry.



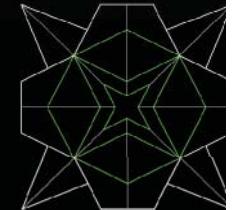
Grid



Subdivision



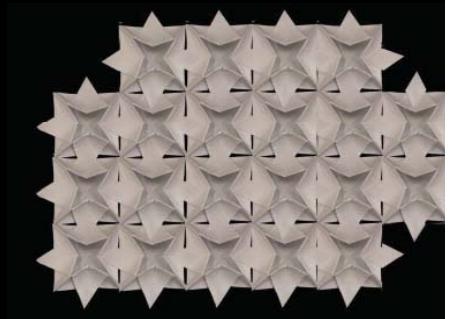
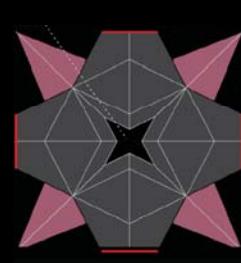
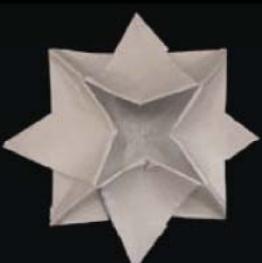
Chamfer



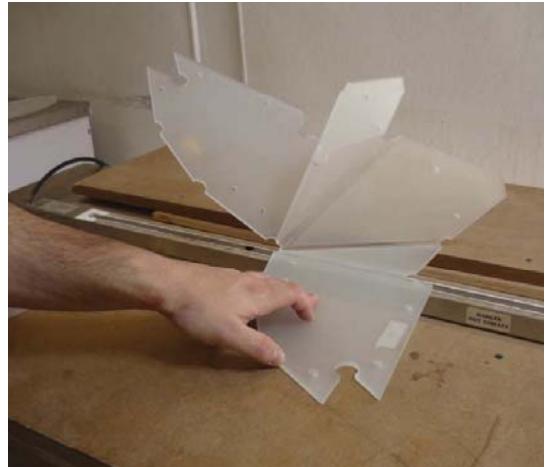
Single Cell

DIGITAL GENERATION:

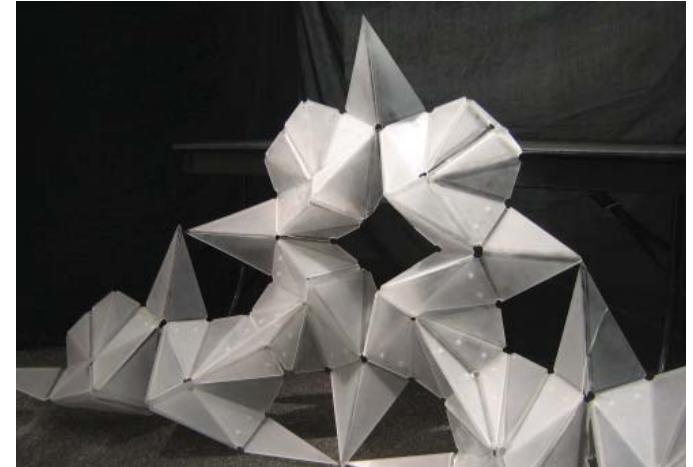
The overall form of the cell is determined by a quadrilateral grid. The two dimensional pattern of triangles and diamonds is superimposed onto the overall surface of the pavilion. Points are pushed and pulled to create a series of triangulated pyramids and perforations which vary in scale.



