

Designing for Chaos

Turning Digital Complexity into a Quantum Science Learning Center

Ari Anderson

Fall 2012

Figure 1.1

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Turning Digital Complexity into a
Quantum Science Learning Center

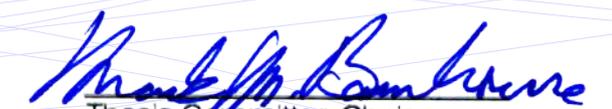
A Design Thesis Submitted to the Department of Architecture and
Landscape Architecture of North Dakota State University

by
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In Partial Fulfillment of the Requirements for the Degree of Master of Architecture

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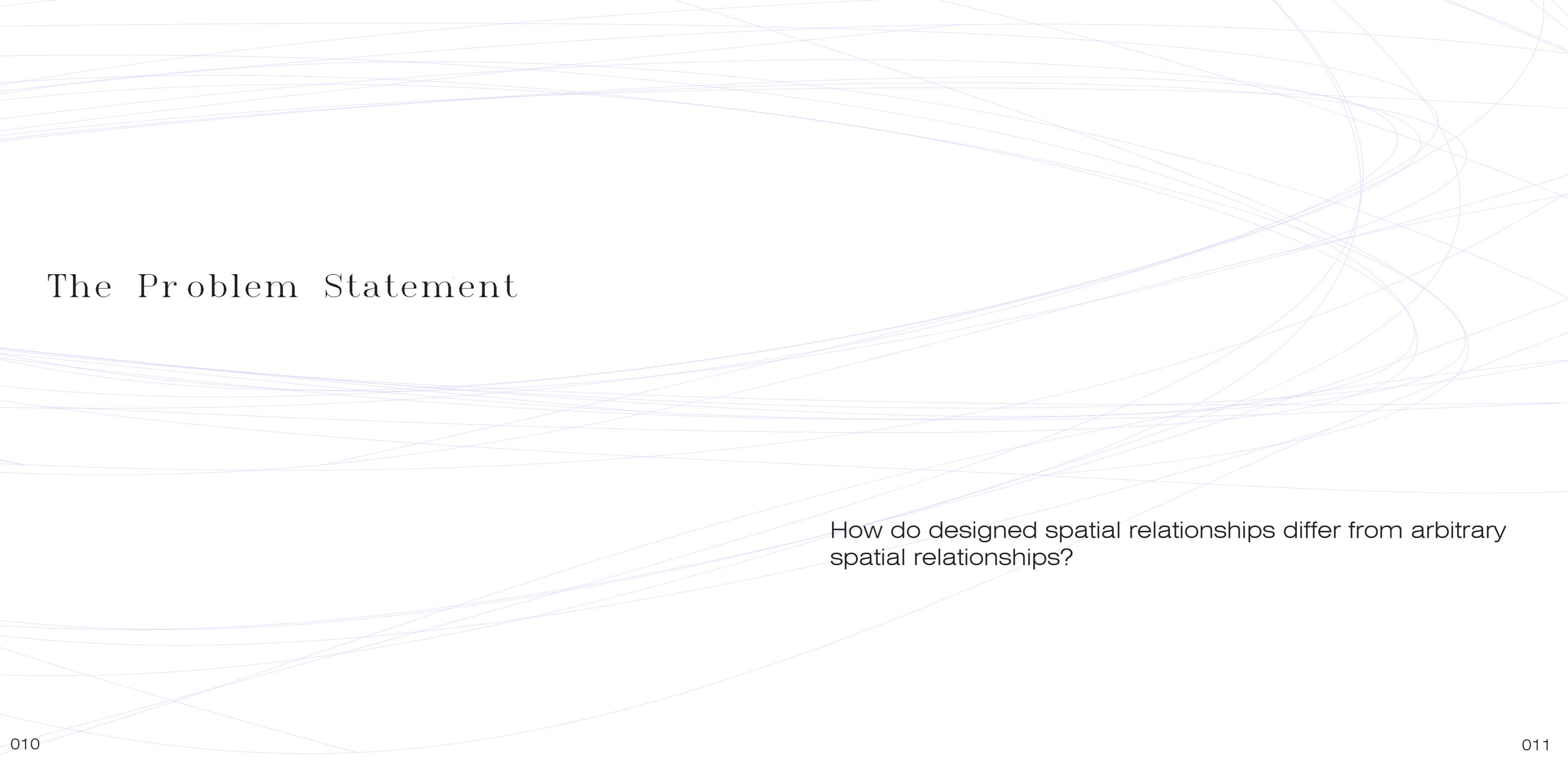
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Abstract:

This thesis will explore the ability of a designer to use the arbitrary relationships generated in complex systems to determine the design of a building. Traditionally, the form of a building is created through a very intentional and precisely thought out process in order to achieve some goal. Recently however, computers have allowed designers to generate forms which emerge from complex systems which produce unpredictable geometries. Today, the form a designer uses in her/his "design" does not have to be designed or intentional at all. These building forms can in fact be arbitrary.

Given the increasing interest in these complex, emergent forms in architecture, it is important to understand how these arbitrary forms can be used to create design solutions. Being able to create a design solution from any type of object (regardless of form or method of generation) will not only validate the use the arbitrary forms generated by the computer in an architectural design, but it opens up new, undiscovered relationships between the building form, function, and site.



The Problem Statement

How do designed spatial relationships differ from arbitrary spatial relationships?

Statement of Intent:

Project Typology

Quantum Science Learning Center

Claim

As design software advances, the generative techniques of the software increasingly surpass the designer's ability to control them. These arbitrary spatial relationships will impact building design and designers must develop tools for not only dealing with unpredictable geometries, but also find ways to unlock the potential of an arbitrary building form.

Actor: A complex or arbitrary form

Action: Reversal of the traditional design process.

Object: The building form

The manner of the action is through a design process and an analysis of the results.

Theoretical Premise

With computer generated forms, beyond the imagination of any designer, at which point does the designer give in and accept the fact that s/he may not be the one designing this century's new building forms? There is an increasing interest in "emergent design" software where unexpected structures and forms are developed through advanced computer modeling. As Kostas Terzidis (2008) explains, "Such systems, despite being human creations, consist of parts and relationships arranged in such complicated ways that often surpass a single designer's ability to thoroughly comprehend them even if that person is their own creator" (p. 75). These emergent structures, or often called, self-organizing structures, are beyond the ability of anyone to predict.

While these, computer generated "mistakes" provide a way to generate intriguing new forms, without an effective way to process these digital outputs the resulting design will suffer.

Traditionally, the form of a building is created through a very intentional and precisely thought out process and the final shape of the building is the result of the function and program of the building. Because these new forms are impossible to predict, it is impossible for these forms to be the final product of this traditional and intentional design process. The introduction of an arbitrary form into an already developed program or layout would create a conflict between the design intentions of the layout and the arbitrary nature of the form. To avoid this conflict one must use an alternative method of design. This method begins with the arbitrary form to realize unanticipated contributions to building design. By beginning with the arbitrary form as a tool for making design decisions, the designer can incorporate the unpredictable form into the design without a conflict between intention and arbitrariness.

Project Justification

Given the increasing interest in computer generated and emergent forms in architecture, it is important to understand how these unintended forms can be used to create design solutions. These forms, which are growing beyond the control of the designer, should be able to create architecture which is as functional and as inspired as architecture which is created from forms determined by the designer. Being able to create a design solution from any type of object (regardless of form or method of generation) will validate the use the arbitrary forms generated by the computer for architectural design.

Furthermore, the arbitrary nature of these forms will allow for new potentials not yet realized by traditional design methods. Because the forms created from this traditional method are derived from an intentional response from the site and program on behalf of the designer, this establishes a fundamentally different method of form creation than an arbitrary, algorithmic based method of deriving form. This fundamental distinction calls for the exploration of new design methods with the aim of producing new, unexplored potentials for design.

Thesis Proposal:

Nar r ative

The Unpredictability of Quantum Mechanics

At the dawn of the 20th century several scientists began to work on answering questions about the atom. What they discovered changed the very foundations of how we were to understand our world. It was found, in stark contradiction to the order and tangibility of classical physics, that objects, space, and time do not operate independently of one another. On the incredibly large scale, space and time do not behave as we would expect. In fact on the cosmological scale objects, space and time are so interconnected that objects begin to warp space and time. What is more is that the degree of this warping changes, not with relation to the objects, but with regard to the observer. This is known as relativity.

This large scale behavior is not nearly as bizarre as what occurs on the incredibly small scale. On the incredibly small scale, elementary particles, which we would assume to behave as objects, in fact do not. This strange behavior on the incredibly small scale is called quantum mechanics. What was found is that elementary particles are not always objects, although sometimes they are. When an elementary particle is not acting as an object it is acting as a range of potentials. This means that if an observer doesn't know if a particle is at point A or point B, the particle behaves as if it were in both places. A physicist by the name of Werner Heisenberg described the bizarre nature of these elementary particles as uncertainty. He made it clear that uncertainty was not our inability to measure these particles properly which made their behavior indeterminate, but it was the fact that by observing these particles we force them to assume a state of existence. As Heisenberg states, it is the act of interacting with the outside world which makes the particle change the nature of its behavior. The very fact that we observe these particles determines their behavior, a behavior which would otherwise exist as a range of various, even contradicting potentials.

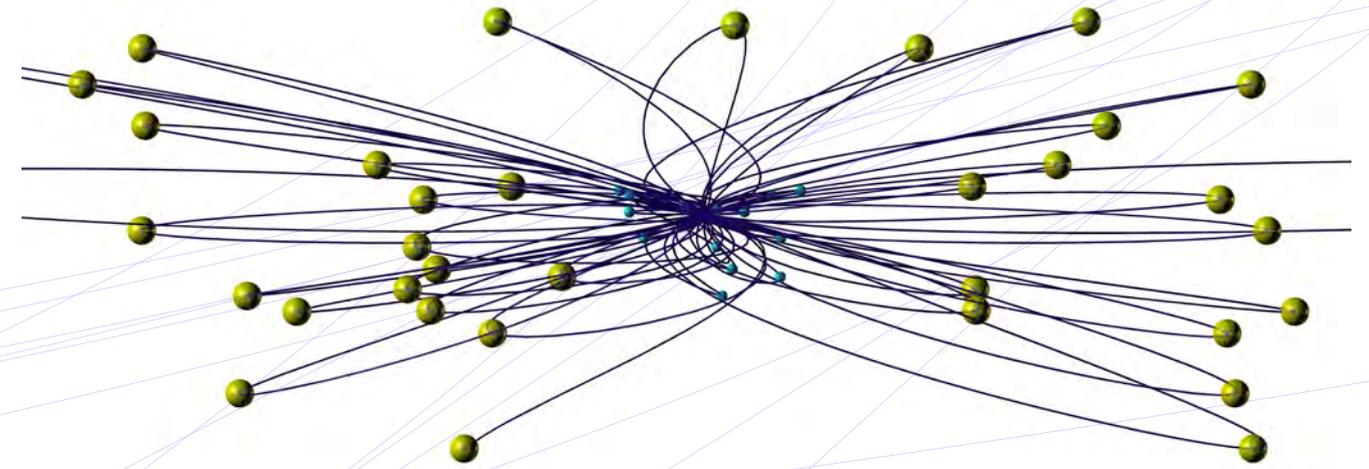


Figure 1.5

Disproving the Classical Order

During the beginning of the 20th century, many experiments were conducted to observe the behavior of these elementary particles. Time after time physicists began to tease out this strange behavior and soon the full implications of these unexpected phenomena became realized. In both the large and small scales, the role of the observer became fundamentally important in how the universe behaves. Classical science during the 19th century was founded on the principle that universe behaves in ways which is independent of the observer. There was an understood order to classical science which was structured and consistent for all frames of reference. As Heisenberg explains,

“The nineteenth century developed an extremely rigid frame for natural science which formed not only science but also the general outlook of great masses of people. This frame was supported by the fundamental concepts of classical physics, space, time, matter and causality; the concept of reality applied to the things or events that we could perceive by our senses or that could be observed by means of the refined tools that technical science had provided. Matter was the primary reality” (Heisenberg, 1958, p. 171)

To a classical physicist it was unthinkable that the fundamental building blocks of our world would behave in a way which is by definition indeterminate. The observations of modern physics, particularly the uncertainty inherent in quantum mechanics, dissolved this “rigid frame” of how the universe ought to behave and opened up a broader understanding of reality. Heisenberg continues,

“it might be that the openness of modern science could make it easier even for larger groups of people to see that the doctrines are possibly not so important for the society as had been assumed before. In this way the influence of modern science may favor an attitude of tolerance and thereby may prove valuable” (Heisenberg, 1958, p. 178).

It is the uncertainty introduced by quantum mechanics and modern science of the 20th century which overturned the unquestioned applicability of natural science to all facets of life.

The four main discoveries of modern science which changed scientific understanding of the universe were, the unavoidable involvement of the observer in the behavior of particles, the acceptance of contradicting behaviors to create a complete description of an event, the behavior of a particle as simultaneously a range of potential and an isolated event, and how changing frames of reference change the nature of both space and time. These new perspectives have changed the way we understand our relationship between ourselves and the universe. The classical perspective that all understanding could be observed, measured, and quantified does not hold in quantum theory. As Heisenberg suggests, it is “in this way modern physics has perhaps opened the door to a wider outlook on the relation between the human mind and reality” (Heisenberg, 1958, p. 176). For this reason, it is important for the concepts modern physics to be accessible and understood by as many as possible.

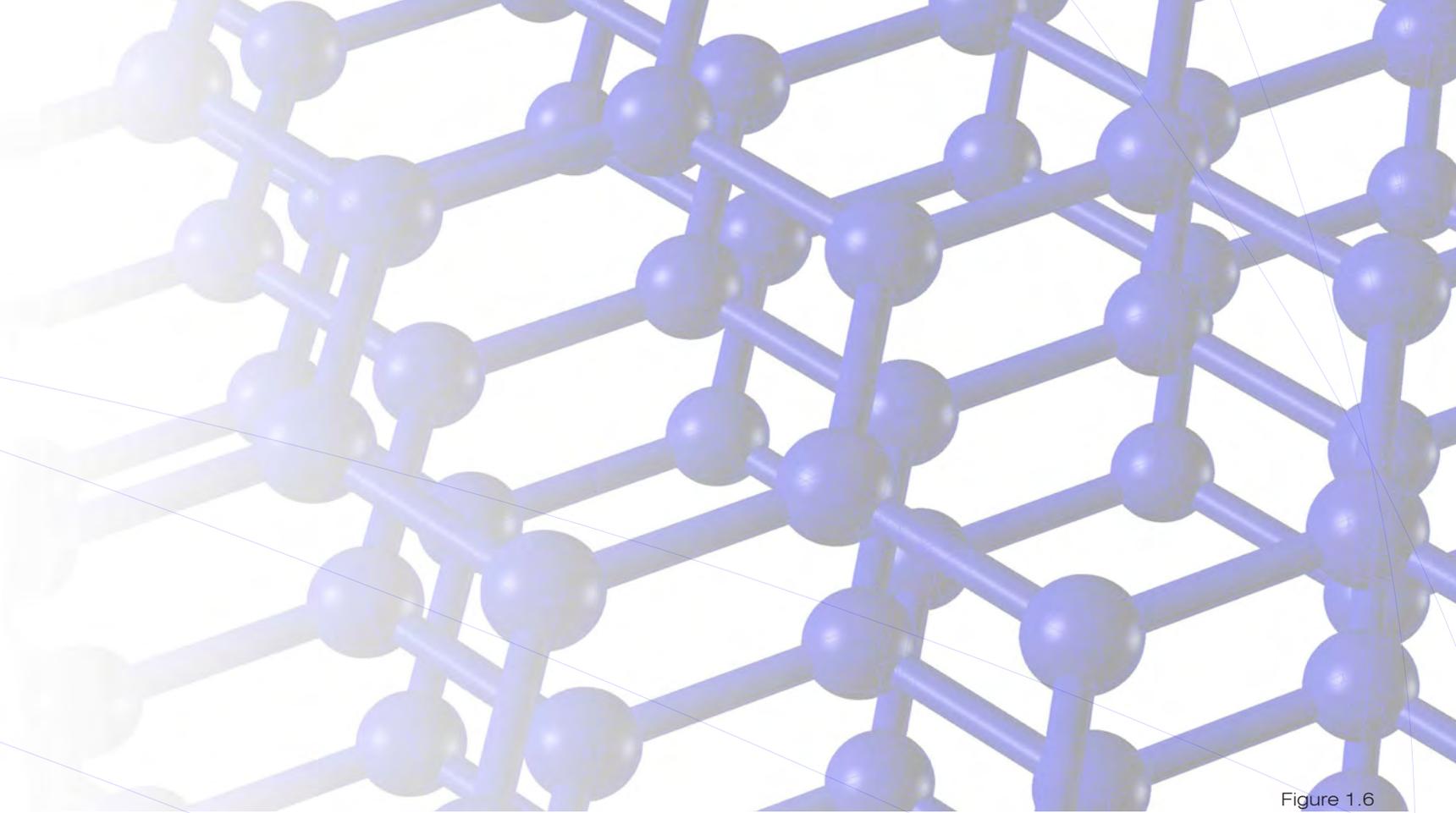


Figure 1.6

The Future Role of Quantum Mechanics

Quantum mechanics is playing an increasingly important role in our lives. Quantum computing, carbon nanotubes, graphene, nanotechnologies, and countless other technologies are increasingly reliant on the principles of quantum mechanics and particle physics. Understanding these concepts is difficult. Quantum mechanics is inherently unintuitive and there is a lack of accessible vantage points with which to grasp the concepts. Television programs such as “Nova” and “Through the Worm Hole” are reasonably accessible, but most science museums focus on topics of Natural, such as Weather systems, momentum, or electricity. One would be hard pressed to find an exhibit displaying and illustrating quantum principles. As our world becomes increasingly quantum, there is an increasing need for a science museum which focuses on the complex and unpredictable nature of quantum mechanics.

Using Complex Emergent Forms to Explore the Concepts Behind Quantum Mechanics

Because of the inherent uncertainty behind complex emergent forms, the ideal building typology for this method of design would resonate with the unpredictability of these forms. Over the past century we have had a revolution in physics. This revolution pivoted around the nature of the very small. This branch in physics, which deals with the very small, is known as quantum mechanics. What quantum mechanics has illuminated is that although on the large scale (the scale on which people, animals or planets interact) events and movements are fairly predictable, on the incredibly small scale (the unimaginably small scale of electrons, protons and other particles) interactions and phenomenon become incredibly unpredictable. According to quantum mechanics, there is an indeterminacy with the position of a particle at any given time, however, when the position of the particle is measured this particle does in fact manifest into a location. The most widely accepted explanation of this phenomenon is called the Copenhagen interpretation which states that, "The particle wasn't really anywhere. It was the act of measurement which forced the particle to 'take a stand' [...] Jordan said it most starkly: 'Observations not only disturb what it is to be measured, they produce it . . . We compel (the particle) to assume a definite position.'" (Griffiths, 1995, p.3-4) In quantum mechanics, it is the experiment itself which determines the results. There is an inherent dialogue between the thing which is attempted to be measured and way in which we attempt to measure it.

This back and forth relationship between particle experiments and the results the experiment produces resonates with Denise Scott Brown's discussion of buildings and context in her essay "Context and Complexity." Brown discusses the influence of buildings on their context and vice versa. She portrays a building as "an element in its own right having an ongoing and changing dialogue with the building" (2008, p. 25). She continues in her essay to argue that "The designer of a building or complex has the opportunity of entering into the changing context, using and adapting its meanings in the individual project, and in doing so, changing the context once again. And both would go on changing forever." Brown is arguing that the introduction of building to a site creates an ongoing dialogue which will inform future design decisions on that site. Essentially the design process continues even after construction.

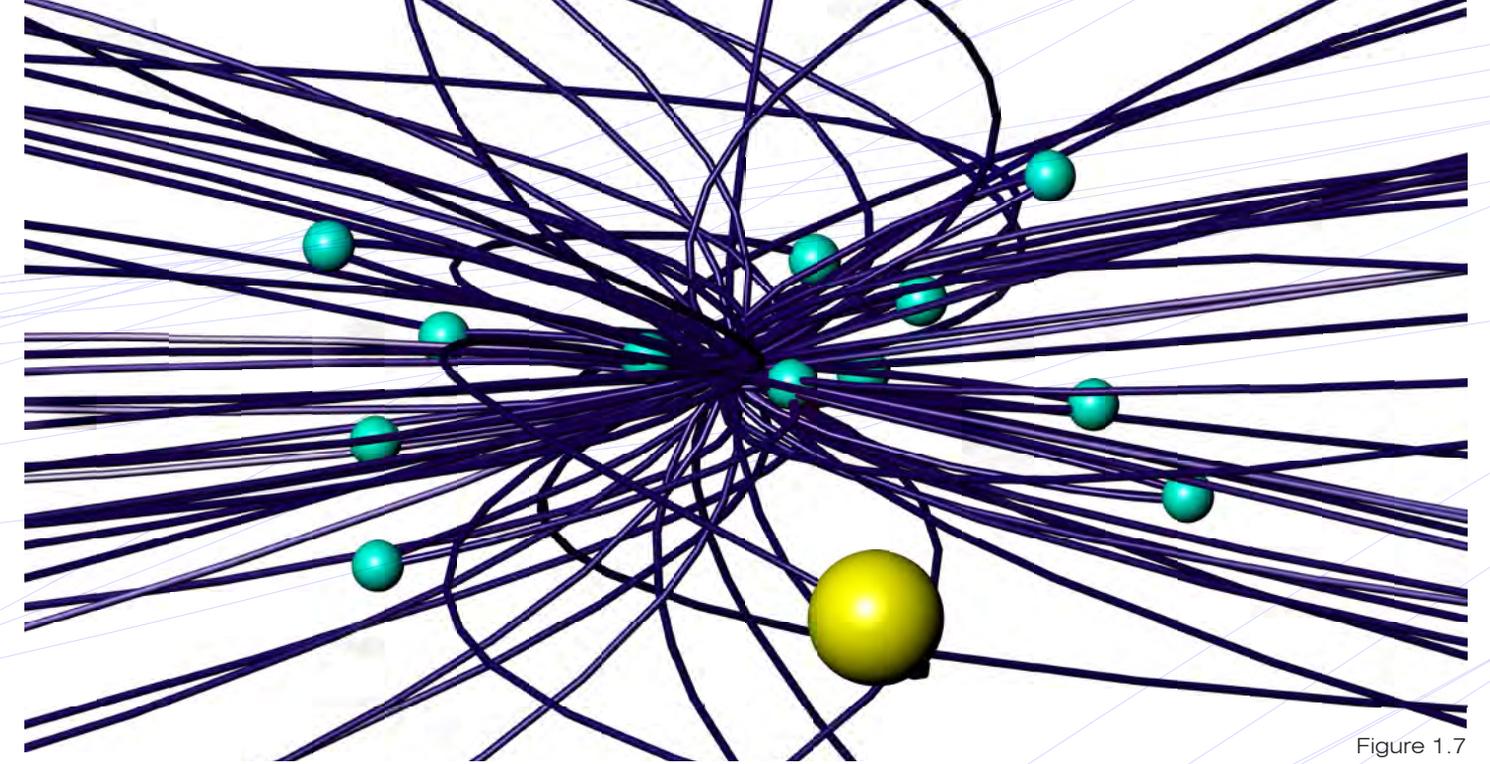


Figure 1.7

To come full circle, the design process outlined by Brown uses this dialogue between buildings and their context as an essential mechanism in making design decisions. Like a quantum experiment making the indeterminate position of a particle produce a position, this alternative design process uses the urban context and design typology to make an arbitrary form produce a substantial building.

For this thesis, I will use the alternative design process which I have outlined to analyze to bring into fruition a Quantum Science Learning Center from an arbitrary form generated on the computer. The complex and unpredictable nature of these emergent forms speaks to the indeterminate and chaotic nature of quantum science. Because of this, the building typology of a Quantum Science Learning Center makes an excellent tool (both practically and metaphorically) for the exploration of a design process which analyzes inherently unpredictable forms. By beginning with an unpredictable, 'indeterminate' form and giving it context, I will generate a dialogue between the existing context and an entirely new object. This dialogue will inform the creation of a new Quantum Science Learning Center which will serve as a center to teach and discuss the concepts and implications behind the science of quantum mechanics.

User Client Description

My Client for this Quantum Science Learning Center is the U of M. The University is the perfect institution to support, advise on, manage and make use of a quantum science learning center.

This building will be used to educate the public about the nature of Quantum Mechanics, to host experiments for U of M researchers, and to function as a resource for the local scientific community.

The building will also be a mixed use project to engage and further develop the surrounding community.

Major Project Elements

The main features of a Quantum Science learning center include:

- Galleries
- Classrooms
- A Presentation Hall
- A Reception Hall
- Laboratories
- Research Library
- Administration and Offices
- A Gift Shop
- Parking

Project Emphasis

The emphasis of this project will be in the process by which I carry out the design. The aim of this approach is to explore new design strategies to capitalize the overwhelming output of unpredictable or arbitrary digital geometries.

Site Information

My site is located within Minneapolis by the University of Minnesota's West Bank.
Notable site features include:

- The University of Minnesota
- The Cedar Riverside Apartments
- A nearby light-rail stop
- A Highway
- A Small Urban District



Figure 2.1

Minneapolis



Figure 2.2 - Google Maps 2012

Plan for Proceeding

I propose to take one of these arbitrary digital forms and transform it into an effective building as influenced by its site and function. This method seeks to transform an abstract digital model into a functioning building. By beginning with an arbitrary building form, this process can explore the serendipitous opportunities made possible by an arbitrarily generated from.

I have scheduled the Form Analysis during most of October and November to coincide with the programming process. This way I can meet the deadline for the program document. I plan to analyse the Form through the making of drawings and models. This is why I have scheduled my Thesis Drawings to begin at the same time as the Form Analysis.

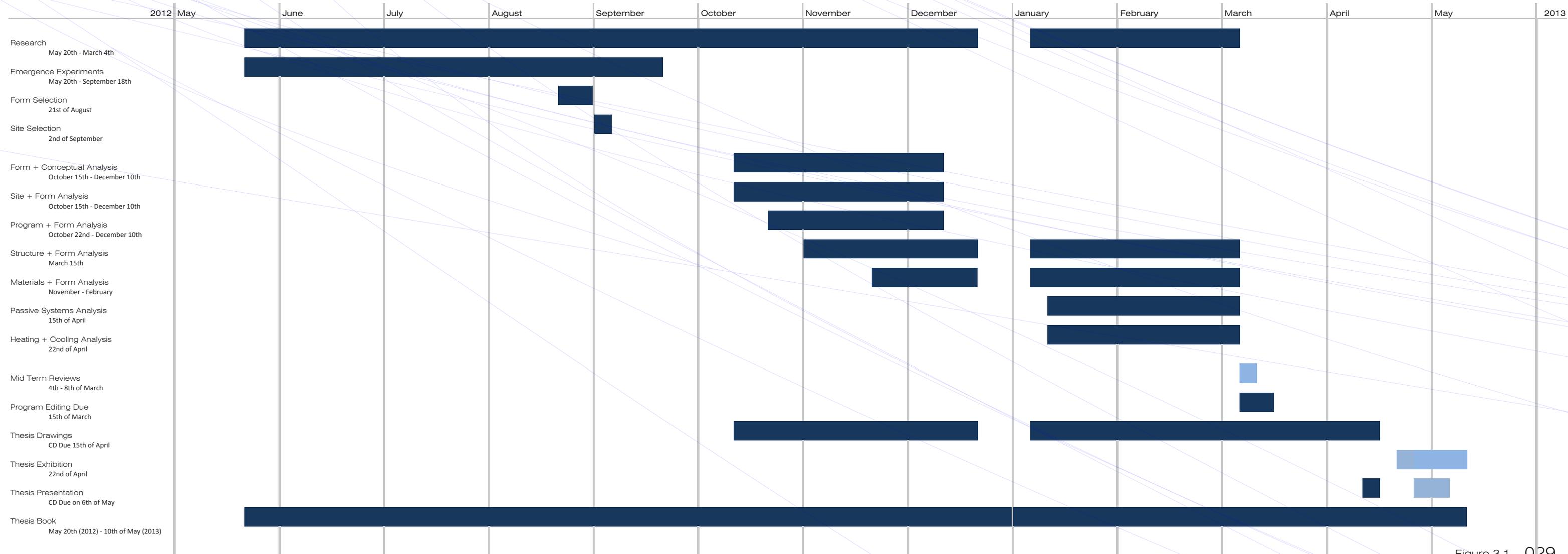


Figure 3.1 029

Design and Studio Experience:

2nd Year:

Fall: Studio - Darryl Booker
HB:BX High Bridge Studio - Design Competition
Spring: Studio - Stephen Wischer

3rd Year:

Fall: Studio - Milton Yergens
Spring: Studio - Mike Christenson
Brazil + Argentina Summer Study Tour - David Crutchfield and Ron Ramsay

4th Year:

Fall: Studio (High Rise Project) - Frank Kratky
ArchMedium Paris Market Lab - Design Competition (Finalist)
Spring: Studio - Paul Gleye - Université Lille Nord de France - Lille France
AC-CA Buenos Aires Museum of Modern Art - Design Competition

5th Year:

Fall: Studio - Ron Ramsay

Figure 3.1

Theoretical Premise
Research:

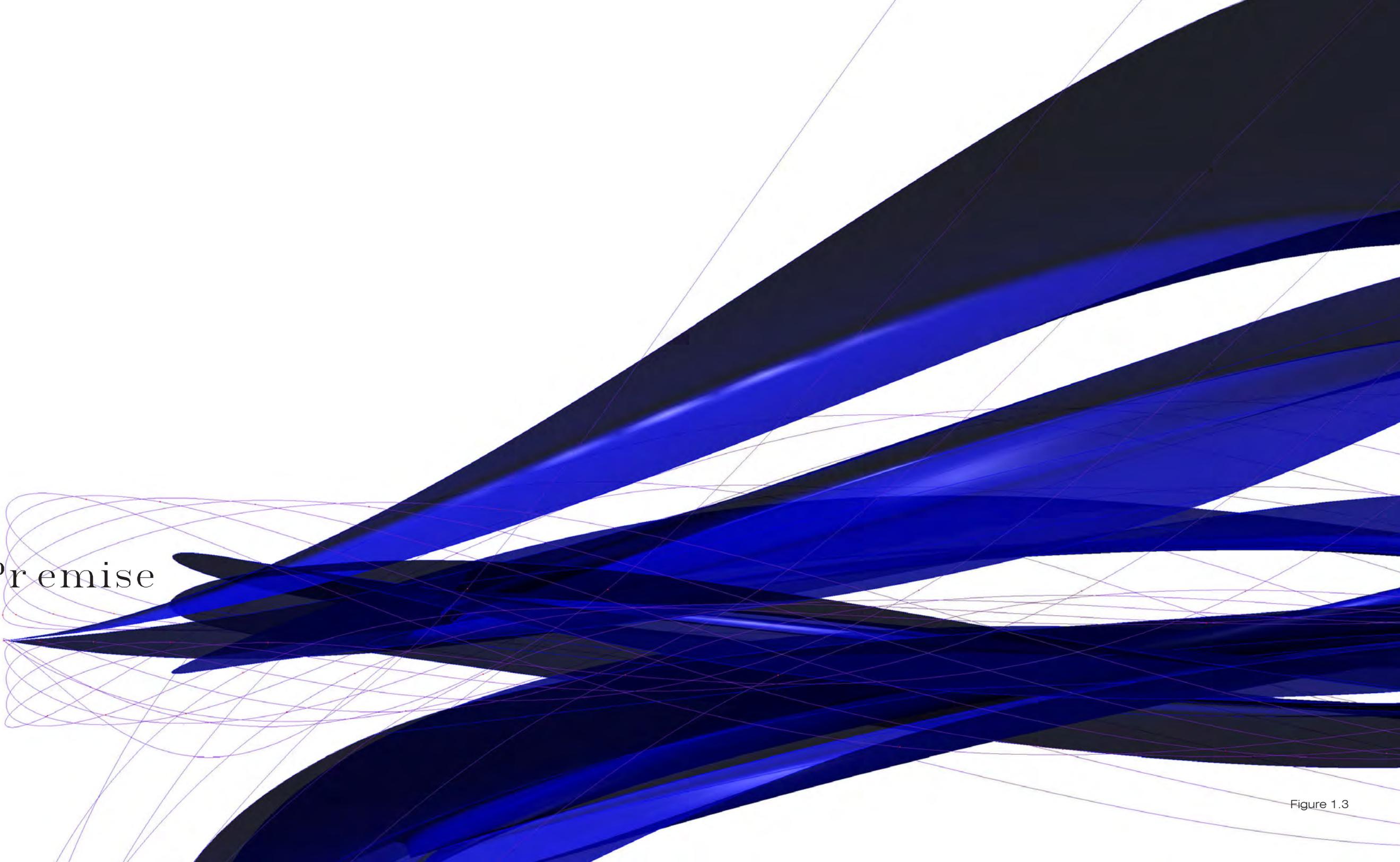


Figure 1.3

Complex Emergent Forms:

For the past half century many architects have been trying to create new architectural forms which are not only unique, but increasingly dynamic and complex. In the quest to explore these new and exciting geometries, the computer has been an invaluable resource which has not only facilitated these geometries, but in fact spurred them on with new tools for producing and understanding these forms. Today these tools have become so advanced that they are not only used to sculpt geometry, but they are used to generate it.

One type of form-generating method produces geometries which are inherently unpredictable. The algorithms used are iterative, which means that each cycle of computation responds to the output of the previous cycle. In order to know what geometry will result after the 100th cycle of a computation, one must first run the other 99 cycles. This type of unpredictable, iterative geometry is known as complexity.

This means that the geometries produced do not come from the mind of the designer, but from the algorithm used and the programming of the computer. Even if the designer does program the form-generating tool, s/he is still creating a form indirectly and will be unaware of what the resulting form will be. S/he may have an idea of what the geometry may look like based on how the program is set up to interact with itself, but the results of that interaction are still unknown. Designers are setting the parameters of the form generating system and waiting to see what geometries emerge. The formation of unexpected geometries out of complexity is called emergence.

