Reverberation of an Object

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Fig 0. Reverberated Object fabricated in C glass and resin with applied pattern.

Abstract

"Reverberation of an Object" is, in part, an analysis of Graham Harman's object-oriented ontology, through which a natural object is stripped of its ontology through a series of craft iterations. The basic idea of this project was to conduct a series of drawing exercises going from analog to digital in order to produce a unique object. This process was inspired by Robin Evans' essay "Translations from Drawing to Building." All steps in the process were unique, though clearly traceable and geared toward the autonomy of an architectural object. Similar to De l'Orme's Diane de Poiters interior, diagrammatic parallel projections guided the object through instances of dimensional, textural, and shape shifting before it reached its final destination. Through a drawing-governed evolution, an object was born governed by methodological iterations, thus the use of the word "reverberations." This object exhibits transplanted characteristics of its source while appearing strange and difficult to read, ultimately enhancing its appeal.

Introduction

We are in a moment where architecture is redefining its position, moving from a subject-centered and systematic discourse to an object-oriented situation. Objects need not be natural, simple, or indestructible. Instead, objects will be defined only by their autonomous reality. They must be autonomous in two separate directions: emerging as something over and above their pieces, while also partly withholding themselves from relations with other entities (1). *Object-oriented ontology* (OOO) is a metaphysical movement that rejects the privileging of human existence over that of nonhuman objects (2). Specifically, object-oriented ontology opposes the anthropocentrism of Immanuel Kant's Copernican Revolution, whereby objects are said to conform to the mind of the subject and, in turn, become products of human cognition (3).

Harman's object-oriented ontology opens up a unique possibility for rethinking the peculiar problems associated with the problem of nature. A return to the object would have to be understood as a turning away from a mythological or sentimental understanding of nature toward the particularities and the essential strangeness of the objects themselves. In this particular project, the use of a seashell, an object of nature, was a deliberate selection. By submitting this "natural object" through a series of drawing translations, a new object related to its autonomous drawing process rather than nature was created. This object doesn't operate in normative representation.

A return to the architectural object as a disciplinary priority cannot be a nostalgic return to pre-modern academic preoccupations with character, propriety, and the idealities of a compositional balance. Nor is this return to the object a simple return to figuration and detached massing. "Object" here should not be understood in a literal sense.

Successful object making cannot be completely encapsulated by a methodology that might repeat the success. There are diverse methodologies to investigate. This object operates outside of formal indexical operations. As a non-theoretical interaction between the maker as an object and the various objects of the making process, "craft" is the ambiguous word that has, in the past, identified the unique expertise of the maker in the relationship to the material. This where the relationship between Evans' position in regards to drawing in terms of inventing complex drawings is what we have referred to as the architect's craft and the object-oriented ontology that allows for the theoretical revisions of the future of an architectural object.

Translations of Drawing to Architecture

"Drawing in architecture is not done after nature, but prior to construction; it is not so much produced by reflection on the reality outside of drawing."
Robin Evans
In the essay "Translations from Drawing to Building," Robin Evans argues that the hegemony of drawing over the architectural object has never been challenged. The discussion goes further into introducing the idea that the architecture drawing does not operate in classic representation but precedes the architectural object, creating a complex relationship between objects—drawing and object. This project relied on the ability to flatten and abstract, to distance itself from the object, and to produce friction between objects and their mutual representations. This project is about a mixture of hand-crafted and computer aided techniques, a kind of low-fi and hi-fi project.

Evans discusses a precedent that influenced this process. The characteristics and relationship between the dome and paving pattern of the Royal Chapel at Anet by de l'Orme upon close analysis are deceptively difficult to describe using structural, geometric, or stylistic terminology. The "expansion of lozenges, rib thicknesses and angles of intersection" were determined protectively, through the rigorous use of stereotomic diagrams generating the complex, hippopede governed patterns through an extrusion of simple, familiar line work (4). The intricate dome articulations were then projected into the pavement and enlarged, and then excess overlap was removed, allowing the pattern, and thus projections, to move full circle (two dimensional [2-D] to three dimensional [3-D] and back to two dimensional; see Figs. 1 and 2).

Through this commission, a new mode of architectural drawing was established in which a diagrammatic matrix was installed, strict though malleable parameters were constructed, and unpredictable yet controlled and intentional results were obtained.