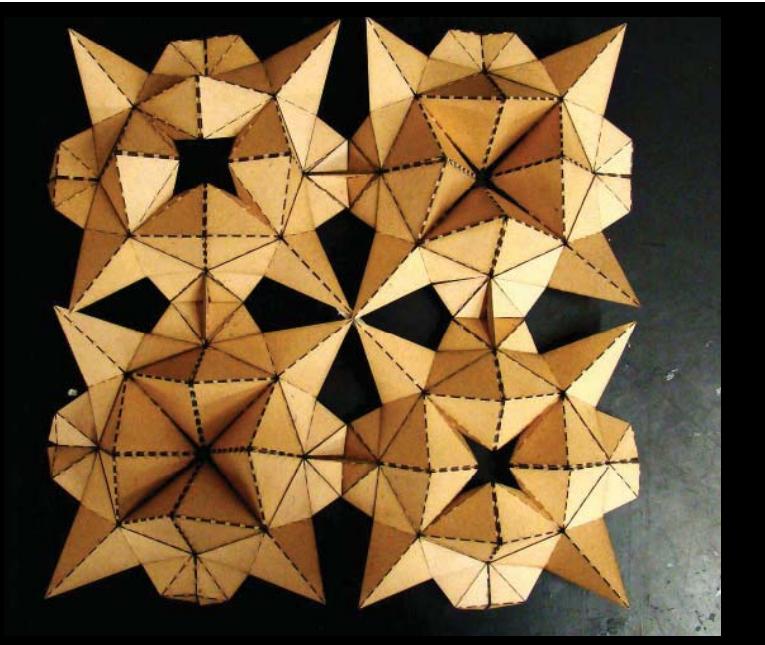
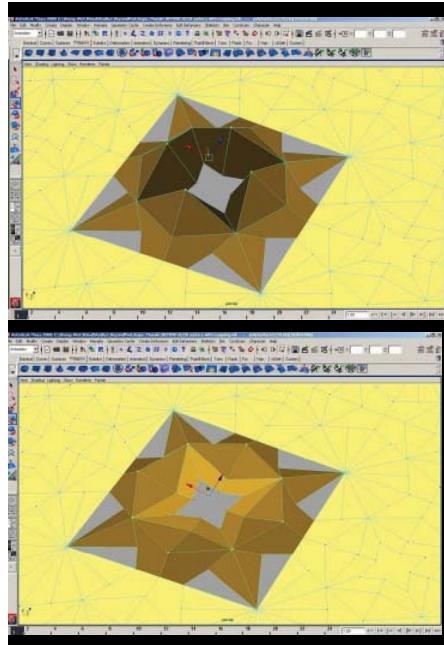
FABRICATION / ASSEMBLY