Complexity and emergence are not just unique to computational algorithms. The inherent unpredictability of complexity is seen every day in weather patterns, air turbulence, flocks of birds, swarms of insects, schools of fish, growth of plants, and almost every aspect of nature. From this complexity in nature we see countless emergent geometries. Cloud formations, the structure of trees, organic growth, the freezing of water, the branching of a leaf, and any other type self organizing structure can be called emergence. In every iterative system in nature the inherent complexity of the system eventually yields some type of emergent geometry (Mainzer,2008).

It is these complex emergent forms that designers are now generating with the computer. With the complexity of the equations and the unpredictability of the resulting forms, there is no way to know the exact shape or behavior of a complex emergent form before it is generated. For these designers, the unpredictability of the system is its value.

Mark Burry, professor and director of the Spatial Information Architecture Laboratory (SIAL) of RMIT University in Melbourne and executive architect and researcher to Gaudi's Sagrada Família, discusses the value of these unpredictable forms. He argues that the accidental or the unpredictable forms are in most cases unrepeatable, but it is in their unrepeatability that these accidental forms have value. Burry compares digital chaos to the work of Jackson Pollock. Burry writes with regard to Pollock's paintings,

"Its inexact definition [...] and nonrepeatability is its uniqueness, and its value. The equivalent in surface representation within the virtual realm comes from deliberate tinkering with on-board algorithms, or through programming which incorporates random numbers or some aspect of chaos theory or from serendipity. In most circumstance the results are unpredictable and unrepeatable. With some unrecorded and poorly remembered series of operations, surprising results nevertheless emerge" (Burry, 1999, p.78).

It is these surprising results which have the potential to both suggest and inspire new architectural ideas. However, the key difference between Jackson Pollock's work and unpredictable algorithms is that the forms produced from these algorithms are documentable, transformable and thereby usable. Unlike Pollock's work, in which the unpredictable result is the end product, the usability of these forms allows unpredictability to act as the starting point.

Many designers are now calling for more unpredictability in our built world. One such designer, Cecil Balmond, is very critical of the ordered, formulaic, predictable architecture which makes up most of our built world. He calls this type of architecture 'Formal'. As Balmond explains, "The Formal marches to strict rhythms. Why the necessity to space out structure equally, like soldiers marching on a parade ground?" (Balmond, 2002, p.62) What Balmond finds interesting and desirable is irregularity, asymmetry and unique geometries. This unpredictable, unexpected architecture is what Balmond calls the 'informal'. According to Balmond, the 'informal' is a method of questioning established methods and circumventing predictability. The 'informal' architecture is provocative, elusive, and is not immediately understood. It demands participation with those who encounter it (Balmond, 2002). Balmond's 'informal' is demonstrated in the uniqueness and nonrepeatability of Jackson Pollock's paintings and it is the inherent unpredictability of emergence. It is the unpredictability of complex emergent forms and the new trend for many designers and architects. The complex forms of some of the most famous architects including, Zaha Hadid, Daniel Libeskind, Frank Gehry, Thom Mayne and Morphosis, and countless others are tending towards the "informal". Since the shift away from Modernism and the order it prescribed, architecture has been looking to differentiate itself from what has been done before. The most appealing design is the one which has something new to say. The most appealing designs are 'informal', unpredictable, and even accidental. As Burry states, "A world that is open to continuous change and to becoming different, requires an *ars accidentalis*. The creativity and the productivity of the accident, the break and the fall, have to be understood as the potential to achieve new forms of heterogeneity and of the disjunctive synthesis" (Burry, 1999, p.78). The "informal" is becoming the new architecture of our time. To create something new, architects are using the unpredictability of complex emergent forms to produce unexpected geometries. Architects are no longer designing forms, they are generating them.

Complex Emergent Forms:

This method of producing forms creates a significant shift in the role of the designer. Instead of acting as a producer of form, a designer must respond to it. The same way a designer responds to the conditions of a site or typology, with a complex emergent form, a designer must respond to what the computer has generated. This may seem like the designer is reducing his/her role in the design process, but Professor Chris Wise, director of expedition engineering and chair of civil engineering at Imperial College London, explains that this is not the case. Wise, acting as an internal examiner to the Emergent Technologies and Design masters program at the Architectural association in London, writes,

“So far, the emerging technologist has to limit the output of the process to an object rather than a project. A project has a definite purpose. A project has a site. A project interacts with people. It interacts with climate. It interacts with time. And unlike a computer process it is made up of imperfect materials and things that change according to this interaction. In short, the project lives. And in part in having life, it enriches the lives of those involved in putting together the project and the next one. Somehow the algorithm and the wax modeller don't quite do this for me. Yet” (Wise, 2004, p.57).

As Wise describes, an emergent form is incomplete without a designer. In this way computer-generated forms have not subverted the role of the designer, but have enhanced their role. With complex emergent forms, it becomes the responsibility of the designer to turn the object a computer produces into a viable, meaningful project. To recognize the potential usefulness of an arbitrary object is an ability which cannot be replaced by anything other than human innovation. This requires a type of thinking that cannot be reproduced within an algorithm. The role of the designer is then to reconcile this arbitrary object with the objectives of the project and turn the object from something arbitrary into something useful. Through the task of reconciling an arbitrary object with an architectural problem, the designer will discover new solutions which would have never presented themselves if it had not been through the use of an arbitrary object.

The Need for an Alternative Design Process:

This reconciliation between the object and problem requires a change in the traditional design processes. Professor Mark Burry explains the traditional design method in regards to unpredictable or accidental geometry, "In many cases architectural design favors a linear process where design can build upon itself. Any reiterative process will require some ability to go back in the design process in order to proceed forward in a different direction. This of course is rather difficult if the process is accidental and less well understood than the outcome" (Burry, 1999, p.78). When using unpredictable forms there, is a need for an alternative method of design.

Traditional Design Process

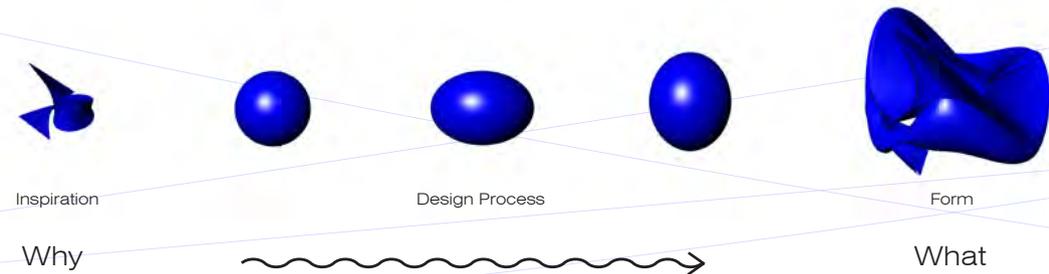


Figure 5.1

In the figure above there is a very simplified diagram of a traditional design process. One begins with the inspiration which may come from the site, the building typology, a parti, or any manner of sources. Through a design process this initial inspiration is translated into a form, and because the form is derived from this design process, the resulting "end form" is very intentional and is designed to meet the goals established during the design process. This form is not at all arbitrary.

Alternative Design Process

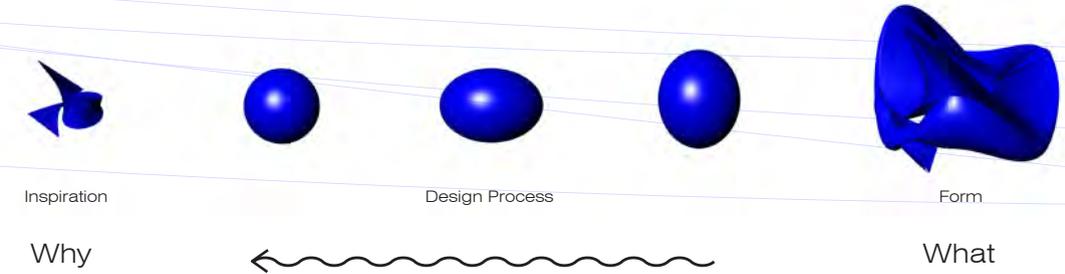


Figure 5.2

In this alternative design process, we begin with an established form and determine what type of inspiration could produce such a form. By beginning with the "end form" this allows the form to be completely arbitrary. Also, because the particulars of the building have not yet been established, there is no disconnect between the form and any initial inspiration, function, or site. With this "end form" already at hand, the designer may realize retroactively what type of site, function or inspiration this "end form" would require. Almost like an archeologist reconstructing a broader picture of a culture from the traces that culture left behind, a designer can reconstruct the purpose of this "end form" s/he created.

This is not to say that the form will not change once the designer takes full control of the process, nor is it suggesting that this is the only process by which architects should design. It simply means that by allowing an initial form to suggest design outcomes, a designer will realize new potentials which otherwise would not be obvious.

By beginning with an object which is arbitrary and thereby independent of a site, program, or context, it is possible to produce something which is completely new. Although old ideas may play a role in the reconfiguration of this object, because the object is completely new, each design decision is inherently a new idea. This means that everything which follows from that object is also completely new. By reconciling an arbitrary form with a site, a typology, and a program, the designer has a starting place which not only addresses the arbitrariness of the form, but in fact affords the designer more control in how this form will be addressed, used, and eventually built. The earlier in the design process these complex emergent forms can be introduced, the more of a role the designer has in reacting to them, improving upon them, making them functional, and understanding their true potential. By starting with the arbitrary form, the designer has the chance to give meaning to something initially arbitrary.

In one way this method of design requires the designer to relinquish an element of control. Cecil Balmond discusses the value of breaking away from this initial control and beginning with something unexpected.

“The creative impulse of jumping out of nowhere is scary. Control and containment are sought. Rigid boundaries are set, chopping up the idea into smaller bits. As a basis of organization we seek an isolated repeating motif as if this reflects an irreducible moment of the continuum; we want to believe in forever and forever. It is hard to believe in singularities or gaps or folds in the thinking, as random start points create fault planes in the belief of homogeneity. In the face of such turbulence, order is endorsed as the safe fortress. But it misses the point: that nature of reality is chance and that ‘order’ may only be a small, local, steady state of a much larger random” (Balmond, 2002, p.115).

The role of design is shifting. More and more designers will have to react to random beginnings and spontaneous discoveries. However these random beginnings are nothing new for designers. Problems which designers have always faced such as site conditions, local building traditions, and demographics are all essentially arbitrary. Even materials gain their properties from inherently arbitrary chemical bonds. Yet time and time again designers have demonstrated their ability to take these arbitrary conditions and produce meaningful, poetic, and lasting designs.

As complex geometries expand in popularity, architects need to reexamine the way they incorporate these complex emergent forms into their designs. To avoid arbitrary glass shells which are disconnected from the architecture they contain, it is crucial to explore new ways of thinking about form. If we do not address the arbitrary nature of these complex forms we will find ourselves overwhelmed with out of control building skins covering unresponsive and boring floor plates, and instead of integrating these complex forms with new and meaningful architectural strategies, we will overlook the real opportunities these new forms offer. By beginning with an arbitrary form, a designer has the chance to produce something, new, meaningful, functional, and unique.

The Applicability of Complex Arbitrary Forms in Architecture:

For a Quantum Science Learning Center the arbitrary nature of complex forms speaks perfectly to the unpredictable and complex nature of quantum mechanics and particle physics. Scientific experiments with subatomic particles consistently show that the world of quantum mechanics is baffling, bizarre, counter intuitive and inherently unpredictable. However, quantum computing, carbon nanotubes, grapheme, nanotechnologies, and countless other technologies are increasingly reliant on the principles of quantum mechanics and particle physics. As technology advances into the realm of quantum physics, it is becoming increasingly important to have an understanding of this unintuitive complex, but important branch of science. As our world becomes increasingly quantum, there is an increasing need for a science museum which demonstrates the complex and unpredictable nature of quantum mechanics.

Priorities of the Thesis project:

The aim of this thesis project will be to design a Quantum Science Learning Center which will utilize the unpredictability of a complex-arbitrary form to create a unique building form which will speak to the unpredictability of quantum mechanics. By beginning with an unpredictable form, it is possible to reveal on unintended or previously unrealized relationships between the site, program, form, and community. The final purpose of this Quantum Science Learning Center will be to explore the potential of complex-arbitrary forms, create an architectural expression of a scientific perspective, and to provide an educational tool for the community and the University of Minnesota with a focus on the complex nature of quantum mechanics and particle physics.

Research Summary:

For the past half century many architects have been trying to create new architectural forms which are not only unique, but increasingly dynamic and complex. One type of form generating method produces geometries which are inherently unpredictable. This means that the geometries produced do not come from the mind of the designer, but from the algorithm used and the programming of the computer. It is these complex emergent forms that designers now generating with the computer. The unpredictable forms are in most cases unrepeatably, but it is in their unrepeatability that these accidental forms have value. It is these surprising results which have the potential to both suggest and inspire new architectural ideas and many designers are now calling for more unpredictability in our built world.

This method of producing forms creates a significant shift in the role of the designer. Instead of acting as a producer of form, a designer must respond to it. Through the task of reconciling an arbitrary object with an architectural problem, the designer will discover new solutions which would have never presented themselves if it had not been through the use of an arbitrary object.

This reconciliation between the object and problem requires a change in the traditional design processes. To fully harness the arbitrary nature of the complex emergent form, the process of reconciling the form and the architectural problem must begin at the beginning of the design process. In this way the form becomes a vehicle for design instead of a result of design. This is not to say that the form will not change once the designer takes full control of the process, nor is it suggesting that this is the only process by which architects should design. It simply means that by allowing an initial form to suggest design outcomes, a designer will realize new potentials which otherwise would not be obvious. By beginning with an object which is arbitrary and thereby independent the site, program, or context, it is possible to produce something which is completely new.

As complex geometries expand in popularity, architects need to reexamine the way they incorporate these complex emergent forms into their designs. If we do not address the arbitrary nature of these complex forms we will find ourselves overwhelmed with out of control building skins covering unresponsive and boring floor plates, and instead of integrating these complex forms with new and meaningful architectural strategies, we will overlook the real opportunities these new forms offer. By beginning with an arbitrary form, a designer has the chance to produce something, new, meaningful, functional, and unique.

Case Studies:



Church of Colònia Güell (1898)

Type: Church (Unfinished)

Location: Santa Coloma de Cervelló, Barcelona

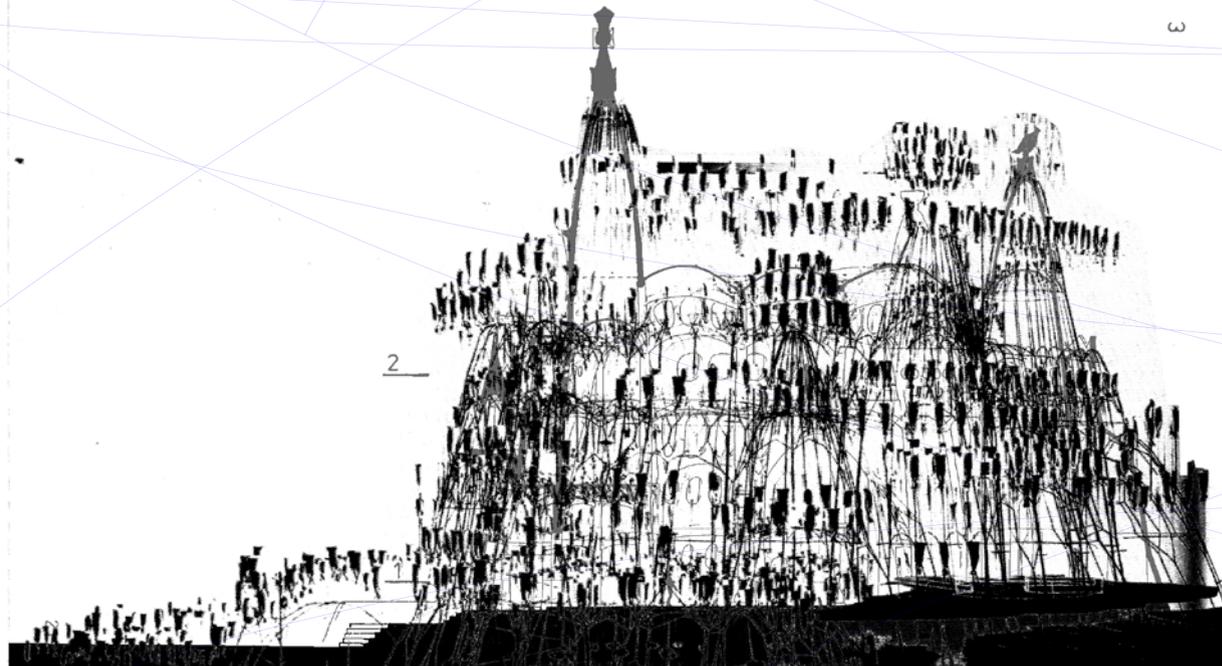
Programmatic Elements: Sanctuary, Entrance Gallery, Basement, Crypt, Baptistry, Library, Choir Gallery.

Figure 6.1 - Church of Colònia Güell hanging model
(Tomlow, 1989)

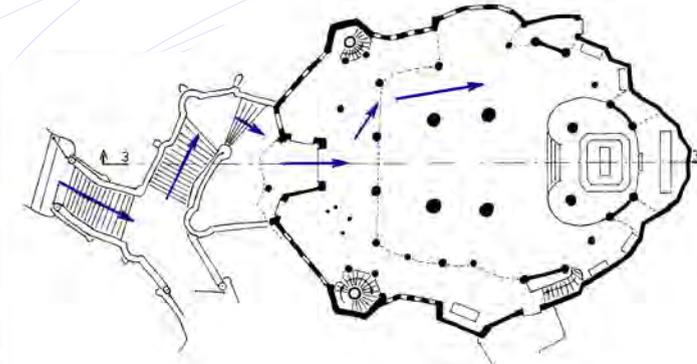
Church of Colònia Güell:

The Church of Colònia Güel is one of Antoni Gaudí's unfinished works in Santa Coloma de Cervelló, near Barcelona. Only the basement and crypt of the church were built. The significance of this church comes from Gaudí's design method. The structure of the church came from the use of a hanging model, a method Gaudí pioneered as a tool for generating structural forms. After the hanging model created the iconic structural geometry of catenary curves, Gaudí took a photograph of the hanging model, flipped it, and drew over it to create the profile of the church (Crippa, 2007, p.43). The form of Gaudí's church was derived from the geometry his model created. Although Gaudí's suspended model predates any computer modeling software by a century, this was one of the first dynamic models to be used, not only as a medium for depicting geometry, but as a tool for generating it. Since this design process is geometrically driven, the form of the Church of Colònia Güel is derived, not from conventional methods of construction, but from an abstracted representation of gravitational forces. The result of this new method of form generation was the first ever architectural use of the hyperbolic paraboloid in a building (Tomlow, 1989, p.21). Even though the Church of Colònia Güel was never completed, the method of hanging wires was used to test structural ideas Gaudí would later use in his masterwork Sagrada Família.

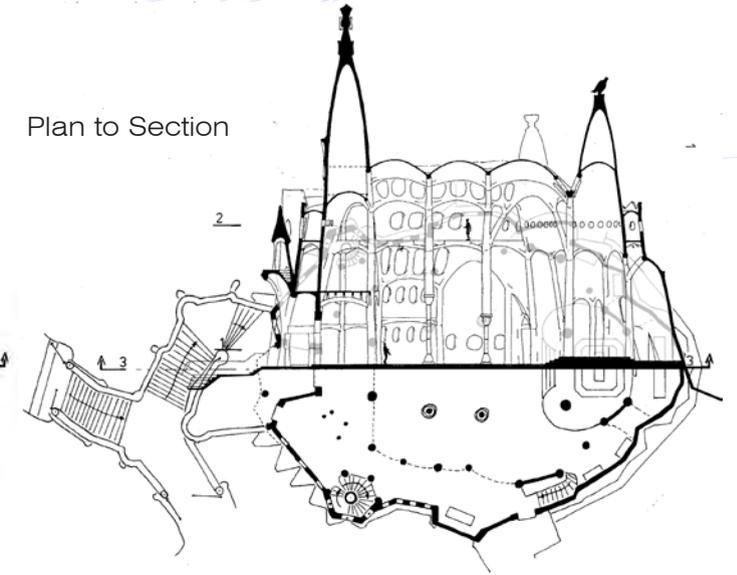
Geometry



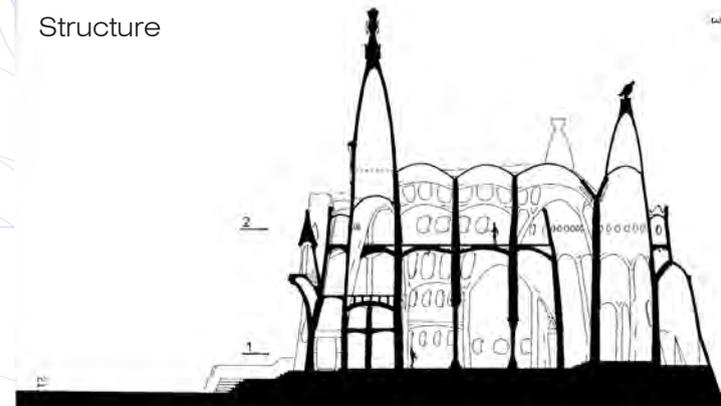
Circulation + Movement



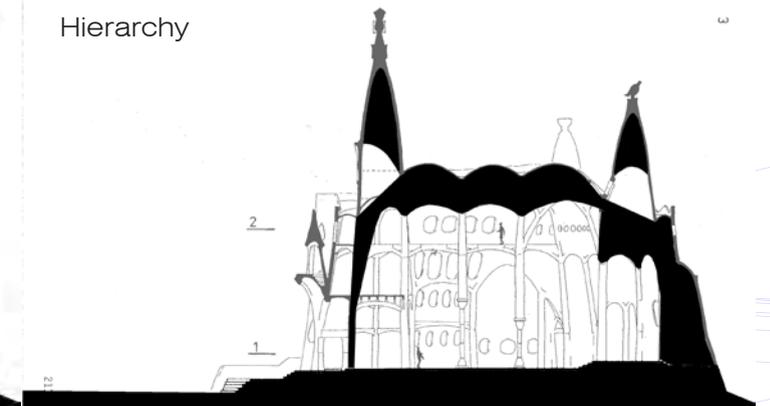
Plan to Section



Structure



Hierarchy



Natural Lighting



Massing

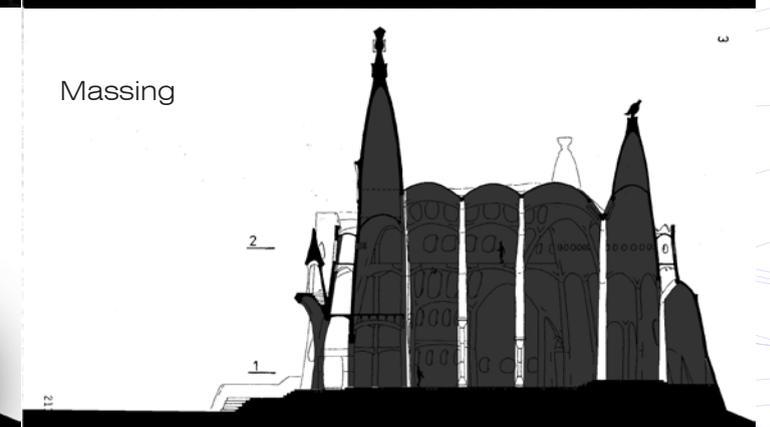


Figure 6.2 (Tomlow, 1989)

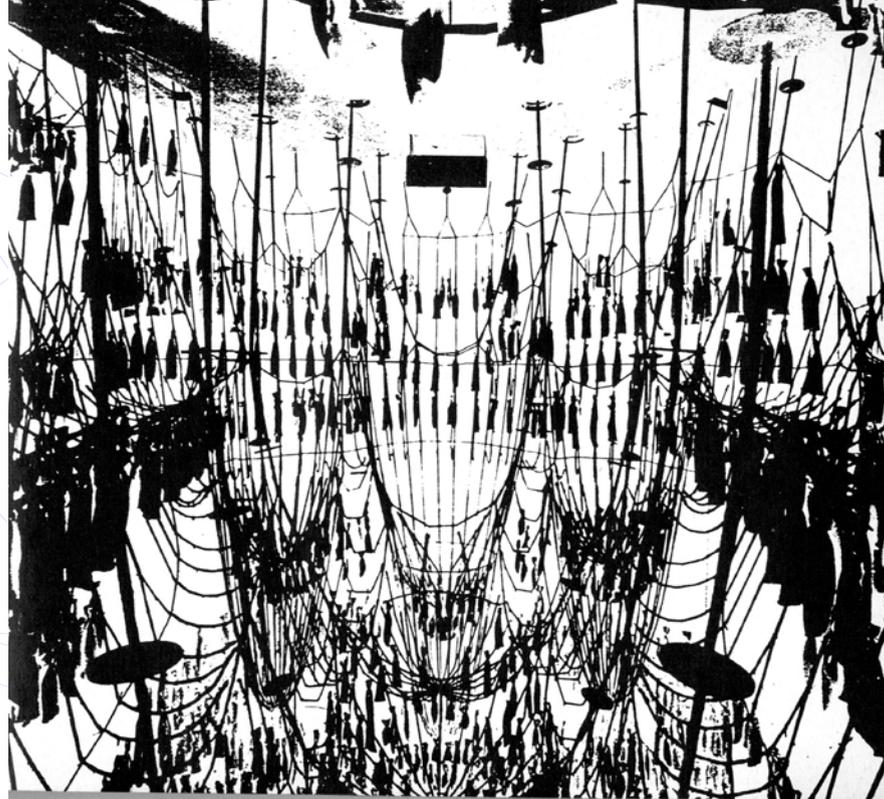


Figure 6.4 - Completed crypt of the Church of Colònia Güell (Tomlow, 1989)

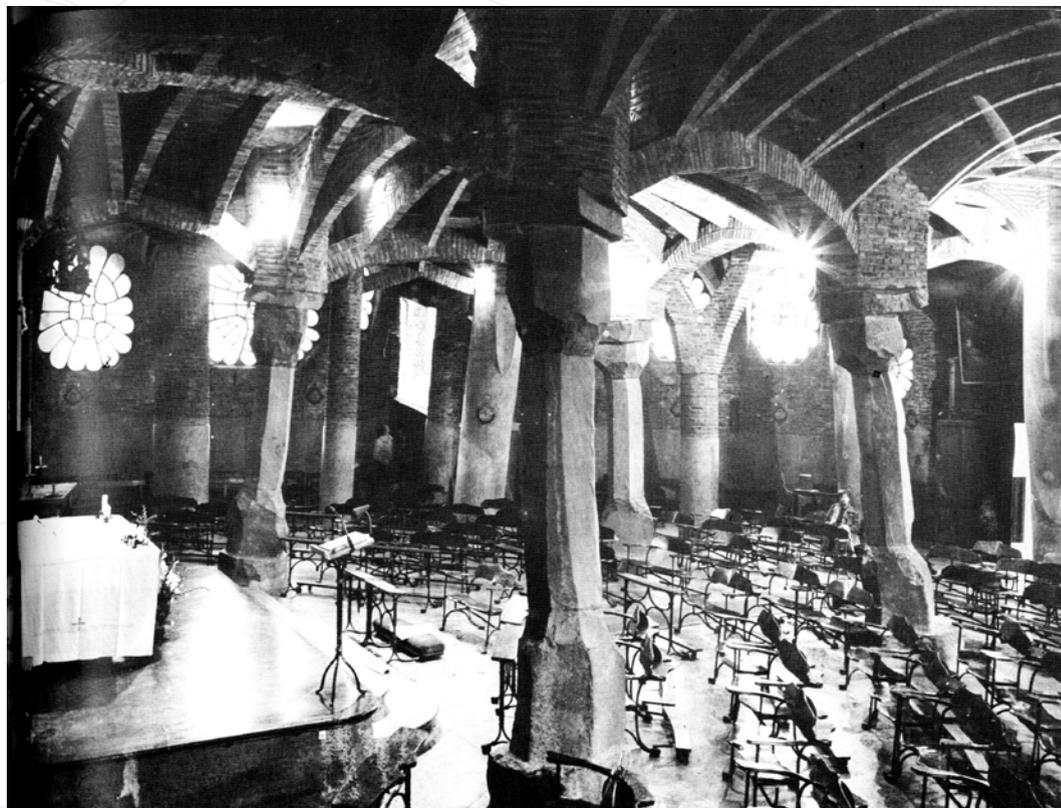


Figure 6.3 - Church of Colònia Güell hanging model in silhouette (Tomlow, 1989)



Figure 6.5 - Reconstruction of Antoni Gaudí's hanging model for the Church of Colònia Güell (Tomlow, 1989)



Figure 6.7 - Church of Colònia Güell hanging model (Tomlow, 1989)

Conclusion:

As one of the first buildings where the geometry was derived, not from the architect's, but from a set of rules imposed upon an interconnected system. Although Gaudi maintained a great deal of control of the shapes generated through his system of hanging wires and weights, by developing a new method of deriving form, he opened his design up to a certain level of unpredictability. This unpredictability led to the first use of the hyperbolic parabolic in architectural construction and the implementation of a similar design method with the iconic structure, Sagrada Familia. Gaudi was famous for his unique designs undulating forms, and the method by which he designed enabled the conception of many of his now treasured buildings. By relinquishing a certain degree of control, Gaudi was able to produce buildings which to this day are inspirational and provocative.

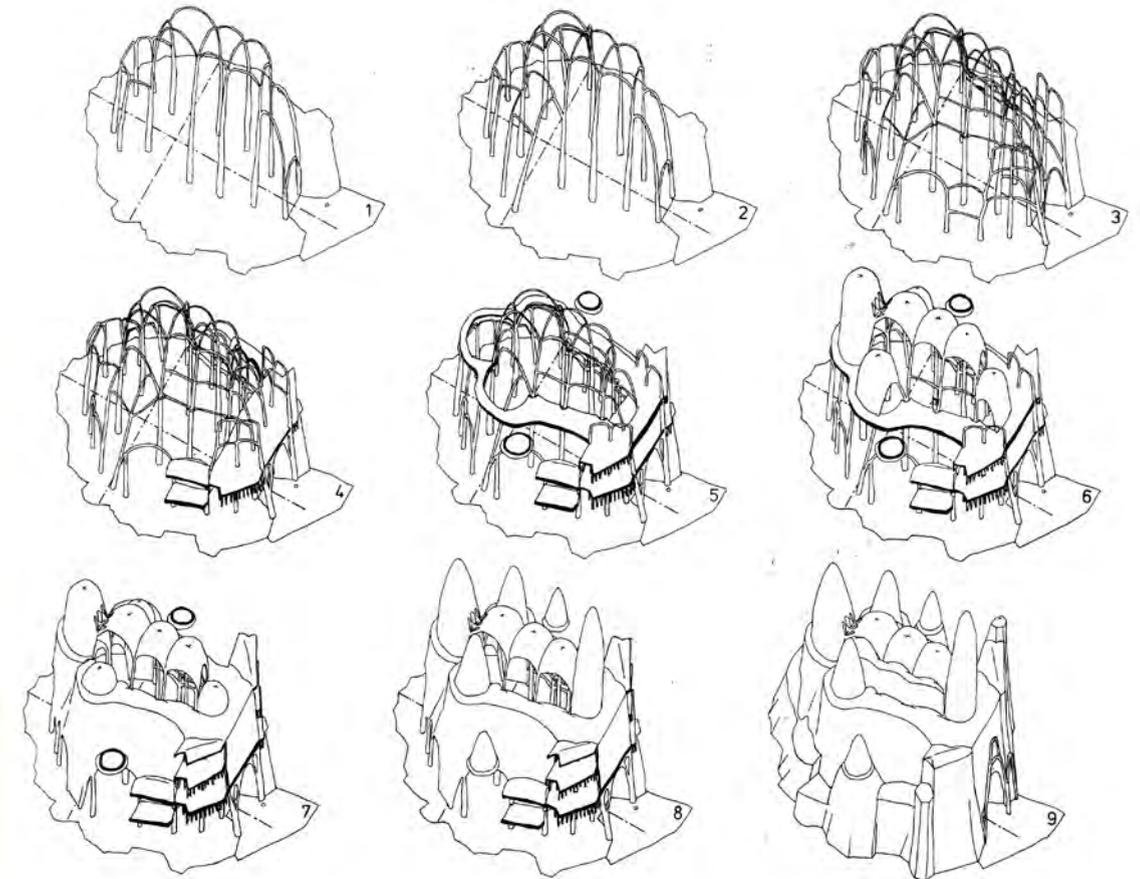


Figure 6.8 - Church of Colònia Güell structure to form iterations (Tomlow, 1989)

Case Studies:

Rose Center for Earth and Space (1999) at the American Museum of Natural History

Type: Museum of Astrophysics and Natural History

Location: New York, New York

Programmatic Elements: Space Theater, Big Bang Theater, Galleries, Offices/Administration, Storage, Gift shop.

