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Building Information Modeling
and the Parametric Boundary of Design

a thesis submitted to the
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Anton Harfman
Technology has transformed the role of the architect and the profession over an arguably short period of time. With the invention of the printing press, the method of architectural representation has shifted from an entirely drafted form to an entirely digital form. Issues of efficiency, control, communication, and value contribute significantly to this transition. Value, as measured through the precision in the built form, has pushed architectural representation to clarify obscure and abstract intent, pushing for what some might label a transparency in design. The transition from hand-drawn to digitally drawn representation has additionally introduced new methods for approaching architectural problem solving, most notably in design forecasting, integrated practice, and multiple-solution design outcomes. Building Information Modeling and Parametric Modeling are current tools that make use of these new design methodologies. Beyond simple computer-aided-design representations (CAD), these tools combine functionality into a single three-dimensional digital model that enable the architect to run quantitative analyses during the design process. The result is a better-informed inquiry to arrive at substantially informed design outcomes. It is the goal of this thesis to evaluate the tools of representation against the issues of efficiency, control, communication, and value from architectural design to the built form. Moreover, it will be important to recognize the use implications of these tools, such as application in the academic realm, ethics of building science in architectural design, and perhaps most importantly the relationship between quantitative and qualitative input in design.
To my family with love,

The pursuit of architecture over the past 10 years would not be possible without the continued support of my parents, Stephen and Frances, and brother, Chris.

Thanks to the thesis faculty, Patricia Kucker, Thomas Bible, and Anton Harfman for all their efforts in directing and clarifying my ambitions.

A special thanks to my architectural mentor, Kevin White, who initially engaged me in the debate on architectural design tools and their impact on the profession.
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What began as a frustrating observation regarding technology in architecture during my early professional experience, has led to a sincere study and appreciation of emerging design methodologies in the form of digital design tools. As an intern at a mid-sized architecture and engineering firm in Norfolk, Virginia, my exposure to the process of design in the office setting was heavily influenced by my perception that every new design software tool needed to be learned and implemented. In three years at the firm, more than ten digital design platforms were introduced. This resulted in a significant amount of time spent learning and implementing the software and, conversely, marginal time spent actually working through design projects. Most digital design tools are sold to firms with the concept of increased control and flexibility for design. A comparison of early digital tools to current tools suggests considerable improvements, including an increase in control due to the sophistication of technology. It was my observation, however, that the firm’s designs were occasionally being simplified in order to satisfy the digital platform’s constraints. Ultimately, there is a question of how much control design professionals should invest in digital design tools. This thesis seeks to evaluate the capacity of the current tools of Parametric and Building Information Modeling for design, including measurable outcomes for design and construction professions.

Evaluating digital design tools requires a clarification of their role to the designer. These tools are tasked primarily with providing representations of design intent and are thus similar to the drafting board, straight edge, and t-square. Measured against these pre-digital-age tools, new design tools demand increasing amounts of information and seek to reduce ambiguity and increase clarity of design intention. This intent must be clarified as encompassing all intuitive decisions made in the de-
sign process, from an initial napkin sketch idea to shop drawings verified against an erected project. Representation, then, leads to a broader discussion than merely lines on a piece of paper; in fact, this discussion leads to issues of data organization, communication with other design and construction disciplines, and the ability to approach design problem solving in new ways.

Upon entry in the graduate program at the University of Cincinnati, the utilization of Parametric and Building Information Modeling in the field of architecture was increasing and practitioners such as Thom Mayne suggested that architects needed to adopt these tools in order for the profession to survive. Beyond another series of slightly modified digital modeling tools, my initial reflections on the software, however, was skeptical and unimpressed. After researching the tools thoroughly, this initial outlook has changed considerably. With origins in the automotive and aerospace industries, parametric modeling is a tool that seeks to organize and arrange user-defined digital components into a single three-dimensional model according to established sets of rules, or parameters. These rule-sets differentiate parametric modeling from earlier digital modeling concepts, which conversely did not rely on data-defined objects, and instead represented unlinked objects in a digital model. Parametric Modeling is fundamental for designers looking for broad ranges of design opportunity rather than focusing on representing a single design solution. By testing broad ranges of design configurations, the digital tool can identify boundaries of increasing and diminishing design values.

Borrowing from the data-rich digital modeling concept of parametric modeling, building information modeling, or BIM, similarly organizes all project data into a single three-dimensional model in order to increase productivity and communication between design disciplines,
while also reducing confusion and interpretation resulting from traditional two-dimensional drawings. With a digital model, multiple disciplines are able to simultaneously manipulate the project data with design changes that propagate throughout the model to the effected elements. The primary goal of the modeling process is to forecast both building performance and construction guidelines in the interest of efficiency and increased design value. Building information modeling thus takes the element of time into the design process to evaluate both current and future design standards.

The research behind these tools has provided an understanding of how they might activate and inform the design process. As a segment of my evaluation, the design project accompanying the thesis will use the tool of parametric modeling in an intensive design setting. A winery in Ohio was chosen as the design project with the hope of dynamically linking the elements of program, structure, site analysis, and overall design intent. Though the project won’t be complete by the conclusion of this document, there is enough information available through the current study to suggest the implicit advantages of adopting these tools.

Based on the combination of value, as measured by design, and construction professionals, design clients, and a global economy, the use of parametric and building information modeling present positive opportunities for focus and control in design. Their utility suggests change in the methods of designing, such as seeking broad design outcomes rather than single solutions and building forecasting. Additionally, these tools raise important ethical, computational, and methodological questions regarding the future of architecture. Ultimately they serve as a link from early pre-digital design representation to completely new concepts of paperless representation, proving their utility in the profession of design and construction. Returning to the initial observation of continued investment in the development and adoption of these new tools, it is clear that the architect’s capacity for understanding design in new ways is paramount to the continued authority of the architect. This is only made easier with a thorough understanding of how the tools function.
Chapter 1: Pre-Digital Representation in Architectural Practice

Illustration 1.1: Early analytical drawings
Etching displaying elevations and details after Alberti’s Tempio Malatestiano - J.B.L.G. Seroux d’Agincourt 1847
Background Purpose and History of Representation

“Like novels, like portraiture, architecture is made into a vehicle for observation and reflection. Overloaded with meaning and symbolism, its direct intervention in human affairs is spuriously reduced to a question of practicality.”  

Robin Evans

Representation constitutes the architect’s primary tools for communication of design intent and analysis with the design and construction laymen. Drawings, composed of symbols and broken down into individual linear elements, are fundamental in synthesizing vast amounts of information. Over time, architects have accumulated various methods of recording and translating this information, from line drawings, to photography, to scaled modeling. Line drawings, over photographic and modeling representations, however, provide a background to styles, and serve as references for clarity and accuracy that can be emphasized. They serve a role of isolating non-important elements, or background features, from graphic content to establish insight about a particular instance or series of instances. These instances provide the ability to rationalize and evaluate, through different methods of analysis, that which is important about a design.  

Recently, the methods of representation have transcended the medium of paper, thanks largely to the emergence of computer technology. This section will investigate and identify how graphic design representation has transitioned to this point, beginning primarily with the Renaissance architect.

The primary methods of graphic representation include the plan,

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detail, section, pure elevation, axonometric, isometric, oblique projection, perspective view at eye-level, bird’s-eye perspective, and projection drawings showing the building as though seen from beneath the ground. Additionally, the diagram has been introduced to simplify analytical content, either graphically or verbally, in order to remove superfluous content not pertinent to the main idea. Though these methods have independently impacted design representation, today they are combined in various configurations to arrive at hybrid forms of representation. Understanding the goals of design representation requires understanding how design was (initially) visualized by the architect. Looking back to architects of the Renaissance reveals an internalized two-dimensional viewpoint that would ultimately be reversed after the 19th century. 3


Up until the time of the High Renaissance, the plan and detail were the primary forms of representation for design intent. Architects initially placed the starting design position at the center of a space and designed to the exterior walls; correspondingly the plan representation was primarily limited to the design that occurred within the designed space. Two key issues were directly related to the reliance on plan drawings. First, Renaissance architects, as influenced by earlier artists, relied on the Roman ruins as examples of successful space management for architectural design. As ruins, there was a of understanding of their exterior and interior section and elevation compositions. The representation of vertical surface was less influential for a detailed understanding of the overall design composition, and explains the plan view as the primary focus of design representation. 4

The second aspect of Renaissance representation was a general disinterest with how the building was placed on the site. Leonardo da
Vinci had a view that all architecture should be separated on all sides of the exterior to give unobstructed view of the building yet stopped short of registering any significant surrounding context in his representation. This suggests that the intent of his representations were likely more about geometric organization through plan and detail and less about precise scale and location of the building. This is evidenced in da Vinci’s sketches for centralized churches, where little information was given for the specific site. It was not until the 17th century that architects began to depict surrounding site context in their plan drawings. During this same time period, the technique of casting shadows in plan began to occur to provide an additional spatial reading. This subtle, yet significant transition in the plan drawings demonstrates the architect’s understanding of space as a volumetric condition. 5

The 1800’s also witnessed a significant change in how design representation was conceived regarding the connection between inside and outside. Previously architecture focused on the interior spaces of the plan, and design representations were limited to those views. Seeking a broader connection to the surrounding site context for their designs, architects extended their visual field beyond the exterior walls of their architecture. Architects began marking their plans with indications of major landscape views and used perspective renderings to explore this visual connection. Credited by James Pierce as the ‘Mesian’ Glass Box, this reversed orientation view indicated a radically new concept of architectural representation. The concept aided in linking the previously separate aspects of inside and outside, pushing for a balance in design representation. 6

Perhaps most important in this changing viewpoint was the understanding of how the architectural design should be perceived as an

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5 Pierce 50
6 Pierce 51
object in a field. The formerly separate views of inside and outside began to be visualized simultaneously, and conveyed in architectural renderings in the form of light, shadow, reflection, and transparency. These changes in representation shifted the objective focus of architecture to a subjective lens where the architecture could be looked into, out-of, and through. This shift in visual perception, from inside to outside, and back again, provided a heightened importance to the myriad of projected and perspective design views that originated in High Renaissance artwork. Today these objective views move beyond simple spatial clues to help suggest and forecast the resultant form of their design.