COMPONENT ASSEMBLY: PLASTIC STRIP HEAT BENDING OF CELLULAR UNITS

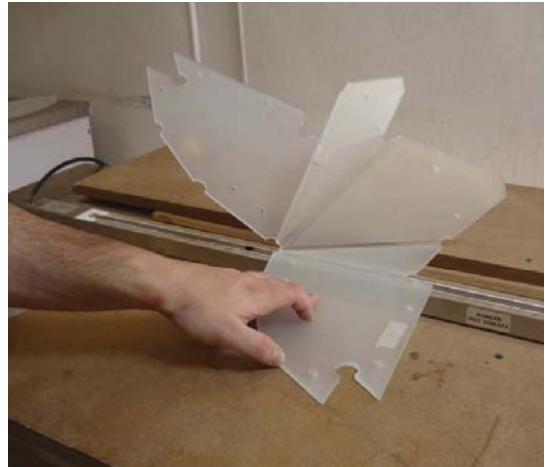


FULL SCALE PROTOTYPE

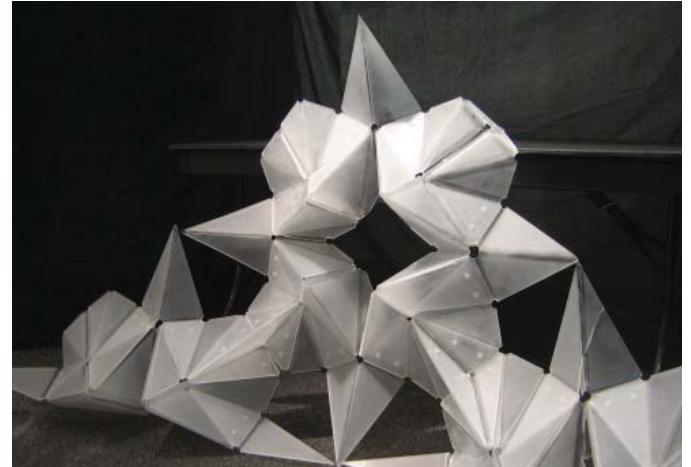


The system is produced by a series of 8 point cells, each containing four triangulated pyramids. **Each set of pyramids can expand and contract increasing and decreasing the porosity of the overall form.** Four outer segments of each cell form a faceted connection with the adjacent component cells while the remaining four segments radiate out from the center to meet at a common point. **The expandable pyramids and multifaceted connections enable the system to adapt to changes in required structural depth, curvature and porosity.**

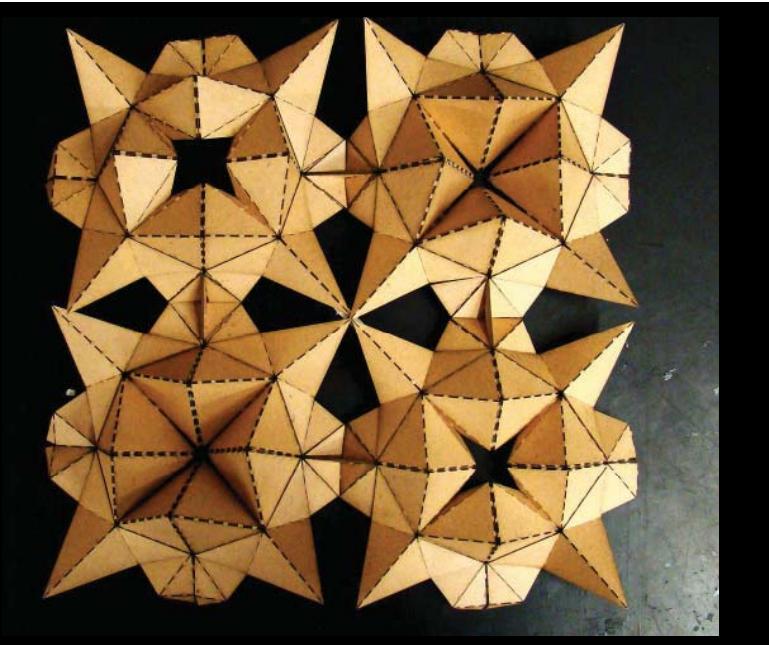
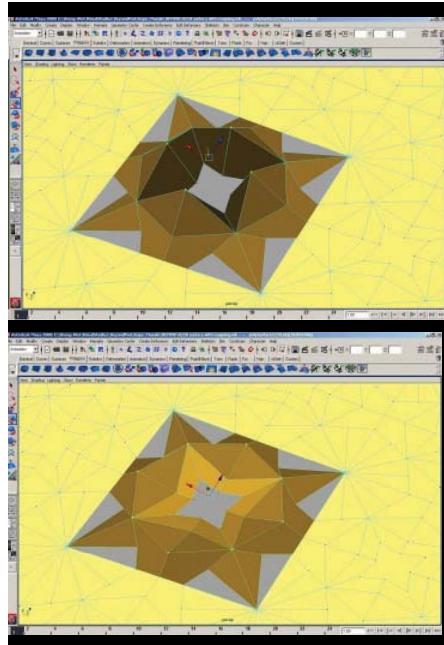
FABRICATION/ASSEMBLY