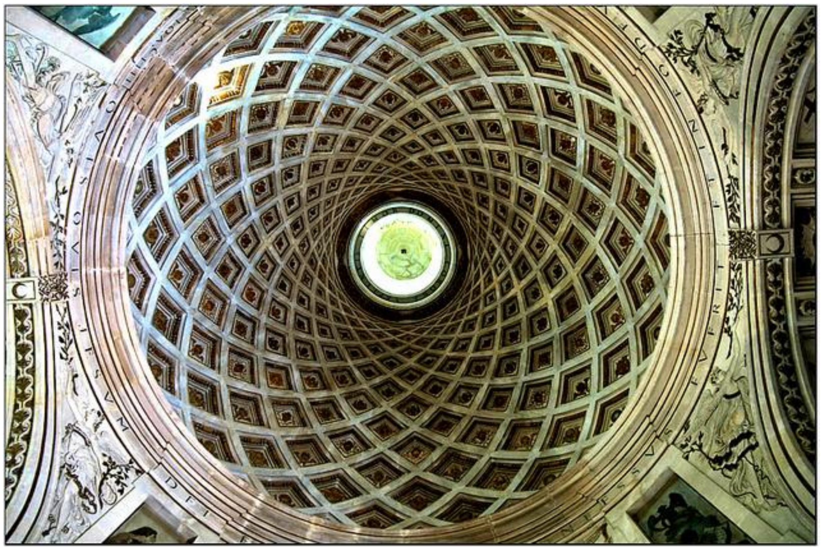

Fig 1. Dome. Anet—Le château de Diane de Poitiers. By De L'Orme,
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Fig 2. Floor Pattern Anet—Le château de Diane de Poitiers. By De L'Orme,
http://www.studyblue.com/notes/note/n/arch-history-exam-3/deck/1356922.

According to Evans, "Despite the possible astronomical roots or symbolic backing of the parallel projections, the architectural meaning and likeness are preserved through the process making the transportation from idea to construction successful and compelling" (5).

This project used a similar process of dimensional translation. While the Royal Chapel at Anet started two dimensionally, the drawings were ultimately derived from three-dimensional mediums that were, in consequence, flattened in Pepakura Designer System, which is not a commonly used software for this type of operations, producing the official point of diagrammatic departure. Also similarly, once the pattern was transferred through the first parallel projection channel creating a three-dimensional object, a rectilinear, seemingly flattened diagram followed. Whereas l'Orme's project went full circle once, the present model did so twice, cycling through various iterations of dimensional status and quality of line work, removing from the object its familiarity without sacrificing its integrity. While the dome and paving of Anet look deceptively similar (despite the removal of excess intersections), the iterations of Reverberation of an Object look deceptively different (6). The digital and craft-oriented shifts are motivated completely by the shell as an object, despite the suggestion of the seemingly alien end product.

Methodology

Cut Lines.

The project began with the observation of seashells in an attempt to understand their characteristics in terms of form, acoustic properties, and surface texture. The next step involved selecting which seashells would be modeled in Maya, initially replicating dimensions, form, and surface nuances (see Fig 3).

Fig 3. Original Seashells and Maya Models.

Hi-Fi Technique.

Then the shells were flattened in Pepakura Design System, which translates 3-D data into a 2-D printable format, stripping their ontology through the removal of qualities attributed to seashells. The methods of capturing the model are often unique to the object and the tools available. In this case, the textures and the wire frame model were, as mentioned earlier, created in Maya and arranged in Rhino before being exported to Pepakura Design System. Before exporting the file from Rhino, all higher-order geometry was converted into polygon meshes (see Fig 4). The 3-D model needed to have correct (outward-facing) normals and correct (counter-clockwise, right-hand-rule-out) polygon vertex order, and adjacent polygons had to meet in a water-tight fashion with no cracks or edge vertices that belong to only one polygon (see Fig 5).

After this, the model was refined to give the proper layout and construction tabs that would affect the overall appearance and difficulty in constructing the model. The properties that were modified were the following:

a. Three dimensional became two dimensional (several planes vs. one plane).
b. Coarse/rough became smooth.
c. Curves became rectilinear.

Fig 4. Process from selected seashells, the first Maya models, and the unfolded flattened model.