The transition from two-dimensional plan view to three-dimensional projected view was heavily influenced by visual experimentation in Renaissance art. It should be noted, though, that while these artists were the first to use the tools of the projected drawing, their primary goal was not an understanding of space as was the focus of post-Renaissance architects. Rather, these artists were striving for an understanding of how light acted upon objects in space. The contribution of Renaissance artists to the visual representation of modern architecture, thus, should not be diminished, but rather understood as acting upon different visual goals. The separation of art and architecture here are fundamental, for some suggest that architecture could continue to learn and employ much from the profession of art. “There is a lot to be said for making architecture once more into art; rescuing it from the semiology under which it has largely disappeared. But too often this restitution has been attempted by taking it out from under one stone and putting it back under another. The result is the same: like novels, like portraiture, architecture is made into a vehicle for observation and reflection. Overloaded with meaning and symbolism, its direct intervention in human affairs is spuriously reduced to a question of practicality”. Where does this practicality originate, and does it arise from a technological imposition? Identifying the users and uses of architectural representation will clarify this dilemma.

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7 Pierce 53

8 Evans 88-89
“Architecture may convey ideas merely by pictorial symbolism and asso-
ciation, but those understandings will remain superficial and glib if
there is not a deeper structure. That reading can only come through our
understanding of a building as the resolution of a series of internal forces
in an assembly that communicates these ideas in a more profound and
more enduring way.” ¹ - Edward Ford

Today representation serves both to educate and direct a myriad
of audiences, from art and architectural students in the classroom, to the
contractor and subcontractor working in the field. Representation may
yield a variety of projections and media, as previously introduced, yet
all representation is best understood through a careful analysis of the
architectural detail. In his extensive insight into the power of the detail,
Marco Frascari states that, “Details are much more than subordinate ele-
ments; they can be regarded as the minimum units of signification in the
architectural production of meanings.” ² This correlation of the detail
to the smallest of units is important in establishing a connection of rep-
resentation to technology in terms of innovation and invention. It is in
this area of technology that the role and ability of the detail has socially
transformed the role of the architect and, through translation, the role of
representation in design.

The responsibilities of the architect, craftsman, and contractor
were hierarchically linked well before the defining technology of the
period of industrialization in the 19th century. Up until this time, the

¹ Edward Ford, Chapter 8, “The Detail as Structural Representa-
tion.” Five Houses, Ten Details. (New York: Princeton Architectural
Press, 2009) 111

² Marco Frascari, “Tell-the-Tale Detail.” The Building of Archi-
tecture. (Cambridge: MIT, 1984) 23
architect had the primary role to design and represent buildings. The craftsmen, who were personally chosen by the architect, developed detailed drawings for construction and fabrication. Buildings at this time were significant cultural cornerstones, wherein construction and design skill was managed and passed down through guilds. The detail was seen as a representation of the joining of materials, elements, components, and building parts in a functional and aesthetic manner. The architect’s detail was developed in the composition of the analytique. This drawing displayed the general ordering principles of a single detail in the overall composition so that craftsmen could understand the appropriate order necessary for construction and fabrication of the design components. ³

After the beginning of the Industrial Revolution in the 19th century, buildings were no longer thought of as “long-lasting cultural and social repositories.” ⁴ Instead, buildings became economic investments and the normal order of design to detailing from architect to craftsman shifted. Draftsmanship replaced workmanship and the development of construction details was replaced by virtual procedures. The detail was no longer understood as part of the building design; it was reduced to what has become commonly understood in industry today as the production drawing. This change to detailing led to a new understanding of construction and the control provided by the detail. Crews of vocation-
less workers interpreted the design details as drafted and coordinated by the architect.

A second, and less prolonged reaction to post-industrial design and construction practices occurred in the Arts and Crafts movement where the detail was the redemption of the working class. Skill and knowledge inherent in the making of details was the purview of the craftsman; building tradition was once again renewed by the details through the architect’s careful selection of appropriate workers for the appropriate details. This reaction was similar to the theory coined by Leon Battista Alberti of “architecture as the art of the appropriate.” Selecting the appropriate details, and concurrently selecting the appropriate workers for the detailed construction resulted in a sense of beauty wherein nothing might be added or subtracted to better the design. “From that point of view architecture becomes the art of appropriate selection of details in the devising of the [design] tale.”

Unfortunately, while this hierarchical organization of visualizing design to detail from architect to general worker was spirited, the reality of the profession grew closer to economic motivations for architectural design, construction, and fabrication. Architects were tasked to pass design schematics to draftsmen whose role was middlemen between the design architect and the construction fabricators. Draftsmen were now assigned the responsibility of working out the construction detail. One might argue that this shift entirely altered the purpose and content of the detail; the change represented a shift in understanding of design intent, construction purpose, and liability, previously held between the architect and his hand-selected team of craftsmen, to the architect and his loose organization of draftsmen.

A significant parallel is the transition of the two-dimensional drawing view to drawings with three-dimensions: the perspective and the projection drawing. The detail was the most important means of deriving three-dimensional information about the joinery of the construction through two-dimensional representation. For the craftsman, it could be assumed that these details could be explained very simply and logically as a combination of handed down- and experienced skills of fabrication, as well as through two-dimensionally drawn analytiques. When the value associated with architectural representation transitioned from

5 Frascari 26
authorship of the craftsman to that of the draftsman, the two dimensional analytiques were inadequate for design intent.  

After the Industrial Revolution, the role of the detail changed accordingly. Tasked with communicating among contractors and subcontractors, the detail had to also speak clearly and efficiently to associated disciplines such as structural, electrical, and mechanical engineering. Today the detail is commonly found in the design and construction documentation drawings, and is described in the text of design specifications, to give specific clarity to areas of the design that are most open to interpretation. It is not difficult to identify the detail with an embedded technical role of communication. A good example of this might take place in a design where different building systems come together causing potential confusion on the parts of the different and independent subcontractors. Here the role of the detail still continues a leading responsibility for communication in design, yet speaks more specifically to the construction professionals involved with the physical translation of the design.

Despite the technical task of the detail, Frascari maintains contrasting viewpoint:

Geometrical and mathematical construction of the architectural detail is in no sense a technical question. The matter should be regarded as falling within the philosophical problem of the foundation of architecture or geometry, and ultimately within the theories of perception.

Similar to the notion of a novelist carefully arranging character personalities and plot changes to derive a certain reaction from the spectator, the detail has the important responsibility of explaining design intent while extracting certain perceptual reactions from its audience. This notion of perception is the result of understanding the internal and external forces acting upon a building, the source of which lends well to educational discourse.

Critics such as Edward Ford approach the role of architectural detailing to suggest that these drawings serve as much to study style as they do to study materials and structural expression. The illustration of the

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6 Frascari 24
7 Frascari 28
gothic cathedral, for example, does not explain the overarching gothic style as much as it proposed principles such as structural forces within an element, and the translation to the corresponding material assembly. The material palette of stone, as studied by architects of this style, was employed to the maximum possible tectonic opportunities to suggest the principle of material maximization. This, for Ford, is the deeper structure that gives the detail its biggest importance, and additionally allows current and dated architectural representation to speak to the future of architectural design.  

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Technology, Science, and Mechanical Representation

“...Scientific phenomena came to be regarded not simply as what can be perceived, but primarily as what can be conceived with mathematical clarity. Things became numbers, not understood as Platonic or Pythagorean transcendental essences, but as objective and intelligible forms... Galilean science thus constitutes the first step in the process of geometrization of lived space; it was the beginning of the dissolution of the traditional cosmos.” ¹ – Alberto Perez

Tracing the rationale and historical progression of architectural representation from the time of the Renaissance begins to explain the underlying impact that technology held on architectural problem solving and the resulting drawings. Proportion, as measured through naturally occurring phenomena, once defined the governing rules of design and representation. These ordering principles are challenged with the thrust of the science and technology during the Renaissance period. This period of scientific advancement included the introduction of the Gutenberg Press in 1440 after which civilization was able to break the social and educational constraints previously held by the Catholic Church. As printed word spread, the scientific community began to dissolve long-held tenets of natural phenomena, providing calculable observations to describe the natural environment. As a result of Claude Perrault’s translation of the *Ten Books of Vitruvius* and other scientific writings during the 17th century, the rigid application of Greek and Roman ordering principles were cast into doubt. The resultant interest in geometry sought to objectively rationalize the external live world. ² This scientific interest


² Pérez 19
caused the architectural community to question the appropriate balance between quantitative, or objective-based design, and qualitative, or subjective-based design, an issue that persists in contemporary architectural representation.

After the introduction of Gutenberg’s printing press, observations of naturally occurring events partnered with the spread of intellectual knowledge proved rational for dismissing cosmological understandings of order within the natural world. The acceptance of these natural events as measurable outcomes ushered in the scientific age of the Renaissance that would ultimately lead to advanced mathematics as introduced by intellectuals such as Galileo, Kepler, and Descartes. Astronomical observations of planets in orbit compelled mathematicians to seek advancements in the areas of algebra and trigonometry to explain the observed universal properties, ultimately leading to analytical and descriptive geometries and the Cartesian coordinate system. Though a brief introduction to this mathematical influence during the Renaissance period, it is important to stage this rationalist development against the changing architectural instrument of proportion during this period.

As an ordering system for problem solving, much of early architectural design was based at least in part by the proportion studied in structures of ancient Greece and Rome. These structures contained numeric relationships commonly found in natural elements. Posited by Vitruvius around 50 BC, “Proportion is a correspondence among the measures of the members of an entire work, and of the whole to a certain part selected as standard. From this result the principles of symmetry.” Without symmetry and proportion there can be no principles in
the design of any temple…” It was his account, later translated by the Renaissance architect Claude Perrault that established the Roman orders of architecture, and further suggested a relationship between the human body and the Roman orders. These proportions successfully established for architects ordering principles to follow in design with a belief that the relationships were based on divine or sacred dimensions.