COMPONENT ASSEMBLY: PLASTIC STRIP HEAT BENDING OF CELLULAR UNITS

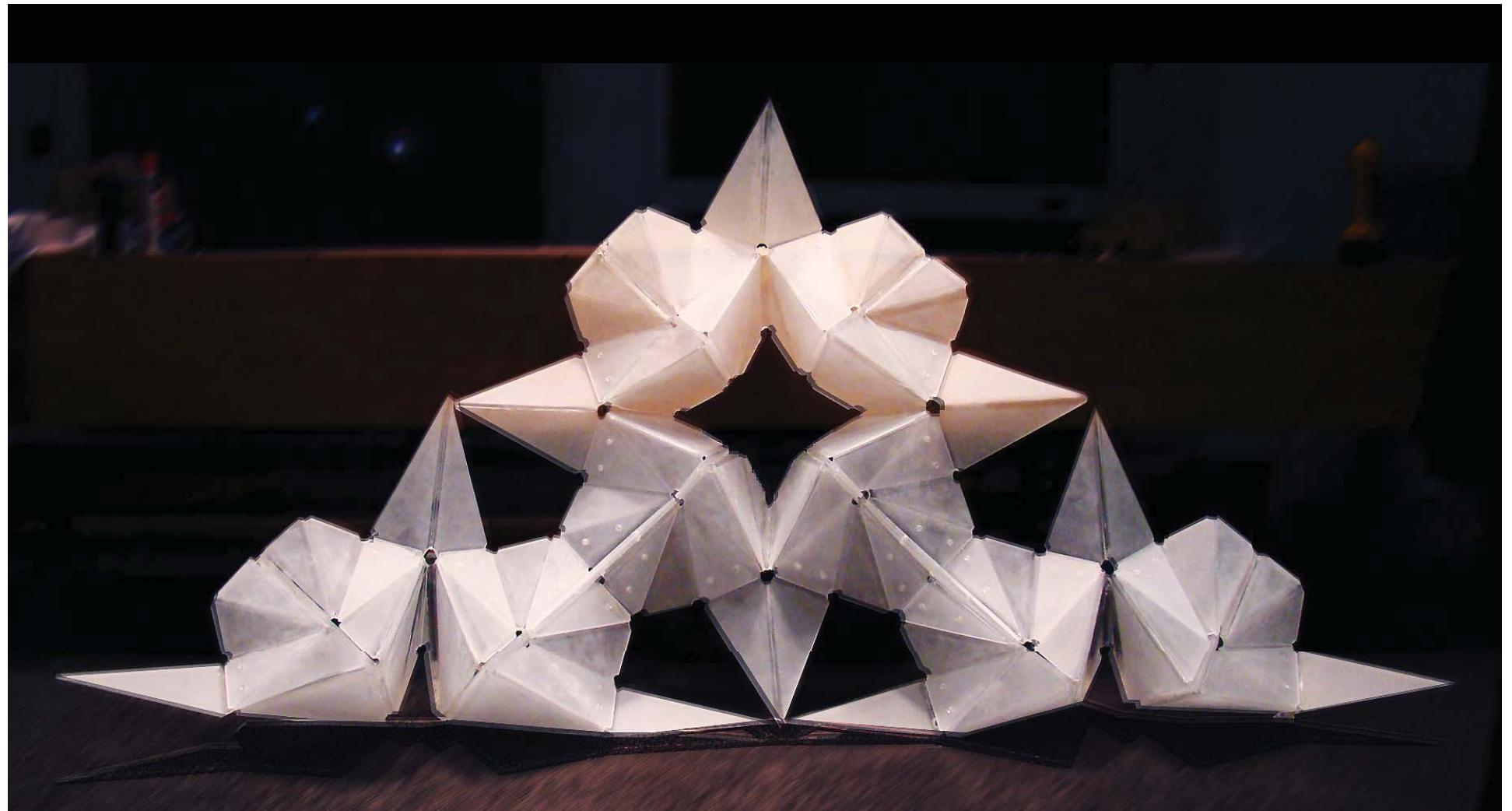


FULL SCALE PROTOTYPE

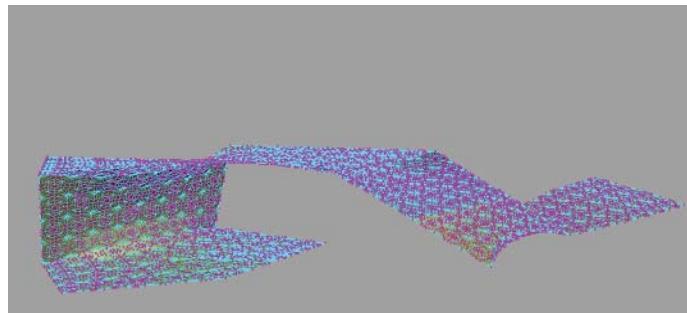


The system is produced by a series of 8 point cells, each containing four triangulated pyramids. **Each set of pyramids can expand and contract increasing and decreasing the porosity of the overall form.** Four outer segments of each cell form a faceted connection with the adjacent component cells while the remaining four segments radiate out from the center to meet at a common point. **The expandable pyramids and multifaceted connections enable the system to adapt to changes in required structural depth, curvature and porosity.**