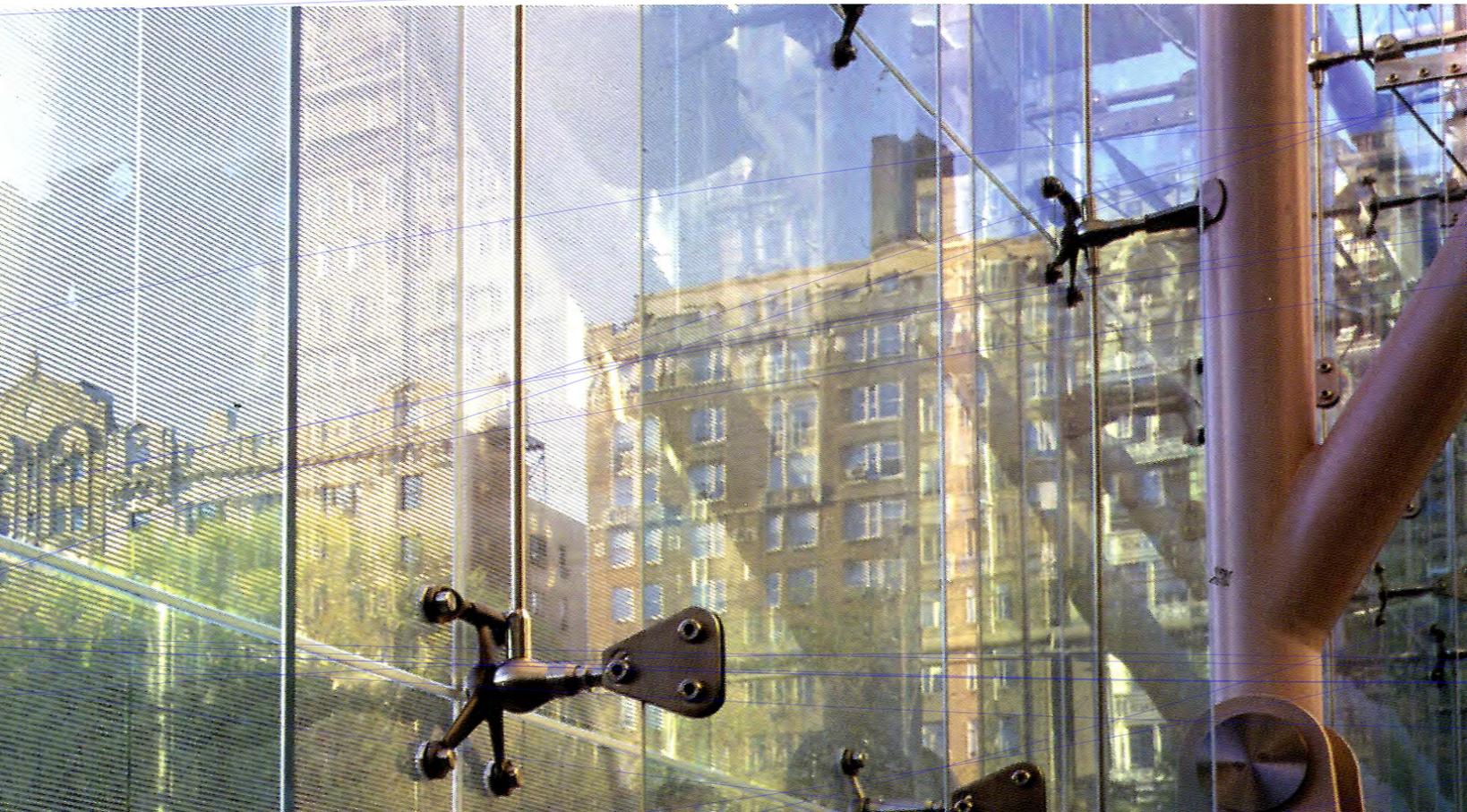


Figure 7.1 - Hayden Planetarium (Lyall, 2002)

Rose Center for Earth and Space: at the American Museum of Natural History

This project is one of the most recent and iconic science museums in the United States. Its design represents not only the missions of the Hayden Planetarium and the American Natural History Museum, but our concept of the universe. The Hayden Planetarium, who's director is astrophysicist Neil deGrasse Tyson, has as its mission to "conduct, interpret, and bring frontier astrophysics research into the educational offerings of the American Museum of Natural History" and to serve "as the premier conduit between the frontier of cosmic discovery and the public's appreciation of it". To facilitate this mission, the architects, Polshek Partnership, have used simple platonic forms to express the idea of cosmic understanding and awareness contained within an earthly, manmade container. The celestial forms within the Rose Center are contrasted by the glass cube which contains them. While the forms within the rose center are sleek simple and clean, reminiscent of the order of the cosmos, their glass container expresses the engineering and technical sophistication of its construction, reminiscent of the telescopes and satellites with which we measure the cosmos. In this way the Hayden Planetarium has brought together the celestial bodies and the manmade instruments which we use to understand them, but more importantly it represents our concept of the celestial universe as a composition of simple, almost elemental geometries (Lyall, 2002).

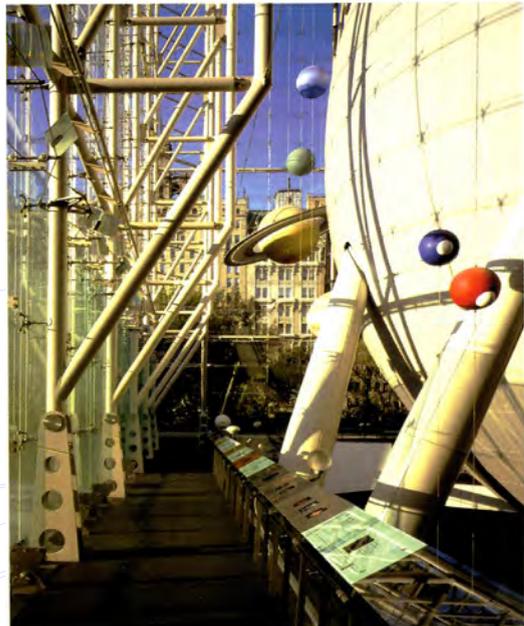
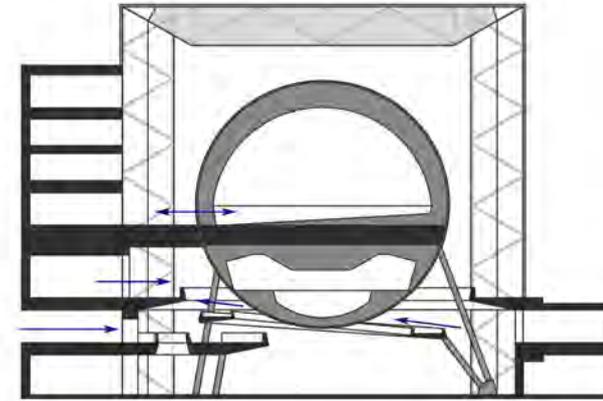


Figure 7.2 - Hayden Planetarium with Planets (Lyall, 2002)

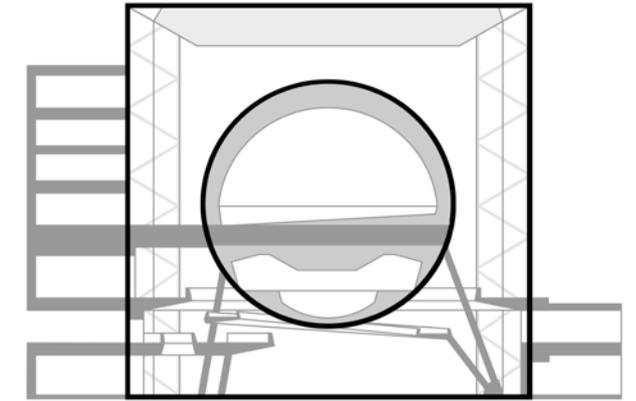


Figure 7.3 - Hayden Planetarium structure (Lyall, 2002)

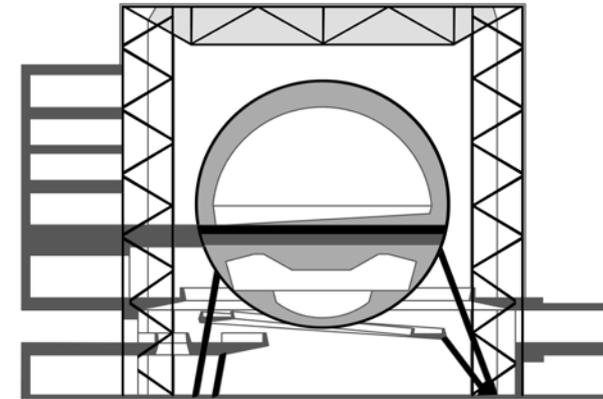
Circulation + Movement



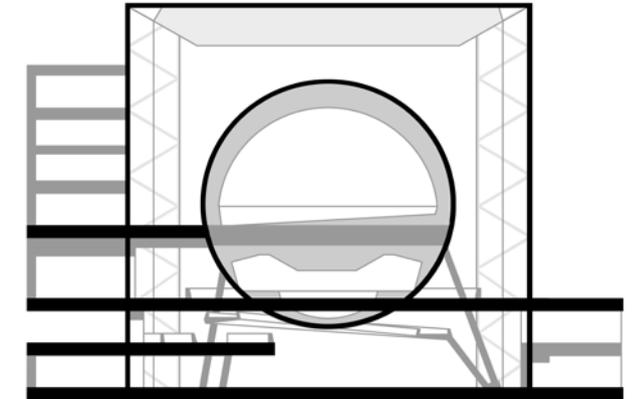
Geometry



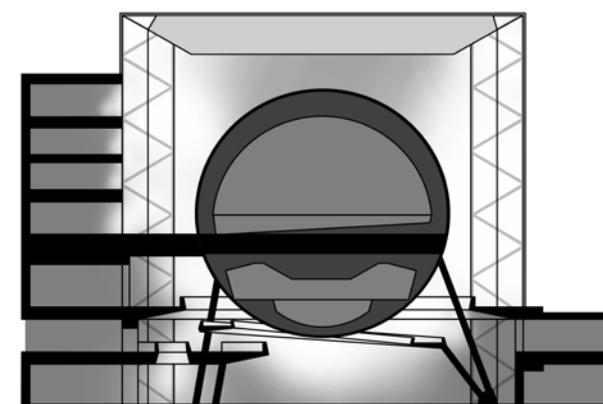
Structure



Hierarchy



Natural Lighting



Massing

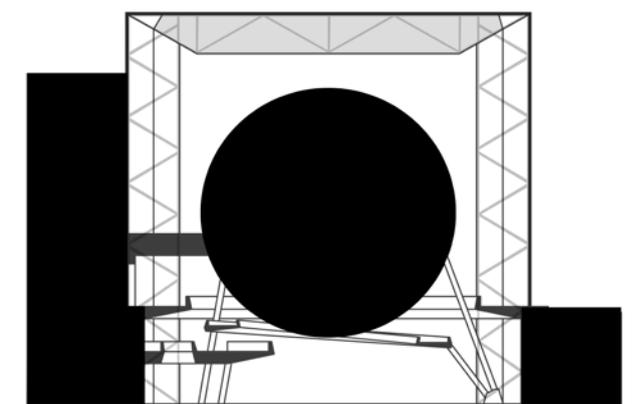


Figure 7.4 (Lyall, 2002)

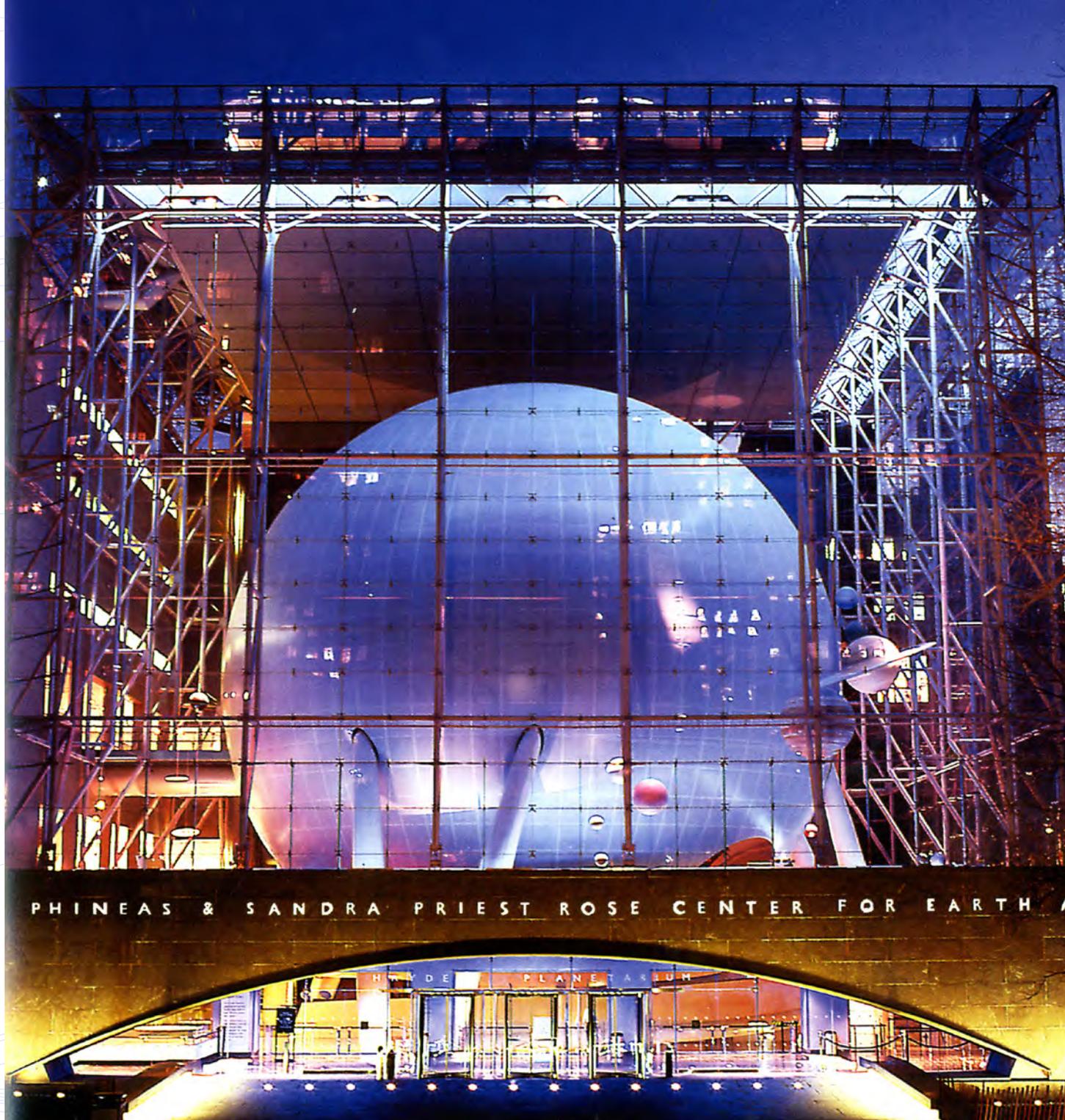
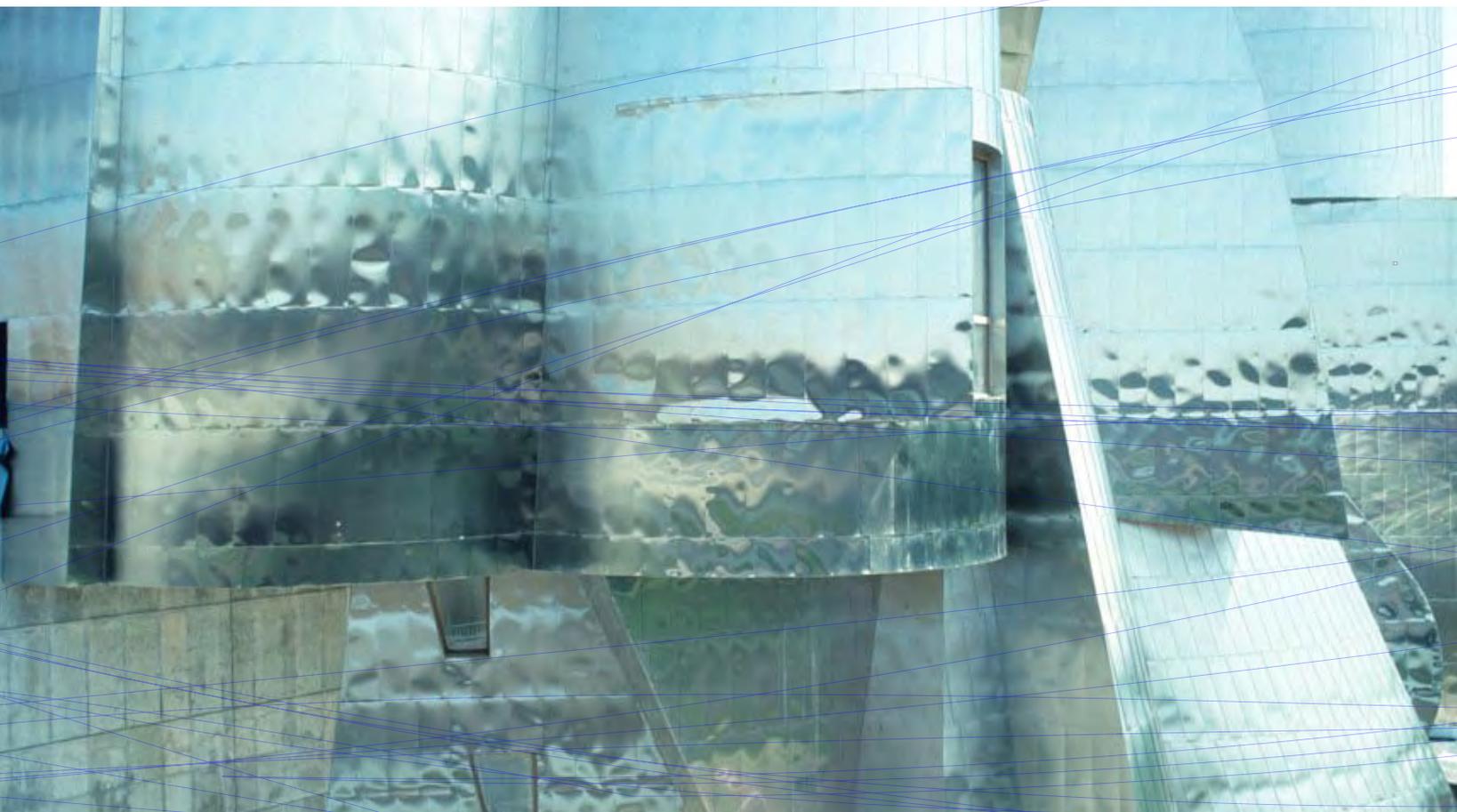


Figure 7.5 - Rose Center for Earth and Space at night (Lyll, 2002)

Conclusion:

While the Rose Center of Earth and Space represents our cosmological perspective of the universe, a quantum science learning center will have to express our understanding of the smallest components of our universe. While the celestial universe seems elegant simple and ordered, the quantum universe is anything but simple. Most describe particle science as bizarre, chaotic and inherently unintuitive. In the same way the Polshek Partnership has used simple, platonic geometries to represent our cosmological perspective; a quantum science learning center will require the use of complex and unpredictable geometries to represent a quantum perspective.

Case Studies:



Weisman Art and Teaching Museum (1993)

Type: Art Museum

Location: Minneapolis, Minnesota

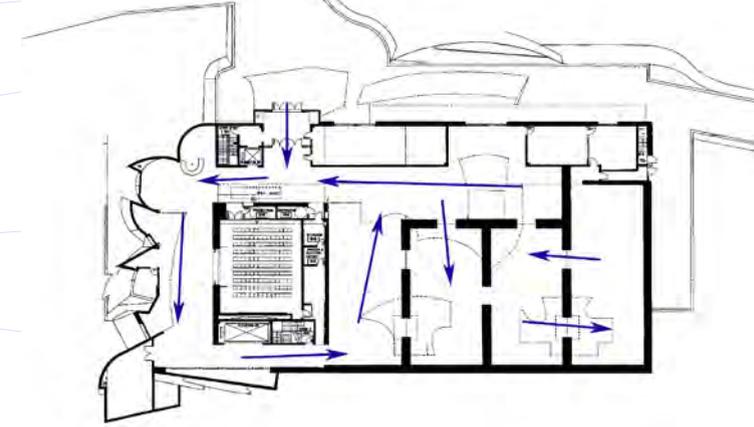
Programmatic Elements: Lobby, Galleries, Offices/Administration, Auditorium, Kitchen, Offices, Carpentry Shop, Loading Dock, Storage, Parking, Gift Shop.

Figure 8.1 - Weisman Art Museum (Mathews, 2011)

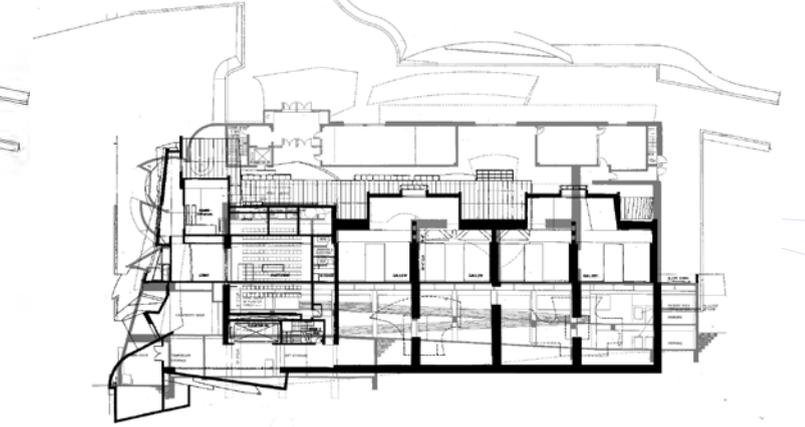
Weisman Art and Teaching Museum:

This Weisman Art and Teaching Museum, designed by Frank Gehry, was inserted into a site on the east bank of the University of Minnesota. It overlooks the Mississippi River and the Minneapolis skyline at the east end of the Washington Avenue Bridge. The Weisman Art Museum is significant because it demonstrates the precedent for form based architecture integrating itself within the University of Minnesota and Minneapolis at a highly visible location. Perched on the high banks of the river, it can be clearly seen by the drivers and pedestrians from the Washington Avenue Bridge as well as from many other vantage points along that section of the river. The aim of the project was to increase awareness of the Art and Teaching Museum's collection and academic resources. The building accomplishes this through its strategic location which makes use of the high traffic surrounding the site, and the original design which stands out from the rectilinear buildings around the museum. The originality of the form comes from Frank Gehry's sculptural based method of form finding. The stainless steel cladding undulates on the west façade in a chaotic unpredictable way. The stainless steel is continued through the awning over the entry and then again acting as a railing along the museum's undulating walkways. The museum's walkways connect the pedestrian level of the Washington Avenue Bridge with the campus and the museum, and the parking below connects with the lower roadways (Steele, 1994, p. 75). In this way the museum negotiates many intersecting modes of transportation, and with the addition of a light rail station at the doorstep of the museum, the museum continues to act as an anchor for various levels of infrastructure.

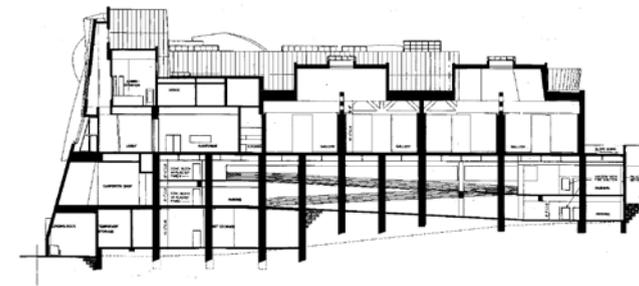
Circulation + Movement



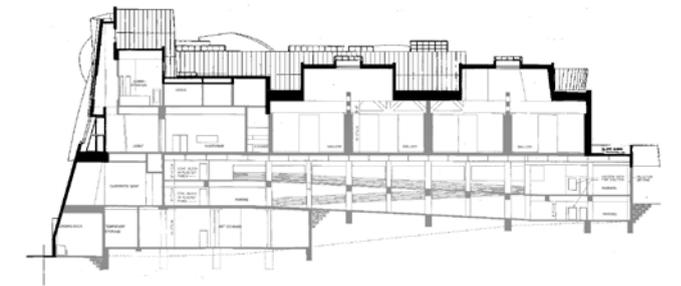
Plan to Section



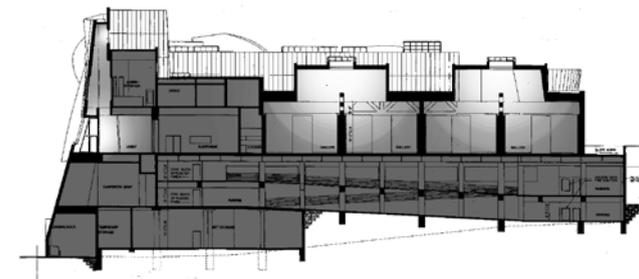
Structure



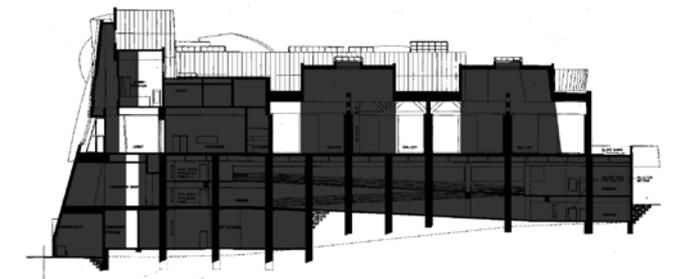
Hierarchy



Natural Lighting



Massing



Geometry

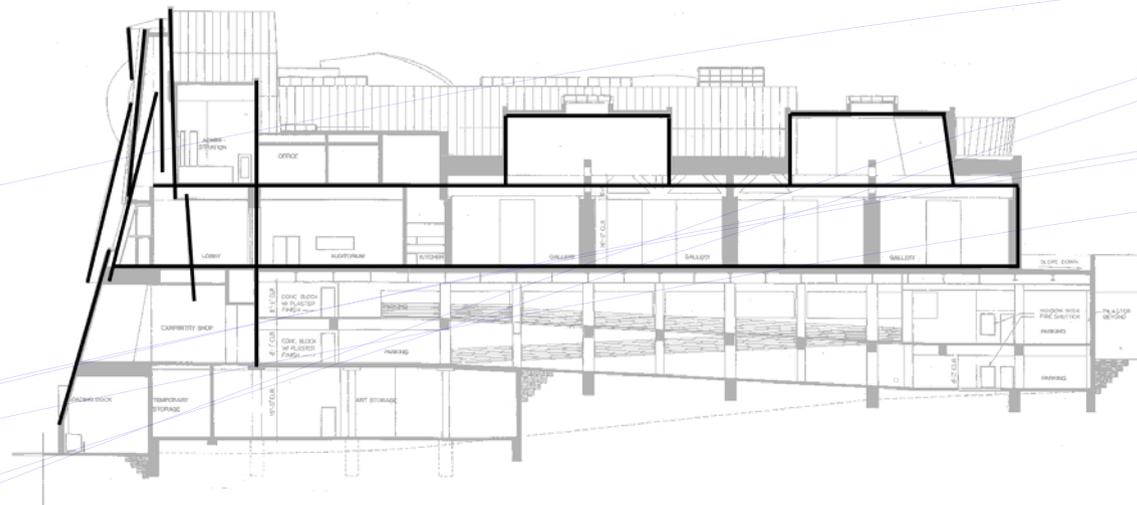


Figure 8.2 (Steele, 1994)

Conclusion:

The Wiseman Art Museum demonstrates the opportunities a museum can have on an area with many modes of transportation and large amounts of traffic. It also demonstrates the capacity for a unique building form to make a large impact on the perceptions of passersby. By functioning as both an art gallery and an academic resource, the Weisman Art and Teaching Museum serves as an example of a form based design succeeding as a tool for learning. A quantum science learning center would also serve this dual role as both a museum and academic resource for the university and community.

Figure 8.3 - Weisman Art Museum
(Mathews, 2011)



Figure 8.4 - Weisman Art Museum
(Mathews, 2011)



Case Studies:

Summary:

With these case studies examine three distinct facets of the proposed Quantum Science Learning Center. The three aspects examined are the precedent for an alternative design method, the architectural manifestation of a scientific viewpoint, and the feasibility and benefits of a museum with a unique architectural form as a part of the University of Minnesota in downtown Minneapolis. The aim of this Quantum Science Learning Center would be to fulfill these three objectives which these case studies exemplify. This science center will explore a new method of design, act as a manifestation of a scientific picture of the universe, and serve as an iconic and resourceful learning tool for both the University of Minnesota and the Minneapolis community.

Antoni Gaudí's Church of Colònia Güell was one of the first and most successful examples of the influence a design method has on the resulting design. Gaudí's method not only produced a unique form which would have been impossible to produce any other way, but it also led to the first use of a hyperbolic paraboloid in architectural construction and became a methodological precedent in his future works.

The Rose Center for Earth and Space, at the American Museum of Natural History in New York City, was designed by the architectural firm, Polshek Partnership, to reflect our understanding of the cosmos. The building's design, described as the sphere of the cosmos contained inside the box of human understanding, represents both poetically and practically the way science relates to and understands the universe. The Rose Center also acts as an iconic symbol for the both museum and for the scientific community, and through programs like Urban Advantage it also serves as an educational resource for New York City schools.

The Weisman Art and Teaching Museum at the University of Minnesota demonstrates the potential for museums to act as entertainment, as educational institutions, as resources for the university, and as icons for a city of Minneapolis. The Weisman art Museum is highly visible, near many intersecting lines of transportation, and because of its iconic form, the Weisman it a destination for many visitors of both the University and Minneapolis. The museum is an established and essential part of the University of Minnesota and is a valuable and beneficial contribution for the Minneapolis community.

The Quantum Science Learning Center on the University of Minnesota's West Bank will build on these three precedents to act as a relevant design for the design community, the scientific community, and the Minneapolis community. The Quantum Science Learning Center will utilize an emerging design method to produce its form. This unpredictable form will be the conceptual manifestation of the uncertainty of quantum mechanics. As a museum and academic institution the learning center will also be well positioned to serve the local community, the University of Minnesota, and the future generations who are anxious to learn more about the strange world of particle physics and quantum mechanics.

Historical Context



Figure 9.1

Science Establishments in the Minneapolis–St. Paul Area:

The Science Museum of Minnesota:

The Science Museum of Minnesota began in 1906 as the St. Paul institute of Science. It was founded as a collaboration of St. Paul business leaders to provide lectures to support the “intellectual and Scientific Growth of St. Paul”. It was not until 1907 the institute revived its first scientific collections from the St. Paul Academy of Natural Sciences. The institute continued to expand, developing its educational programs, youth activities, and research. The Science Museum’s currently sits on the St. Paul water front on the banks of the Mississippi River. The Museums main focuses are anthropology, biology, paleontology and meteorology. (“Science Museum of Minnesota,” 2012).



Figure 9.2

The University of Minnesota:

The University of Minnesota was founded in 1851 before Minnesota was declared a state. The university was able to achieve public support as a land-grant university from the Morrill Land-Grant Act. The land grant status, along with the reopening of the University after The Civil War, was accomplished with the help of Minneapolis entrepreneur John Sargent Pillsbury, who is considered to be the ‘father’ of the University. The University has three museums (the Bell Museum of Natural History, the Goldstein Museum of Design, and the Weisman Art Museum), six art galleries, as well as public art around the campus (“University of Minnesota,”2011). The College of Science and Engineering was created in 1935 offers 18 degrees from the baccalaureate through the doctoral levels. The William I. Fine Theoretical Physics Institute is within the College of Science and Engineering in the school of Physics and Astronomy. The school’s community outreach and education programs include Physics Force, PACES (Parents and Children Experiencing Science), REU (Research Experience for Undergraduates), and RET (Research Experience for Teachers). The School of Physics and Astronomy has had 6 Nobel prizes from physicists associated with the school. The current physics building is Tate Laboratory of Physics and is located on the historic mall of the university (“School of Physics and Astronomy,”2012).



Physical and Social Context:

The Cedar Riverside Area:

The Cedar Riverside area is a unique district within Minneapolis because of its cultural diversity and geographic conditions. It is contained by two highways and the Mississippi River. The University of Minnesota, Augsburg College and Fairview Hospital are the largest institutions within the area and provide the largest pool of jobs within the Cedar Riverside area. Combined they take up about a third of the Cedar Riverside area. A quarter of the land is designated as park area or open space. Although most of this park area is located down the hill alongside the river and is inaccessible to most of the community, but Riverside Park, Murphy Park and Currie Park are located within the main district. The Cedar Riverside area has an operating light rail line which stops at Hiawatha Ave, and a second light rail line is planned to be open in 2014 (Department of Community Planning, 2008). The Cedar Riverside area is known for its rich music, theater, and arts culture, its large immigrant population and its proximity to the West Bank of the University of Minnesota.



Figure 9.4



Figure 9.5

Social Trends:

The Cedar Riverside Area Development Plan:

The Cedar Riverside Area is unique in location, cultural diversity, and economic opportunity. In 2008, a plan for the Cedar Riverside Area created by the Department of Community Planning & Economic Development was adopted by the Minneapolis City Council. The plan outlines the issues, opportunities, and strategies for the continued development and economic growth of the area. Capitalizing on the unique location and the diversity of the community, the plan seeks to improve the safety, quality, and economic prosperity of the Cedar Riverside Area. By focusing on residential development with mixed use and parking, the plan hopes to encourage more restaurants, offices, and housing. Increased focus on the maintenance and improvement of the parks and public areas will create more appealing and desirable public spaces. In addition, with the opening of additional light rail Line in 2014, the area will see increased access to the city of Minneapolis and the East Bank of the Mississippi river. The plan aims to increase the economic activity of the area by tapping into the key economic institutions (University of Minnesota, Augsburg College, and Fairview Hospital), businesses which are geared towards the large populations of students, faculty, visitors, residents, and immigrant populations, and the rich music, theater, and arts culture which currently exists in the Cedar Riverside area (Department of Community Planning, 2008). In several years, the Cedar Riverside area promises to be a rich, diverse, and cultural icon for the Minneapolis-St. Paul area.

Urban Advantage Program:

Urban Advantage began in New York City as a partnership between the American Museum of Natural History and the New York City Department of Education. It brings together science institutions and local schools to expose children to science and real world research. Urban Advantage sets up field trips to local science and research institutions and coordinates museums, and scientific establishments with the schools to optimize the field trip. The program also provides support for schools, teachers and principals to provide scientific investigation for the students from the urban area. Students' participation in Urban Advantage has been shown to increase scientific understanding, improve teaching strategies, and spark interest in science and problem solving within the classroom and in future grade levels ("Urban Advantage Network," 2010). Although the Minneapolis/St. Paul area does not yet have an Urban Advantage program, the introduction of a Quantum Science Learning Center downtown would call for a very similar collaboration with the local school districts, if not an implementation the Urban Advantage program itself.



Figure 9.6



Figure 9.7

Conclusion:

A Quantum Science Learning Center in the heart of the Cedar Riverside area creates an opportunity to capitalize and reinforce the area's growth. With Proximity to the University of Minnesota, the science center is well positioned to partner with the University. With proximity to two light rail lines, a large residential and student population, and a major highway, the science center will be accessible to rail, pedestrian, and vehicular traffic. Currently, the site is owned by the city and planned to be a mixed-use development which encourages the development of a varied and flexible program with focus on street-level accessibility and unobtrusive parking. The development of a Quantum Science Learning Center will benefit the Cedar Riverside area as they seek to grow, develop unused lots and create even stronger cultural and institutional ties within the community.