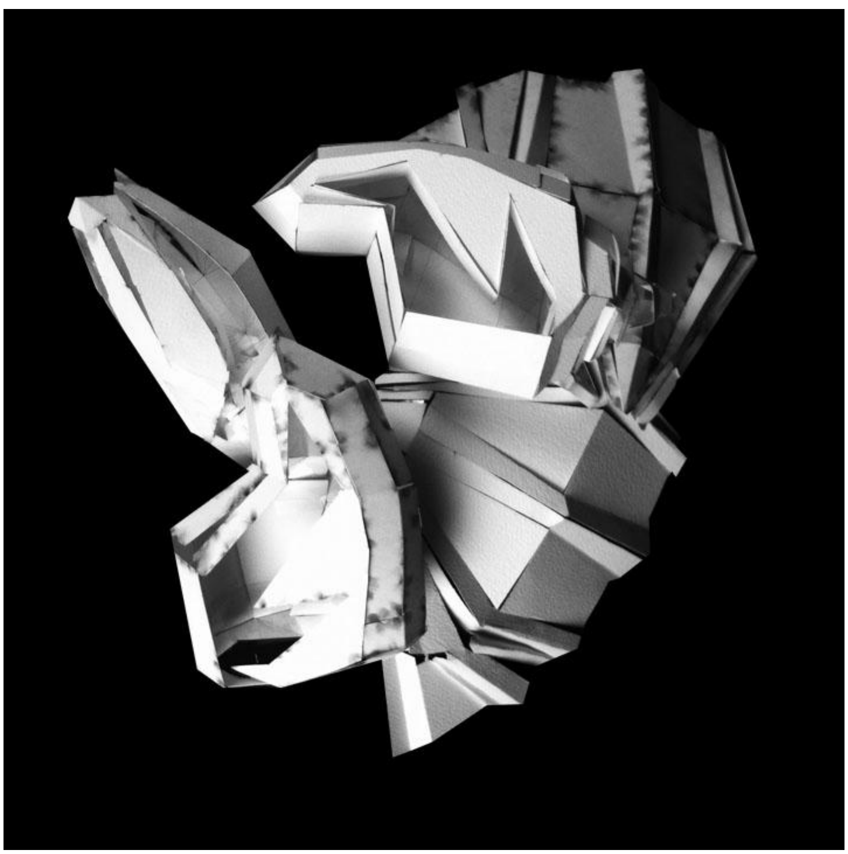

Fig 5. Pepakura Model.

Low-Fi Technique

Three-dimensional moments were then injected back into the Pepakura Design System planes, giving the model the appearance of a "cubist" object. Once the file was ready, the 2-D version was printed out on 110 lb cardstock and cut out using a laser cutter. This mass reinterpretation suggests that rather than using digital technology to reverse engineer the construction of the complex form, the digital tools should become a mechanism to better understand material and fabrication potential. It is an argument for developing and refining precise parametric systems of material properties, tooling/fabrication behaviors, and construction contingencies and using them to forward engineer use and architectural form. It is in essence an argument for architects to begin developing systems of constructional knowledge, by and through which we can design.

In general, the areas of the original model with the highest **absolute Gaussian curvature** generated the most deviation in the Pepakura Design System and required the most additional cut lines. In general, a flat plane, or any surface extruded from a 2-D curve, will have zero Gaussian curvature; however, the shell models that were used had some absolute Gaussian curvature. The flattened model was imported into Maya, and the process of cut lines and line work began (see Fig 6).