Claude Perrault eventually translated the classical proportions detailed in Vitruvius’ *Ten Books* into French in 1673. As a rationalist, Perrault was heavily involved with both architecture and science and later became a founding member of the French Academy of Sciences in 1666. “He was not only the author of an important architectural treatise…and the reputed architect of the eastern façade of the Louvre, but possessed a brilliant and far-ranging intellect.” Around the time of his writing, a divide took place between theorists regarding perception and conception as they relate to the ordering principles of nature. The Church still possessed a large degree of political importance in society and did not want the idea of divinity, or perceptual significance, to be swept away by objective empiricism. Perrault, siding with mathematicians such as Descarte, provided a belief that all natural events could be rationalized based on measured empiricism.

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4 Perez 18

This opinion essentially opened the door for 17th century architectural theorists to raise concerns about the legitimacy of early systems
of design problem solving. While the proportion and orders handed down from the ancients established a clear method for organizing space, so too could descriptive geometries and Cartesian coordinate mathematics. The underlying faith-based premise of perceptual divinity established proportions rather than rational, empirical truth. Contrastingly, advanced mathematics and science offered the roots of a system of spatial organization that could resolve itself in empirical truth. In such a system, design could be calculated as coordinates on a three-dimensional grid, with proportions established as mathematical calculations. Beyond a computational rationale, this gridded proportional system could additionally provide a visual tool for all design elements to be combined, measured, and sized for a comprehensive view of the design.

It is not difficult to understand a gradual movement towards this empirical method of design problem solving, and this system eventually leads to the systems of organization within digital design problem solving today. An important consequence of this empirical rationality is that it initiated a debate regarding whether there was a relationship between objective and subjective reasoning in design. Subjective, or qualitative reasoning differs from objective, or quantitative reasoning in that it suggests a response to design based on experience rather than calculation. The advancement of science and technology has increasingly turned to objective design reasoning as a driver, though as will be discussed later, modern architectural tools suggest a delicate balance between these two areas of reasoning.
Chapter 2: Digital Representation in Architectural Practice

Digital analytical model of Cooper Union skin and vertical movement through central atrium

Illustration 2.1: digital analytical model
Introduction of Digital Tools

“But if architecture is not to give up its own very specific instrumental-
ity – which lies primarily in the world of things, and not information, it
is necessary to look more closely at the paradigms and protocols at work
in the use of the computer in the studio.” ¹ - Stan Allen

The practice of architecture in the 21st century operates on in-
formation production and sharing in order to form and define space: to
design and construct complex buildings. It involves progress from the
conceptual to the practical application of design problem solving. As
seen previously, the method of producing and sharing this representation,
from architect to other disciplines, has modified the manner in which
the information has been represented and translated. Technology has
impacted this translation due to interests in efficiency, communication,
and overall design value. Value, as measured through performance in
the built form, has pushed architectural representation to clarify obscure
and abstract design intent with the goal of arriving at design transparency
and accountability. As a result of these interests, architectural represen-
tation has moved from hand-produced drawings to a digitally produced
process, due in large part to the ability of the computer to process large
quantities of information safely, securely, and most importantly, accu-
trately.

Computer-aided-design software, or CAD, was introduced to the
architectural community beginning in the early 1980s following its suc-
cessful use in the automotive and aeronautical industries. CAD was pro-
moted to the design community as a tool to solve the issue of ‘complete

view’, usurping the many two dimensional views needed to describe the three-dimensional building. By digitally reproducing this information, early CAD systems were conceptually able to visualize this complete view of design components, both two and three dimensionally, through vector-based geometries that could be scaled accordingly. 

Technology increased building systems at the turn of the 20th century and consequently created complications for architectural representation. Highly coordinated and accurate drawings coordinated the growing number of disciplines contributing to the design construction of a building. The introduction of CAD drafting accommodated this need for accuracy while reducing the time necessary to produce the design documentation. This electronic information was easily transferable without the expense of time and space necessary for hard drawings to be hand-reproduced for other design disciplines. The introduction of the world-wide-web provided additional accessibility to this electronic CAD data that was increasingly streamlined; clients, developers, and design disciplines could meet virtually rather than in person to save time and expense on travel.

Stan Allen, Dean at Princeton, is an early critic of computer-aided-design and he suggested that the tool’s ability to easily and accurately reproduce perspective views, which were previously difficult and time-consuming, gave the tool perhaps its most influential and controversial selling point. The notion that the CAD-based design could illustrate

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how the building would look upon completion of construction was marketed for client satisfaction. While hand-produced architectural representation had been tasked with this responsibility, these illustrations functioned conceptually for the ability of the architect to isolate and describe important design information. Conceptual information allowed for subjective, abstract interpretation, looking beyond the objective goal of merely producing an object in space.

The accuracy of computer-aided-design gave an increased ability to predict the outcome of design based on quantifiable inputs. Today this quantitative rationality extends beyond the field of representation into areas such as three-dimensional printing, material research, and component fabrication. In his essay entitled “Antitectonics: The Poetics of Virtuosity,” William Mitchell described these rapid prototyping processes as being the result of the computer transferring construction details to a stereolithography machine to construct a three-dimensional architectural model. At larger scales, various kinds of CAD/CAM devices (computer-controlled cutting, routing, milling, and bending machines, for example)
can automatically convert digital models into full-size architectural components – as brilliantly exemplified in the later work of Frank Gherry, such as the Guggenheim Museum in Bilbao.”

Precision in the machining and fabrication process distinctly links the abilities of CAD/CAM to the ambitions of the automotive and aerospace industries, where systematized component-development leads to highly precise component assemblies. This precision has given insight into new uses of the tool in the construction industry. Through increased control and speed of computer-based technologies, architectural CAD systems have advanced beyond their initial organization of loosely defined geometries to suggest increased user-defined characteristics in digital representation. The result of this smart-CAD technology has opened up vast opportunities in terms of design quantification, leading back to the issue of balancing subjective and objective design input. With the science-backed initiative of quantitative analysis, computer-aided technology has provided architectural representation with an opportunity to combine subjective design intent with high levels of scientific accuracy. This digital tool of representation thus provided a stepping-stone for architects to re-establish their instrumentality beyond intuitive analysis and representation.

Parametric Modeling

“Computation has exaggerated the broad social and cultural tendency toward knowledge leading to predetermined outcomes (certainty), and despite the association of ideas such as mass customization, variation, and difference with current digital processes, what we are experiencing is arguably a continuation and acceleration of a modernist obsession with control, optimization, and efficiency through machine processes.”

1 - Scott Marble

The CAD/CAM tool provided a means for digitally ordering and rationalizing geometrically coded architectural design with precision outcomes. Where the tool was responsible for enabling expedient two-dimensional drafting, CAD also generated a highly characterized digital three-dimensional modeling. The goal of this design methodology differed very little from the previous hand-drafted conceptualization in that both carefully paired intuition with objective reasoning to arrive at predictable design outcomes that were evaluated through representation. In a departure from this form-driven methodology, but borrowing from the characterized modeling opportunities in CAD, contemporary architecture has introduced calculated design outcomes based on quantitative parameters with the computer. Parametric modeling is a system that values logic over geometry, and uses codes to organize vast amounts of information that is input, linked, and merged together in a single digital model. 2 Examples of this software are CATIA, Solidworks, and Ghery Technologies and are used by industry leaders such as Greg Lynn, Zaha Hadid, and Frank Ghery.


2  Marble 39
The importance of parametric modeling deals less directly with the resultant design form and more with understanding the relationships among dynamically linked design rules. Using the three-dimensional model of advanced CAD, digital objects are created and manipulated by their associated geometric properties. This object-to-object control is defined as a parameter, or rule, that affects all corresponding rules and associated geometric objects. “By assigning different values to the parameters, different geometric configurations can be created,” leading to manual or automatically controlled variation. The interdependencies between objects and rules become the hierarchical structure and order in the parametric model.

Understanding this order allows for ease and accuracy in generating a broad range of design outcomes. An infinite number of geometric objects and rules may govern the hierarchical structure of the model, and the computational method used allows for highly computable outcomes. In this way, the tool answers the questioned certainty that was initially promised by computer-assisted design, but does so only through solving for the intricate relationship between pieces of the design. Similar to the evaluation of a typical math equation, the resultant design form in parametric modeling is much less important than understanding the associated linked rules and geometries that led to the final outcome. The design methodology thus pushes the designer to edit the “generative potentiality of the designed system, where the choice of emergent form is driven largely by the designer’s aesthetic and plastic sensibilities.”

This generative potential thus displaces the formal role of the par-

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4 Kolarevic 70
ti in traditional design, as the particular forms, or geometries, of expression are less deterministic than the relationship, or topology, between design elements. ⁵ For instance, site and structural forces paired with economic constraints may constitute the driving variables to derive an ordered hierarchy rather than a pre-determined assumption or choice of approach. This is not to say that parametric design is devoid of pre-determined assumptions or weighted values, as the project variables merely test for combinations of design opportunities that must be evaluated for driving hierarchies. Because of this, some critics maintain the need for a driving parti in parametric design, and an example of this might be seen in Zaha Hadid’s Contemporary Arts Center in Cincinnati, Ohio. Here the concept of an “urban carpet” sweeping through the building was used to parametrically define a vertical circulation core at the rear of the building with gallery spaces feeding directly outwards from this core. ⁶ Without this sense of a driving variable or dynamic rule, the limitless opportunities provided by parametric modeling don’t hold comparable value, and therefore can’t inform the design.

Still, while the method of parametric modeling provides a level of calculable determinism, it does not suggest automation or determinism in realizing or reacting to the relationships between different variable rule-set combinations. By manipulating the generative system, the architect is not focused on, nor can he predict the precise resultant solution. This “nonlinearity, indeterminacy, and emergence are intentionally sought out, with a considerable degree of risk involved as the successful outcomes – however determined – are anything but certain.” ⁷ It is perhaps this indeterminacy and associated risk that creates concern and interest in the skeptics of the methodology. On the one hand, technical determinism, as postured by the modern movement, had intentions of eliminating the inefficiencies and risk associated with physical human input, and when exploited through the industrial revolution, displaced physical labor. New technologies are attempting to alleviate the risk associated with input of the human mind by creating intelligent machines, but in translation are displacing mental labor. Both movements are seen

⁵ Kolarevic 70


⁷ Kolarevic 71
as extreme and unbeneficial, suggesting an appropriate amount of risk should be carried in design methodologies.  