Goals for the Thesis Project



Figure 10.1



Goals for the Thesis Project:

Academic:

To question and probe the traditional way of doing things. Because my architectural education has had such a heavy emphasis on meaning and intentionality, I wish to test the importance of meaning in the initial stages of design and in the nature of the building form.

Professional:

To develop and demonstrate a way of thinking which sets me apart from other designers. I hope that my thesis may act as a career tool and as a vehicle for demonstrating the value and uniqueness of my ideas.

Personal:

To answer my own questions about what it means to be arbitrary and with hope, to tease out my own philosophy of where meaning in architecture comes from.

Figure 10.2

Site Analysis

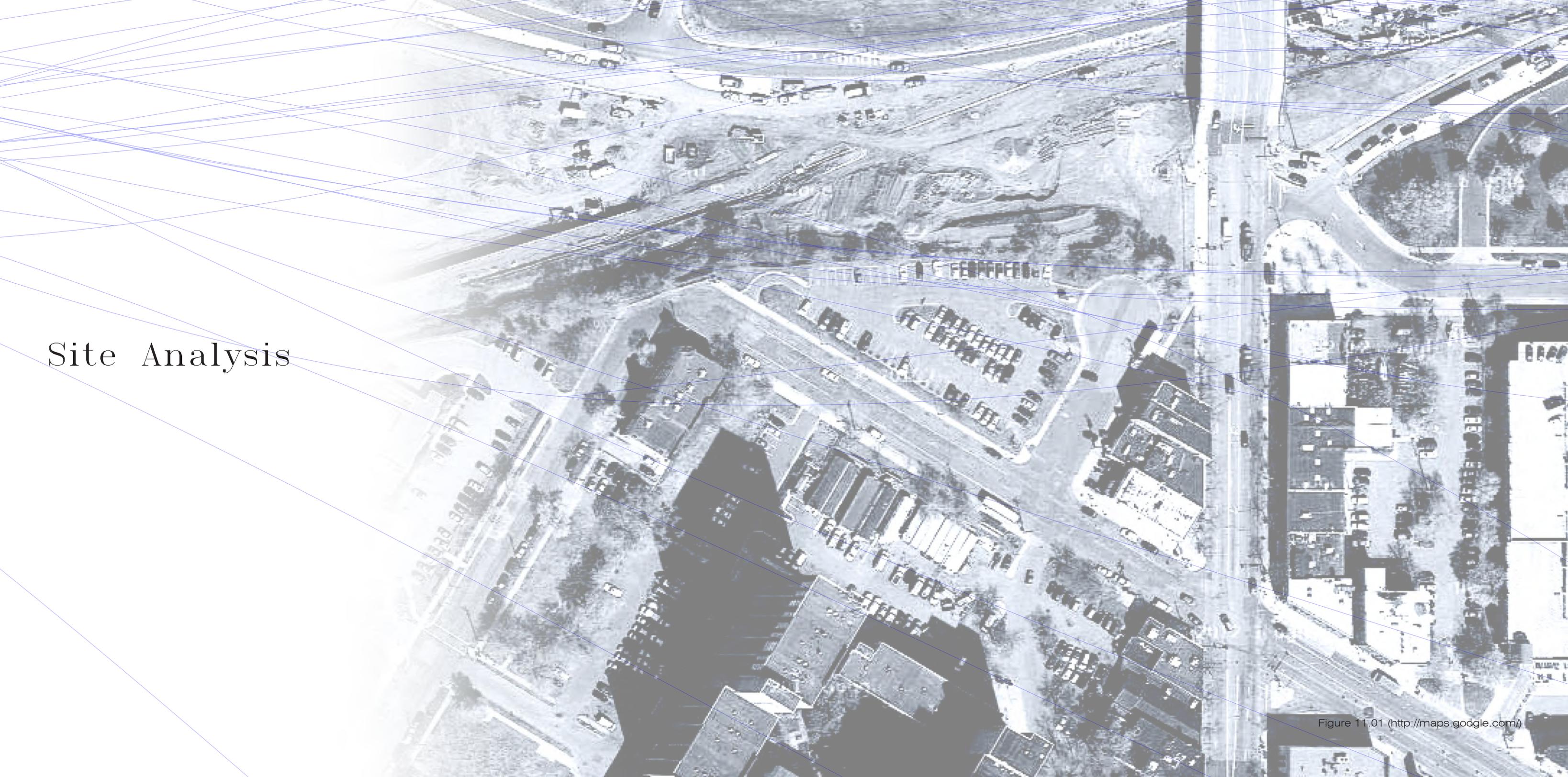
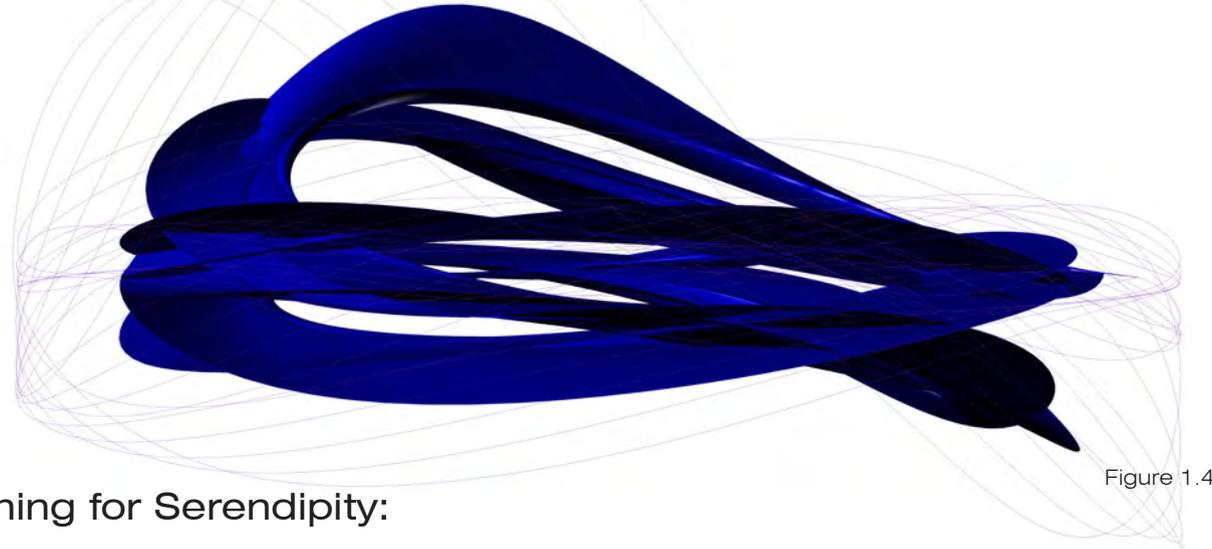


Figure 11.01 (<http://maps.google.com/>)

Site Narrative:



Searching for Serendipity:

When I first began searching for my site I knew very little about what my project was going to be. I knew that I would be eventually designing a Quantum Science Learning center, I knew the form I was going to use, (this form had been generated arbitrarily from a circular wave equation) and I knew that I wanted to affiliate the science center with the University of Minnesota. To find a site I first began by searching the larger East Campus of the University for a potential site. I had a clear image of the shape I had created earlier that summer. It moved in a circle to make a ring and as it moved around the perimeter it undulated up and down, moving above and below the equator, folding in on itself and weaving past other layers in the ring. It was dynamic, fluid, lithe, and very curvilinear. It was also blue. For some reason or another, the computer decided to produce this shape in the most remarkable deep blue. As soon as the image of this circular cobalt wave appeared on my screen I knew that this was the arbitrary form that I was hoping to stumble upon.

And now I was hoping to stumble upon a site while wandering around the University of Minnesota. No matter where I wandered no parking lot or empty courtyard between buildings seemed to fit this lithe, blue object. Every space on the east bank was too flat and too closed in. I wandered over towards the river, where there was a hill and a wide valley with an amazing view of the city. Even along the river where there were amazing views, lost of space and an entire campus to respond to, there just wasn't a site to fit this form.

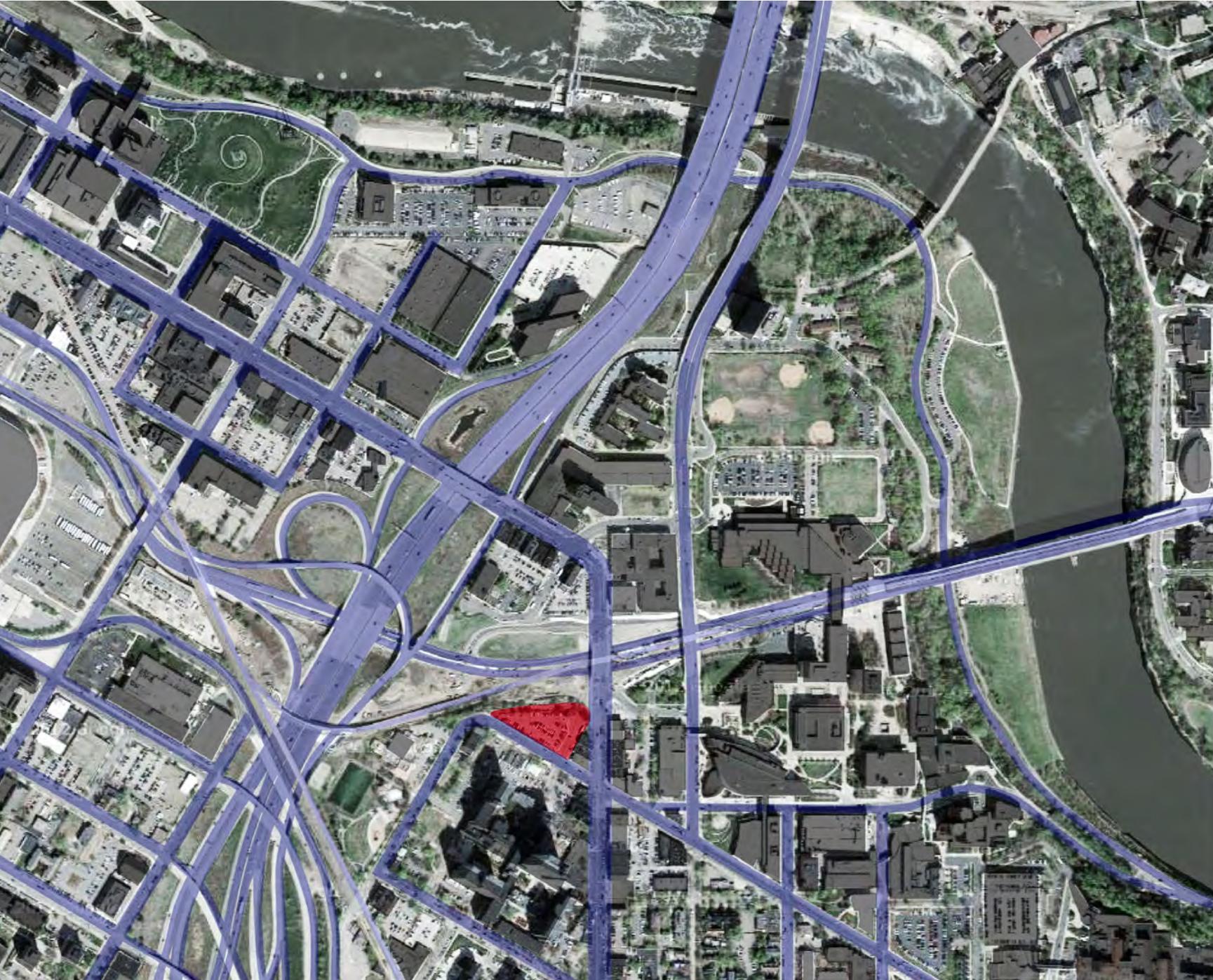
It wasn't until I returned to Minneapolis that I found what can only be described as the perfect site. My friend had asked to meet me by the Cedar Riverside apartments for his own studio project, which he had just been assigned a few weeks ago. Before my second trip to Minneapolis he had told me about the Cedar Riverside area. He told me about the two light rail stops of which one was complete and the other was being constructed. I had arrived early and spent the intervening time wandering the area. It was then that I realized that I had wandered onto my site. The site was a parking lot just north of Ralph Rapson's Cedar Riverside apartment towers. It was an awkward triangular parking lot and it overlooked the interstate highway. I realized that what I needed was not to overlook the river, but to overlook the interstate. The on-ramps and off-ramps and weaving lanes of traffic spoke to the weaving and undulating layers of my circular object. The downwards slope of the overlook would be perfect for the layers which scooped below the object's equator and the layers which arced upwards above the object's equator would perfectly frame the Minneapolis skyline. The Site is also just off Cedar Avenue which hosts a small urban district with restaurants, bars and the notable Hardtimes Café. The newest light rail station was essentially next door the site. The most important thing however is that the University of Minnesota is only one block away.

I had my camera and I began to document everything. I photographed the Minneapolis skyline, the Ralph Rapson apartment towers, and the small urban district along Cedar Avenue. At the moment the parking lot was sad, empty, and was not contributing very much community. I knew that in a few years with the completion of the new light rail not even a block away, this site would become incredibly valuable and would not be vacant for very long. I could not have asked for a better site to work with.



Charts and Diagrams:

Satellite Map



-  Building Site - City Owned
-  Vehicular Transit
-  Light Rail Transit

Figure 11.03 - (<http://maps.google.com/>)

Charts and Diagrams:

Contour Map



-  Building Site - City Owned
-  Vehicular Transit
-  Light Rail Transit

Figure 11.04 - (USGS, 2010)

Charts and Diagrams:

Transit Map

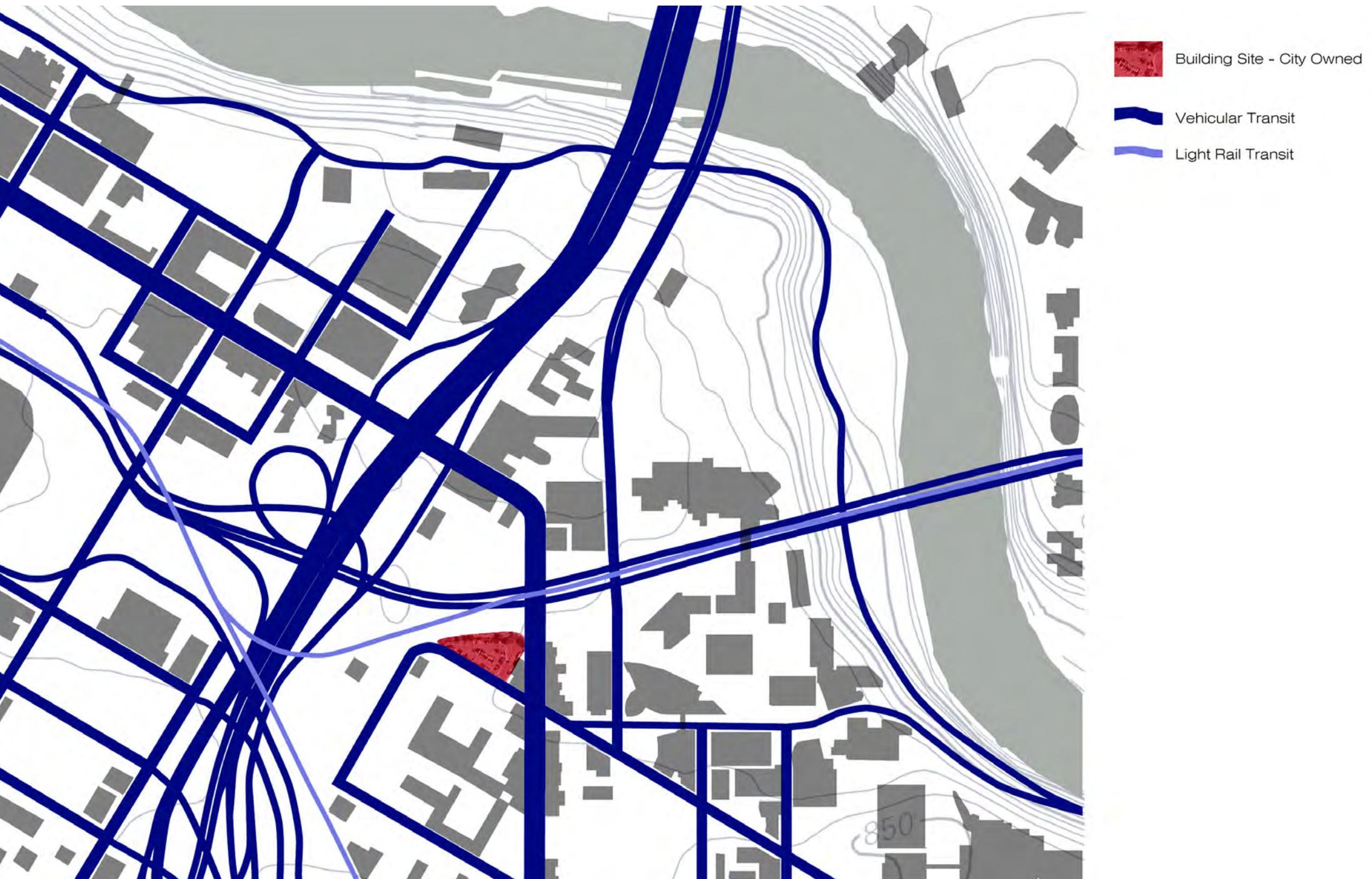


Figure 11.05 - (Department of Community Planning, 2008)

Charts and Diagrams:

Current Development



Figure 11.06 - (Department of Community Planning, 2008)

Charts and Diagrams:

Current Problem Areas



Figure 11.07 - (Department of Community Planning, 2008)

Charts and Diagrams:

Future Activity Center



-  Building Site - City Owned
-  Vehicular Transit
-  Light Rail Transit
-  Future Activity Center

Figure 11.08 - (Department of Community Planning, 2008)



Figure 11.09

Views:

Cedar Riverside
Apartment Towers
Figure 11.11



Cedar Avenue - Figure 11.10





Figure 11.12



Figure 11.13

Views:



Figure 11.14



Figure 11.15



Figure 11.16



Figure 11.17

Charts and Diagrams: Sun Diagrams



Figure 11.18

-  Building Site - City Owned
-  Vehicular Transit
-  Light Rail Transit

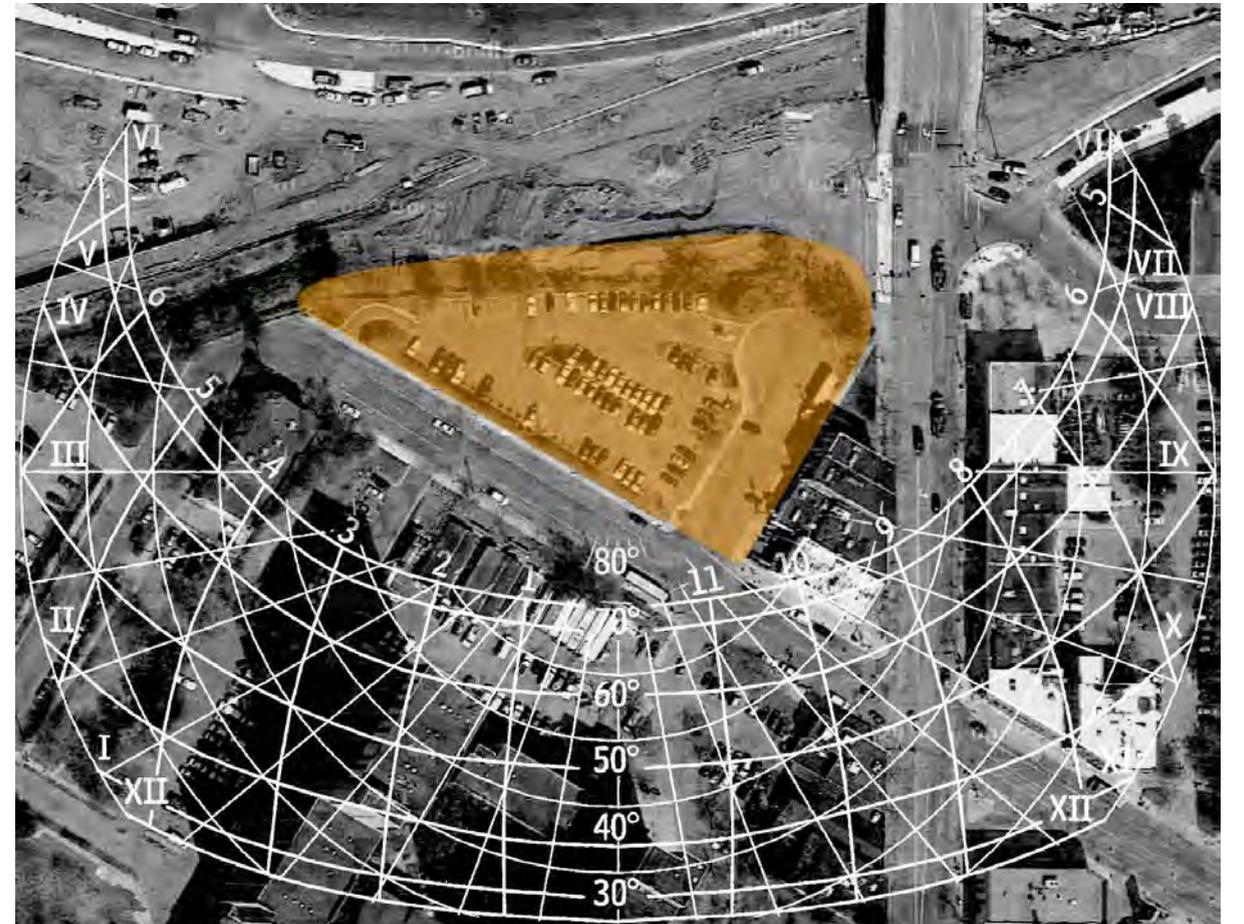


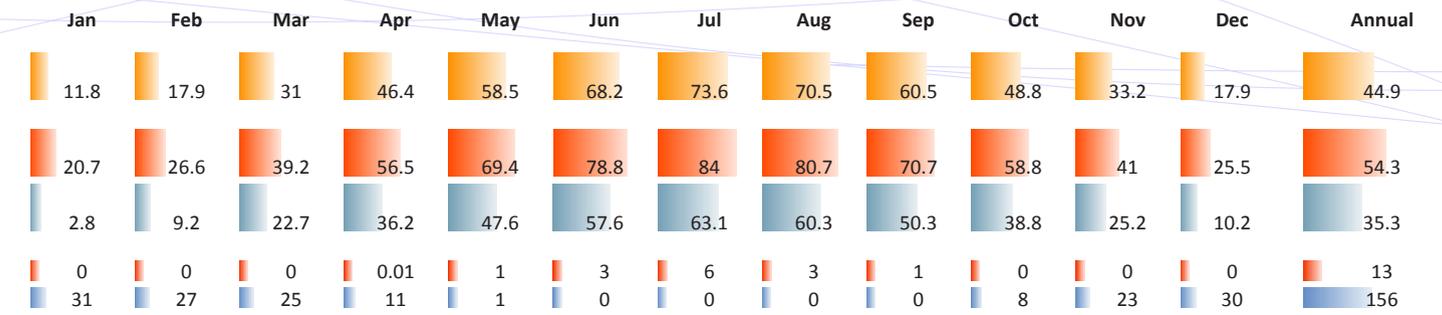
Figure 11.19 - (Lechner, 2009)

Charts and Diagrams:

Climate Diagrams for Minneapolis, MN

Temperature

Avg. Temperature
 Avg. Max Temperature
 Avg. Min Temperature
 Days with Max Temp of 90 F or Higher
 Days with Min Temp Below Freezing



Annual Wind Rose

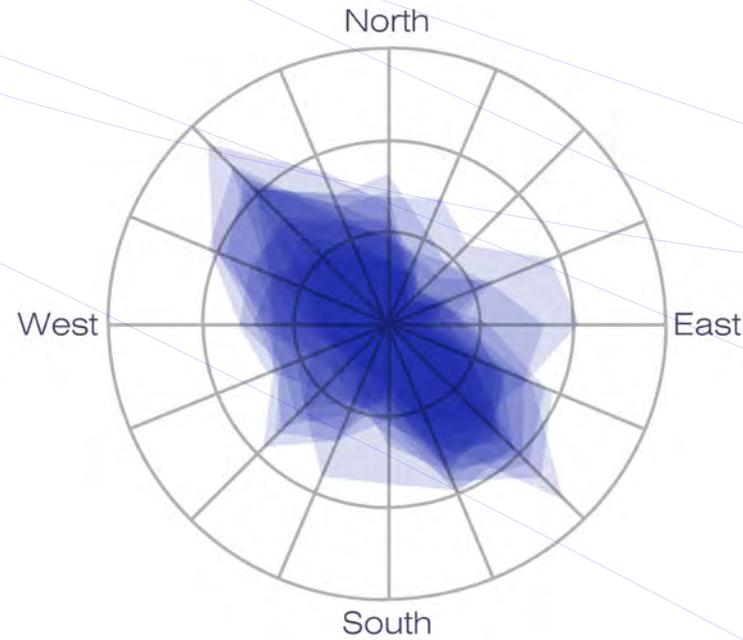
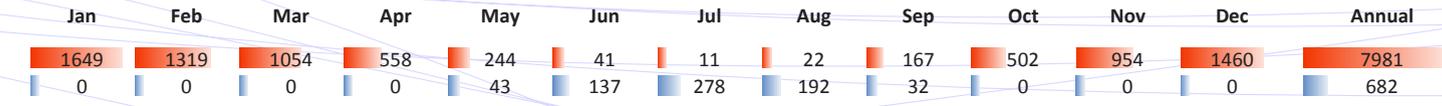


Figure 11.21 - (Minnesota Department of Transportation,

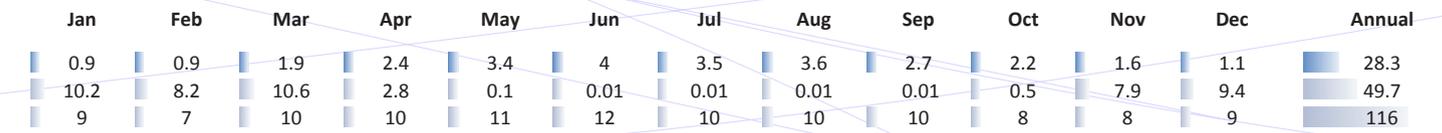
Heating and Cooling

Heating Degree Days
 Cooling Degree Days



Precipitation

Precipitation (inches)
 Monthly Snowfall (inches)
 Days with Precipitation 0.01 inch or More



Other Weather Indicators

Average Wind Speed
 Clear Days
 Partly Cloudy Days
 Cloudy Days
 Percent of Possible Sunshine
 Avg. Relative Humidity

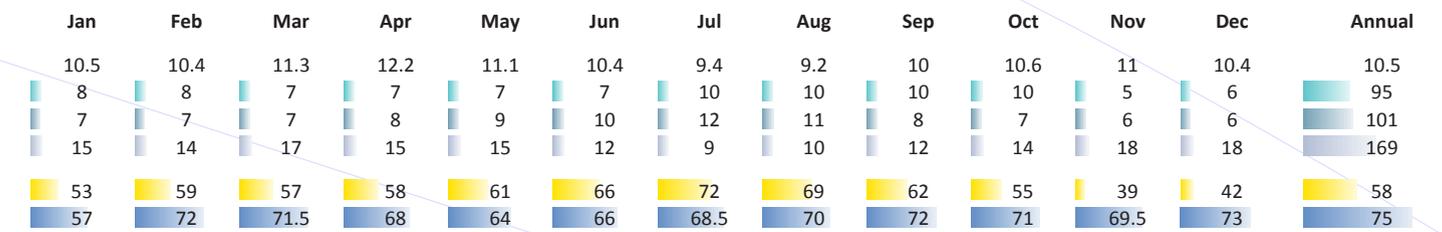


Figure 11.20 - (CIA World Fact Book, 2004)

Wind Rose by Month

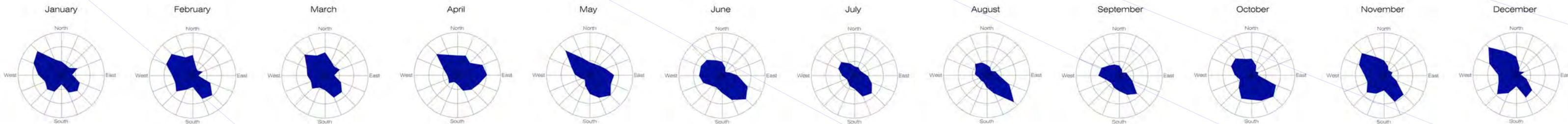
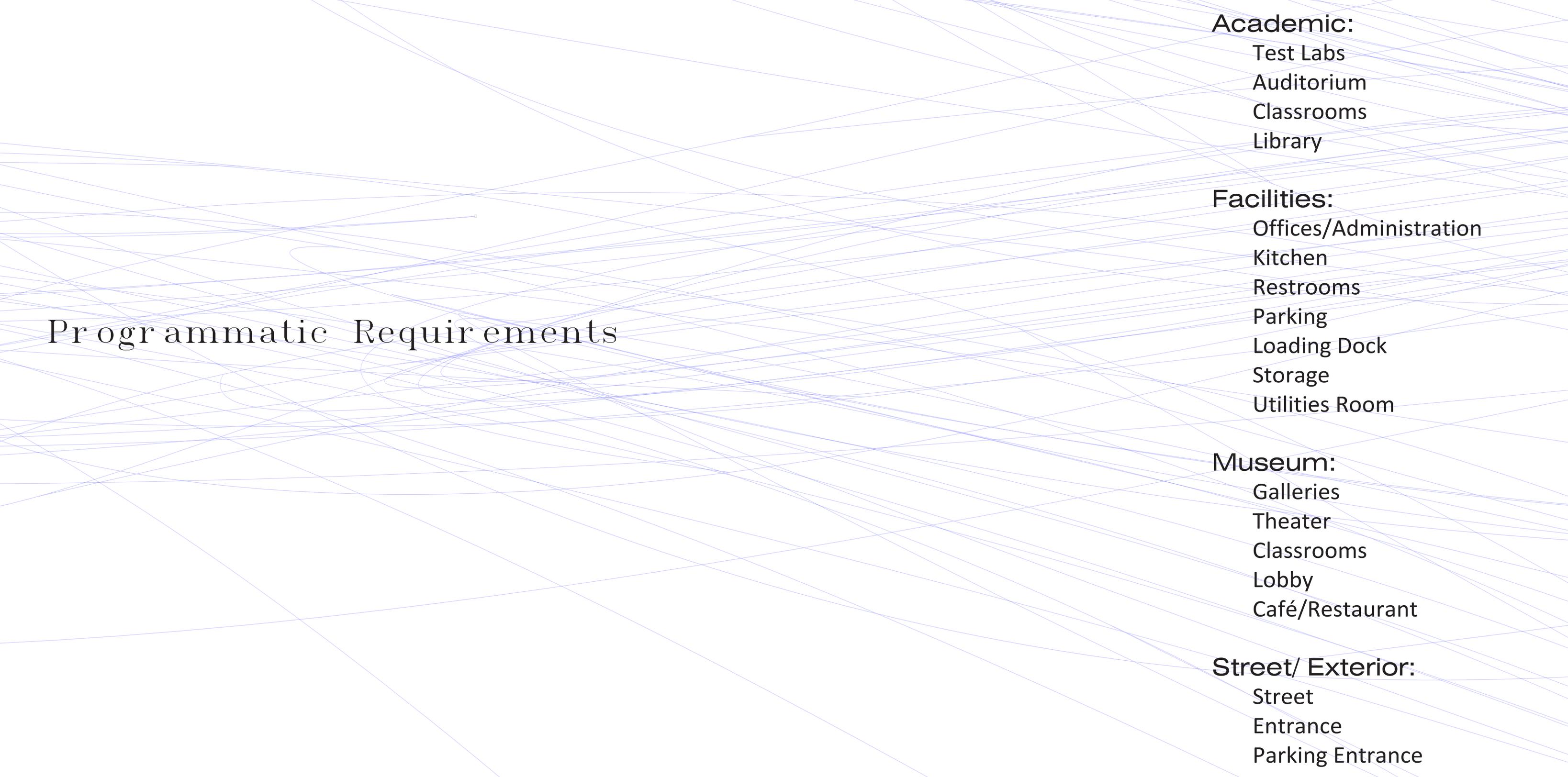


Figure 11.22 - (Minnesota Department of Transportation,

Programmatic Requirements



Academic:

- Test Labs
- Auditorium
- Classrooms
- Library

Facilities:

- Offices/Administration
- Kitchen
- Restrooms
- Parking
- Loading Dock
- Storage
- Utilities Room

Museum:

- Galleries
- Theater
- Classrooms
- Lobby
- Café/Restaurant

Street/ Exterior:

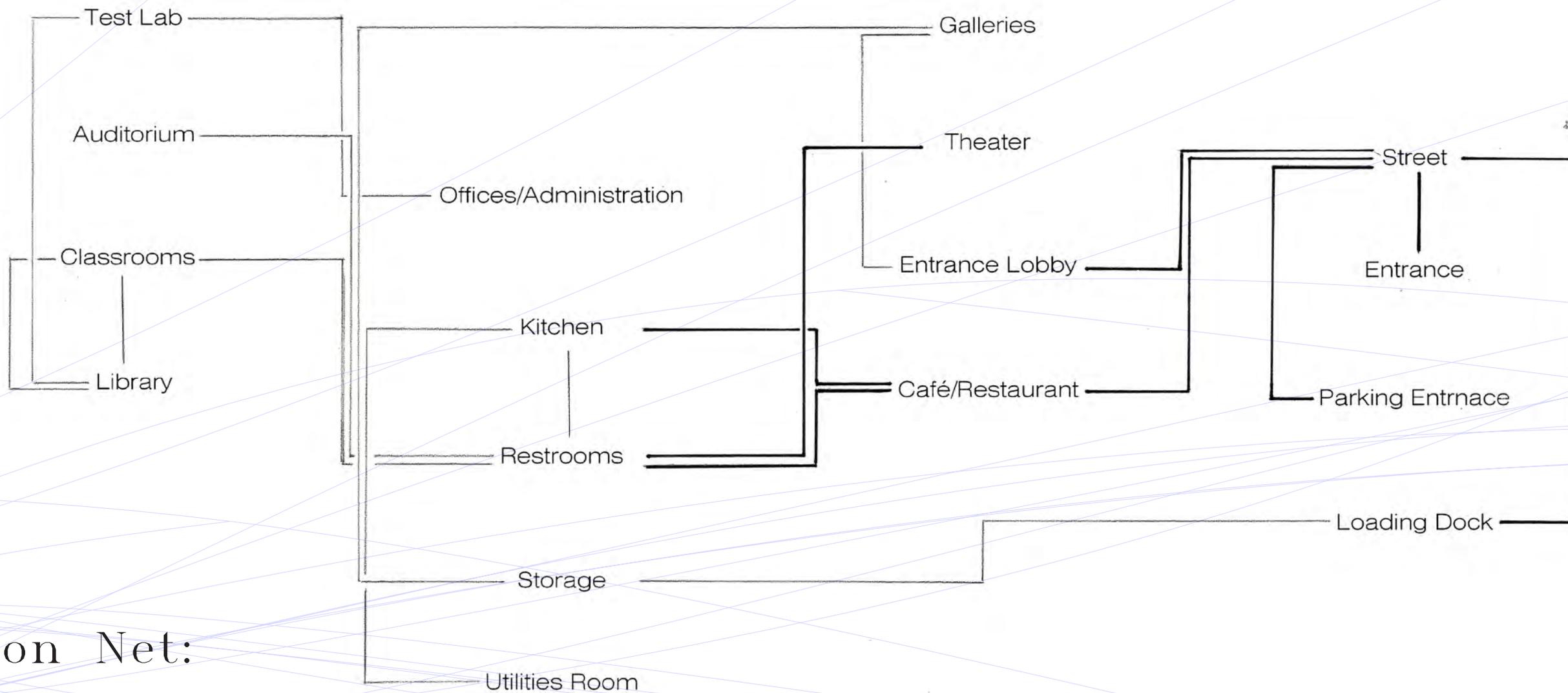
- Street
- Entrance
- Parking Entrance

Academic

Facilities

Museum

Street/Exterior



Interaction Net:

Figure 12.1

Interaction Matrix:

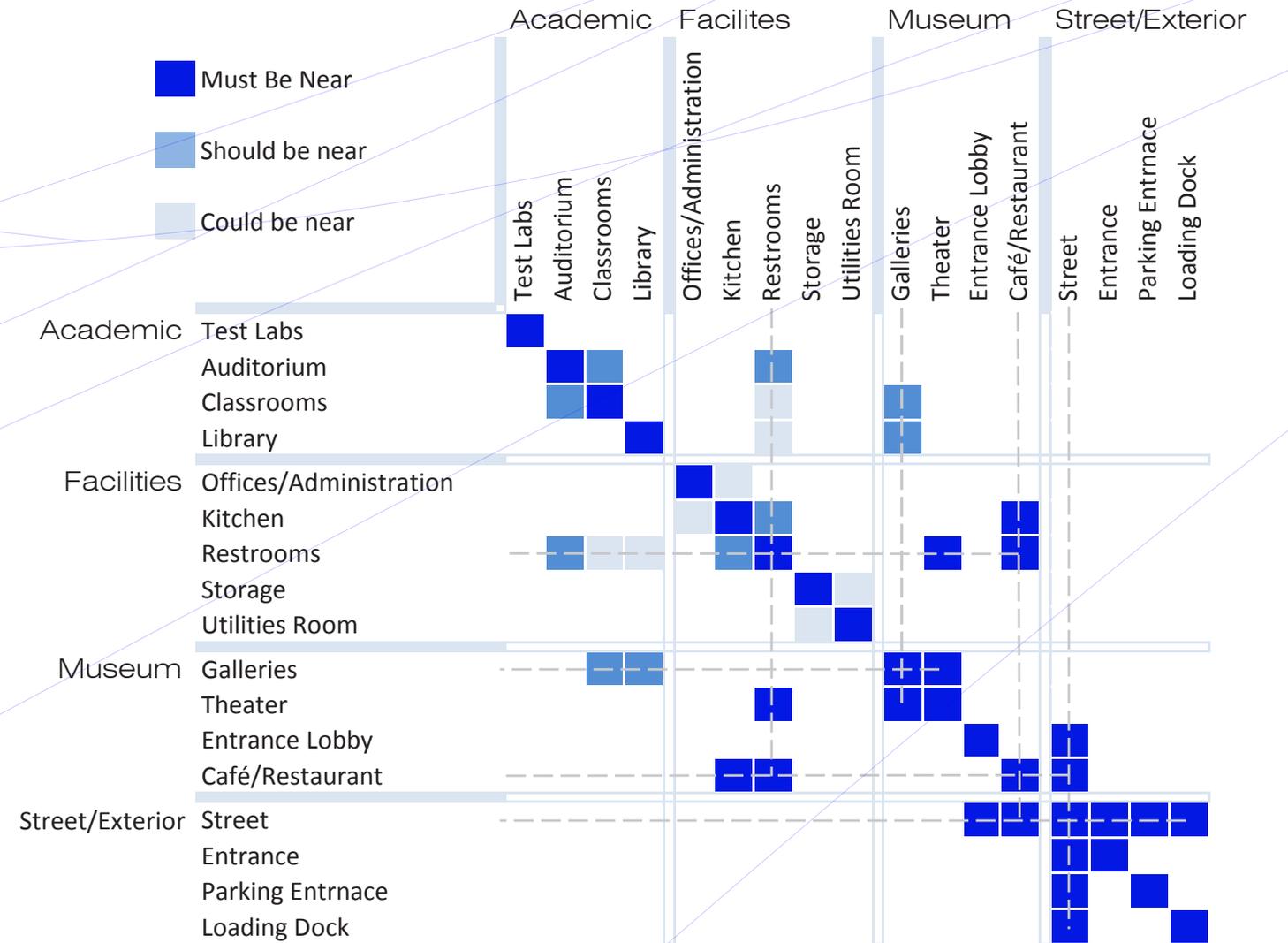


Figure 12.2

Design Process:

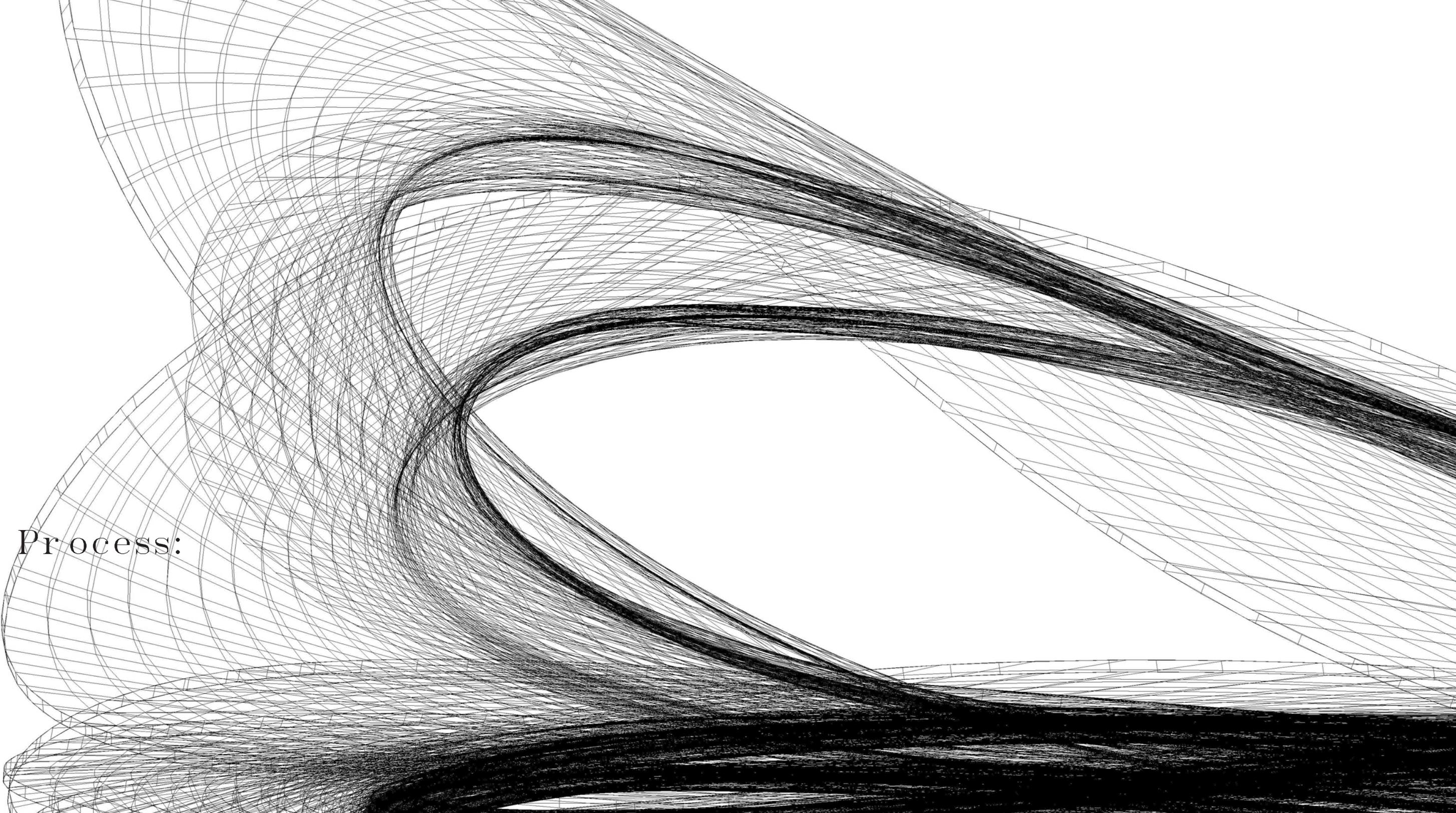


Figure 13.1

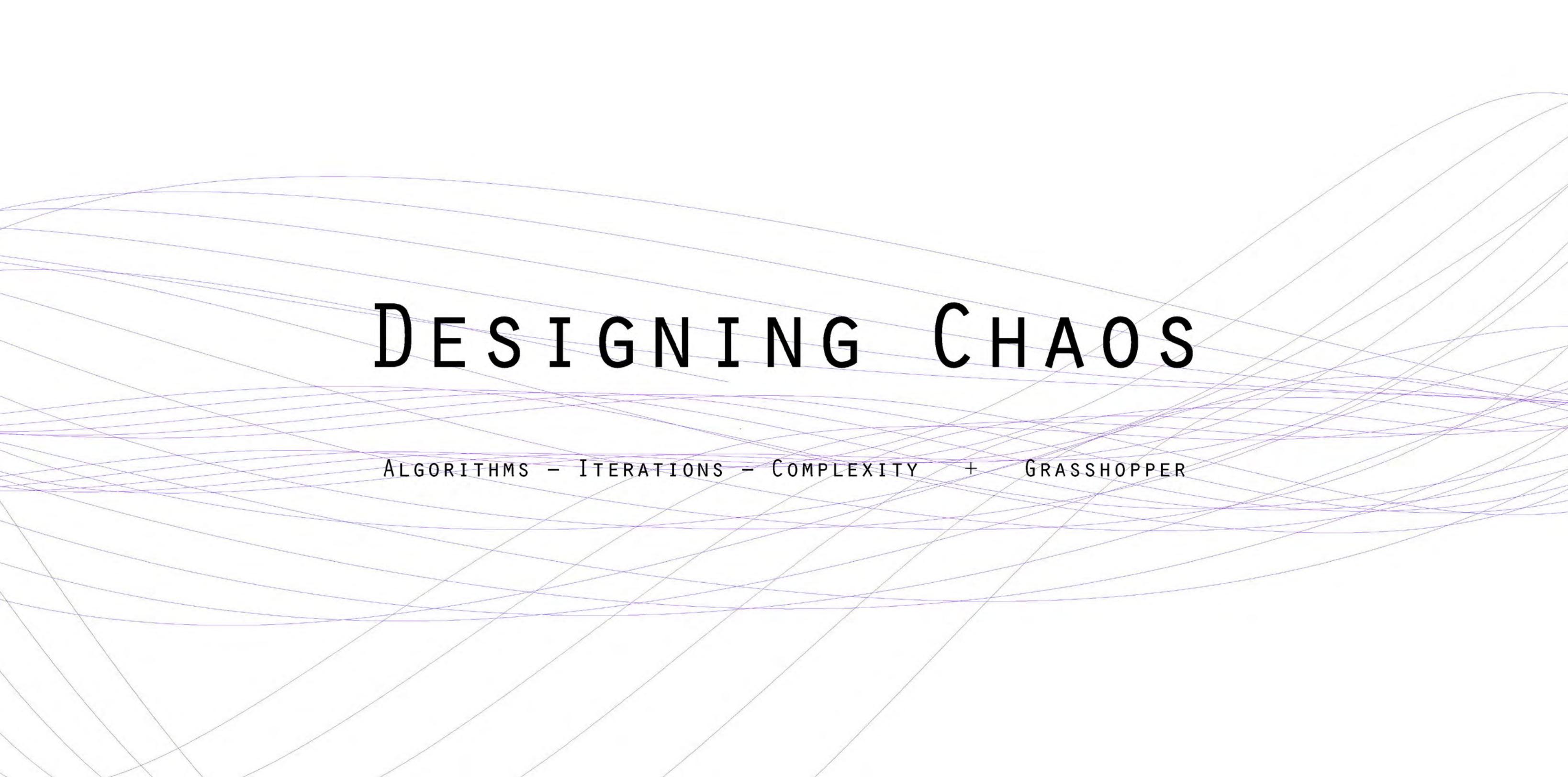
"A WORLD THAT IS OPEN TO CONTINUOUS CHANGE AND TO BECOMING DIFFERENT, REQUIRES AN ARS ACCIDENTALIS.

THE CREATIVITY AND THE PRODUCTIVITY OF THE **ACCIDENT**, THE BREAK AND THE FALL, HAVE TO BE UNDERSTOOD AS THE POTENTIAL TO ACHIEVE NEW FORMS OF HETEROGENEITY AND OF THE DISJUNCTIVE SYNTHESIS"

(BURRY, 1999)

"WE LIKE TO LOOK FOR PATTERNS, FORMS, FOR AN UNDERLYING STRUCTURE. AND EVEN IF WE DON'T QUITE UNDERSTAND ALL OF THE EQUATIONS, WE GRASP AT THE BEAUTY OF THE ANSWERS"

(WISE, 2004)



DESIGNING CHAOS

ALGORITHMS - ITERATIONS - COMPLEXITY + GRASSHOPPER

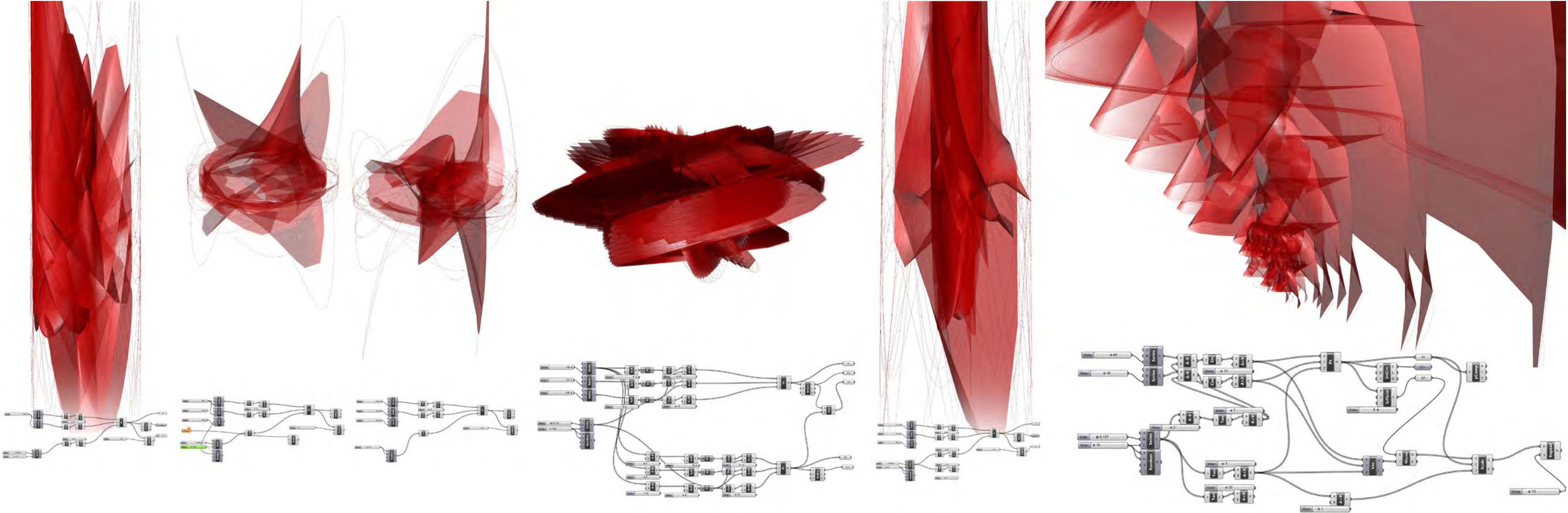
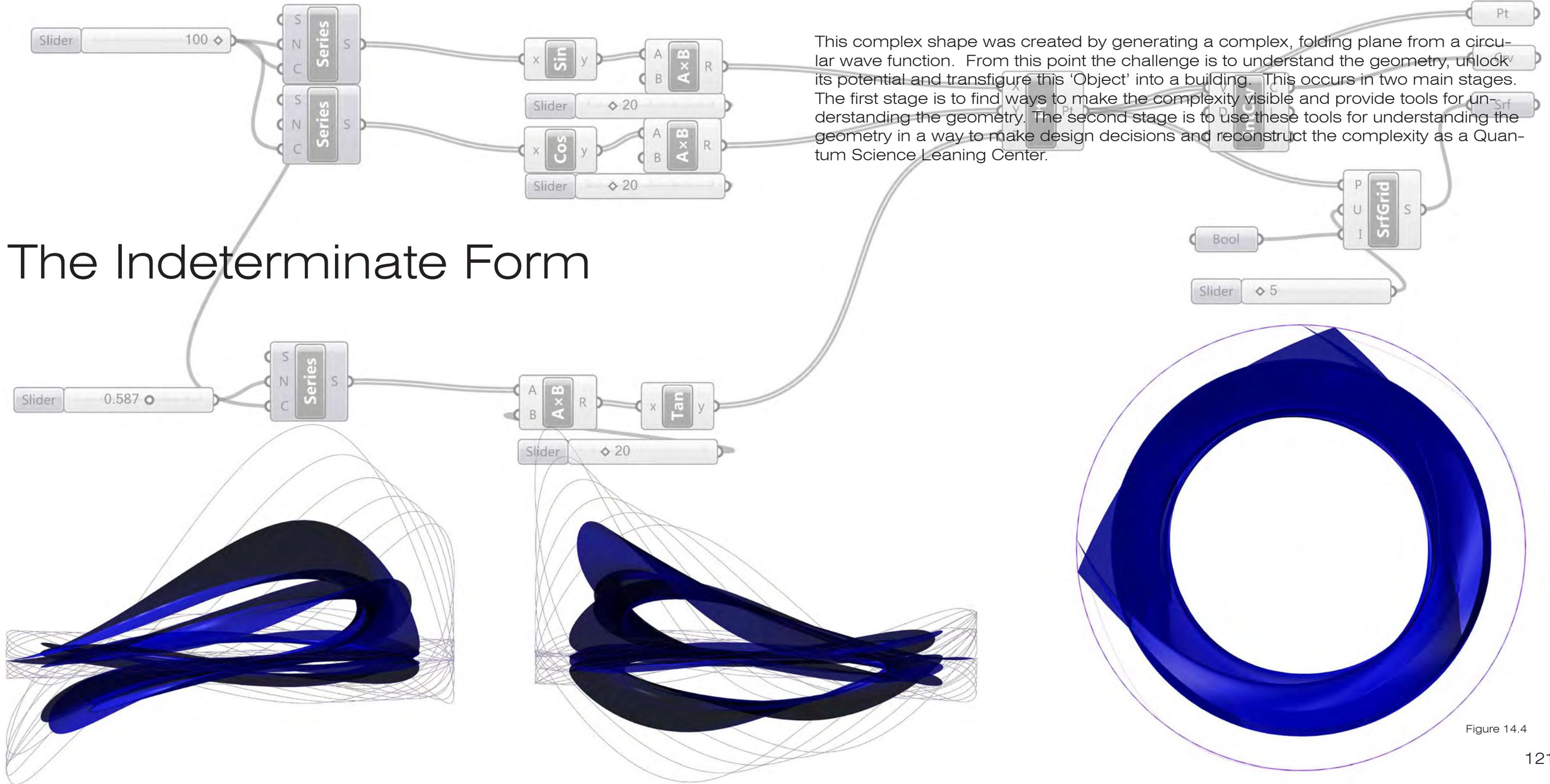


Figure 14.3

These experiments are exploring various methods for generating forms using the parametric software Grasshopper. A wide range of varying geometries with varying levels of complexity can be created through this parametric process. As computers advance the processing power of will increase, allowing for the creation of increasingly complex geometries.

The Indeterminate Form



This complex shape was created by generating a complex, folding plane from a circular wave function. From this point the challenge is to understand the geometry, unlock its potential and transfigure this 'Object' into a building. This occurs in two main stages. The first stage is to find ways to make the complexity visible and provide tools for understanding the geometry. The second stage is to use these tools for understanding the geometry in a way to make design decisions and reconstruct the complexity as a Quantum Science Learning Center.

Figure 14.4

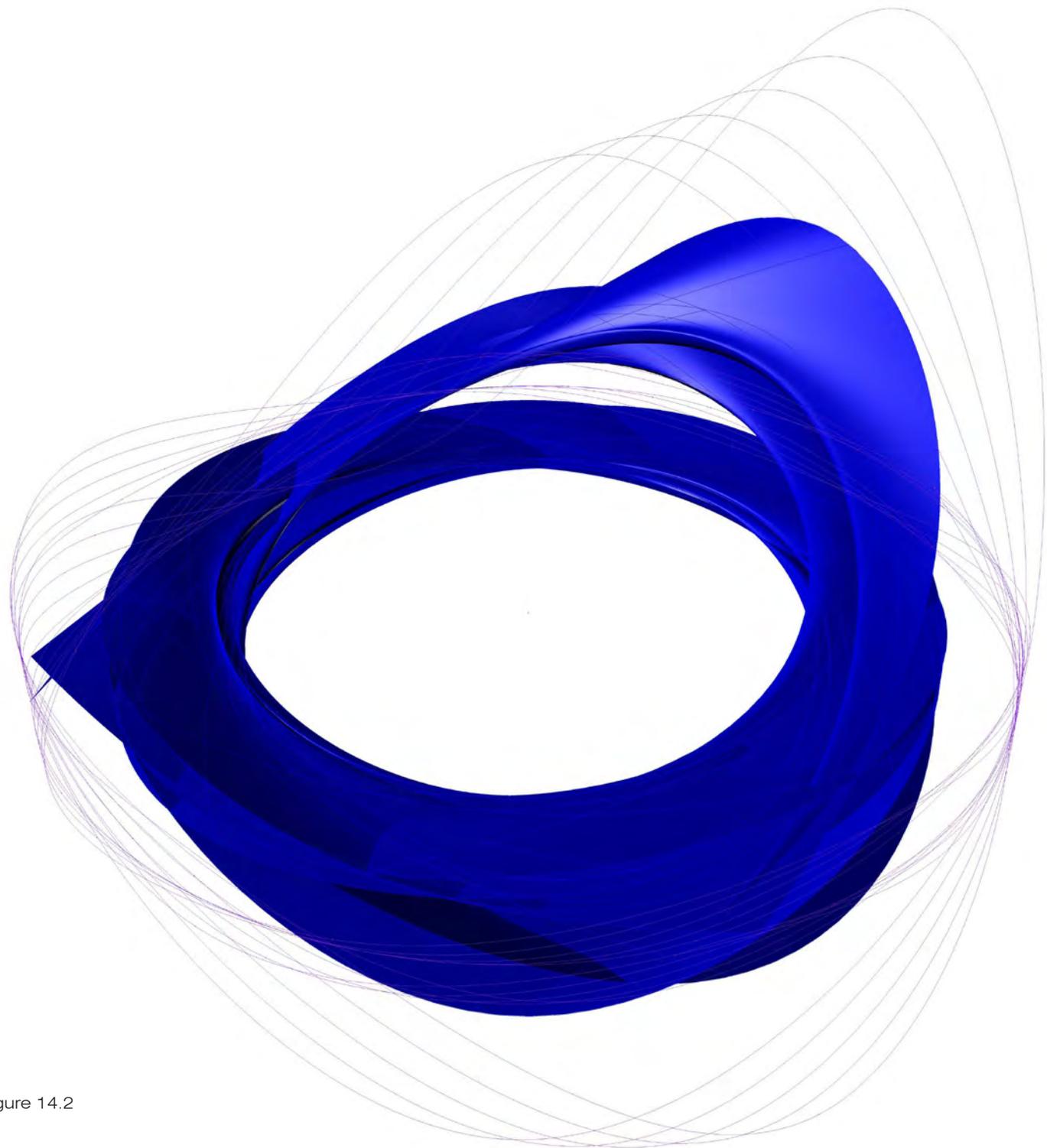
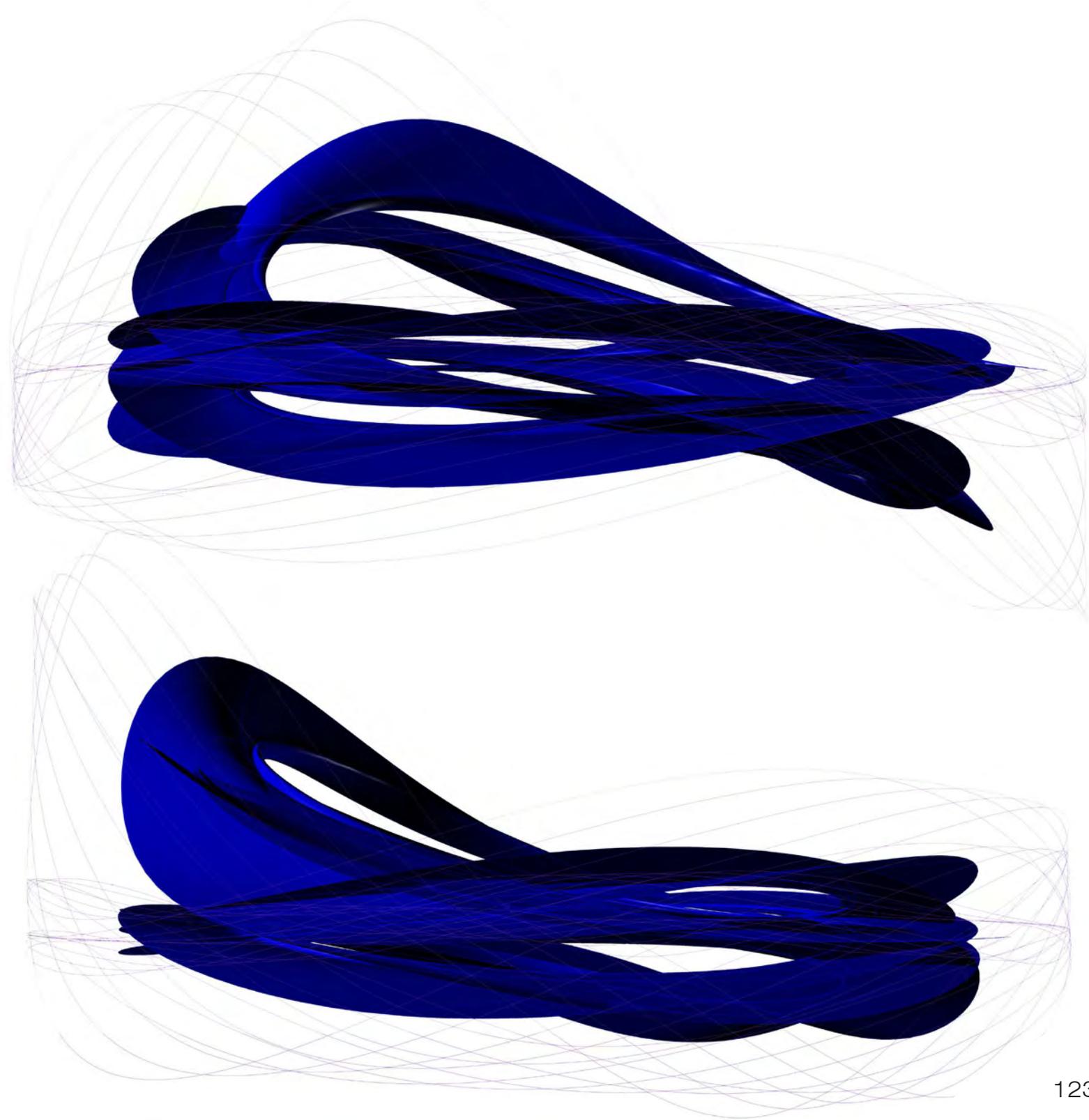


Figure 14.2



"BOHR CONSIDERED THE TWO PICTURES - **PARTICLE** PICTURE AND **WAVE** PICTURE - AS TWO
COMPLIMENTARY DESCRIPTIONS OF THE SAME REALITY.

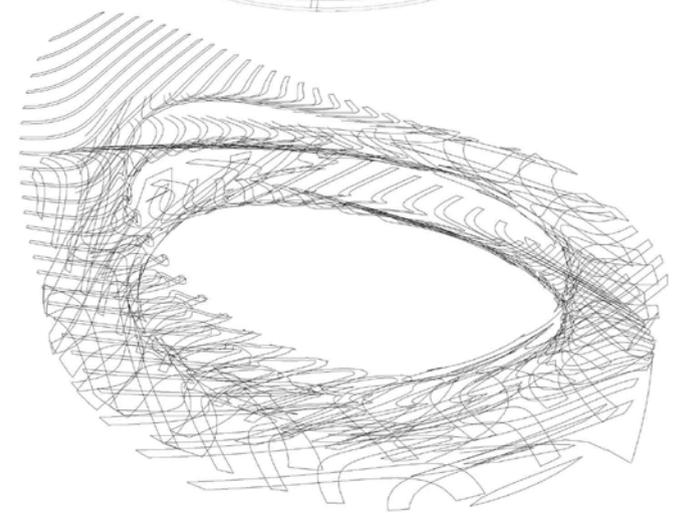
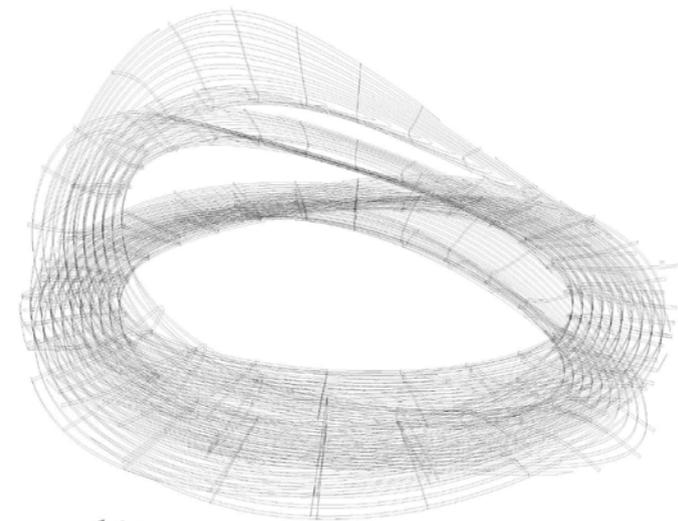
**ANY OF THESE DESCRIPTIONS CAN ONLY BE
PARTIALLY TRUE,**

THERE MUST BE LIMITATIONS TO THE USE OF THE PARTICLE CONCEPT AS WELL AS OF THE WAVE CONCEPT,
ELSE ONE COULD NOT AVOID CONTRADICTIONS.

IF ONE TAKE INTO ACCOUNT THOSE **LIMITATIONS** WHICH CAN BE EXPRESSED BY THE
UNCERTAINTY RELATIONS, THE CONTRADICTIONS DISAPPEAR"

(HEISENBERG, 1958)

THE PROBLEM OF
VISIBILITY



The problem of understanding complex geometry is similar to Heisenberg's uncertainty principle for understanding quantum mechanics. Heisenberg states that the way in which one observes a phenomenon influences the very nature of that phenomenon and how that phenomenon then enters into reality. Similarly, the way one observes complex geometry, determines how one understands that geometry, and inevitably impacts the way one designs from that geometry. Therefore, the way one makes the complex geometry visible is crucial to how that geometry will be used for design.

Quantum mechanics is distinct to classical physics in that describes two ways of understanding subatomic phenomenon which are inherently contradicting, yet co-dependent for a complete picture.