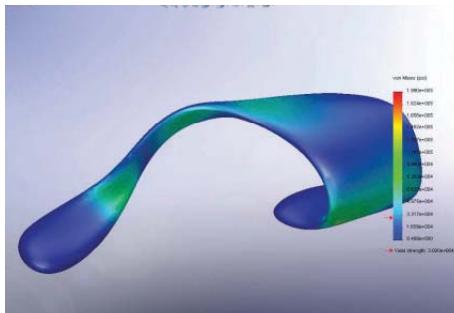
FABRICATION / ASSEMBLY



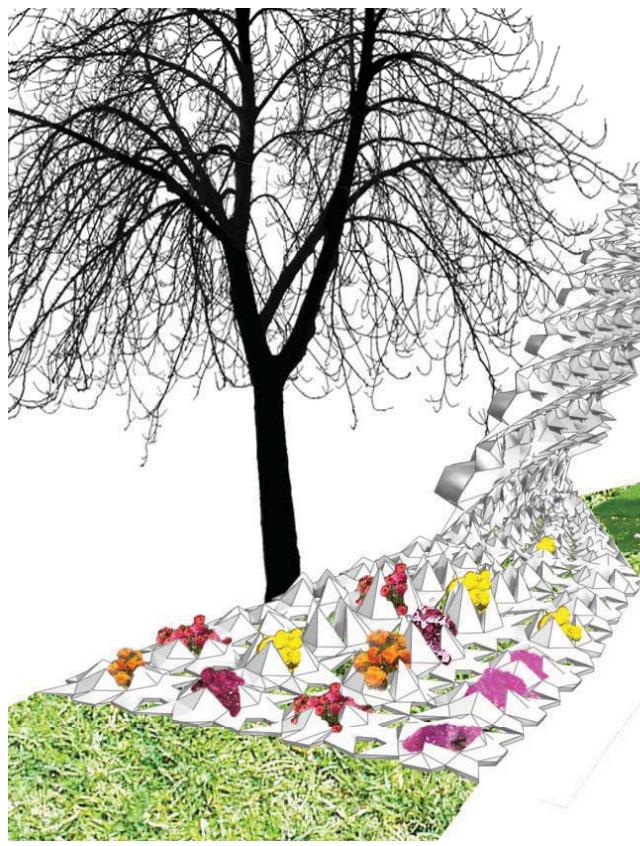
DIGITAL VISUALIZATION



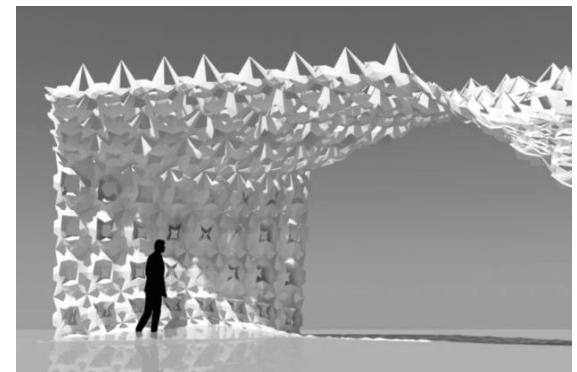
PARAMETRIC MAYA MODEL

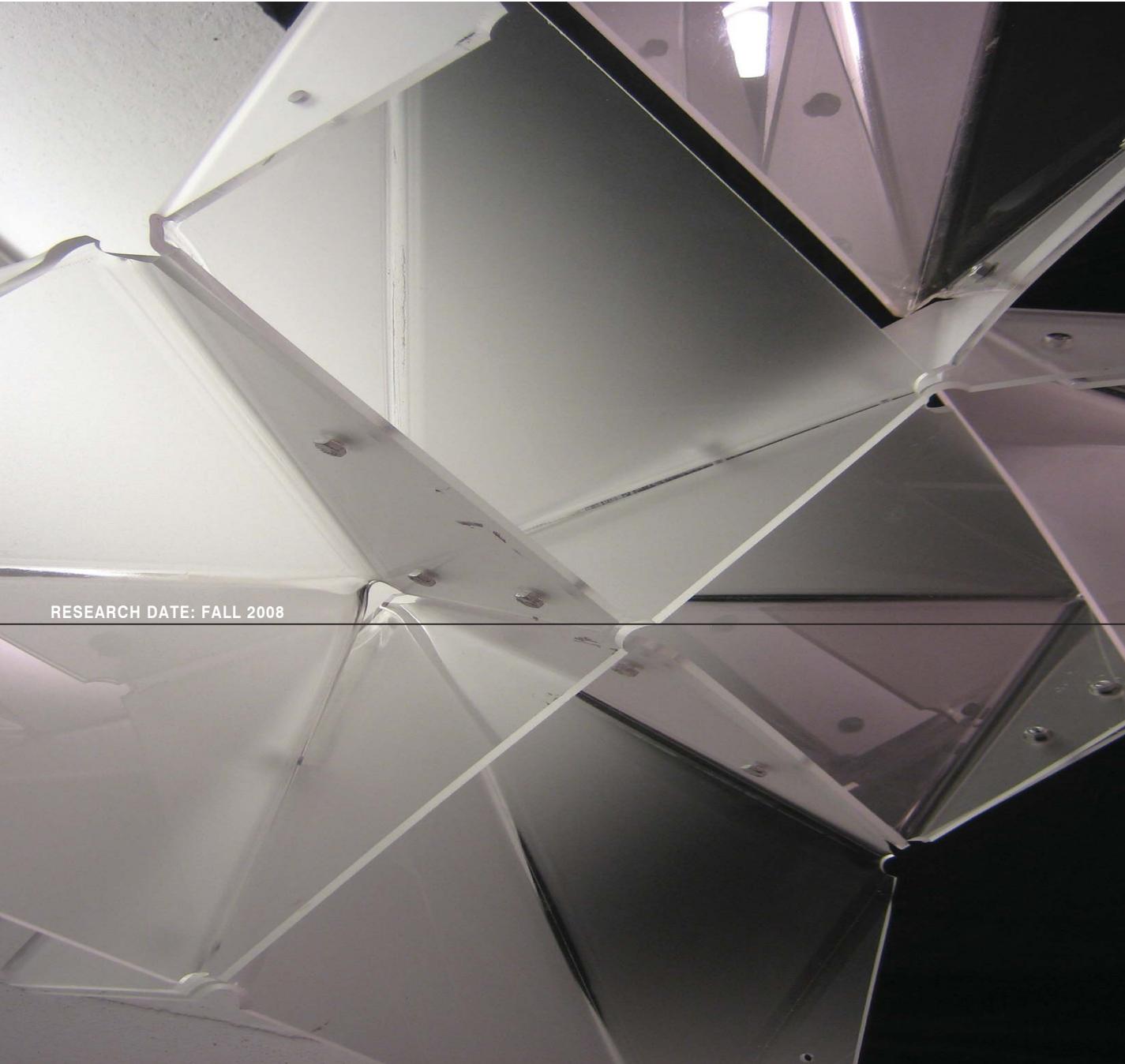


FINITE ELEMENT ANALYSIS OF OVERALL FORM



PROPOSED WEDDING PAVILION DESIGN