Parametric modeling is a good example of this compromise between technical determinism and human input. It optimistically shifts the risk associated with purely intuitive input from earlier design methodologies towards the idea of shared input between the user-defined parameters and the computer. In this extreme, the computer output isn’t independent of the user in terms of recognizing the design problems and inherent hierarchies. The user isn’t independent of the computer in terms of recognizing the calculated design result. This co-dependence between technical and human input is exemplified when considering that design is based on the “mental process to quantify and write in code the contextualization of information” and simultaneously decipher which information is “relevant in a given situation.” Computer technology has not progressed to a point where it can process the correct information with the proper scenario, but it does provide the ability to contextualize mass quantities of information given topologically organized filters. In this way, parametric modeling provides a balance between determinism and risk.

The issues of determinism and risk directly correlate to the question regarding the balance between quantitative and qualitative design.

Traditional hand- and early-CAD-developed design processes relied heavily on qualitative input with moderate quantitative output. With technological improvements through advanced CAD systems, digital modeling has shown increased interest in quantified input and output with considerably less qualitative input. While it could be suggested that design could be quantified as a result of many calculable variables, the rationality necessary to correctly order these variables requires qualitative input. For instance, a particular room in a museum may be quantified as light entering a space through a particularly sized aperture, with particular orientation at a particular time of day and in a particular geographic location, etc; these variables all helped create the spatial setting, but without proper design intuition to order and evaluate these variables, the space would be devoid of design meaning. Parametric modeling represents a conscious effort to balance these qualitative and quantitative

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8 Marble 42
9 Marble 43
inputs by allowing the user to carefully define and rationalize the driving parameters for the digital model to quantify. The designer of the museum room might use parametric modeling to identify the size and orientation of the window as driving variables through which the other variables can topologically react.

The goal of parametric modeling, then, is to understand the defining relationships between programmatic and aesthetic design components in order to generate a hierarchy of design rules. The result of these parameters allows broad opportunities of design outcomes in order to determine boundaries of increasing and decreasing variable values. Through evaluation of these boundaries, it is possible to quickly analyze and dynamically edit a multitude of parameters, and subsequent design output, given the ordering hierarchy. The experienced architect might understand these boundaries as rules of thumb in design, meaning that a calculated analysis of certain design variables might provide expected, or intuitive, results. This is more likely to occur with an experienced designer who has already tested broad ranges of variables in his design practice. Because of this, parametric modeling is best geared for designers interested in learning how particular design variables impact and influence design decisions, looking for driving design relationships, rather than a finished result.
Building Information Modeling

“In examining the current state of BIM, it is interesting to remember that CAD came out of CAD/CAM and the promise of the full automation of factory fabrication. The software originally developed to make perfect pieces of machinery was co-opted by the architectural industry essentially to make beautiful drawings. Will BIM be the paradigm shift that brings architectural drawings to life by moving seamlessly from concept to integration to fabrication, or will it fall apart in a wave of liability fears and take root as yet another tool to make better documents instead of better projects?” 1 - Nat Oppenheimer

The introduction of parametric modeling provided the means to shift the focus of design intent from the resultant object to the subjective topologies between programmatic and component elements. This tool has been highly influenced by advanced CAD drafting tools that sought to convey a complete digital view of design, and later established highly characterized digital components within the comprehensive three-dimensional model. The most recent digital development has combined with a dynamic topological organizing feature of parametric modeling to create building information modeling, or BIM. As an extension of parametric modeling, building information modeling is a data-filtering tool used to collect and analyze particular digital model information regarding broad ranges of design performance. Varying in analysis from material cost estimation to energy performance, building information modeling adds a dimension of time to parametric modeling that can expediently and accurately predict both building performance and construction guidelines. Examples of BIM software include Revit, Microstation, CATIA, and Gh-
ery Technologies and are increasingly being pushed in the architectural industry by leaders such as Thom Mayne, Frank Gherry, and Coren Sharples.

The importance behind building information modeling is a combination of project data organization and analysis along with a re-organization of “the means and methods of design and construction” as used over the past half-century. Using a three-dimensional digital model for all project data, users of BIM work beyond CAD and parametric geometries of model information and digitally encode physical properties of design components such as material weight, structural capacities, and acoustical capabilities. One goal of this tool is to simulate precisely how a design will function particular to specific environmental and programmatic scenarios; data inputs are measured against user-definable testing parameters, built into the BIM software, to arrive at highly predictable design behaviors.

BIM’s calculation-based process raises similar concerns of technical determinism as in parametric modeling; what is the appropriate
balance of quantitative and qualitative design input? When used as an analytical tool to evaluate the performance of a design, building information modeling must be understood as quantitative output. Used to compile all project input into one model, however, the tool transcends purely quantitative output and requires qualitative input to organize, react-to, and inform the design. One such potential for change regards all design disciplines representing their design elements on a single digital project model to avoid misinterpretations that commonly occur in contemporary practice. “The single model means that structure and service clashes are dealt with before tender, and that bills of quantities and the implications of construction sequence are more accurately ascertained and priced.” ³ Issues resulting from design overlap in contemporary practice often create financial and scheduling problems during construction that are easily avoidable with appropriate cooperation between design team members.

BIM has broader potential, however, than detecting design clashes, projecting cost analyses and applying scientific predictability to design. These benefits, introduced by Dennis Sheldon as:

Downstream capabilities include those for consultants’ models to be applied to fabrication and construction processes, from detailed component engineering and site component placement to project control procedures. ⁴

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Moving beyond the concept of three-dimensional digital modeling, building information modeling enables the fourth dimension of time to be considered for purposes of directing construction procedures. This enables facilities management opportunities after the construction of the project through life-cycle analysis and building systems control.

Beyond the technical standpoint, building information modeling has reorganized how design teams are structured and the manner in which design proposals are communicated. Previously, consultants developed individual CAD models; authority was granted to the architect who would coordinate disciplinary content and changes needed. Often this process resulted in miss-communication, broken, or entirely lost content between the multiple models and various forms of data being transferred. BIM has accordingly modified the authority of design input, and the concurrent building information model, so that all design disciplines are responsible for sharing and entering digital design information from the beginning of the project. The digital file, controlled and managed by the project architect, is lent out via the electronic network where multiple users can make changes. The model is then reassembled, nearly instantaneously, for all project team members to review. While some critics disagree with a parceling out of the building information model, the issue has been blamed on technological growing pains that should eventually be remedied with improved BIM software platforms.

The reorganization of information authority through BIM parallels current industry movements towards Integrated Project Delivery, or IPD. Though not directly related, these industry concepts regarding team organization suggest changes from practices based in hand- and CAD-developed design. As Sharples points out, “In the traditional owner-architect-constructor model, the architect and the constructor have an
adversarial relationship. The joint-venture nature of the IPD concept not only adds value to the design process by engaging a wider knowledge base at an earlier stage of the project; it also places parties on the same team and changes the liability landscape. The development of project data and design by all team members has the positive impact of promoting proactive solutions rather than those that are reactive. Productive communication is encouraged at all stages of design and construction.

This movement towards project design integration has some industry leaders, such as Nat Oppenheimer questioning several observations made from early use of building information modeling. The opportunity to change how teams and contracts are operated for accuracy, efficiency, and design clarity is now a reality. While the tool has shown significant benefits in cost savings for large firms, the complexity and cost of implementing BIM teams, and digital models, has prevented smaller design firms from affording its use. A significant concern is that current BIM trends may dictate that all design, from large to small scales, will be standardized under building information modeling with the simplification of design, lower fees, and shorter design schedules as an end result. This kind of standardization could effectively reduce or eliminate those architects and contractors not using BIM.

Such a threat was initially raised by Thom Mayne during his keynote lecture at the 2005 AIA Convention in Las Vegas when he suggested that adaptation with building information modeling was the only way designers would maintain relevance in the near future. The role of architecture would eventually be as much about design development as

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5 Sharples 44
6 Oppenheimer 101
it is about information development. In an interview with Thom Mayne three years following his AIA keynote lecture, he maintains that his prediction of “Change or Perish” has slowly become realized in the design and construction industry as a result of building information modeling. What began as merely a tool for representation has evolved into what some believe to be a complete change in the ideology of the design and construction industry, mounting large speculation as to future changes in the profession.

Still, with the current developments in customization and global networking as result of technological improvements, critics such as William Mitchell have suggested that paperless technology will eventually drive us away from repetitive standardization. In contrast, he believes that the valued ability of entirely customizable projects will ultimately lead us towards greater variety, increased complexity and local responsiveness. This raises questions regarding how the tool of building information modeling could be used, in light of industry standardization. The ability of the tool to translate early design intentions throughout the design and construction process promotes the tool to afford highly customizable solutions to component fabrication.

Used as a means to more accurately analyze design decisions for efficiency and cost-saving practices, building information modeling provides benefits to the industry and empowers the architect. Notwithstanding, the tool has positive opportunities for advanced architectural understanding in the academic setting where data-rich design feedback can inform decisions otherwise not considered; its true value, however, rests in professional application due to its high level of complexity and specificity from schematic design to construction administration. The

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8 Mitchell 435
issue of standardized control in the construction industry through use of BIM, however, must be carefully evaluated against perceived design value output to prevent a blind acceptance of the tool. This conditional application of building information modeling suggests that, as particular design scenarios may occasionally necessitate alternate design methodologies, the design industry remains in flux, and concurrently BIM may not be a final solution to the notion of universal design. While the value of digital design tools has indicated a positive impact on environmental and programmatic constraints through increasing specificity in representation, the future remains open to new variations on the capacity of digital tools in architecture.
Chapter 3: Design Study: Parametric Modeling in Academicy Pedagogy

Hand-sketched and digitally created process drawing showing parametric academic design methodology for a winery in southwestern Ohio

Illustration 3.1: Parametric Methodology Palimpsest
Representation in design is more than simply lines on a piece of paper or physical modeling representing design. As presented in the body of research, design representation is the comprehensive tool for methodological research, exploration, evaluation, and visualization of this body of information about a design. The methods of design representation vary in the academic and professional settings for different reasons, as architects and students choose a combination of multiple tools available to accomplish the final representation. The introduction of digital tools such as parametric modeling and building information modeling suggest new opportunities for efficiency, transparency, communication, and control of design input, therein raising expectations for design output, and consequently raising concerns about objective and subjective design reasoning throughout the process.