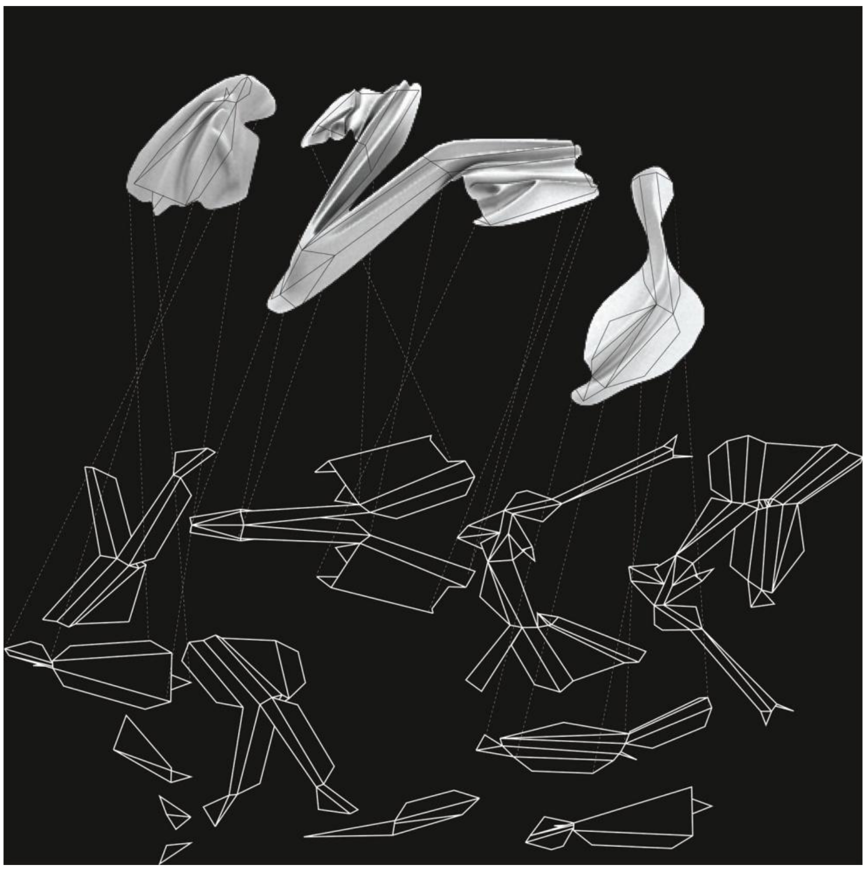

Fig 6. Relationship between cut lines and surface line work in Maya.

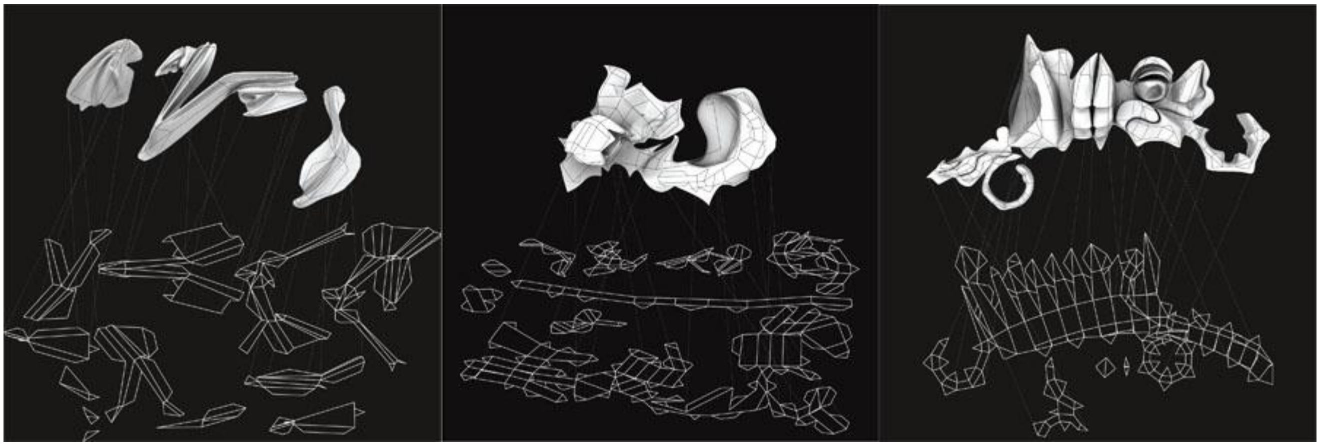

Fig 7. Three flattened objects with their corresponding Maya Models.

The three shells were merged through line work and the connection or rhythmical movement of one nuance into another. The fabric was then fractured, and the pieces were reassembled, giving mass and spatial variation to the object. Using the rigid line work of the Pepakura model, fragments were stitched (see Fig 7).
The most important guideline for the next exploration back to Maya was the use of the cut lines from the Pepakura model. These lines were transferred to the Maya polygonal surface as line work that would be interpreted as edge loops to give by creasing specific definition and articulation to the digital 3-D model.

Line Work and Edge Loops

Once in Maya, an important part in developing proper edge loops involved understanding poles. The E(5) Pole and the N(3) Pole were the two most important poles in developing both proper edge loops and a clean topology on the model. The E(5) Pole was derived from an extruded face. When this face was extruded, four 4-sided polygons were formed in addition to the original face. These pole theories allowed the reinterpretation of the line work into edges for definition and creasing to be more precise.

The dimension in terms of how high the edge loops should be pulled was taken from the Pepakura model. Several commands were used to work with the edge loops; the Select Edge Loop Tool and Select Edge Ring Tool, as well as the Offset Edge Loop Tool and the Insert Edge Loop Tool, use a variety of criteria for the selection of the various edge types, depending on the specific model and modeling style. Users can crease or harden the edges on their polygon meshes (see Fig 7). The final goal was that the object be strategically tightened through subdivision modeling. The final result was an object represented as a product of the “craft” of drawing with a new ontology different from the seashells (see Fig 8).