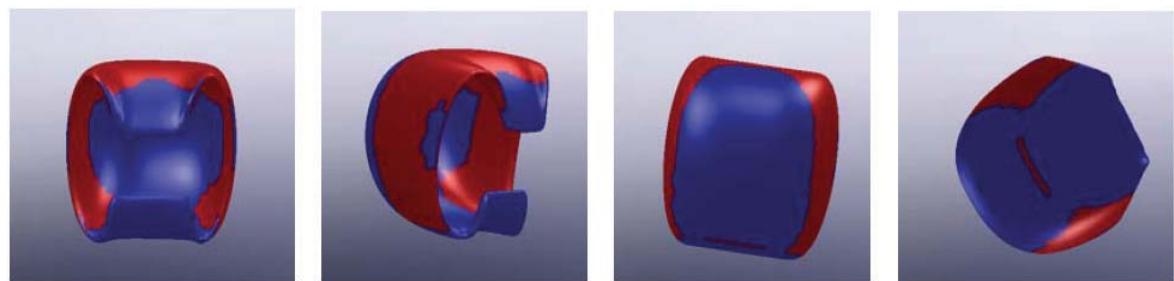
RESEARCH DATE: FALL 2008

POD SHELL SYSTEM

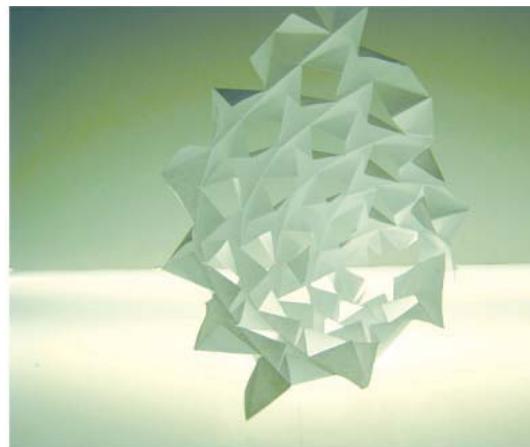
Frosted Translucent Acrylic

Team:
Rajiv Fernandez
Eunki Kang
Sungab Kim

MESH GENERATION

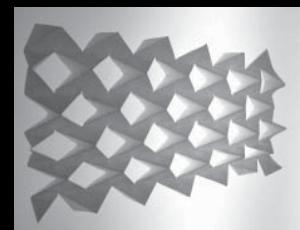
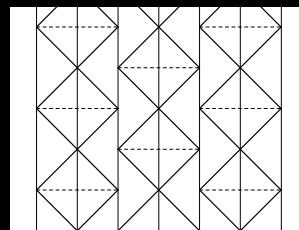


FINITE ELEMENT ANALYSIS: Stress is based on a point connection at the top of the pod, revealing that tension occurs along the sides rather than the back of the pod



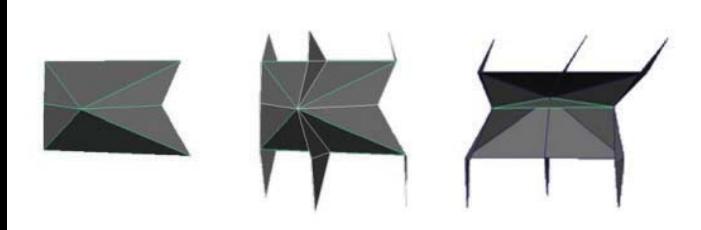
STUDY MODEL PROCESS:

The paper model is made from one sheet of paper with one slit cut into it following the base-grid pattern shown to the right.