The question resulting from the introduction of these methods of representation is whether they should be adopted, and if so, what the consequences are for this adoption? A consequence of tools like parametric modeling and building information modeling is that they require a new understanding of how to approach design input. Notably this requires a shift from any preconceived formal expectations of design outcome to understanding the intangible relationships between program elements. Initially this means a departure from traditional modeling techniques of physical and digital massing, and also included notions of site-related design response. The real design solutions come from the necessary programmatic relationships, and only after these were established can site and massing conjectures be formed and employed. Above all, the use of these tools rely on the subjective delineation of design intent in the hand-sketch format, through which all objective calculation can be digitally
coded and evaluated. This is important because it allows a disconnect for individual design freedoms to occur without the need to determine initially how they affect the final outcome.

One implication for use of these tools in the academic setting is that the tools require time to adapt to and adopt for specific inquiries. Growing with the technologies requires a constant cycling process of testing, reviewing, editing, and retesting that can consume a significant portion of time. It is entirely feasible, thus, that only after several academic projects are produced with the tools can some of the their beneficial outcomes become realized. Because of this, a constant evaluation of the design methodology used through these tools must be completed to ensure that the specific design inquiries are being addressed with the greatest potential of design outcome. There is hope that the use of these tools can bring about a deeper understanding of how each design relationship translates throughout the academic design much more comprehensively than traditional methods of modeling, massing, and detailing. An evaluation for this conjecture will thus act as the conclusion following the thesis design project.

Given the implications for use of these new tools, it is important to question which of the tools should be used for the thesis design? There are several advantages to the use of parametric modeling over building information modeling for the purpose of academic research. First, the parametric tool allows for the investigation of the topological relationships between design elements, with the primary purpose of identifying driving conditions in design. The result of understanding these driving conditions can benefit the under-experienced designer in establishing future design decisions. While BIM is a parametric model, its primary
purpose is to forecast performance and construction of a more finalized design. As a sizeable goal more conducive for professional practice, academic design studies commonly leave an element of unfinished resolve in them with the purpose of stressing a deeper understanding of particular consequences of the design process.

A second reason to investigate the tool of parametric modeling over BIM in this academic setting is the reduced complexity imbedded in the parametric modeling process. Applications such as Solidworks offer a light introduction into parametric modeling that requires less pre-requisite technical information. As an extension of the parametric model, building information modeling requires a higher initial level of technical understanding to establish the parametric foundation along with a refined insight as to the final building design. In a sense, the building information model would appropriately occur after the initial parametric modeling investigations had occurred, with a significant portion of the design determined. While the data feedback from BIM on project investigations would be highly beneficial in the academic realm, the combination of methodological complexity and time to establish the initial parametric base model might prove too ambitious for the academic setting.

For these purposes, the thesis design project employs parametric modeling over building information modeling, with the expectation that some finite data, as partially derived from BIM processes, may be used to evaluate the resultant design. It is also important to note that the initial conjecture that parametric modeling is an all-in-one design tool assumes proficiency with the parametric tool that is not necessarily true for first-time users. For this reason, it is assumed that other digital design tools will be used in the parametric design process to complement the visualization of pertinent design information. The coupling of different
digital tools in this methodology is not intended to support or deny the claim that all design can be accomplished through the digital process of parametric modeling. On the contrary, the goal is to analyze the inherent design implications for topological component development, and furthermore to identify and enhance the driving conditions in the process.

This brings up perhaps the most important question regarding the design process: How will the parametric modeling process be used in the design? The use of parametric modeling in the thesis design is to supplement the research and to activate research assumptions. As with most methods of design, modeling cannot become fully engaged until questions of program type and scope are revealed. For the purpose of this study, a particular program type is less significant than identifying the programmatic needs and variables of a simple program to test. A straightforward program allows for easier delineation of component relationships, and for this reason the design of a winery in southeastern Ohio is chosen. The historical background of wineries in Ohio gives an important initial grounding to the regional conditions of winery development. Precedent research of national and international projects provides further insight regarding variations of programmatic elements. The physical requirements of a winery and vineyard also require an understanding of the viticulture process, from planting and harvesting, to the detailed machine process of wine fermentation and bottling.

Once this information is established, subjective and objective goals have to be identified in order to determine the driving conditions of the program. The objective variables for appropriate production in a gravity flow wine fermentation system, for example, must be considered along with subjective responses such as visitor experience and response to site. This information initiates the parametric process as a series of hand-sketches that identify the driving relationships in an abstract form. The Solidworks platform will perform the digital parametric modeling and initial investigations will look into how generic dynamic rule sets function. The abstract hand-sketch relationships are then codified as formal dynamic rule sets in a single parametric Solidworks model to test.

The order of these dynamic rule sets proves to be an important component of the modeling process to develop, as simply rearranging the driving rule sets could completely modify the end result. Measured as series of component variable configurations, this information provides seemingly infinite opportunities for design response. The variables chosen to manipulate the dynamic order of the design provide an additional layer of analysis and control, and a continual manipulation of these variables is important to succinctly depict the driving relationships of the design. The modeling process proves most beneficial through a combination of these reorganization studies and a continuation of the abstract codification of driving program elements. Similar to the cyclical process of traditional academic design, the parametric process relies on a non-
linear progression of hand sketching to digital codification to dynamic organization to variable manipulation.
Defining the Study: Winery in Ohio
Historical Background of Ohio Wineries

The program typology of a Ohio winery is rich with historical background worthy of exploring before initiating programmatic studies. The power of the fermented grape has long since been the focal point of social libation, bringing family and friends together over various forms of celebration. The process of growing, harvesting, pressing, fermenting, and aging of grapes to wine represents a long journey in which energies employed transform a naturally occurring element into a precious commodity. It is not uncommon to consider the world’s finest wines originating in Europe, specifically France, Italy, and Switzerland, where the earliest civilizations have fostered a deep philosophical meaning in the libation of wine. Transferred to American soil, the wine industry has continued an evolution of grape typologies grown and fermented. When considering the source of America’s premier wines, it is common to look to the west for these estates. The Napa Valley, in particular, is today’s home for some of the finest grapes produced, primarily due to a perfect combination of soil types, weather patterns, irrigation practices, and direct exposure to sunlight.

It is thus not uncommon to look beyond states such as Massachusetts, Connecticut, Virginia, and Ohio as being original leaders in the American wine industry. As nationalization took shape in Europe during the 18th and 19th centuries, the newly formed American nation began looking to the wine production practices of western Europe to adopt and adapt for its developing territories. Interestingly, vineyards were not able to directly transfer the western European practices due to the fact that vine species displayed incredibly rigid requirements in order for fruit to grow. Today, American vineyards are the beneficiaries of a great deal of trials of vine testing.

It was due to one particular pioneer of vineyards that Ohio even-
tually became the nation’s leader in grape harvests, and subsequently in the wine production process. Nicholas Longworth, a lawyer practicing in the city of Cincinnati, was a product of western European influence, with interests in developing his family’s estates in southeastern Ohio. After visiting several Native American fruit plantations, he observed that several of these plantations were testing a number of different European grape species, or *vitis vinifera*, with varied results. Longworth conjectured that through similar testing in the region, he might stumble upon a successful species to grow in the southeastern Ohio region.

He discovered that the Catawba grape species was exceptionally versatile in Ohio due primarily to its ability to avoid crop disease while thriving in the combination of clay and rocky soil substrate. Longworth found that Cincinnati’s soil base near the Ohio River was ideal for the Catawba grape due to the area’s glaciated terrain, which disrupted the area’s limestone as the glaciers shifted during melting. It could be argued that the natural environment of 19th century Cincinnati is drastically different than the landscapes surrounding the region today, primarily due to bold deforestation efforts during the industrial age. Before this transformation, issues such as soil contamination, over exposure to solar properties, and the urban heat-island effect were not direct threats to the plantations. However, as the industrialization process took place in America, the Cincinnati area began to see its grape harvests decline, and is a clear indication why the Cincinnati area today has very little plantations.

Because of his plantations in Cincinnati, however, Longworth’s success began spreading north to other regions of Ohio and Indiana. As grape harvesting had yet to spread west prior to the Civil War with any measured success, the process began to thrive in Ohio, boosting levels of wine production to a leadership roll in America. It is estimated that
prior to the Civil War, wine production in Ohio easily surpassed 500,000 gallons of wine each year; the state’s closest rivals were to the east and northeast, where levels of production were well below half of that in Ohio.

By 1860, Lincoln was heralded in as the Nation’s newest president and slavery was prohibited. Following South Carolina’s succession from the Union, the state of Ohio was thrust into a Civil War that would ravage the state’s reserves of vineyard plantations. Ohio wine production steadily declined for several decades following the war’s conclusion. A rebirth occurred during the late 19th and early 20th century, but then was devastated yet again when law was set into place making any mode of alcohol production illegal. The Prohibition of 1919 crippled Ohio’s claim to wine superiority, forcing wineries to convert to juice production over wine production, or shut down altogether. Without a market for wine-production, the value of grape harvests dropped severely, forcing vineyards to make a transition to orchards or cornfields.

Fifteen years following the Prohibition’s start, Congress repealed the law, once again opening the door for vineyards and wineries to re-establish operation. The Prohibition, however, proved too costly for many Ohio wineries and vineyards, and while some were able to re-establish some levels of production, the onslaught of depression had sunken in to the Midwest, preventing most farmers from the resources necessary to convert their plantations back to vineyards and operating wineries. Not long after the end of the Great Depression, grape harvesting and wine production started taking off on the west coast; there was enough interest in development in this region to begin testing different forms of agriculture, specifically in areas such as northern California. This would signal the transition of wine production leadership from the east to the west, and the beginning of anointing Napa valley as America’s premier region of wine.