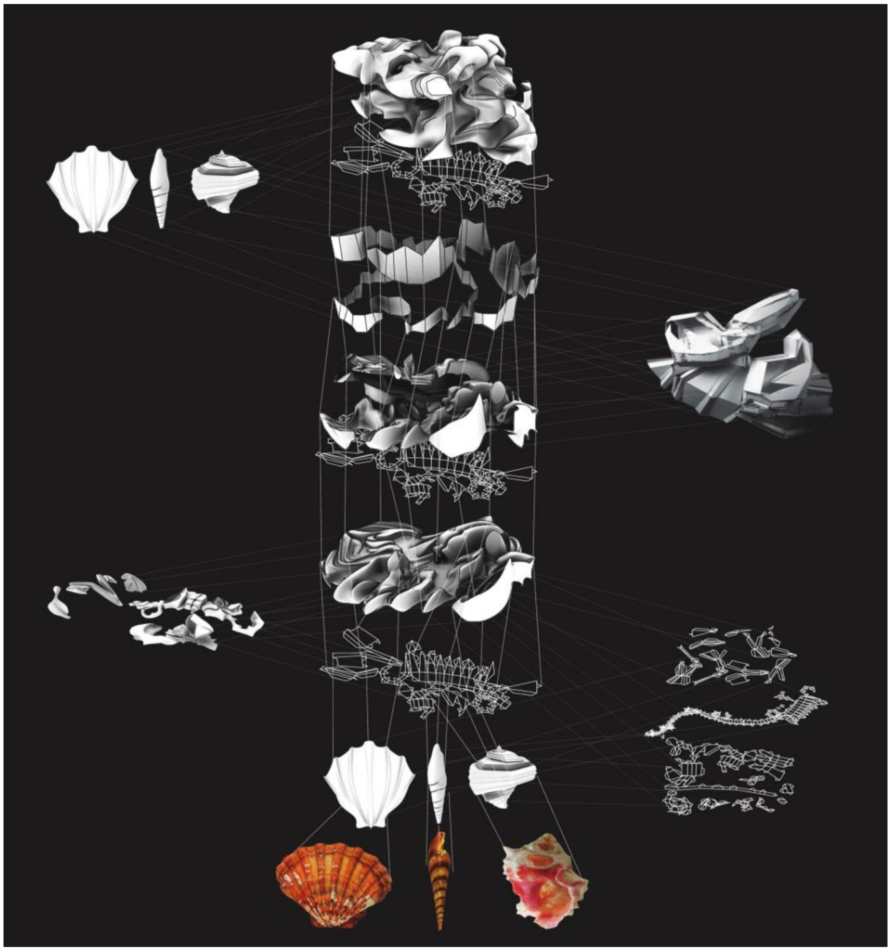

Fig 8. Complete non-linear process from the seashells, flattened objects, Papekura Design System Model , and final composite of new ontology Maya model. It is important to observe the different object representations from a 2D line drawing to a 3D polygonal model as well as the point when the Papekura analog model was generated.

After the new object in Maya was developed from the composite of the three original seashells, several sections were cut to study the object even further (see Fig 9).

The final step was the pattern application that came from a 2-D study of the shells and their flattened patterns. The textures and nuances of various distorted seashells were flattened uniformly, generating fragments of line work that were bridged strategically to remove any doubt of unity (see Fig 10). This pattern was applied to the object using the stencil function within ZBrush. Group loops were generated based on this pattern, allowing the crisp application of a shell-reminiscent color scheme. Noise was applied to selected brushstrokes as well as the texture of the object, reinstating the porosity discarded during the primary Pepakura flattening phase. Initially, the qualities essential to the object were removed, only to be returned in different proportions and states throughout its evolution (see Fig 11).