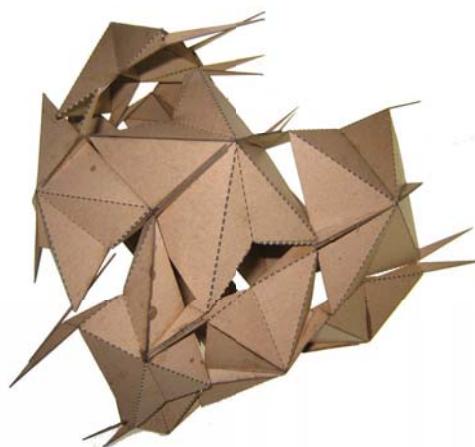
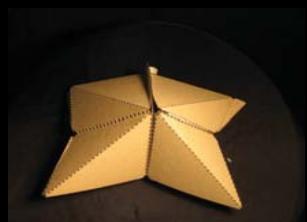
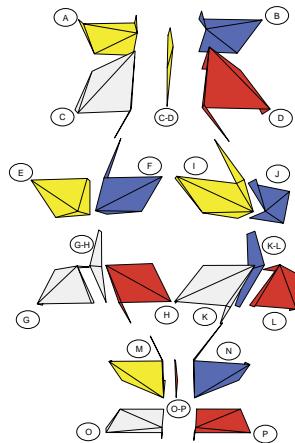
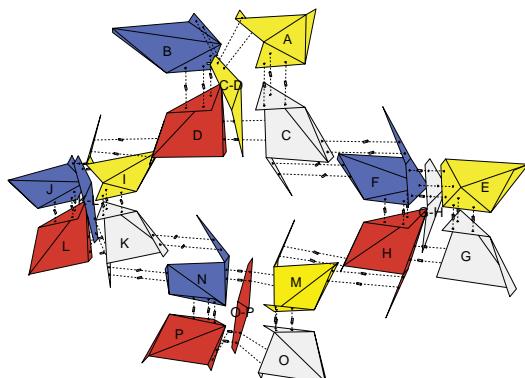


DIGITAL GENERATION:

The base grid is used for recreating the paper model in Maya. The surface in the paper study lacks structural and connective pieces that will be required for fabrication. Triangular wedges are added to the cell and produce a complex pattern when assembled.



FABRICATION / ASSEMBLY

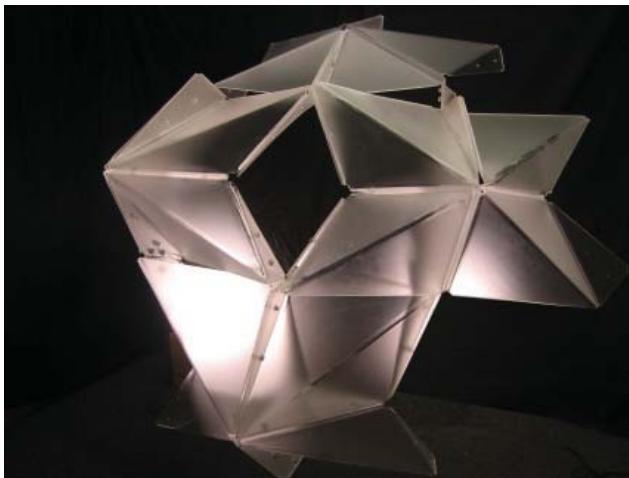


The initial paper models for this project are made from a single sheet of paper with a series of cuts. However, the fabrication process requires the system to be divided into several components. By dividing the cells into individual pyramids connected by structural wedges, a new organization of cells is revealed. The model is made of all triangular faces which allows almost any form to be produced using this cellular system of parts. In this case study, the system is a structurally rigid pod.

FABRICATION / ASSEMBLY



CONTEXTUAL VISUALIZATION:
The Pod used as a Gondola Cab.



FINAL FABRICATION: View from outside the Pod.



FINAL FABRICATION: The 4 cell system from the inside. Person is used in photo to demonstrate scale of the fabrication.