Following the conclusion of World War Two, America gained a favorable standing in the global community, both financially and due to positive gross-domestic productivity. With the birth of the notion of a global economy in the late 20th century, certain industries began to flourish in international markets. The wine market was impacted by this as
western European producers maintained a stronghold in the international market. The newly christened wine-production dominance of the American west coast saw unique opportunities to break into the international scene by participating in wine-tasting festivals across the globe, even inviting other international wine-leaders to participate in American-hosted festivals. The western American wines surprisingly won the hearts of many international minds through blind-tasting festivals, and as a result, Napa Valley and other various west-coast regions gained indelible marks on an international wine-scene.

Now over eight decades following Ohio’s dominance over the domestic wine industry in America, the state has maintained a moderate amount of wine productivity, with a predominant agricultural niche in corn and soy-based growth. Ohio is home to five viticultural appellations, or premier grape harvesting regions, most of which occur in the northeast region of the state, around the greater Cleveland area. One particular region in the southern region of the state exists along the banks of the Ohio River. In particular, areas to the east of Cincinnati’s populated urban density contain steadily sloping terrain, good soil quality, and predominately southern solar exposure that are excellent conditions for grape growth and irrigation strategy along with scenic connections to the Ohio River. This area will be the basis for designing a winery and vineyard for the thesis design.
Defining the Study: Winery in Ohio
Winery/Vineyard Process and Programming

The history of winemaking in Ohio has been prosperous and is defined by a very specific fermentation and bottling process. Fundamental to programming a winery are the eleven stages of wine production. Grapes are harvested and collected for crushing and de-stemming en route to the fermentation tanks. Once the grape ‘must’ is allowed to ferment completely it is pressed and set in tanks for further aging before being barreled and set to age yet again. Once the wine has reached the desired composition, it is filtered and bottled where it is again thrust into a shelf-aging process. The sizing requirements for the machinery along with variations in wine harvesting capacity will become influential variables in the winery design because they are both linked in determining the size and capacity of the project.

The basic winery program is thus a linear process, from grape growth to wine bottling, and allows for direct sizing and capacity relationships between adjacent program components. These relationships allow for a straightforward winery program and allow it to respond to the sloped site of Cincinnati’s banked hillsides along the Ohio River. A new development in premium wine-production is the gravity flow process that replaces machine-pumped wine-flow during production. One benefit of the process is a better tasting wine resulting from the grape must gently passing from stage to stage instead of the pressurized process of mechanically pumped wine must. As the name suggests, this process involves wine moving from program stage to stage by the force of gravity and the adjacent program spaces are set apart vertically to allow for the gravity-fed process. This is beneficial for winery sites that have pre-existing sloped terrains because the winery program spaces are then able to step vertically into the terrain as needed for the gravity flow process. This gravity flow will become a calculable variable in the design that is
dependent upon the capacity and site orientation of the winery.

An additional program variable to consider in the sizing of a winery and vineyard is the relationship between land needed for grape growth, the amount of wine produced by the grapes, and the amount of grapes needed for production of a bottle of wine. Specific numbers vary on amount of possible harvested grapes per acre, but even more surprising is the range of grapes needed to produce a bottle of wine. The discrepancy in these numbers, as illustrated in the accompanying diagram, comes from an estimated range of grapes per cluster, clusters per crate, crates per ton, and tons per acre. If calculated out, this estimate shows that an acre of vineyard can produce anywhere from 720,000 to 6,480,000 grapes. There is also a range associated with the number of grapes needed to produce a bottle of wine, varying from 500 grapes to 750. If this is calculated against the previous range of grape-growth per acre, then the numbers show than an acre of vineyard can create as little as 959 bottles and as much as 12,987 bottles of wine. While there are a number of variables of which to attribute this discrepancy in land-bottle production, this range will serve to define the limits of production and will help to establish a reasonable land-bottle calculation for the purpose of this study.
Defining the Study: Winery in Ohio
Winery/Vineyard Programming

To help develop the winery program, a series of winery visits and case studies were conducted to develop the layout of a 450-barrel capacity winery. It was especially helpful to visit and speak with the owner of a local Cincinnati winery, Harmony Hills Vineyard and Winery Estates, which coincidentally also uses a gravity flow process in making his wine. The winemaking process information translated to machine and tank sizing and spacing giving a rough overall relationship between winemaking capacity and facility size. The study began as an investigation into the possible user groups of the winery/vineyard, from production workers to visitors, including special guests such as wedding parties and bed and breakfast patrons. The range of activities was charted to determine the limits of scope in a winery design, looking next to the typical day at the winery.

This investigation charted the movement of visitors and workers on site through the 11 steps of the winemaking process over the course of a day. After some research, it was clear that there was a typical set of components used in the linear process that could be broken down into 5 stages of a typical winery. After compiling a chart of general and specific winery components, these numbers translated to sizing requirements for the 5 stages of a typical winery. These spaces were further investigated individually, listing out the specific functions occurring along the linear axis. When composed together, it was easy to visualize the wine process as a linear trajectory, and with an interest of gravity flow pumping, vertical adjacencies were modified for a gradual stepping of the program. This typical winery study suggests a number of objectives that will be followed in setting up the design of a winery in Ohio.
### Part 1a: Classifying the Activities and Functions (Begin as an inventory of all activities that will be part of the use and experience of your building, or facility)

**Building/Facility:** Winery/Vineyard

### Activities:
- Grape Harvesting/Collection
- Grape Crushing/Stemming
- Grape 'Must' Fermentation
- 'Must' Pressing
- Wine Tank Setting
- Wine Barrel Aging
- Wine Filtration
- Wine Bottling
- Bottle Corking
- Bottle Aging
- Wine Tasting
- Distribution
- Facility Touring

### Functions:
- Machine Operation
- Management of Field Hands
- Management of Machine Operators
- Management of Property
- Management of Financial Operations
- Community Involvement
- Local/Regional Advertisement
- Supplies Purchasing
- Management of waste and recycling
- Vineyard Storage (fertilizer/tools/nursery)
- On-Site Housing of Owner and Family
- Parking Services

### Superfluous Activities:
- Bed and Breakfast
- Sleeping
- Daytime Resting
- Local Tour Organization
- Lake Loomis State Park Tour
- Wedding Ceremony Planning
- Wedding Reception Planning
- Music Festivals
- Local Orchard Education Programs

### Superfluous Functions:
- On-Site Laundry Services
- Part-Time Kitchen Services
- Maid Services

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*illustration 3.11: Classifying the Vineyard/Winery Activities and Functions*
Part 1. Describe a ‘day-in-the-life’ of the facility (playing the role of each of its users and audience types. Fundamental for qualitative and quantitative programming information)

### Building/Facility: Winery/Vineyard

#### Facility Users:
- Owners/Managers (2-3)
- Chief Wine Specialist (1)
- Machine Operators (3-4)
- Field-Hand Operators (5-10 seasonal)
- Barreling/Bottling Specialist (1-2)
- Wine-Tasting Servers (2-3)
- Packaging and Distribution (3-4 seasonal)

**Total:** 17-27 (peak season), 9-13 (low season)

#### Facility Visitors:
- Orchard Produce Visitors (20-40/day)
- Wine Tasting Visitors (10-20/day)
- Bed/Breakfast Patrons (4-6/week)
- Wedding Party (100-150/season)
- Education Visitors (150-200/season)
- Wine Tour Visitors (10-20/season)

**Total:** 5,000-5,800 (peak season), 2,500-3,000 (low season)

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**Illustration 3.12:** Defining Program Users And Typical Day

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Note: Because of the number of different facility users, it will be important to choose the most important use of the facility (the owner) due to his/her relationship with a majority of the other users of the program. In this way, one day-in-the-life of the owner/manager/operator will encompass all the different user activities and functions.
Part 2.a: How big is it, what does it consist of, what does it require, and how is it laid out? Space standards not only refer to the size of the space, but also to the accommodation of the contents of the space: people, furniture and equipment.

<table>
<thead>
<tr>
<th>Building/Facility: Linear Winery Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Winery Specific Components:</strong></td>
</tr>
<tr>
<td>Crushing/Stemming Room</td>
</tr>
<tr>
<td>Fermentation Room</td>
</tr>
<tr>
<td>Pressing/Tank Setting Room</td>
</tr>
<tr>
<td>Barrel Aging Room</td>
</tr>
<tr>
<td>Filtration/Bottling/Corking Room</td>
</tr>
<tr>
<td>Bottle Aging Room/Serving Room</td>
</tr>
<tr>
<td>Packaging/Distribution Room</td>
</tr>
<tr>
<td><strong>Winery Generic Components:</strong></td>
</tr>
<tr>
<td>Bathrooms (1 public, 1 private)</td>
</tr>
<tr>
<td>Chemical Storage</td>
</tr>
<tr>
<td>Managerial Offices (3)</td>
</tr>
<tr>
<td>Indoor Public Gathering Space</td>
</tr>
<tr>
<td>Outdoor Public Gathering Space</td>
</tr>
<tr>
<td>Managerial Break Room</td>
</tr>
<tr>
<td>Circulation</td>
</tr>
<tr>
<td><strong>Winery Specific Machines:</strong></td>
</tr>
<tr>
<td>Grape Crusher/Stemmer (2)</td>
</tr>
<tr>
<td>Fermentation Tanks (4-8)</td>
</tr>
<tr>
<td>Must Presser (1-2)</td>
</tr>
<tr>
<td>Industrial Chiller</td>
</tr>
<tr>
<td>Setting Tanks (8-20)</td>
</tr>
<tr>
<td>Oak Barrels (200-2000)</td>
</tr>
<tr>
<td>Wine Filtration Machines (2-4)</td>
</tr>
<tr>
<td>Bottling Pump</td>
</tr>
<tr>
<td>Corker</td>
</tr>
<tr>
<td>Elevator/Vertical Circulation</td>
</tr>
</tbody>
</table>

Illustration 3.13: Program Overview: 5 Stages of Production
Part 2: How big is it, what does it consist of, what does it require, and how is it laid out? Space standards not only refer to the size of the space, but also to the accommodation of the contents of the space: people, furniture, and equipment.