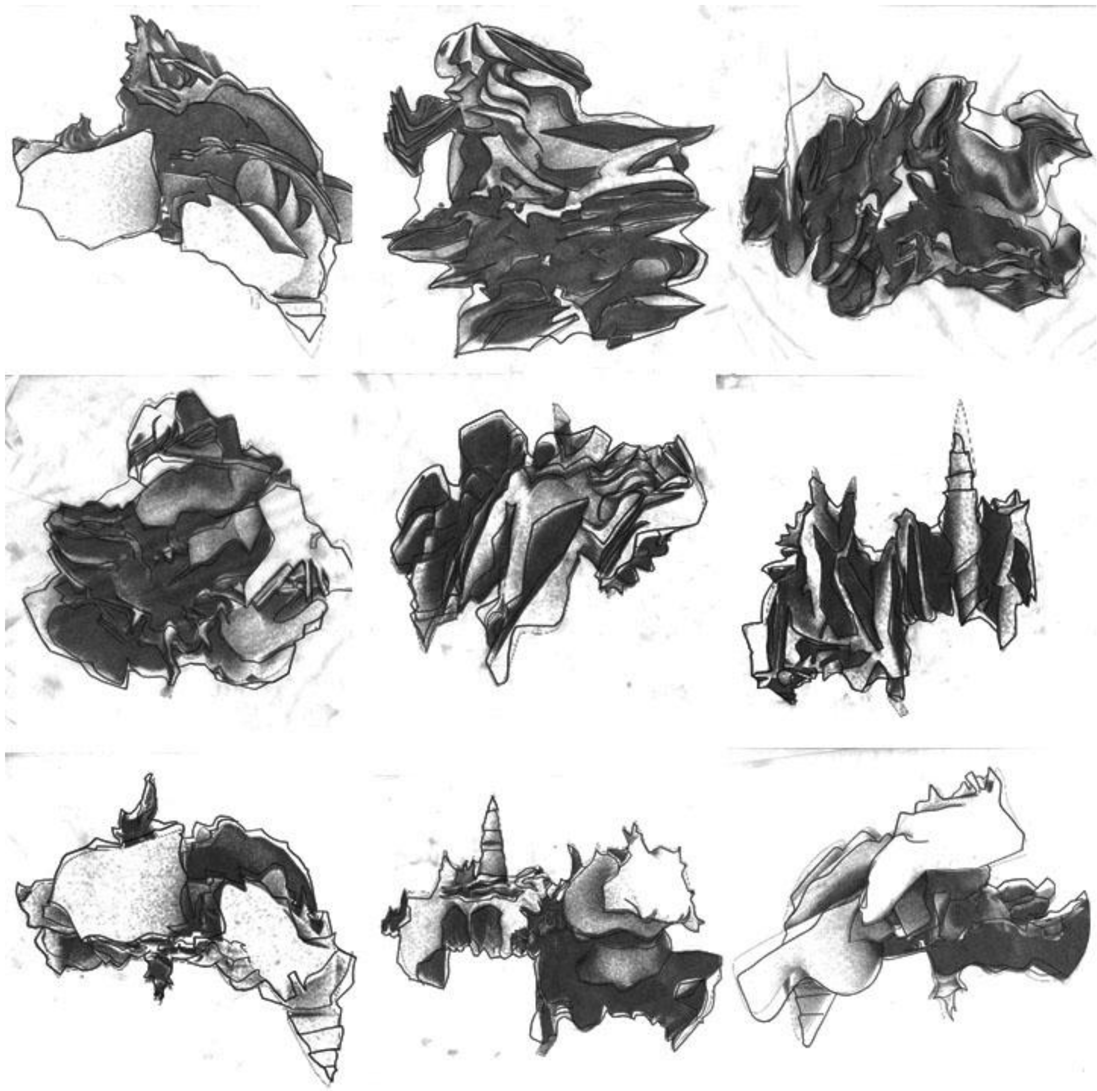

Fig 9. New Object Sections. The are different object representations using ZBrush as a way to represent the 3D digital model as a conventional analog drawing.

The motivation for taking the steps between 3D to 2D is mainly because of two reasons, the first convert a three dimensional object into a two dimensional drawing using a computer aided technique and transform the two dimensional drawing into an analog three dimensional object using a hand-crafting technique. The Second reason is to demonstrate that in architectural object making there are a series of possible translations using a hi-fi/low-fi methodology that can be applied in different scales.

Fig. 10. Preliminary pattern to be imported to ZBrush.