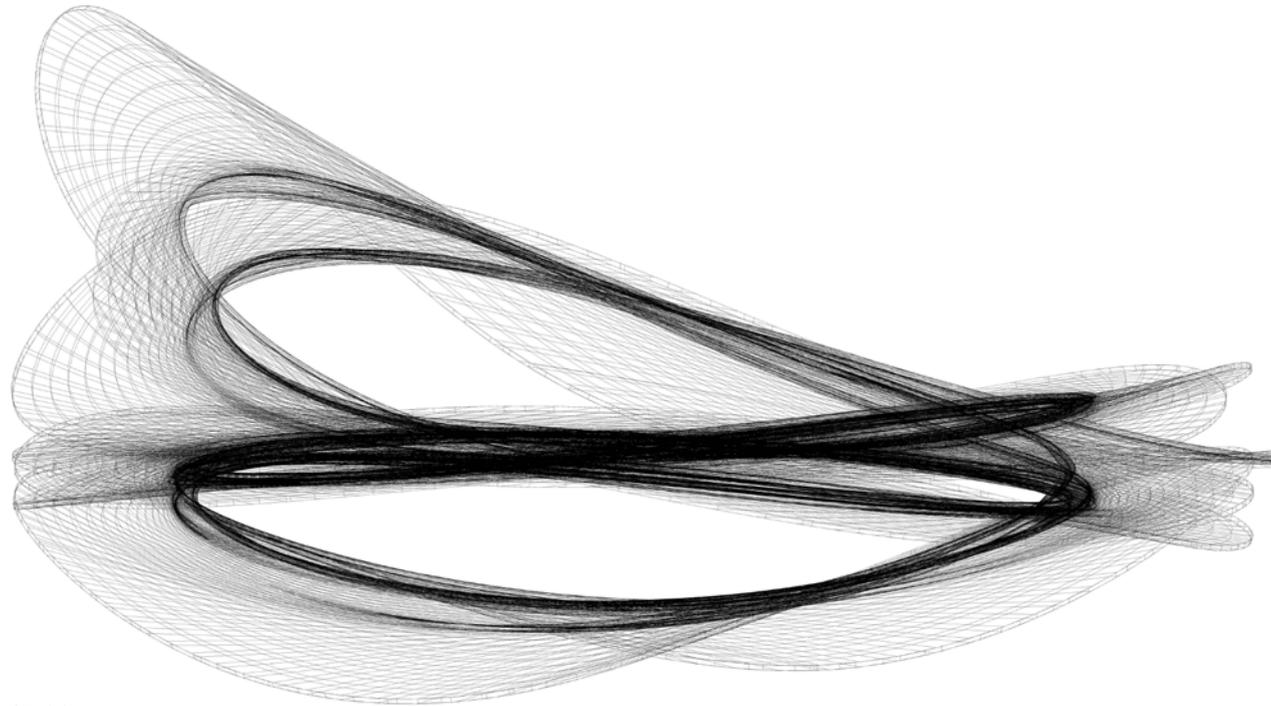


Figure 15.01

“Bohr considered the two pictures – particle picture and wave picture – as two complimentary descriptions of the same reality. Any of these descriptions can only be partially true, there must be limitations to the use of the particle concept as well as of the wave concept, else one could not avoid contradictions. If one takes into account those limitations which can be expressed by the uncertainty relations, the contradictions disappear” (Heisenberg, 1958, p. 17)

Heisenberg is illustrating how different descriptions of the same event can be used to understand an inherently indeterminate phenomenon. By employing complimentary descriptions of complex geometry, one can find new way of viewing and thereby understanding that geometry.

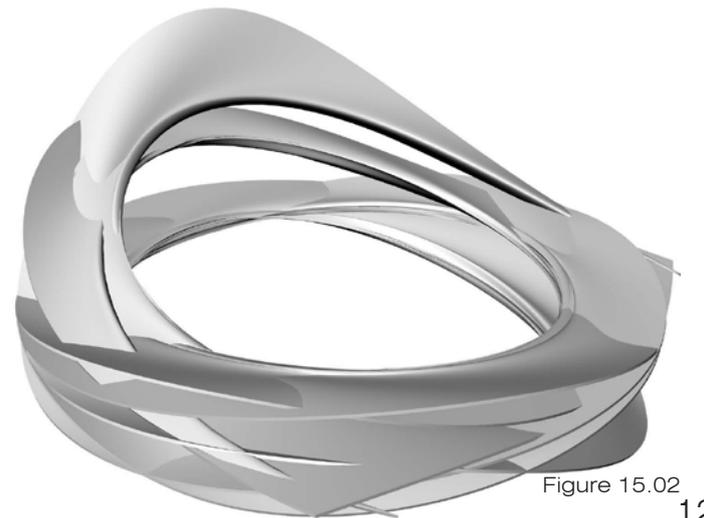
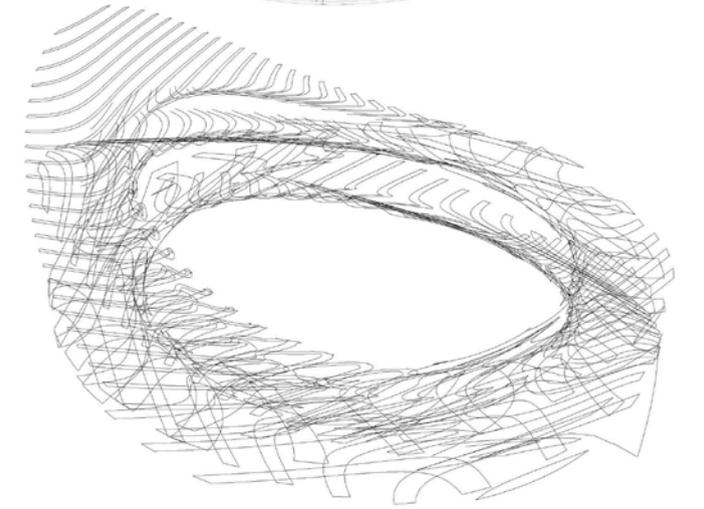
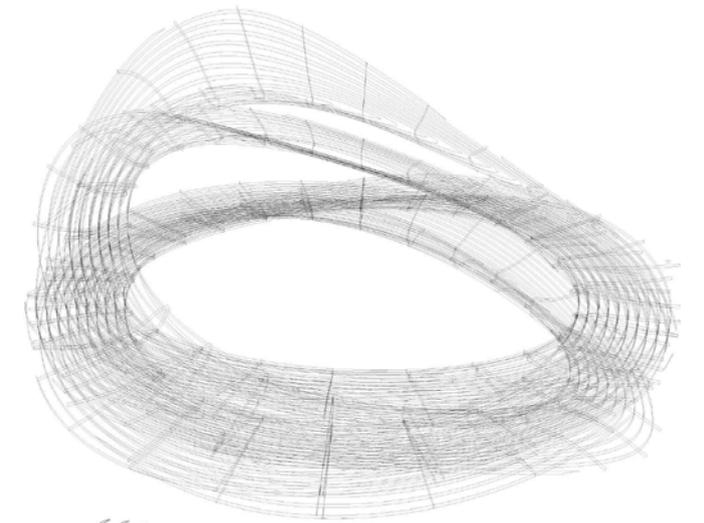


Figure 15.02

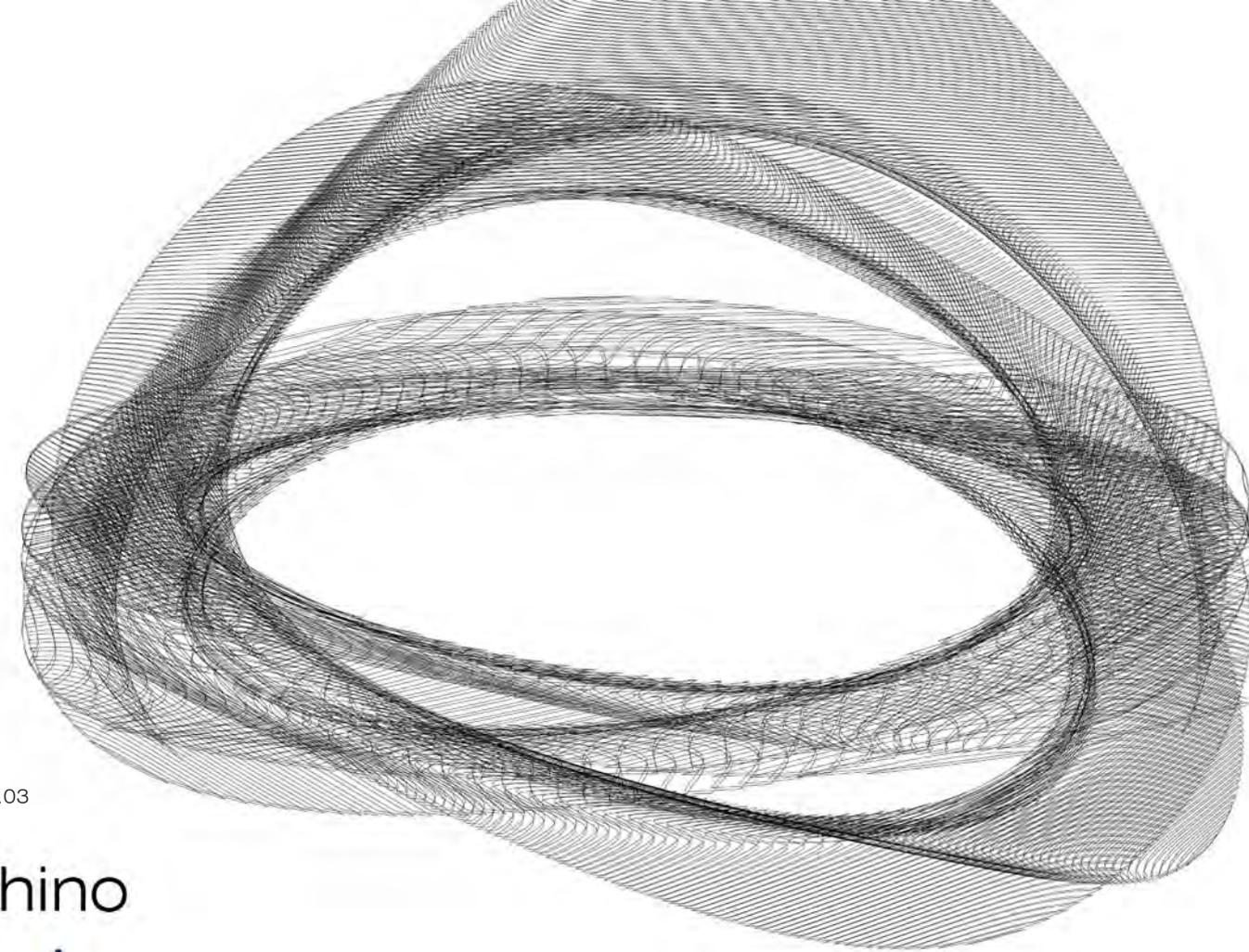
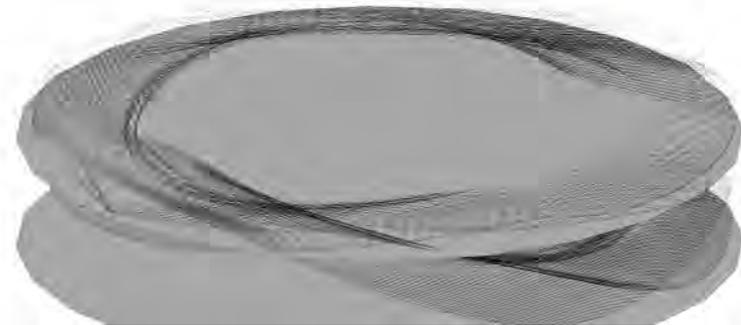
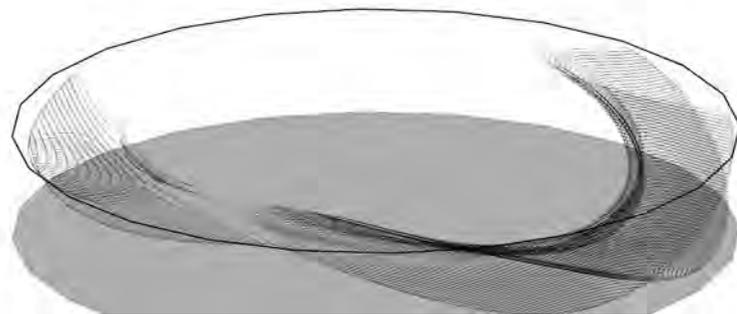


Figure 15.03

Rhino



In a complex form, placing floor planes is a way of creating reference points. These reference points makes the geometry more accessible and allow for clearer design decisions

Drawing

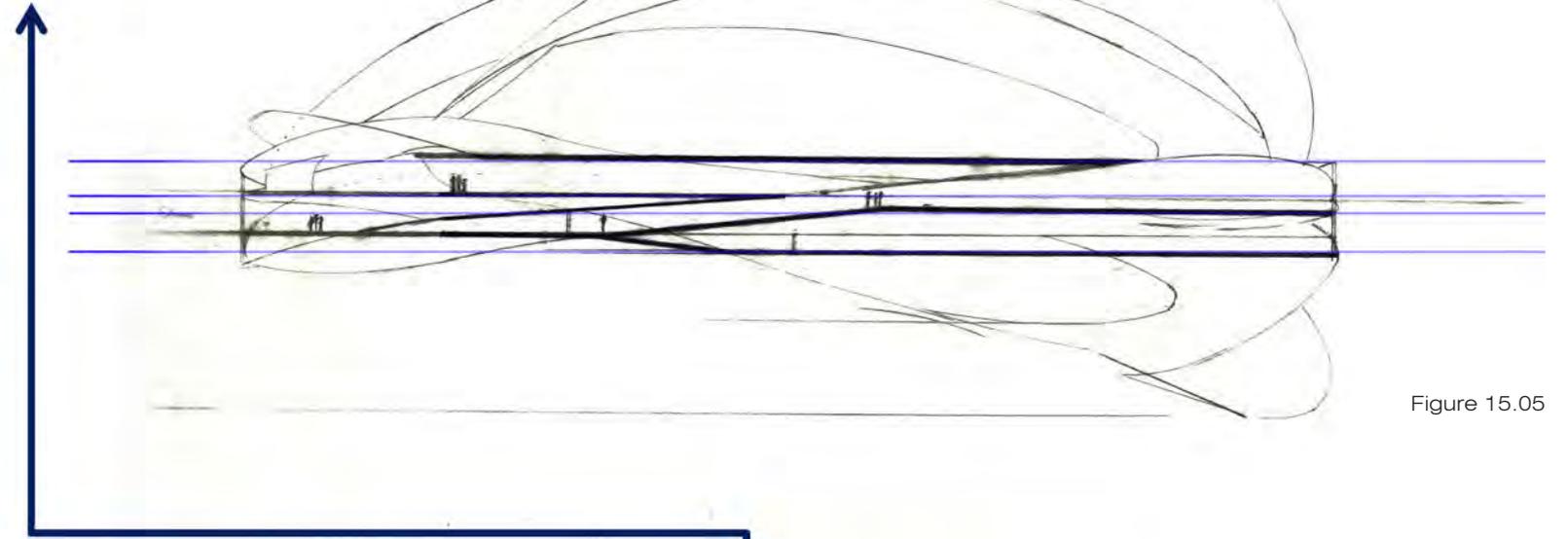


Figure 15.05

Sketch-up

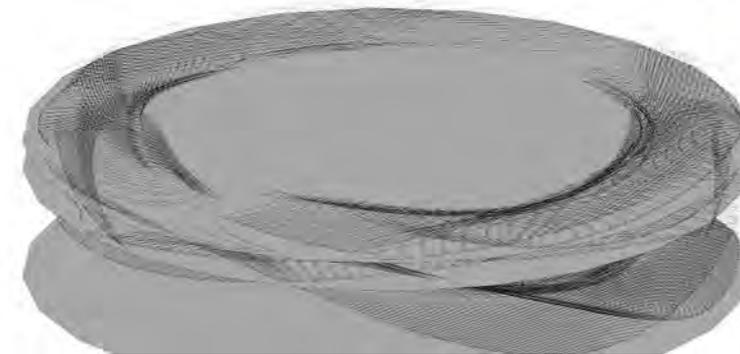
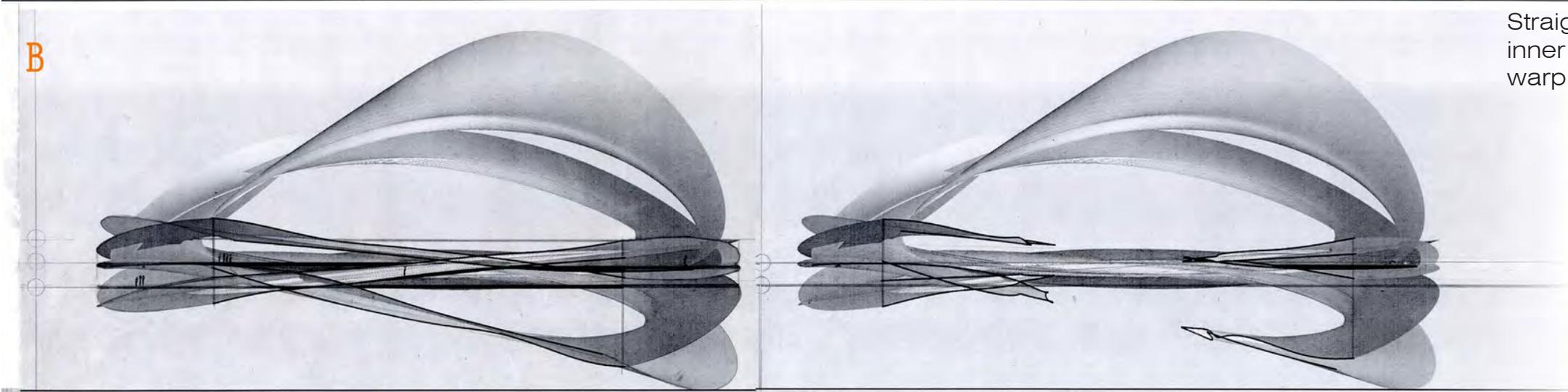
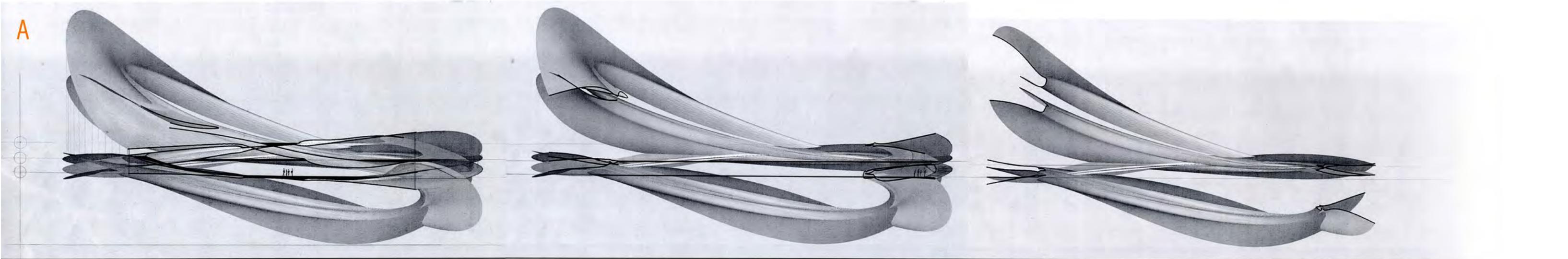
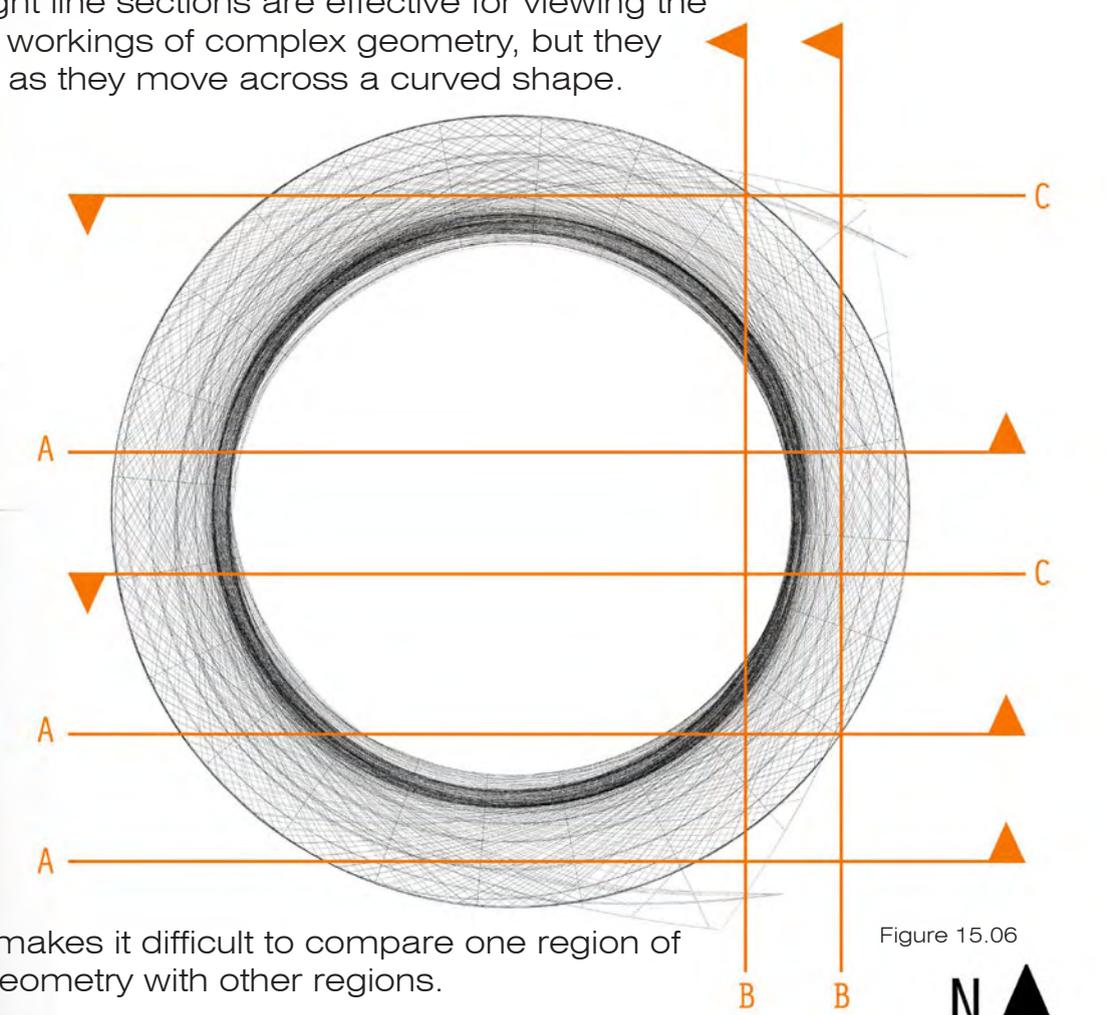
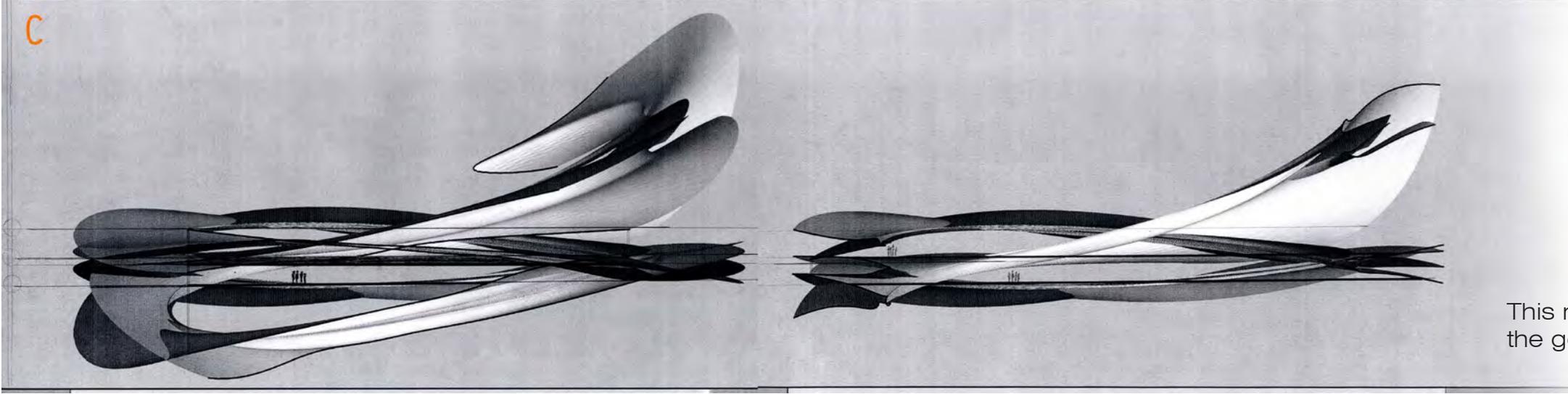


Figure 15.04



Straight line sections are effective for viewing the inner workings of complex geometry, but they warp as they move across a curved shape.



This makes it difficult to compare one region of the geometry with other regions.

Figure 15.06



3D Printing is an accurate way of reproducing geometry in a physical model, but it doesn't lend itself well to alteration or reinterpretation.