<table>
<thead>
<tr>
<th>Building/Facility:</th>
<th>Linear Winery Complex</th>
<th>Size of Components/Machines</th>
<th>Notes: Spaces, Occupancy (Human), etc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winery Program Components:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crushing/Stemming Room</td>
<td>(48 x 60) x 150 = 358 sqft</td>
<td>Crusher, Storage, Circulation, Entry Gathering, (6)</td>
<td></td>
</tr>
<tr>
<td>Fermentation Room</td>
<td>(576 x 100) x 25 = 901 sqft</td>
<td>Fermentation Tanks, Storage, Circulation, Bathroom, (3)</td>
<td></td>
</tr>
<tr>
<td>Pressing/Tank Setting Room</td>
<td>(250 x 150) x 150 = 457 sqft</td>
<td>Must Presser, Setting Tanks, Circulation, Office (4)</td>
<td></td>
</tr>
<tr>
<td>Barrel Aging Room</td>
<td>(540 x 35) x 288 = 2,078 sqft</td>
<td>Barrels, Circulation, Offices (14)</td>
<td></td>
</tr>
<tr>
<td>Filtration/Bottling/Corking Room</td>
<td>(48 x 48) x 144 = 298 sqft</td>
<td>Filtration Machine, Bottle, Corker, Office, Circulation (4)</td>
<td></td>
</tr>
<tr>
<td>Bottle Aging Room</td>
<td>(420 x 200) = 620 sqft</td>
<td>Shelving, Circulation (5)</td>
<td></td>
</tr>
<tr>
<td>Packaging/Distribution Room</td>
<td>(100 x 100) x 250 = 1,000 sqft</td>
<td>Storage, Prep Tables, Break Room, Bar Area, Circulation, Sales, Bathrooms (20)</td>
<td></td>
</tr>
<tr>
<td>Winery Program Total:</td>
<td>5,064 sqft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generic Components:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bathrooms (2 public, 1 private)</td>
<td>(6 ft x 5 ft) x 3 = 75 sqft</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Chemical Storage (3)</td>
<td>(10 ft x 10 ft) x 3 = 300 sqft</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Managerial Offices (4)</td>
<td>(12 ft x 12 ft) x 4 = 576 sqft</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Indoor Public Gathering Space</td>
<td>(20 ft x 20 ft) x 1 = 400 sqft</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Outdoor Public Gathering Space</td>
<td>(15 ft x 10 ft) x 1 = 250 sqft</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Managerial Break Room</td>
<td>(15 ft x 20 ft) x 1 = 300 sqft</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Bar Area</td>
<td>(7 ft x 13 ft) x 1 = 105 sqft</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Circulation</td>
<td>975 sqft</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Generic Program Total:</td>
<td>2,566 sqft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific Machines:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grape Crusher/Stemmer (2)</td>
<td>(4 ft x 6 ft) x 2 = 48 sqft</td>
<td>All machines are based on 50,000-75,000 case production program</td>
<td></td>
</tr>
<tr>
<td>Fermentation Tanks (16-36)</td>
<td>(6 ft x 6 ft) x 16 = 576 sqft</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Must Presser (1-2)</td>
<td>(15 ft x 10 ft) x 2 = 300 sqft</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Industrial Chiller</td>
<td>(10 ft x 10 ft) x 1 = 100 sqft</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Setting Tanks (8-20)</td>
<td>(4 ft x 10 ft) x 10 = 400 sqft</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Oak Barrels (200-2000)</td>
<td>(3.2 ft x 2.25) x 200 = 1,440 sqft</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Wine Filtration Machines (2-4)</td>
<td>(5.75 ft x 2.5 ft) x 4 = 46 sqft</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Bottling Machine</td>
<td>(11 ft x 1 ft) x 1 = 4 sqft</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Machine Piping</td>
<td>(2,000 ft x 0.25 ft pipes) x 10 pipes = 1,000 sq ft</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Corker</td>
<td>(4 ft x 1 ft) x 1 = 4 sqft</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Elevator/Vertical Circulation</td>
<td>(6 ft x 8 ft) x 1 = 48 sqft</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Machine Total:</td>
<td>5,486 sqft (2,084 sq ft non-piping)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

illustration 3.14: Program Overview: Generic and Specific Components
Port 2.b and 3. Please demonstrate an example of a) a space square footage derived by standards [research]; b) a space derived by examining a similar facility [research], and c) a space derived by a process of trial design that includes furniture or equipment lay out. In this section, use diagrams to articulate the relationship among spaces within section II.

### Crushing/Stemming Components:

<table>
<thead>
<tr>
<th>Component</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crusher</td>
<td>48sqft</td>
</tr>
<tr>
<td>Chemical Storage</td>
<td>100sqft</td>
</tr>
<tr>
<td>Circulation</td>
<td>150sqft</td>
</tr>
<tr>
<td>Entry Gathering</td>
<td>60sqft</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>358sqft</td>
</tr>
</tbody>
</table>

---

**Winery Program Components:**

- Crushing/Stemming Room
  - Crushes, Storage, Circulation, Entry Gathering

---

**STAGE 1**

Total Space: 358 sqft

Illustration 3.15: Program Stage 1: Crushing and Destemming
Part 2.b and 3: Please demonstrate an example of a) a space square footage derived by standards [research]; b) a space derived by examining a similar facility [research], and c) a space that is derived by a process of trial design that includes furniture or equipment lay out. In this section, use diagrams to articulate the relationship among spaces within section II.

Fermentation/Pressing Components:  
- Fermentation Tanks: 576 sq ft
- Chemical Storage: 100 sq ft
- Circulation: 200 sq ft
- Private Bathroom: 25 sq ft
- Machine Operator’s Office: 144 sq ft
- Settling Tanks: 160 sq ft
- Must Pressers: 250 sq ft

Total: 358 sq ft

Winery Program Components:  
- Fermentation Room
- Pressing/Tank Setting Room
  (Fermentation Tanks, Storage, Circulation, Bathroom)
  (Must Presser, Settling Tanks, Circulation, Office)

STAGE 2  
Total Space: 1,455 sq ft

Illustration 3.16: Program Stage 2: Fermentation and Pressing
Part 2b and 3: Please demonstrate an example of a) a space square footage derived by standards (research); b) a space derived by examining a similar facility (research), and c) a space that is derived by a process of trial design that includes furniture or equipment lay out. In this section, use diagrams to articulate the relationship among spaces within section II.

**Barrel Aging Components**:  Size

- Oak Wine Aging Barrels: 1,440 sqft
- Circulation: 350 sqft
- Chief Wine Specialist Office: 144 sqft
- Barreling Specialist Office: 144 sqft
- Total: 2,078 sqft

**Winery Program Components**:  
- **Barrel Aging Room** (Barrels, Circulation, Offices)

**STAGE 3**
Total Space: 2,078 sqft

Illustration 3.15: Program Stage 3: Barrel Aging
Part 2.b and 3. Please demonstrate an example of a) a space square footage derived by standards [research]; b) a space derived by examining a similar facility [research]; and c) a space that is derived by a process of trial design that includes furniture or equipment layout. In this section, use diagrams to articulate the relationship among spaces within section II.

### Filtration/Bottling Components:

- **Filtration Machines:** 46sqft
- **Bottling Machine:** 4sqft
- **Corking Machine:** 4sqft
- **Machine Operator’s Office:** 144sqft
- **Central Circulation:** 100sqft
- **Bottle Aging Shelving:** 420sqft
- **Bottle Aging Circulation:** 200sqft

**Total:** 918sqft

### Winery Program Components:

- Filtration/Bottling/Corking Room
- Bottle Aging Room
- (Filtration Machine, Bottler, Corker, Office, Circulation)
- (Shelving, Circulation)

**STAGE 4**

**Total Space:** 918 sqft

**Illustration 3.18:** Program Stage 4: Filtration and Bottle Aging
Part 2.b and 3: Please demonstrate an example of a) a space square footage derived by standards [research]; b) a space derived by examining a similar facility [research]; and c) a space that is derived by a process of trial design that includes furniture or equipment layout. In this section, use diagrams to articulate the relationship among spaces within section II.

<table>
<thead>
<tr>
<th>Packaging/Distribution Components:</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Room:</td>
<td>100sqft</td>
</tr>
<tr>
<td>Distribution Prep Room:</td>
<td>100sqft</td>
</tr>
<tr>
<td>Employee Break Room:</td>
<td>250sqft</td>
</tr>
<tr>
<td>Central Circulation:</td>
<td>200sqft</td>
</tr>
<tr>
<td>Wine Serving Bar:</td>
<td>105sqft</td>
</tr>
<tr>
<td>Public Bathrooms:</td>
<td>50sqft</td>
</tr>
<tr>
<td>Sales Area:</td>
<td>200sqft</td>
</tr>
<tr>
<td>Total:</td>
<td>1,005sqft</td>
</tr>
</tbody>
</table>

Winery Program Components: Packaging/Distribution Room
(Storage, Prep Tables, Break Room, Bar Area, Circulation, Sales, Bathrooms)

STAGE 5
Total Space: 1,005 sqft
Part 3: Please demonstrate an example of a) a space square footage derived by standards [research]; b) a space derived by examining a similar facility [research]; and c) a space that is derived by a process of trial design that includes furniture or equipment lay out. In this section, use diagrams to articulate the relationship among spaces within section II.

B. Horizontal Proximities among like areas [interdependent]

C. Vertical proximities / linking hierarchies [interdependent]

With all 5 stages placed together, the overall building form resembles a bar with circulation to all spaces on the central axis. The program is segmented and is perceived to be able to be broken into the individual segments if needed, depending on site placement.

Because the program is seeking to use a gravity flow process, wherein the wine flow process is gravity fed rather than pump-fed, the 5 stages can easily be staggered vertically to allow for gravity to control the linear process.