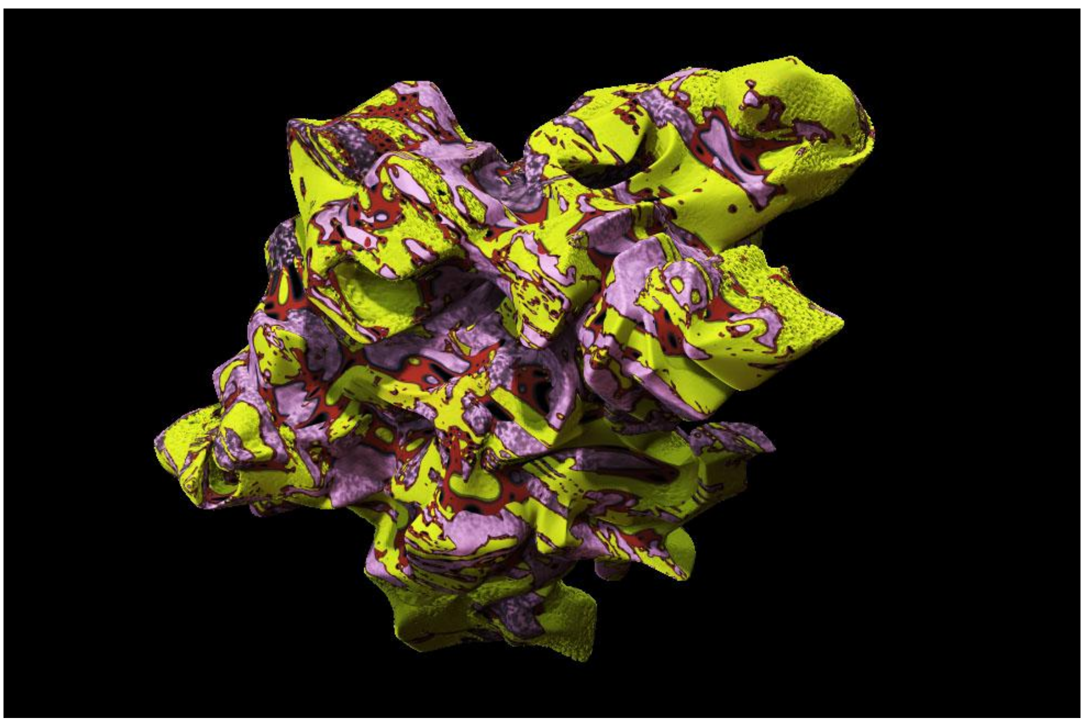

Fig. 11. Final Object with ZBrush Pattern.

Fabrication using Composite Materials and pattern application.

After generating the object in Maya, a section cut was taken through an area and exported it to Rhino. Once in Rhino, the exterior and interior shells of the building were sliced into 5 4" fragments allowing a workable depth for the CNC router. Then exported the sections to Mastercam, which programs the CNC and rendered the slices in foam, which were glued together to create the molds for both the interior and exterior shell.

After flattening the shell-inspired pattern in Zbrush, this pattern was overlaid on top of the flattened Pepakura Design System linework, scaled the image to match the scale of the model, printed, and applied to the model using resin and an additional layer of C-glass. The base of the model was cut with CNC out of foam, similar to the mold of the interior and exterior shells. (see Fig. 12)

The fabrication began with the use of specific materials like fiberglass and C-glass reinforced with a matrix (resin) specifically epoxy, fiberglass and polyester. Following this material combination we created a CNC milled mold derived from the final object exploration. We applied the soaked C-glass onto a Styrofoam mold covered with truck bed lining, to prevent the resin from corroding the Styrofoam and also to spray the smooth lining surface with de-molding spray to assure an easy and clean removal of the C-glass. The goal was ultimately produce light, rigid and semi-rigid, and most importantly almost transparent pieces to be able to apply the ZBrush UV master unfolded printed pattern. (see Fig. 13)

Fig.12. Fabrication Process

It was decided to use Epoxy and Polyester resin, which fortunately feature an available working time from half an hour to four hours depending on the type of hardener one uses. These two resins also have a more sustainable aspect in terms of the amount of toxic material they release while curing. However, the Polyester proved extremely sensitive to the weather and presented difficulties to cure under hot and humid conditions. This sensitivity to weather left Epoxy as the resin to use. The direction of the C-glass fibers was also related to the line-work producing different rigid and semi-rigid areas.