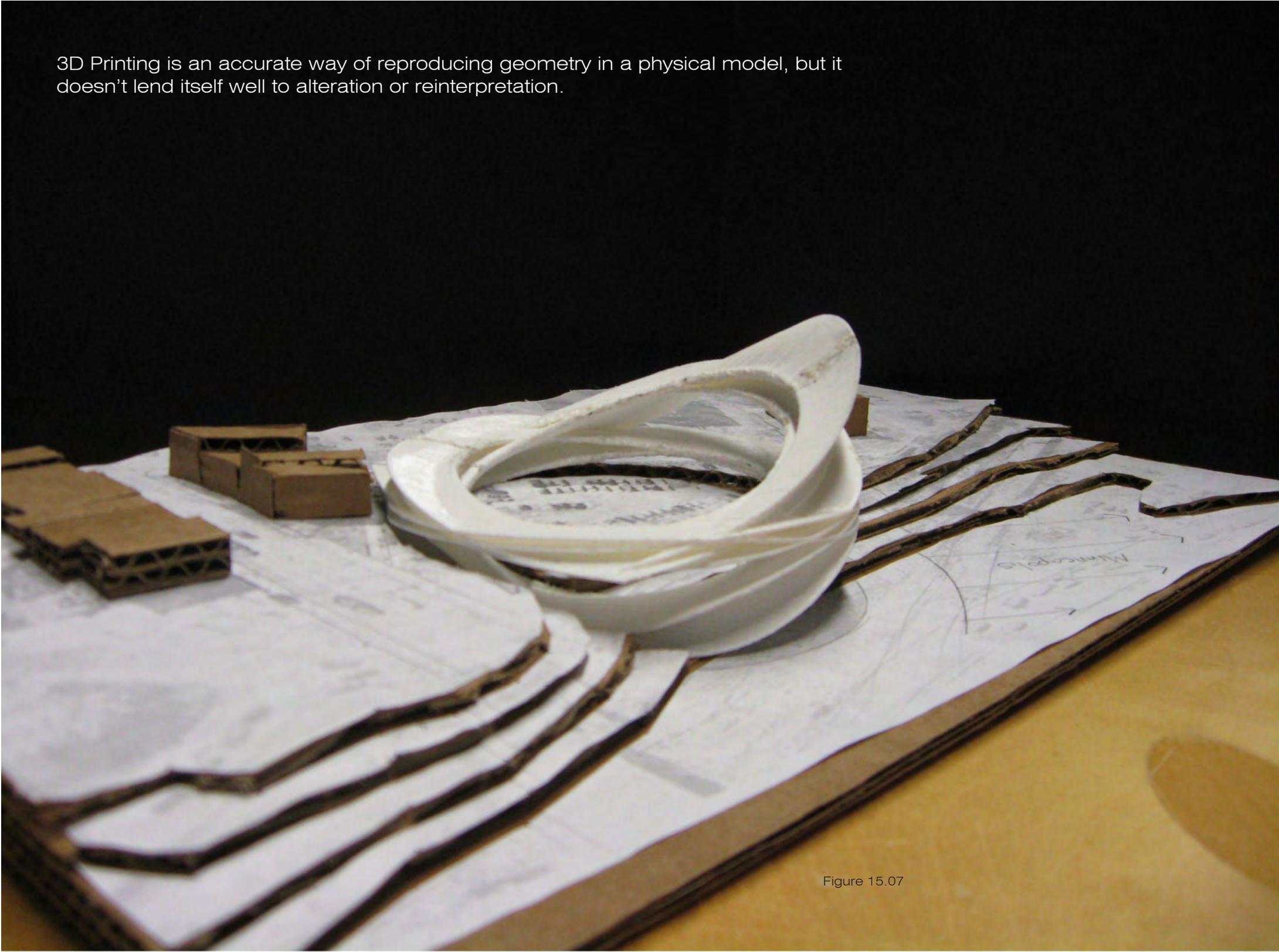


Figure 15.07



Figure 15.08

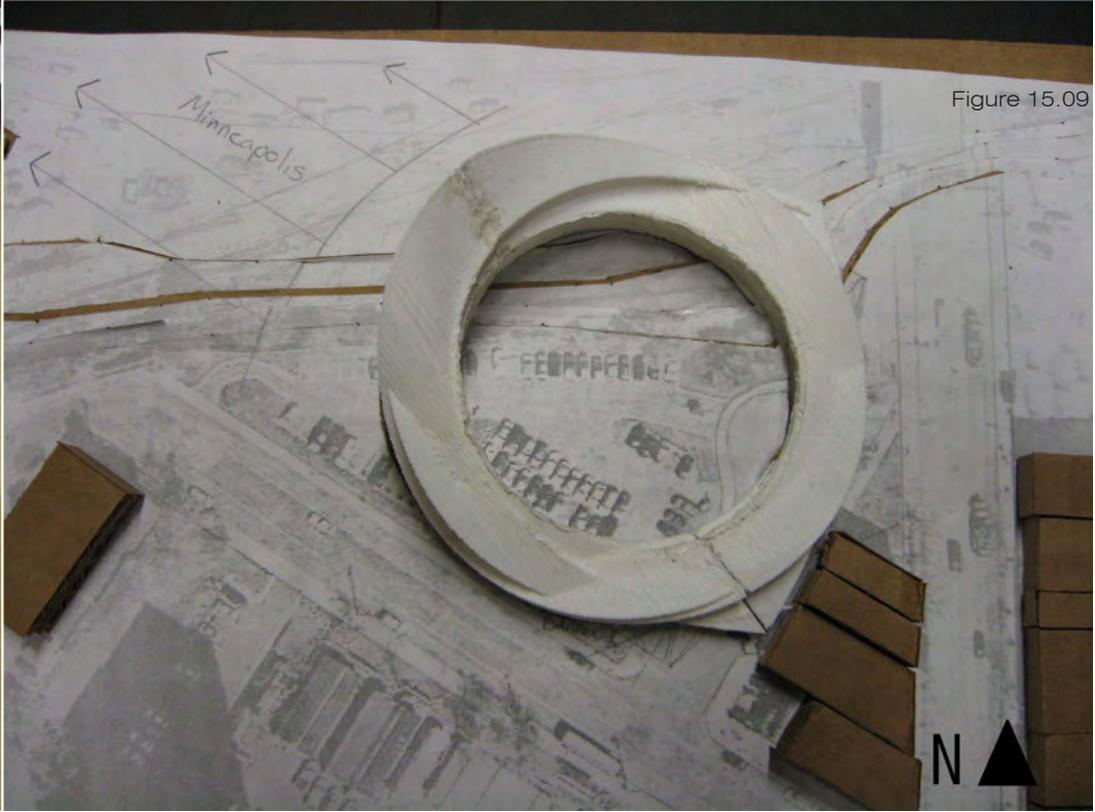


Figure 15.09



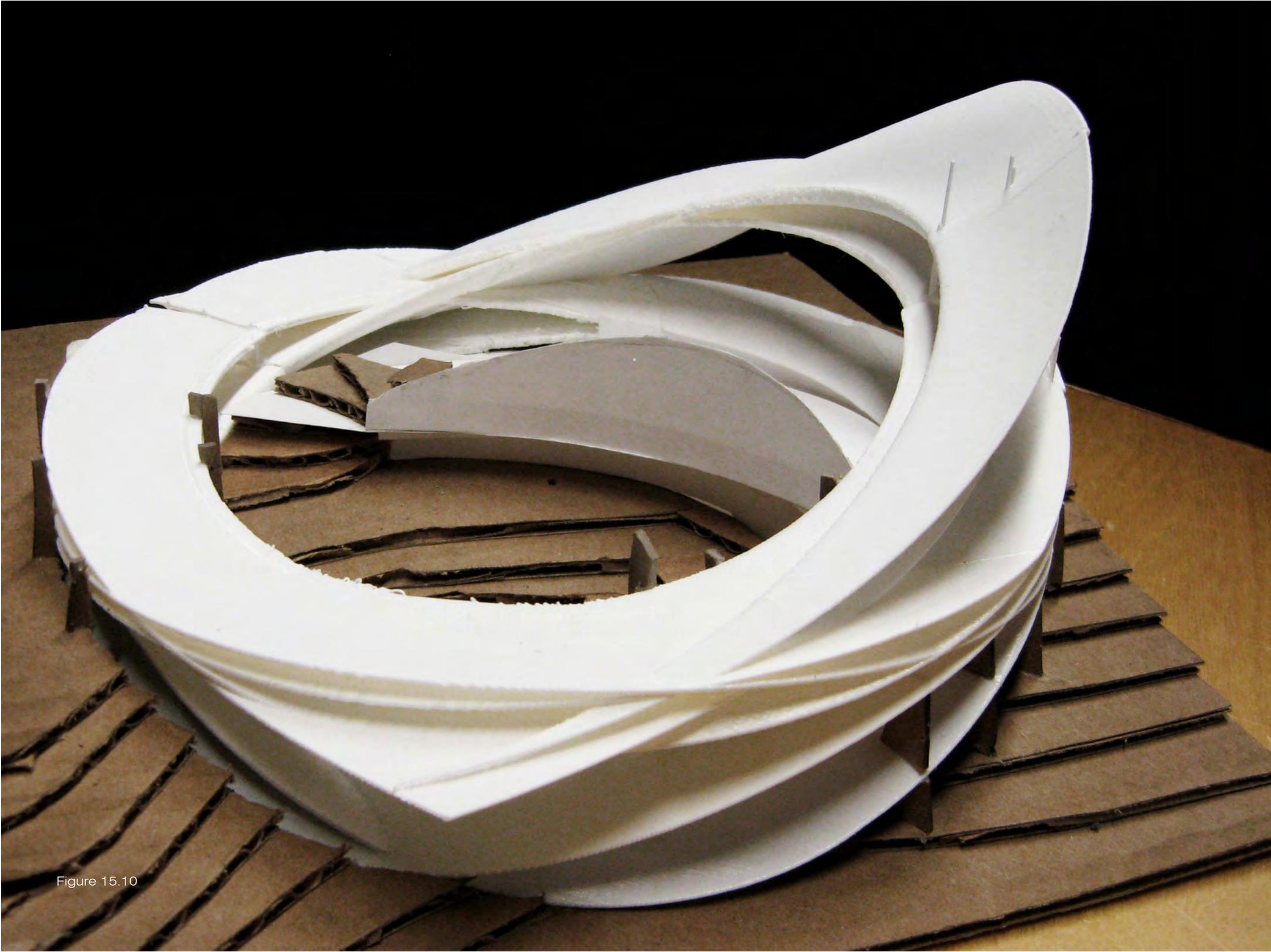


Figure 15.10

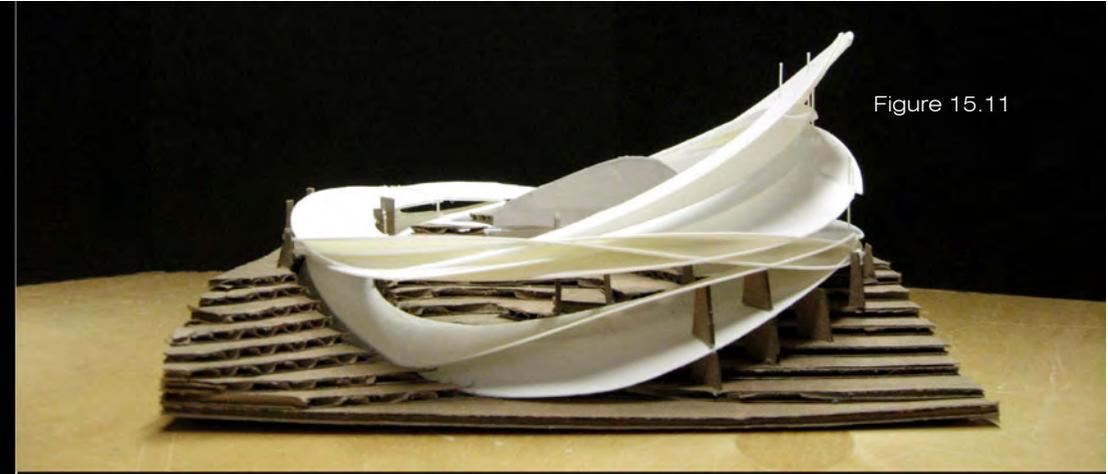


Figure 15.11

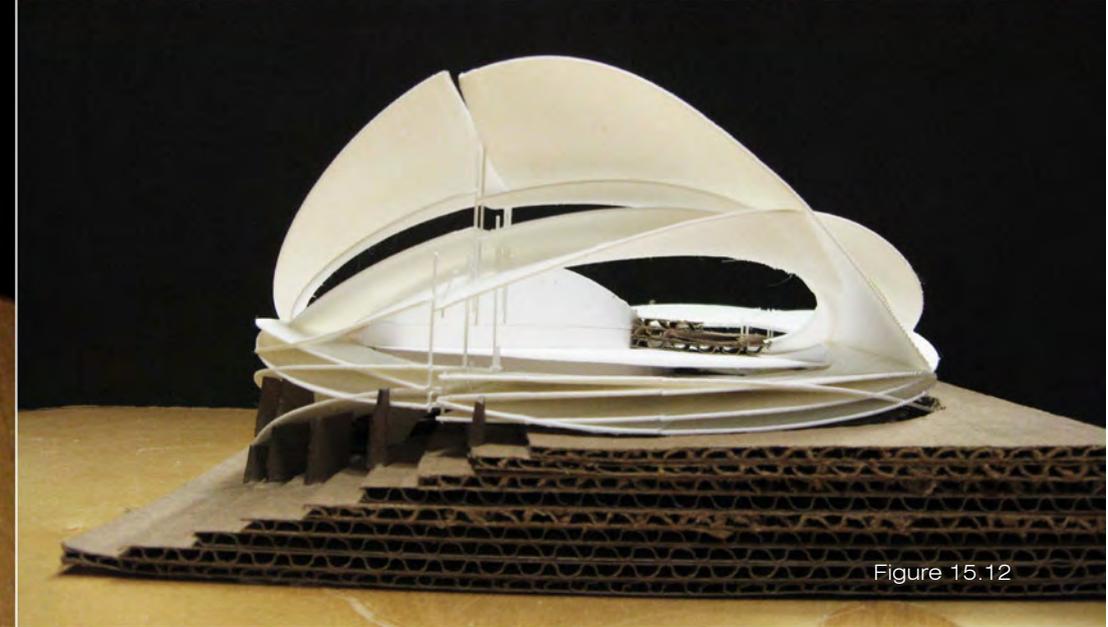


Figure 15.12

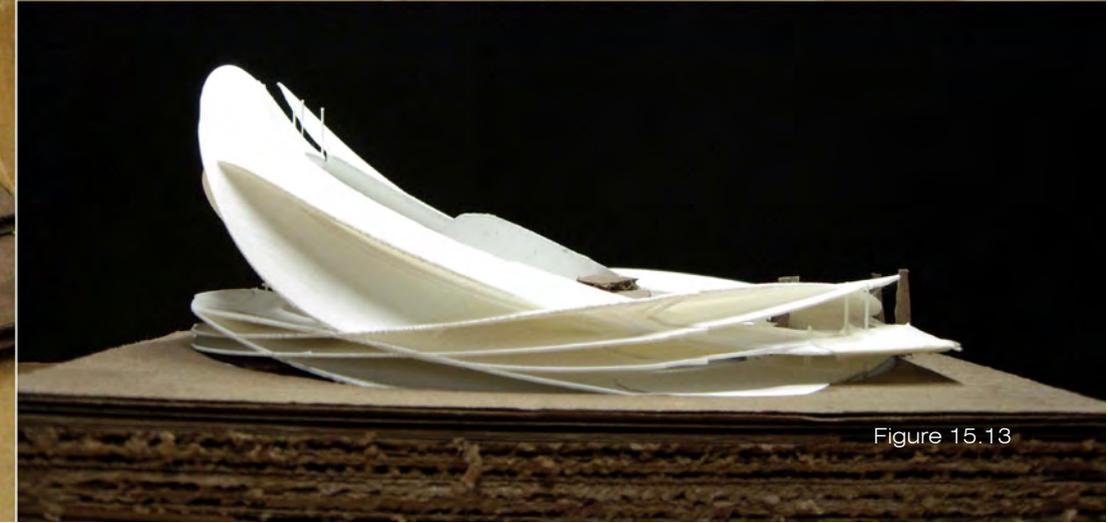


Figure 15.13

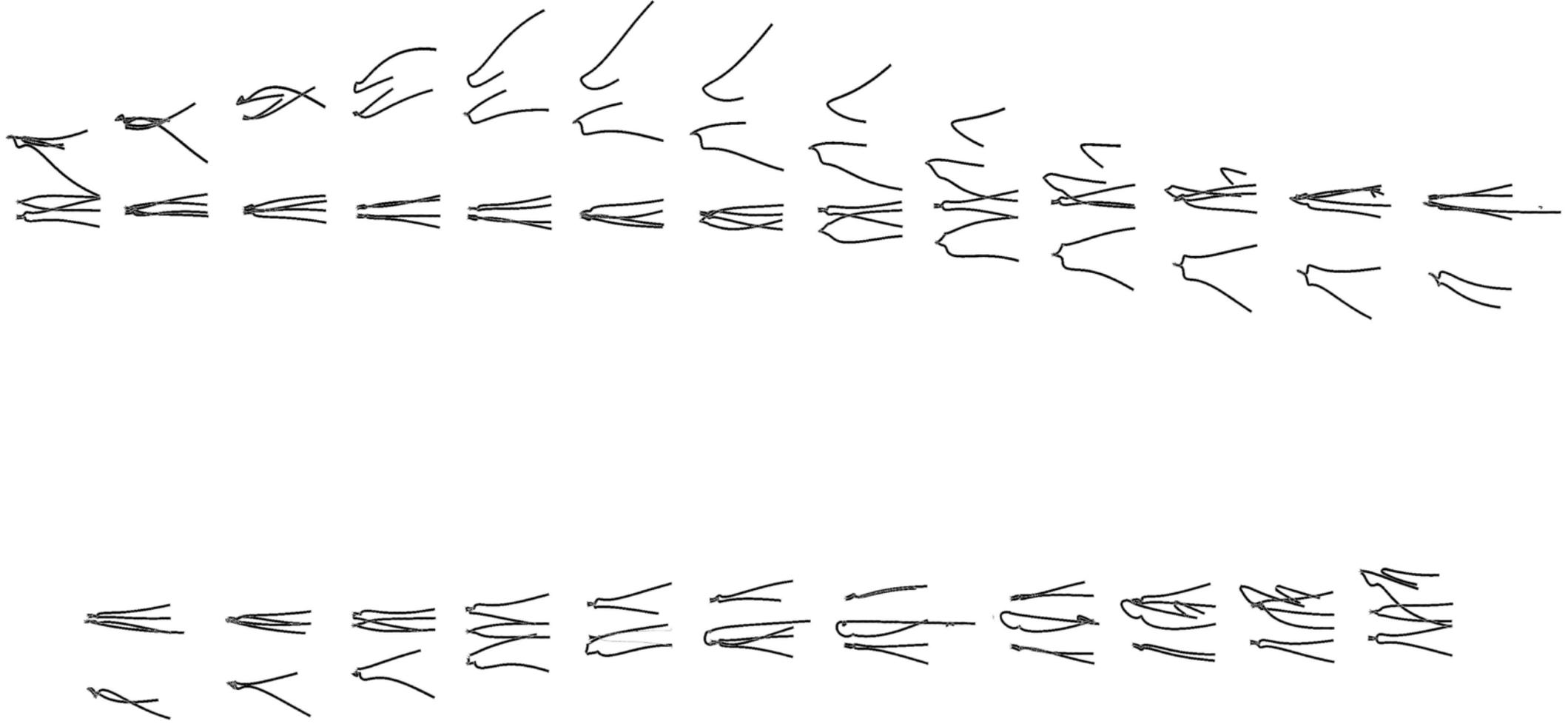
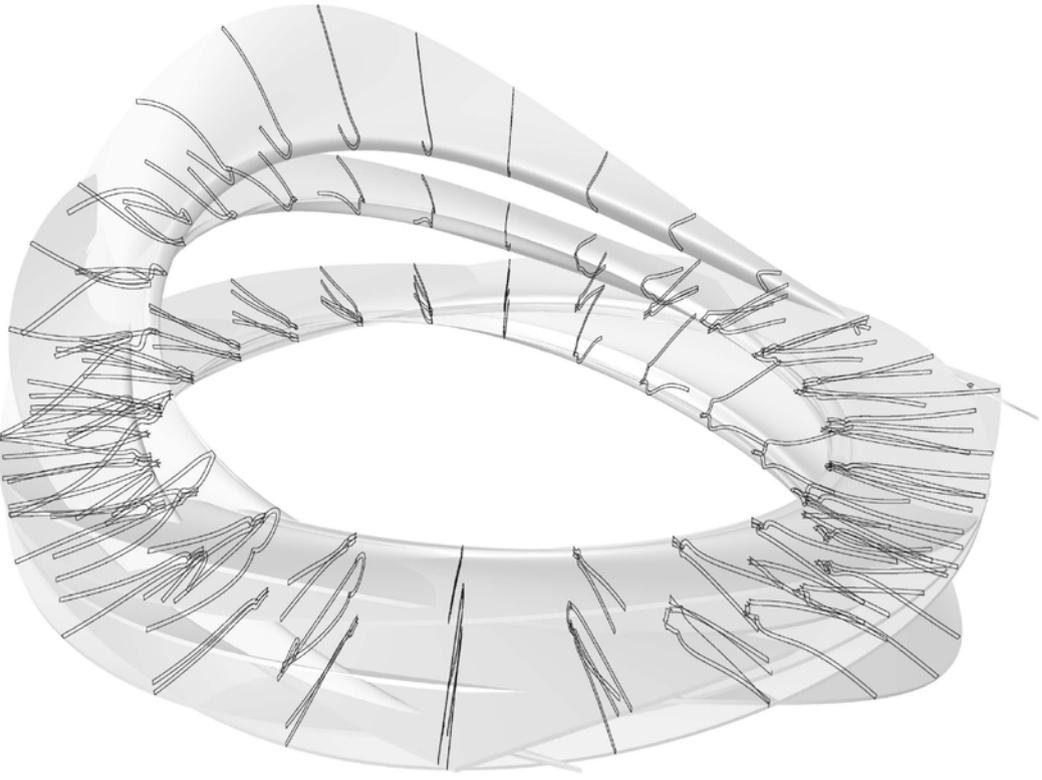


Figure 15.14

Dividing the shape into 24 radial sections makes it possible understand the geometry in a new way.

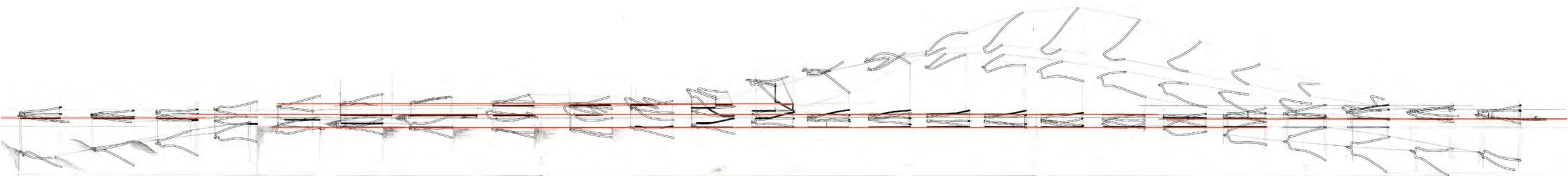


Figure 15.15

These Radial sections provide an effective framework for making design decisions with respect to the changing nature of the geometry.

"THE **OBSERVATION** ITSELF CHANGES THE PROBABILITY FUNCTION DISCONTINUOUSLY; IT SELECTS FROM ALL THE POSSIBLE EVENTS THE ACTUAL ONE THAT HAS TAKEN PLACE. [...]"

THEREFORE, THE TRANSITION FROM THE 'POSSIBLE'
TO THE 'ACTUAL' TAKES PLACE DURING THE ACT OF
OBSERVATION.

[...] AND WE MAY SAY THAT THE TRANSITION FROM THE 'POSSIBLE' TO THE 'ACTUAL' TAKES PLACE AS SOON AS THE INTERACTION OF THE OBJECT WITH THE MEASURING DEVICE, AND THEREBY WITH THE REST OF THE WORLD, HAS COME INTO PLAY"

(HEISENBERG, 1958)



**THE CHALLENGE OF
RECONSTRUCTION**

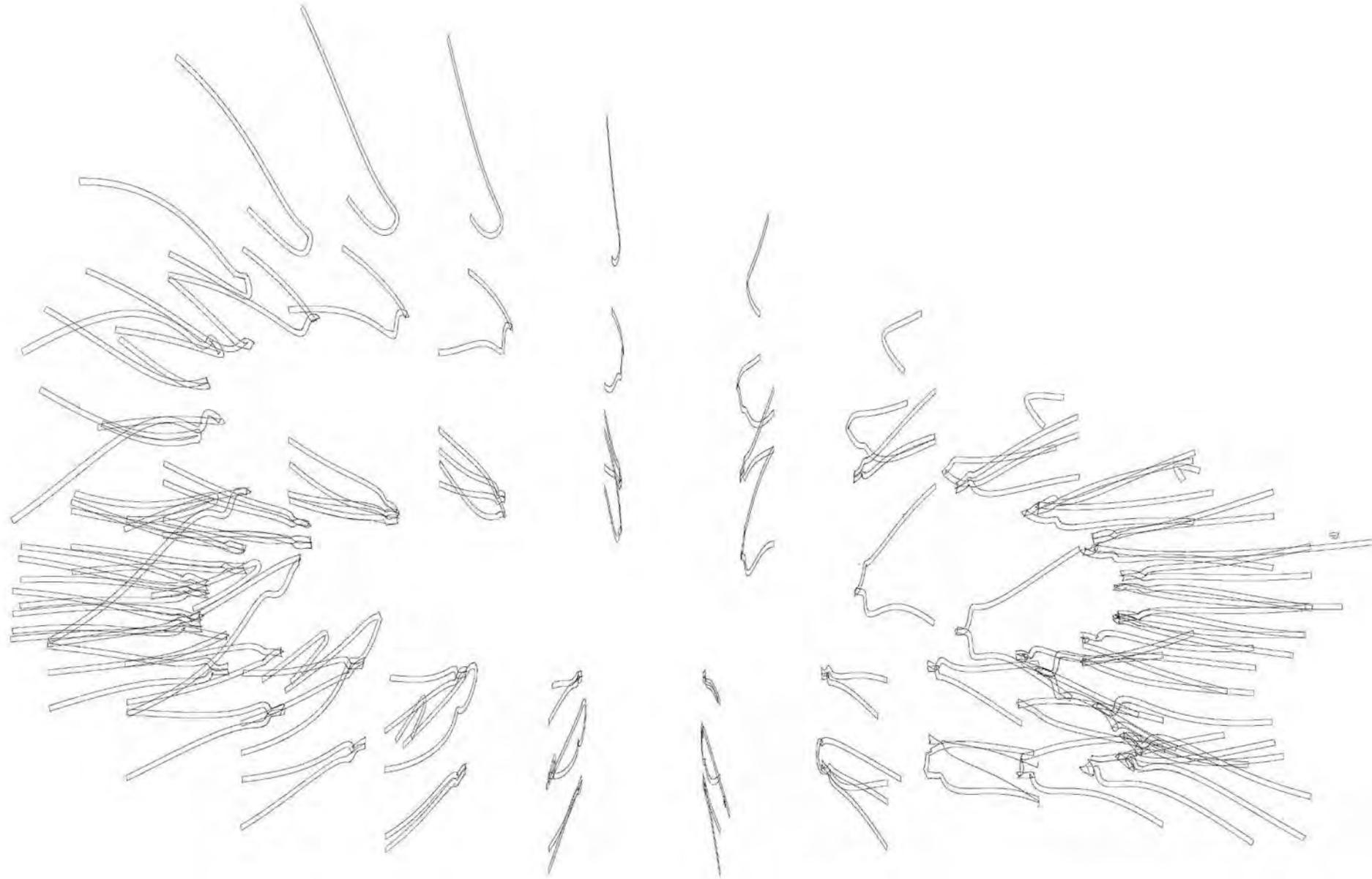


Figure 16.1

After understanding complex geometry, another step must be taken to turn an algorithm into a design. The complex geometry must be recreated. Remaking the complex shape forces the designer to interpret and redefine the nature of the complex shape. Through remaking the designer engages in rethinking. This engagement of rethinking moves the abstract geometry into meaningful decision making. Through this engagement the shape is transfigured from a mathematical algorithm into a design. It is the designer's reconstruction which makes something initially arbitrary become meaningful decision making.

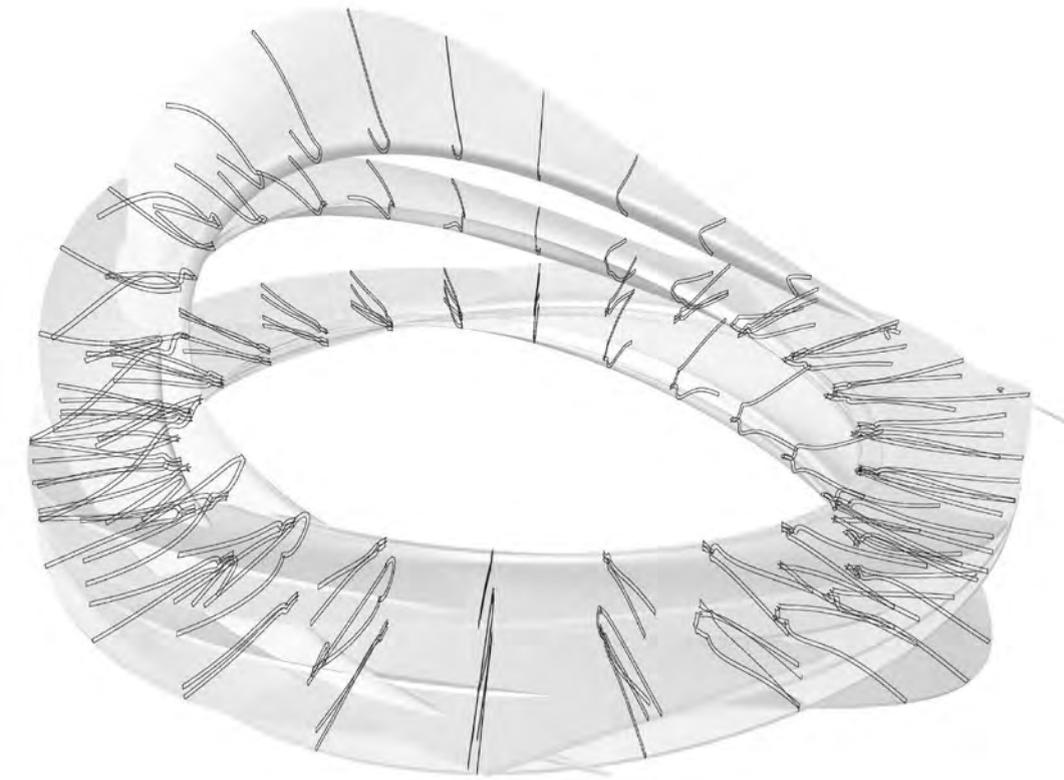
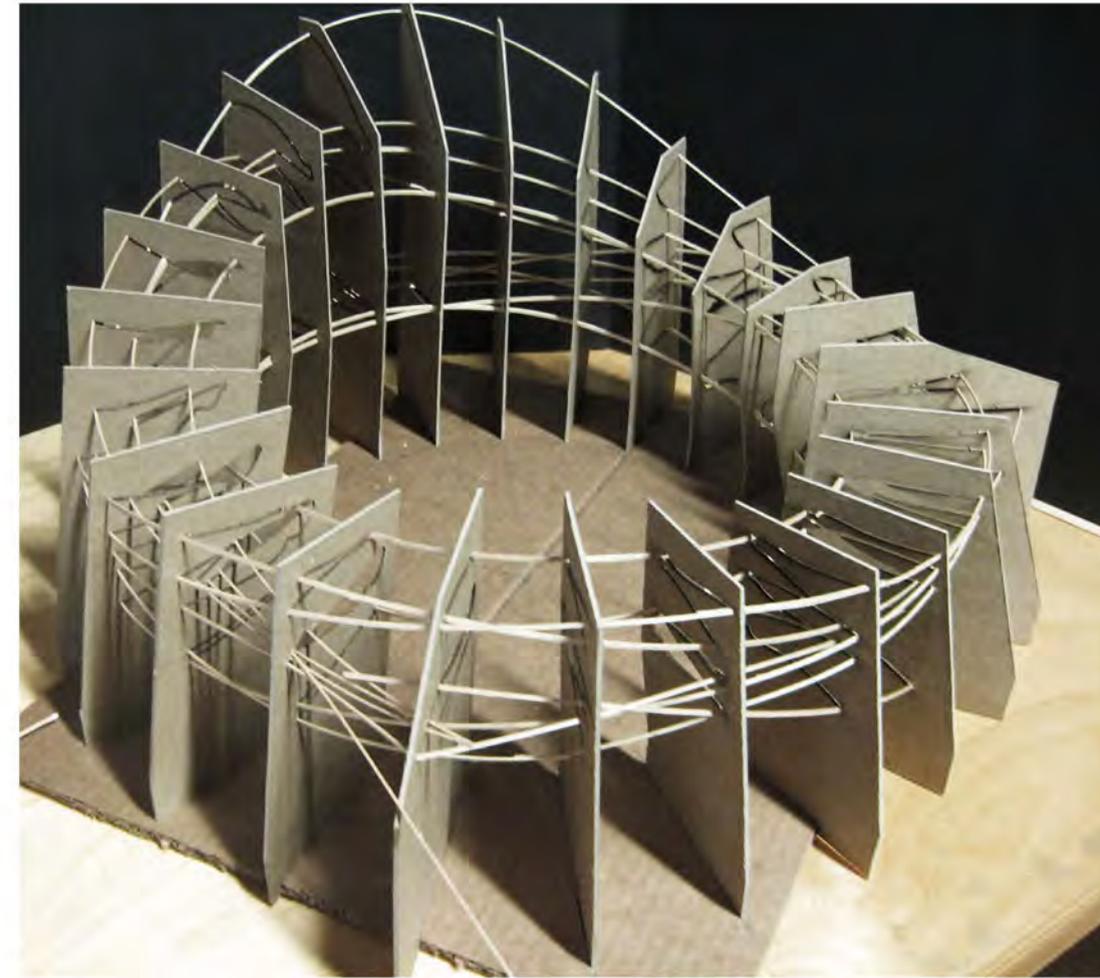
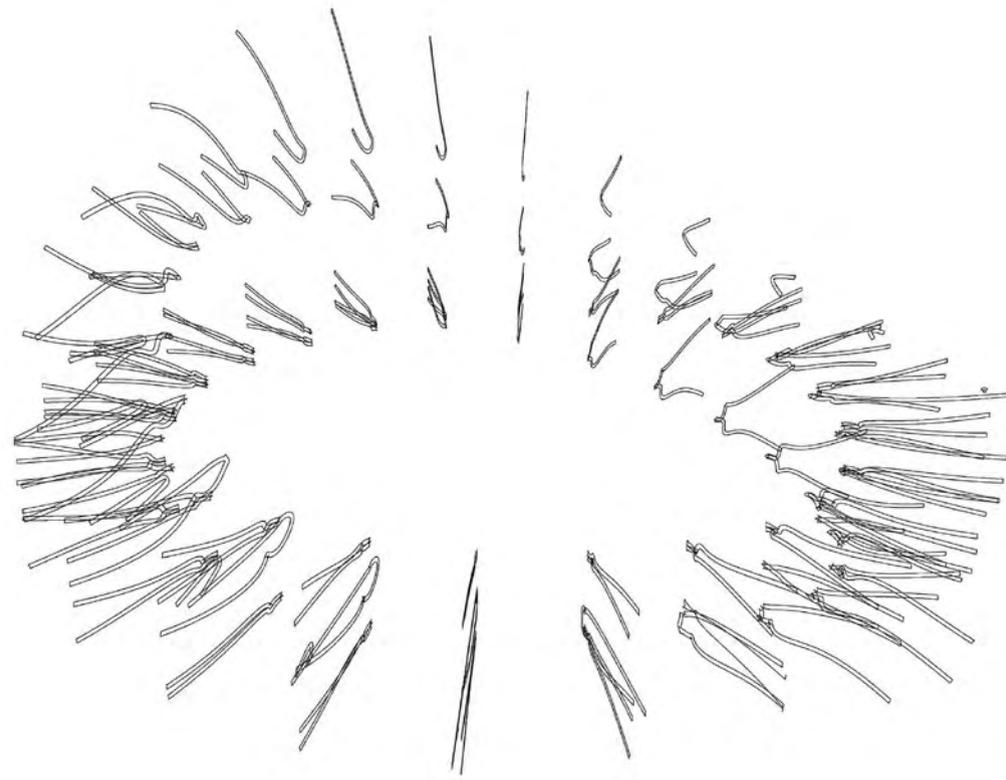


Figure 16.2



By taking the 24 radial sections and using them as reference points, the complex geometry can be reconstructed accurately with a digital or physical model. Through this reconstruction, design decisions can be introduced. Without this simplified framework it is nearly impossible make changes and achieve a comprehensive building design.

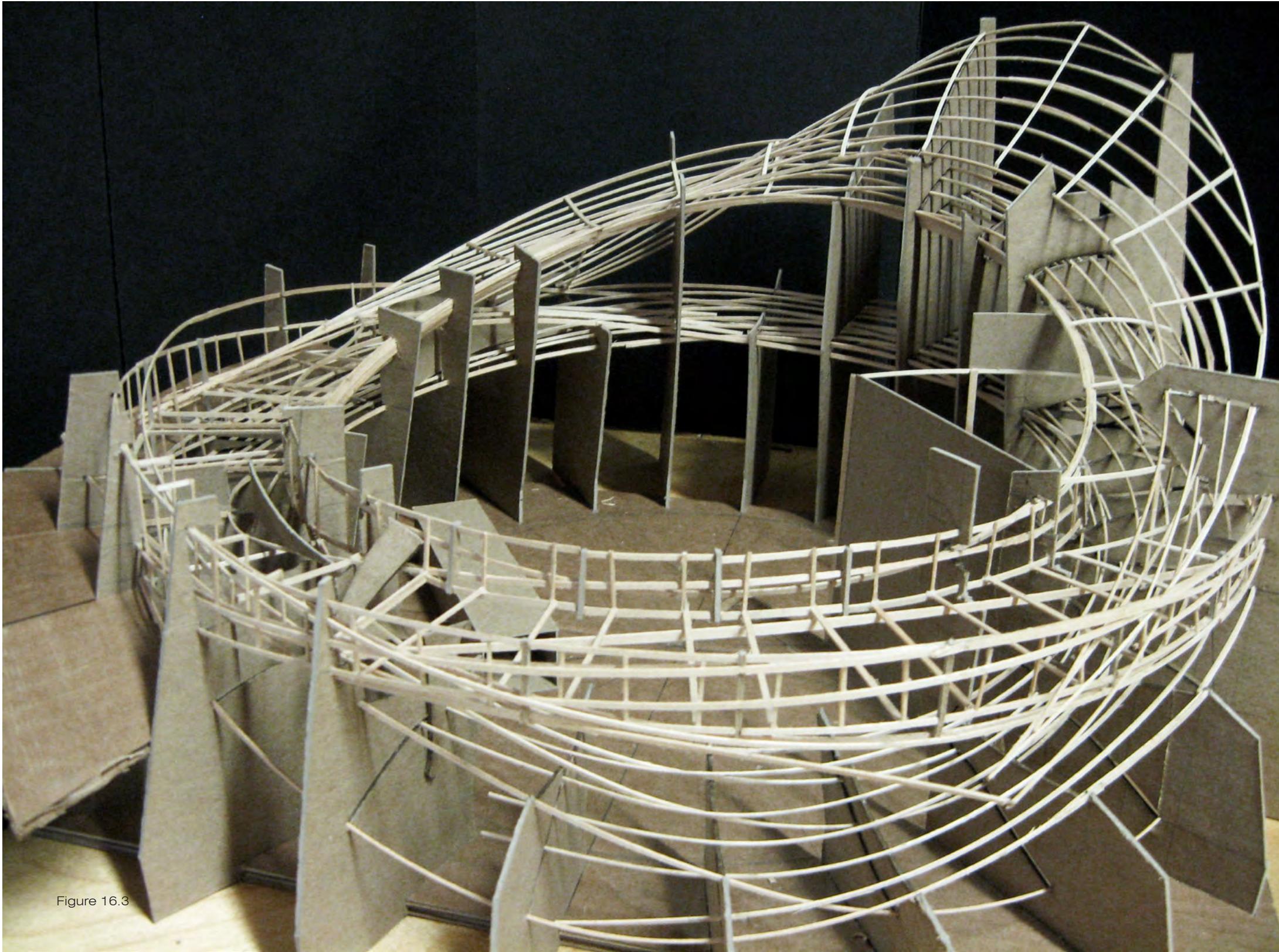


Figure 16.3

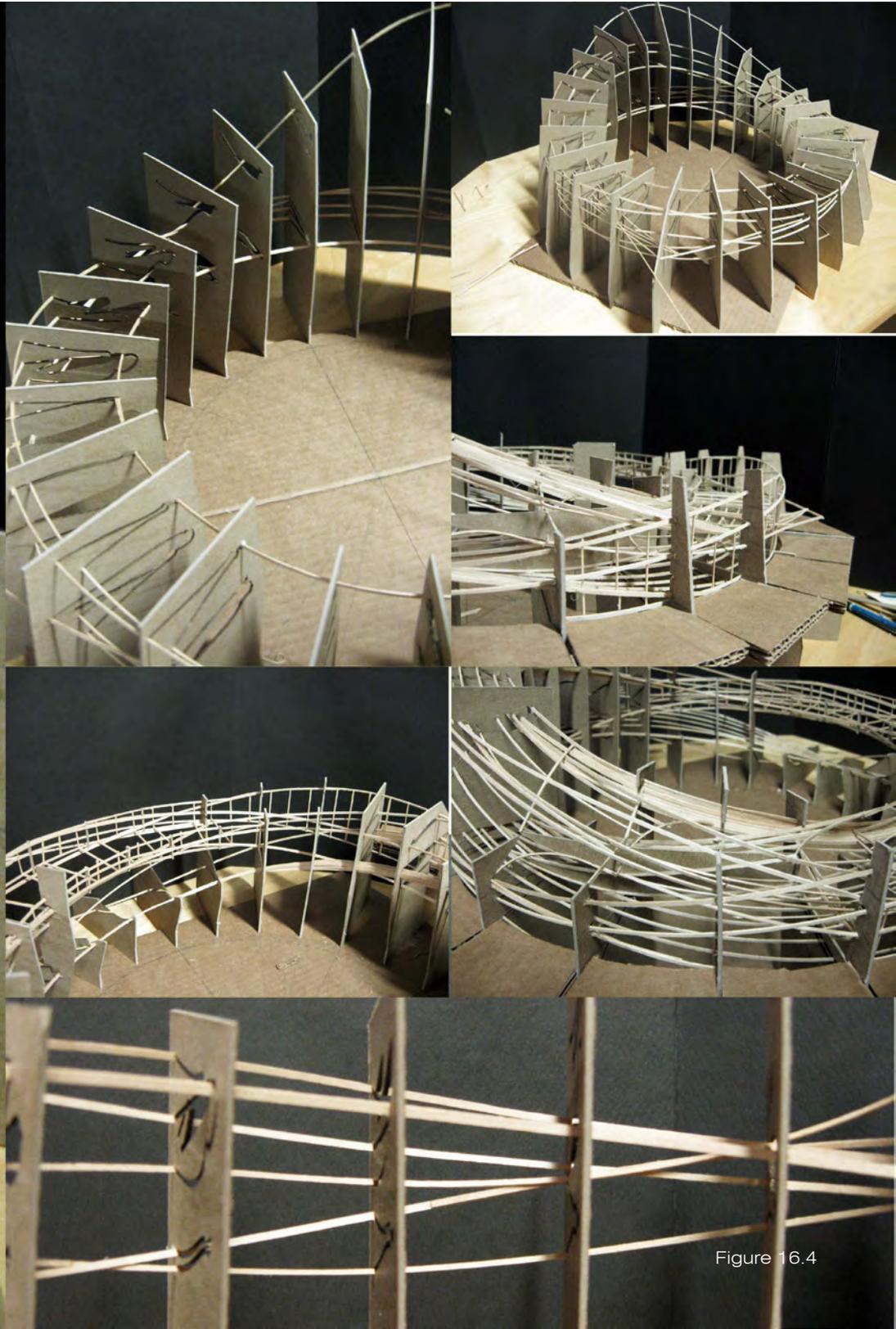


Figure 16.4

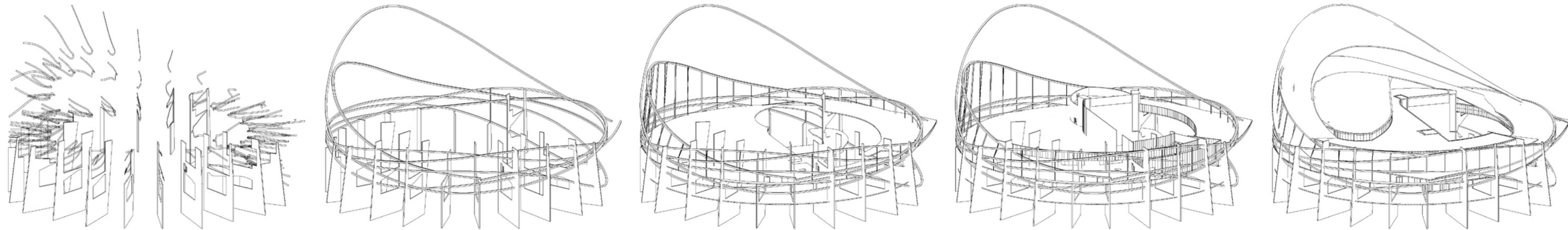


Figure 16.5

This diagram shows the interaction of many pieces and how the radial sections informed the foundation structure to the mullions, the floor plates and interior walls, and finally the roof.

During the digital reconstruction, there was a constant reference to drawings of floor plans, the linear section drawings, the radial section drawing and the physical model. Although the framework of the radial sections allowed for a reconstruction of the shape into a building, many different ways of framing the design were required to make design decisions. In this way, one single way of understanding complexity is not enough. Similar to the two models Bohr and Heisenberg use to frame quantum events, complexity requires many descriptions to be understood.

“The observation itself changes the probability function discontinuously; it selects from all the possible events the actual one that has taken place. [...] Therefore, the transition from the ‘possible’ to the ‘actual’ takes place during the act of observation. [...] and we may say that the transition from the ‘possible’ to the ‘actual’ takes place as soon as the interaction of the object with the measuring device, and thereby with the rest of the world, has come into play” (Heisenberg, 1958, p. 28-29)

As Heisenberg describes, through interaction with the real world, through context, programmatic requirements, site, and scale, the transition from the ‘possible’ to ‘actual’ occurs through the act of observation and through interaction with the rest of the world.

Radial Sections to Building Sections

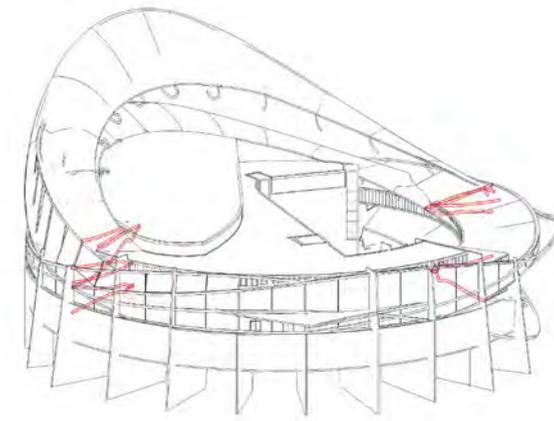
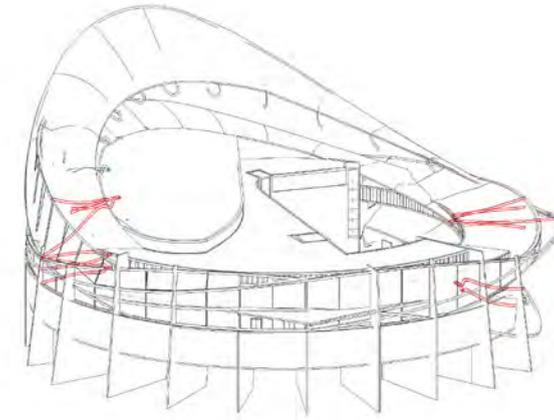
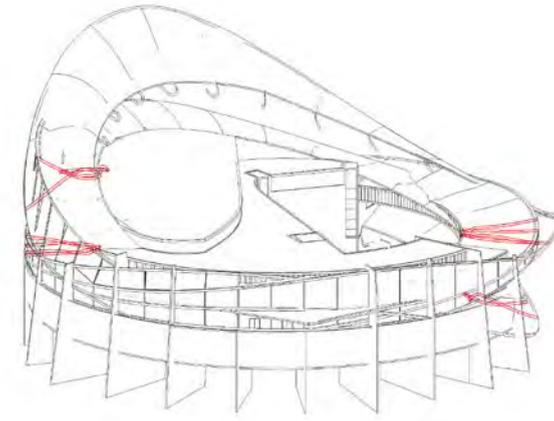
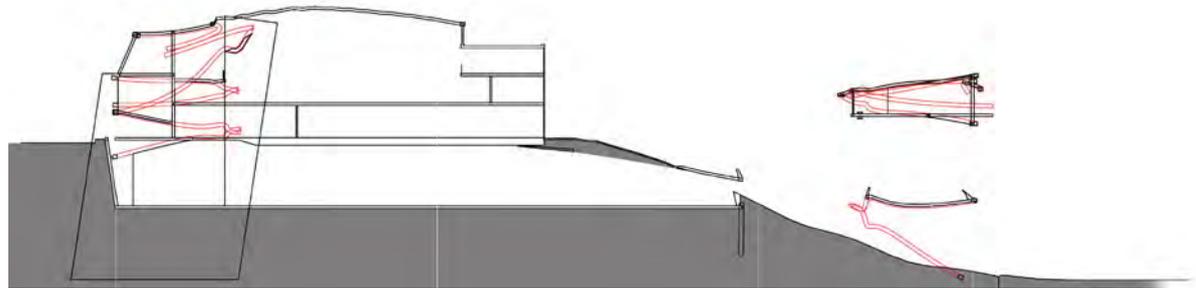
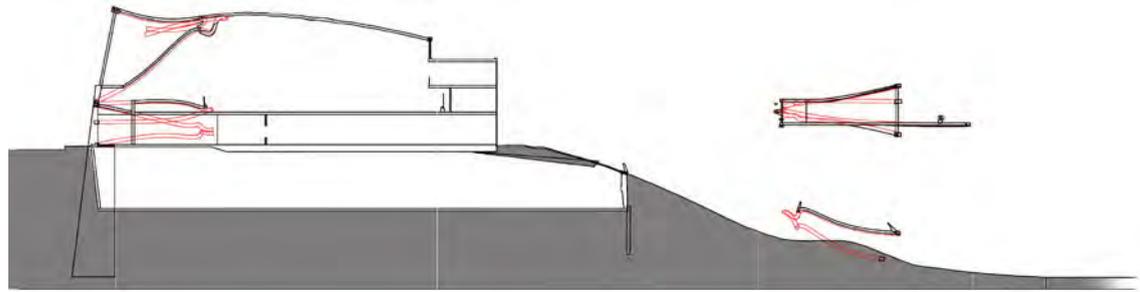
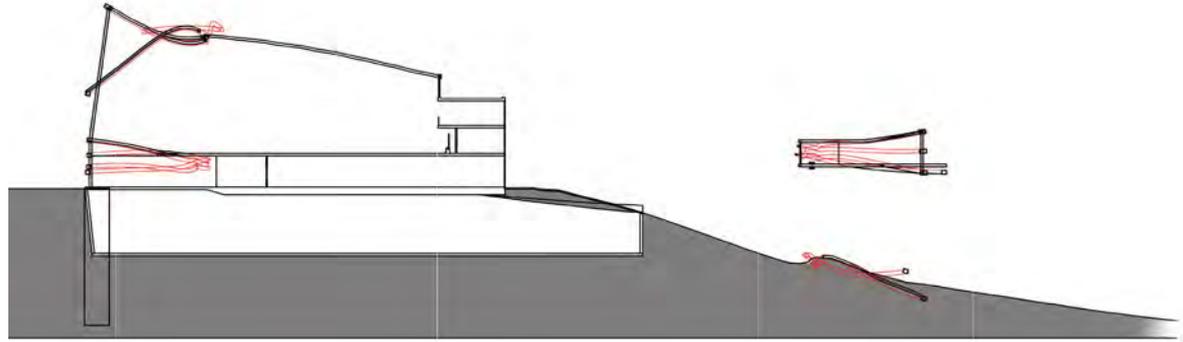


Figure 16.6

Figure 16.7

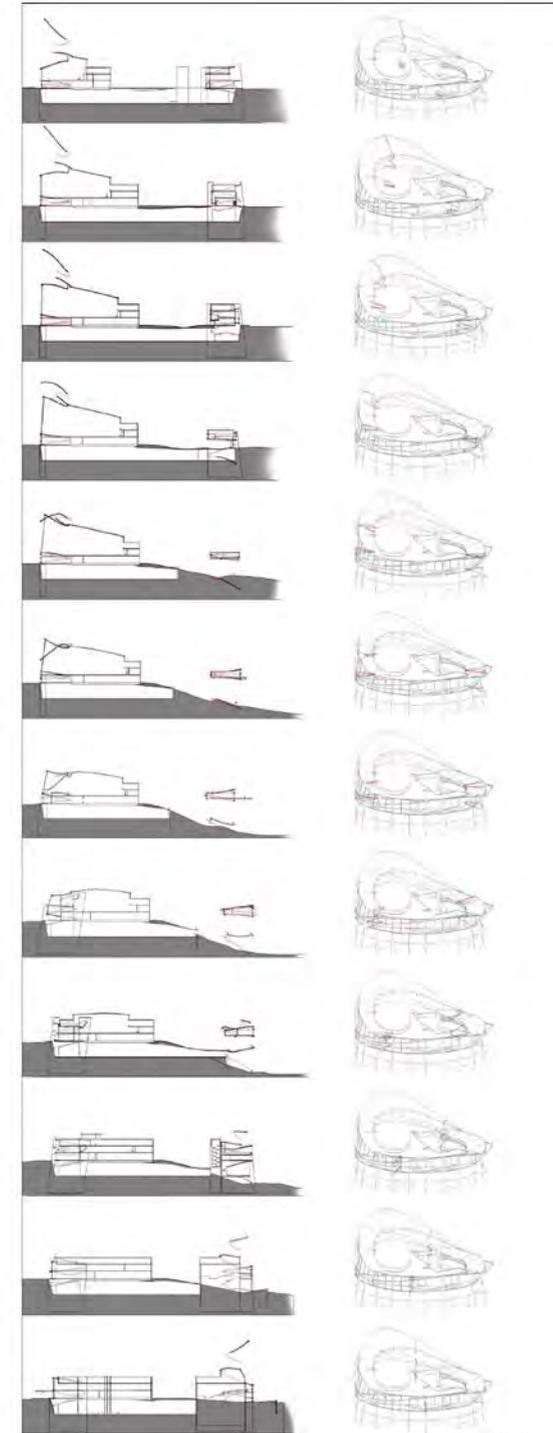
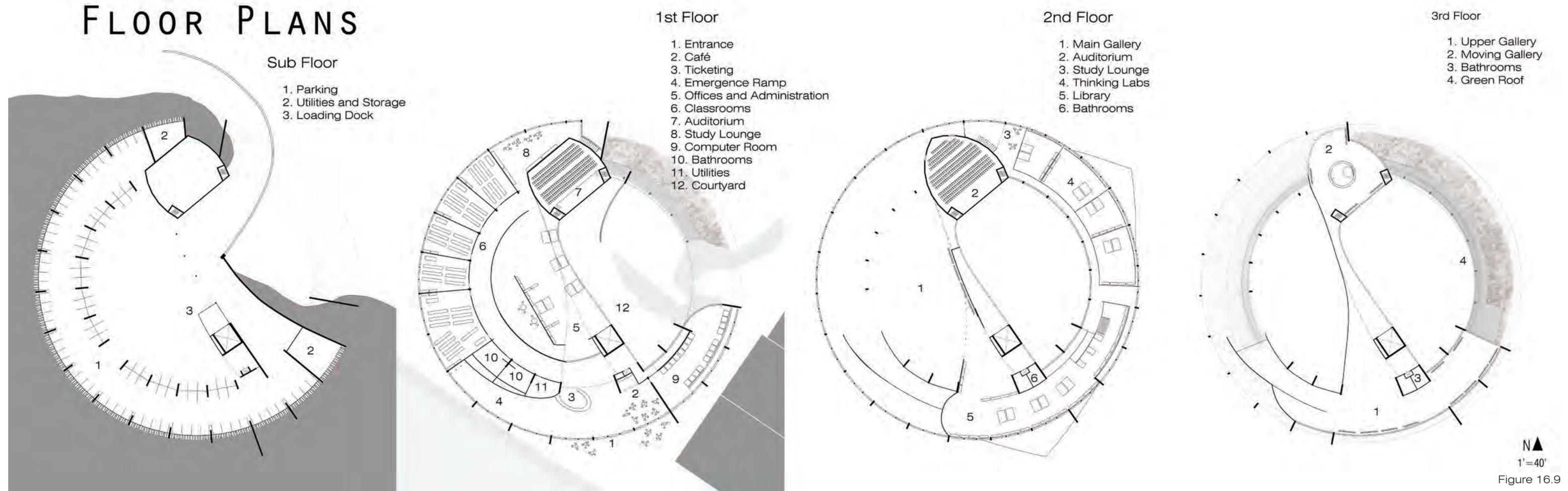


Figure 16.8

Through constant reference between floor plans drawings, section drawing, physical models and digital models, a layout was achieved. Because this layout was achieved through a negotiation between a given geometry and a desired functionality, great consideration was given to the placement of each space. For example, the café had to be near the entrance, but the entrance also had to connect to the administration, the main gallery as well as the thinking labs and classrooms. Ramps following the shape of the given geometry provide access to the thinking labs and the main gallery from the ground level. Another set of ramps following the curve of the geometry connect the thinking labs to the computer room and the main gallery to the third floor gallery.

The given geometry also informs the shape of the courtyard as well as the circulation patterns which moves in a circle through the entire building. The sloped roof planes above the thinking labs provide an ideal south west facing slope for green roof, and the glazing which surrounds the building ensures that every space receives natural light. Every exterior window is framed with the curved lines of the geometry creating a dynamic window frame unique to each space. Through negotiating the programmatic requirements and the given geometry, one is able to find an ideal building layout as well as discover unique opportunities for the building design.

FLOOR PLANS



“SO FAR, THE EMERGING TECHNOLOGIST HAS TO LIMIT THE OUTPUT OF THE PROCESS TO AN OBJECT RATHER THAN A PROJECT.

A PROJECT HAS A DEFINITE PURPOSE.

A PROJECT HAS A SITE.

A PROJECT INTERACTS WITH PEOPLE.

IT INTERACTS WITH CLIMATE. IT INTERACTS WITH TIME. AND UNLIKE A COMPUTER PROCESS IT IS MADE UP OF IMPERFECT MATERIALS AND THINGS THAT CHANGE ACCORDING TO THIS INTERACTION.

IN SHORT, THE PROJECT LIVES. AND IN PART IN HAVING LIFE, IT ENRICHES THE LIVES OF THOSE INVOLVED IN PUTTING TOGETHER THE PROJECT AND THE NEXT ONE. SOMEHOW THE ALGORITHM AND THE WAX MODELLER DON'T QUITE DO THIS FOR ME. YET”

(WISE, 2004, P.57).

EMERGENCE

The comprehensive design and its real world impact for the Cedar Riverside area.

West

South

North

East

Figure 17.01

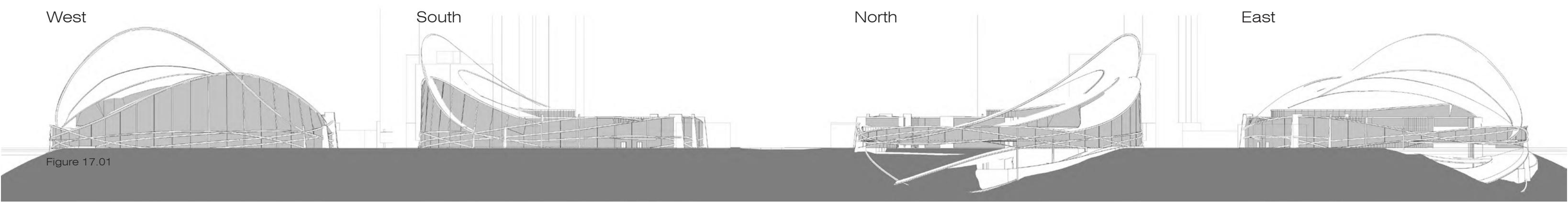




Figure 17.02



Figure 17.03

Figure 17.04



Figure 17.06



Figure 17.05



Figure 17.07

Courtyard:

The courtyard is an outdoor gathering space which acts as a venue for performances, outdoor movies and events hosted by the Quantum Science Learning Center. The courtyard has a path which leads to the new light rail stop and connects the administration offices and the thinking labs to the outdoors.



Figure 17.06

Thinking Labs:

Most quantum physics involves complex computations and advanced modeling. The Thinking Labs provide high resolution monitors for visualizing and exploring these advanced concepts. For optimized computational power, the thinking labs are connected to a large computer array in the room below.



Figure 17.08

Figure 17.07

Figure 17.04



Figure 17.09

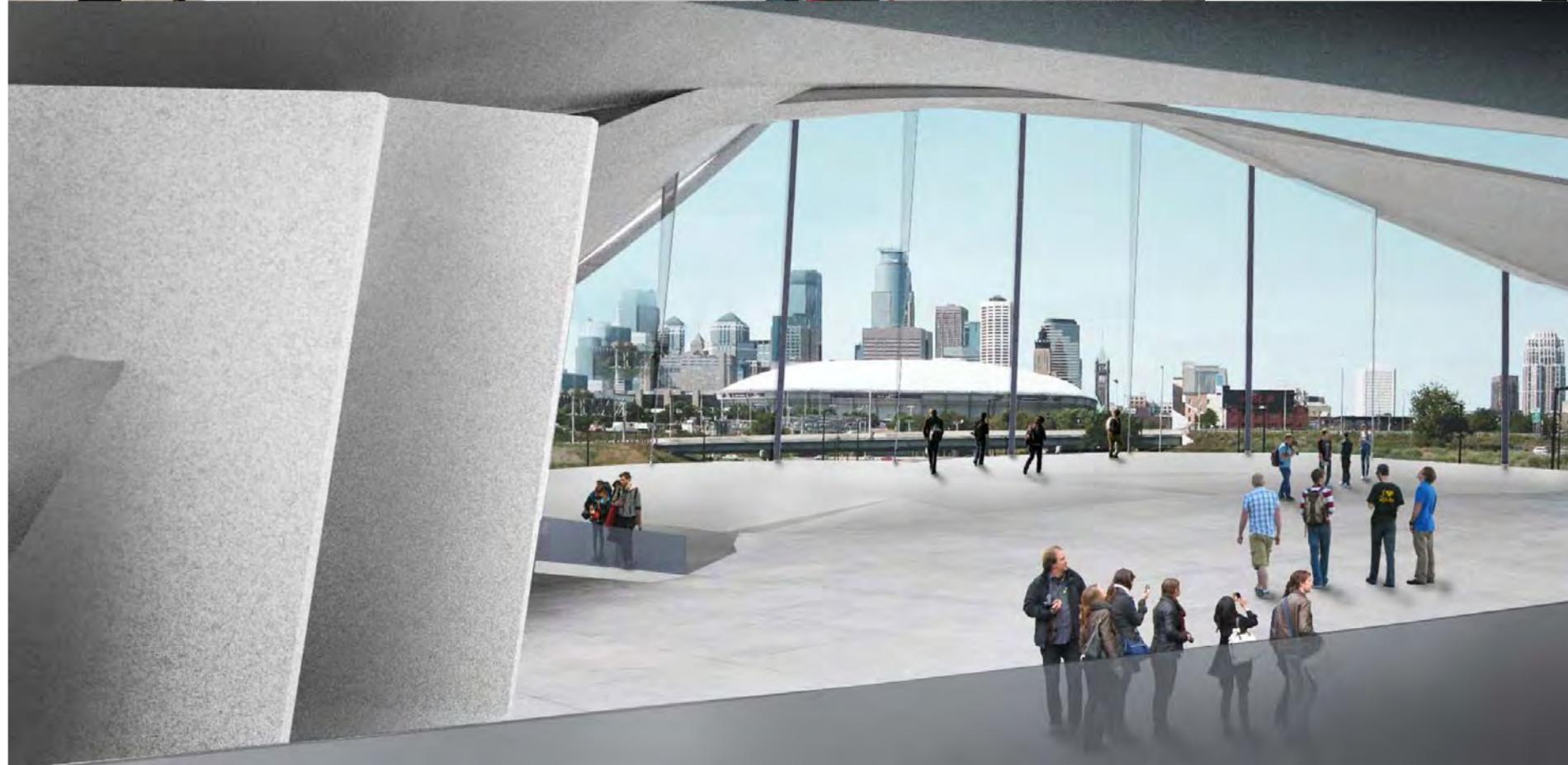


Figure 17.05

Main Gallery:

The Main Gallery is a place to illustrate quantum physics concepts and features a view towards the Minneapolis skyline. The ramp from the Entrance Lobby up to the Main Gallery reveals the skyline. The space is open to allow for large installations and has clear story windows to provide an abundance of natural light.

Emergence Ramp:

The ramp up to the Main Gallery illuminates the path of visitors who walk on top of it. These paths then interact to show the iterative and unpredictable nature of complex emergence.

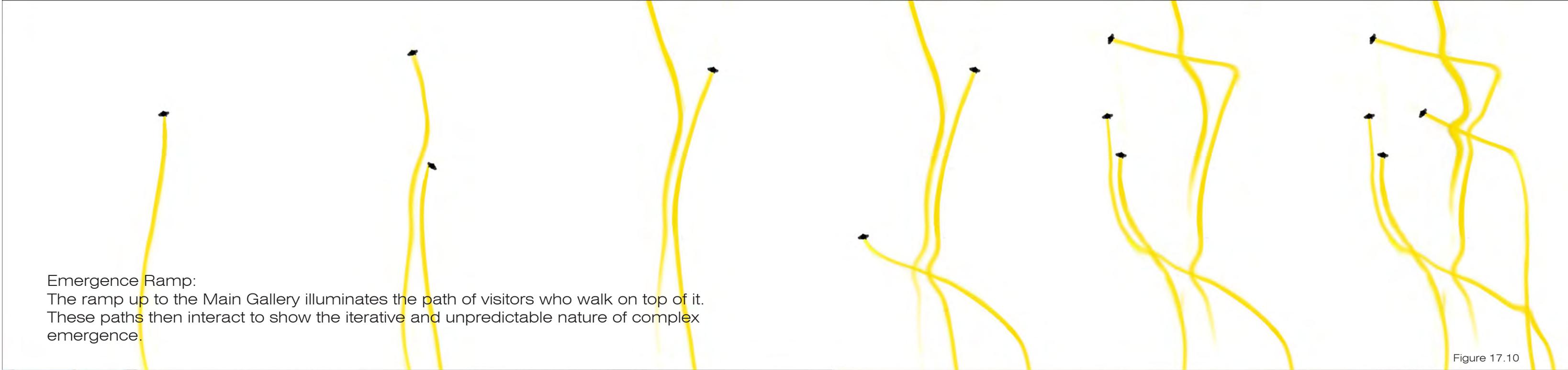


Figure 17.10



Figure 17.09



Figure 17.04

One can see the transformation from the initial radial sections into a building design. With the radial sections the complex form can be transformed into function.

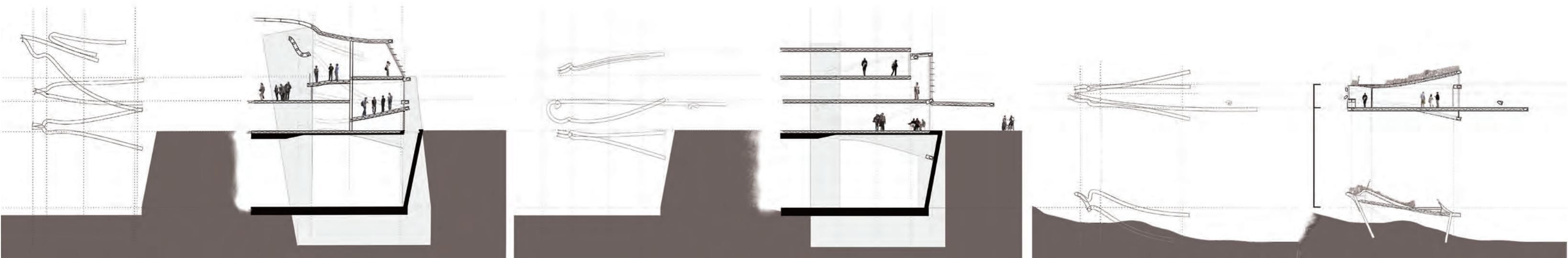


Figure 17.11

With the capacities of the computer increasing every day, it is important to search for new ways to engage with the increasing levels of complexity the computer is able to generate. By searching for new ways to make complexity visible, one can discover new ways to interpret this complexity. The way a designer elects to frame complexity impacts the way he/she can understand it. Through the negotiation of many different ways to view, and thereby understand complex geometry, the designer can reconstruct it, and through this reconstruction the designer is able to make decisions. Therefore, by searching for new ways to understand complexity, designers can find new ways to design.



Figure 18.1



Figure 18.2 - Photo by Jeremiah I. Johnson

“...we have to remember that what we observe is not nature in itself but nature exposed to our method of questioning. [...] In this way quantum theory reminds us, as Bohr has put it, of the wisdom that when searching for harmony in life one must never forget that in the drama of existence we are ourselves both players and spectators”

Heisenberg, 1958

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About Me

My Name is Ari Anderson. This is my graduate thesis from North Dakota State University

I believe that by responding to current context, history, beliefs or questions, architecture can set the stage for life and provide a framework to create new contexts, stories, beliefs and questions. In this regard I am optimistic for the profession of architecture, for the future of our built world, and for the stories that we will help to create and play a role.

I love to write when inspiration hits me. My favorite album is Foxtrot by Genesis, I play both the electric and string bass, and I like to cook.

“Students demonstrate success in exploring this (critical thinking) realm through a variety of media. The team is impressed with the broad integration of topics into studio projects and seminar courses. This integration reflects the program’s prioritization of critical thinking skills and recognition of the complex nature of design”

— NAAB Accreditation Team on NDSU Architecture’s Critical thinking and Representation

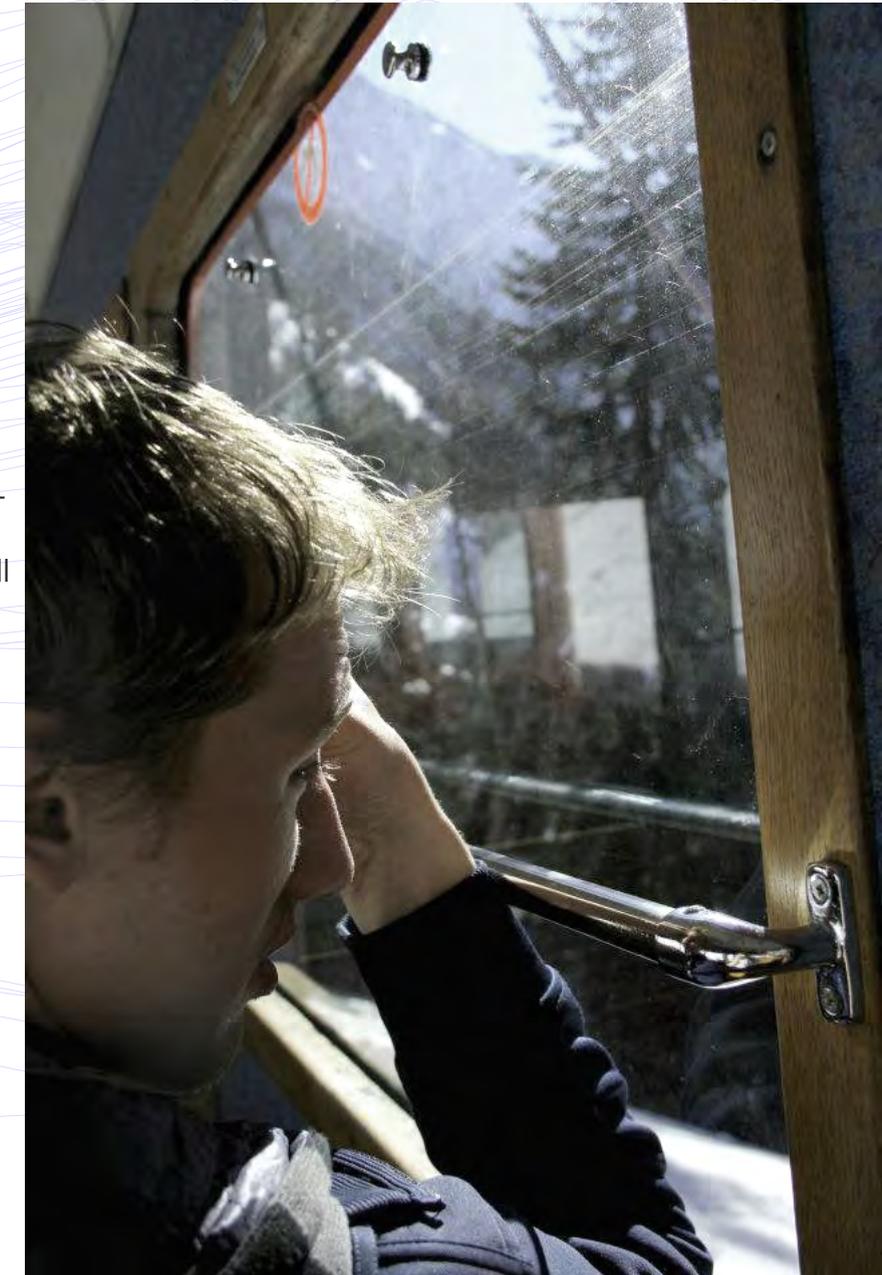


Figure 18.3

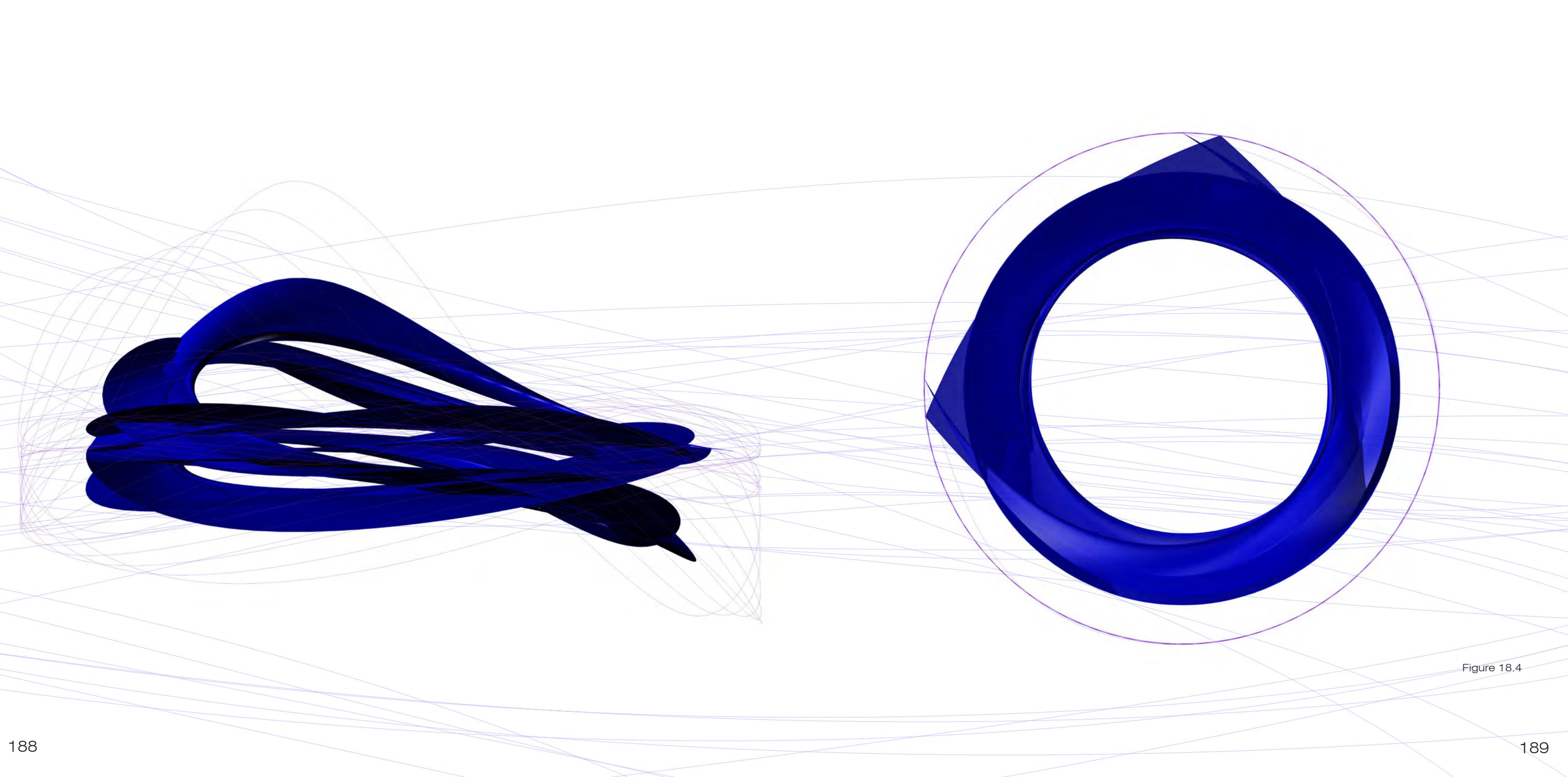


Figure 18.4