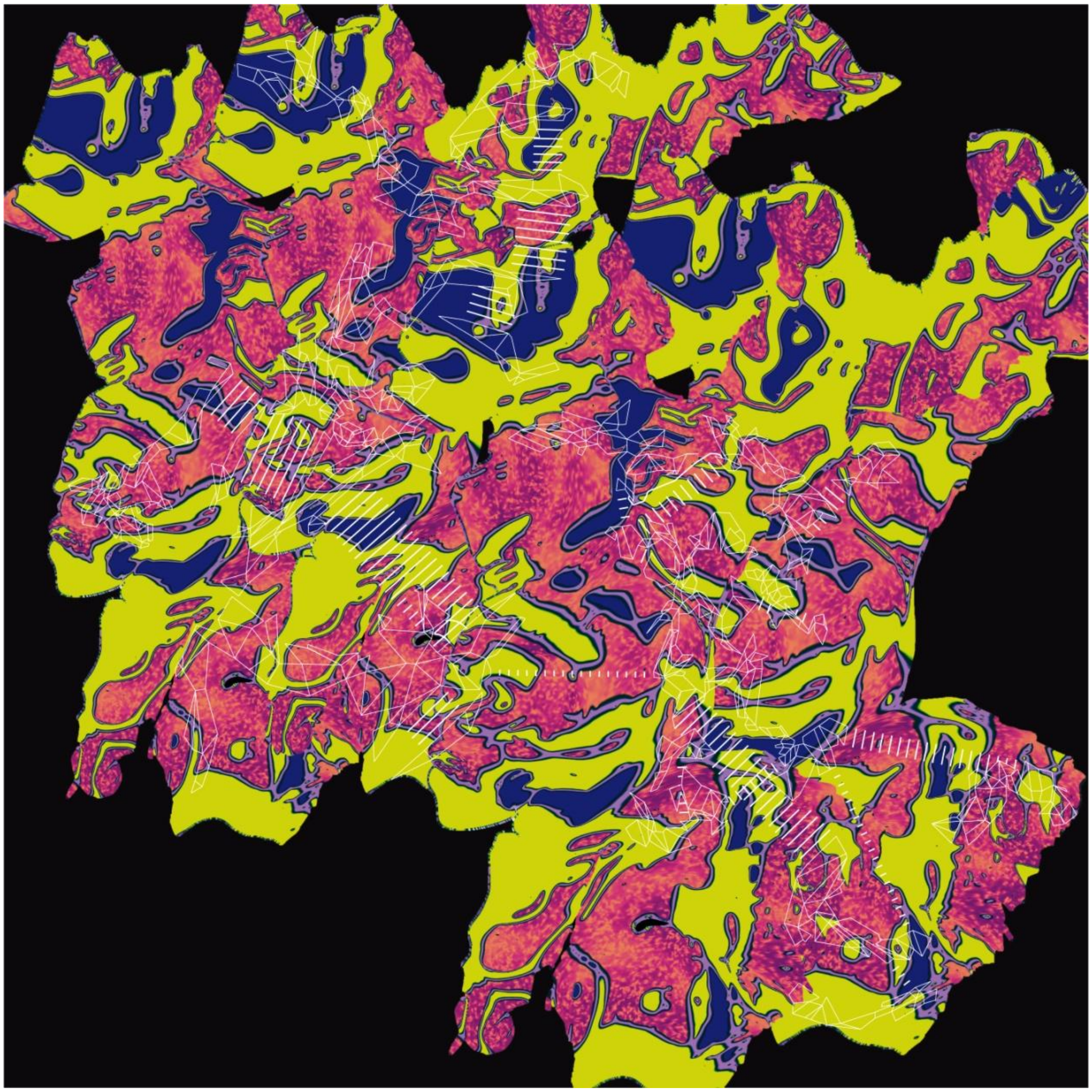

Fig.12. Fabrication Process. ZBrush UV master unfolded printed pattern before applied to the fabricated model.

While the first two coats of C-glass had been applied, we took the Rhino model, un-rolled it and with the make 2d function we were able to flatten the object with the pattern on. We added line work directly from the iso-mesh to serve as guideline to know where the 2d pattern had to be placed on the 3d model. After several printing experiments until we got the right scale and color we proceeded to apply to pattern on to the physical model. This process took about 12 hours and several prints until it worked. The final step was to add a new C-glass layer to protect the pattern. Once it cured, we de-molded the object from the foam base.

The important argument in terms of fabrication using composite materials is in the way the line-work information gets interpreted at different stages; first as form, by reading surface from the lines (cut lines), then the iso-Mesh produces thickness and scalar articulation. Surface performance structural and others are interpreted precisely from these nuances. These conditions and characters are taken directly into the design of the mold including the line-work that reinforces the structural performance of the surface and suggests the alignment of the C-glass fabric for performative reinforcement.

Conclusion and Future Work

This project involved generating an object that departed from nature by changing its ontology at the end of the process. Use of the drawing craft presents alternatives for architecture to apply normative modes of production in a different way, through the combination of analog and digital presentations in 2-D and 3-D. The most immediate future development that we will undertake is to fabricate our object using the CNC milling machine to create a base form made out of foam.

After the prototype was built, we did a structural analysis using ABACUS, a software used by aerospace engineering, and determine the performative needs and properties of the object's surface. Additionally, we are currently researching materiality concerns and construction techniques on an architectural scale. Once the properties of each material are deduced, our focus will shift to solving various technical challenges of fabricating parts of the object full scale.

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