The illustrations below show each stage of the program offset from the adjacent program stage by 2 feet. It is assumed that this number will change as necessary once further information is gathered on the wine-making process.
Defining the Study: Winery in Ohio
Early Design Conjectures

My initial interest in the ability of parametric and building information modeling to analyze both quantitative and qualitative information. An early series of overall design conjectures were paired with programmatic design conjectures. In a similar fashion, a set of qualitative aspects of design was charted with a set of quantitative aspects of design. The design conjectures listed in the vertical column were tested against the qualitative and quantitative inputs to suggest which inputs directly applied to each conjecture. For example, the conjecture stating “A design should suggest a single-overarching form” applies qualitatively to: Quality of Light, Sound, Space, Construction Feasibility, Personal Experience, Programmatic Constraints, and Client Needs. The same conjecture applies quantitatively to: Day lighting Calculations, Material Data, Clash Detection, Component Development, Interior Visibility Analysis, 4-D Construction Animation, Acoustic Clarity Analysis, and Structural Load Analysis. Using several international winery projects as precedent studies, the initial design conjectures were evaluated to identify how the precedent studies compared to and answered the design conjectures. While this study was relatively crude and incomplete, it served a dual purpose of establishing organization to study the impact of conjectures to qualitative and quantitative input and additionally it helped connect those conjectures to the precedent studies.
### What does the Information Convey? Conjectural Matrix

<table>
<thead>
<tr>
<th>Formal Conjectures</th>
<th>General or Program Specific?</th>
<th>Areas of Qualitative Analysis</th>
<th>Areas of Quantitative Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design should capitalize on energy efficiency.</td>
<td>General</td>
<td><img src="image1" alt="Quality of Light" /> <img src="image2" alt="Quality of Sound" /> <img src="image3" alt="Quality of Space" /> <img src="image4" alt="Construction Efficiency" /> <img src="image5" alt="Quality of Design" /> <img src="image6" alt="Qualitative Personal Impression" /> <img src="image7" alt="Programatic Constraints" /> <img src="image8" alt="Impact on Site" /> <img src="image9" alt="Financial Contex" /> <img src="image10" alt="Users Needs" /></td>
<td><img src="image11" alt="Designing Calculations" /> <img src="image12" alt="Material" /> <img src="image13" alt="Cost" /> <img src="image14" alt="Detection" /> <img src="image15" alt="Component Development" /> <img src="image16" alt="Site Shading Analysis" /> <img src="image17" alt="Solar Radiation Analysis" /> <img src="image18" alt="Sustainability" /> <img src="image19" alt="Cost-Benefit Analysis" /> <img src="image20" alt="Wind Velocity Analysis" /> <img src="image21" alt="Thermal Comfort Rating" /> <img src="image22" alt="Component Engineering" /> <img src="image23" alt="Structural Analysis" /> <img src="image24" alt="Material Energy Impact" /> <img src="image25" alt="Structural Load Analysis" /></td>
</tr>
<tr>
<td>Design should suggest a single over-arching form.</td>
<td>Program Specific</td>
<td><img src="image26" alt="Design Specific" /> <img src="image5" alt="Quality of Design" /> <img src="image6" alt="Qualitative Personal Impression" /> <img src="image7" alt="Programatic Constraints" /> <img src="image8" alt="Impact on Site" /> <img src="image9" alt="Financial Contex" /> <img src="image10" alt="Users Needs" /></td>
<td><img src="image11" alt="Designing Calculations" /> <img src="image12" alt="Material" /> <img src="image13" alt="Cost" /> <img src="image14" alt="Detection" /> <img src="image15" alt="Component Development" /> <img src="image16" alt="Site Shading Analysis" /> <img src="image17" alt="Solar Radiation Analysis" /> <img src="image18" alt="Sustainability" /> <img src="image19" alt="Cost-Benefit Analysis" /> <img src="image20" alt="Wind Velocity Analysis" /> <img src="image21" alt="Thermal Comfort Rating" /> <img src="image22" alt="Component Engineering" /> <img src="image23" alt="Structural Analysis" /> <img src="image24" alt="Material Energy Impact" /> <img src="image25" alt="Structural Load Analysis" /></td>
</tr>
<tr>
<td>Design should investigate an efficient 'gravity-based' process to manufacture and distribute wine.</td>
<td>Program Specific</td>
<td><img src="image26" alt="Design Specific" /> <img src="image5" alt="Quality of Design" /> <img src="image6" alt="Qualitative Personal Impression" /> <img src="image7" alt="Programatic Constraints" /> <img src="image8" alt="Impact on Site" /> <img src="image9" alt="Financial Contex" /> <img src="image10" alt="Users Needs" /></td>
<td><img src="image11" alt="Designing Calculations" /> <img src="image12" alt="Material" /> <img src="image13" alt="Cost" /> <img src="image14" alt="Detection" /> <img src="image15" alt="Component Development" /> <img src="image16" alt="Site Shading Analysis" /> <img src="image17" alt="Solar Radiation Analysis" /> <img src="image18" alt="Sustainability" /> <img src="image19" alt="Cost-Benefit Analysis" /> <img src="image20" alt="Wind Velocity Analysis" /> <img src="image21" alt="Thermal Comfort Rating" /> <img src="image22" alt="Component Engineering" /> <img src="image23" alt="Structural Analysis" /> <img src="image24" alt="Material Energy Impact" /> <img src="image25" alt="Structural Load Analysis" /></td>
</tr>
<tr>
<td>Design should minimize excessive use of materials by investigating simple structural forms.</td>
<td>General</td>
<td><img src="image27" alt="General" /> <img src="image5" alt="Quality of Design" /> <img src="image6" alt="Qualitative Personal Impression" /> <img src="image7" alt="Programatic Constraints" /> <img src="image8" alt="Impact on Site" /> <img src="image9" alt="Financial Contex" /> <img src="image10" alt="Users Needs" /></td>
<td><img src="image11" alt="Designing Calculations" /> <img src="image12" alt="Material" /> <img src="image13" alt="Cost" /> <img src="image14" alt="Detection" /> <img src="image15" alt="Component Development" /> <img src="image16" alt="Site Shading Analysis" /> <img src="image17" alt="Solar Radiation Analysis" /> <img src="image18" alt="Sustainability" /> <img src="image19" alt="Cost-Benefit Analysis" /> <img src="image20" alt="Wind Velocity Analysis" /> <img src="image21" alt="Thermal Comfort Rating" /> <img src="image22" alt="Component Engineering" /> <img src="image23" alt="Structural Analysis" /> <img src="image24" alt="Material Energy Impact" /> <img src="image25" alt="Structural Load Analysis" /></td>
</tr>
<tr>
<td>Design should capitalize on site placement to inform entry, flow, expansive growth opportunities, and waste removal and treatment.</td>
<td>Program Specific</td>
<td><img src="image26" alt="Design Specific" /> <img src="image5" alt="Quality of Design" /> <img src="image6" alt="Qualitative Personal Impression" /> <img src="image7" alt="Programatic Constraints" /> <img src="image8" alt="Impact on Site" /> <img src="image9" alt="Financial Contex" /> <img src="image10" alt="Users Needs" /></td>
<td><img src="image11" alt="Designing Calculations" /> <img src="image12" alt="Material" /> <img src="image13" alt="Cost" /> <img src="image14" alt="Detection" /> <img src="image15" alt="Component Development" /> <img src="image16" alt="Site Shading Analysis" /> <img src="image17" alt="Solar Radiation Analysis" /> <img src="image18" alt="Sustainability" /> <img src="image19" alt="Cost-Benefit Analysis" /> <img src="image20" alt="Wind Velocity Analysis" /> <img src="image21" alt="Thermal Comfort Rating" /> <img src="image22" alt="Component Engineering" /> <img src="image23" alt="Structural Analysis" /> <img src="image24" alt="Material Energy Impact" /> <img src="image25" alt="Structural Load Analysis" /></td>
</tr>
<tr>
<td>Design should maximize material/product re-use through innovative planning and forward engineering.</td>
<td>General</td>
<td><img src="image27" alt="General" /> <img src="image5" alt="Quality of Design" /> <img src="image6" alt="Qualitative Personal Impression" /> <img src="image7" alt="Programatic Constraints" /> <img src="image8" alt="Impact on Site" /> <img src="image9" alt="Financial Contex" /> <img src="image10" alt="Users Needs" /></td>
<td><img src="image11" alt="Designing Calculations" /> <img src="image12" alt="Material" /> <img src="image13" alt="Cost" /> <img src="image14" alt="Detection" /> <img src="image15" alt="Component Development" /> <img src="image16" alt="Site Shading Analysis" /> <img src="image17" alt="Solar Radiation Analysis" /> <img src="image18" alt="Sustainability" /> <img src="image19" alt="Cost-Benefit Analysis" /> <img src="image20" alt="Wind Velocity Analysis" /> <img src="image21" alt="Thermal Comfort Rating" /> <img src="image22" alt="Component Engineering" /> <img src="image23" alt="Structural Analysis" /> <img src="image24" alt="Material Energy Impact" /> <img src="image25" alt="Structural Load Analysis" /></td>
</tr>
<tr>
<td>Design should invoke sense of local culture while inspiring high quality regional product.</td>
<td>Program Specific</td>
<td><img src="image26" alt="Design Specific" /> <img src="image5" alt="Quality of Design" /> <img src="image6" alt="Qualitative Personal Impression" /> <img src="image7" alt="Programatic Constraints" /> <img src="image8" alt="Impact on Site" /> <img src="image9" alt="Financial Contex" /> <img src="image10" alt="Users Needs" /></td>
<td><img src="image11" alt="Designing Calculations" /> <img src="image12" alt="Material" /> <img src="image13" alt="Cost" /> <img src="image14" alt="Detection" /> <img src="image15" alt="Component Development" /> <img src="image16" alt="Site Shading Analysis" /> <img src="image17" alt="Solar Radiation Analysis" /> <img src="image18" alt="Sustainability" /> <img src="image19" alt="Cost-Benefit Analysis" /> <img src="image20" alt="Wind Velocity Analysis" /> <img src="image21" alt="Thermal Comfort Rating" /> <img src="image22" alt="Component Engineering" /> <img src="image23" alt="Structural Analysis" /> <img src="image24" alt="Material Energy Impact" /> <img src="image25" alt="Structural Load Analysis" /></td>
</tr>
</tbody>
</table>

**Illustration 3.21: Conjecture Matrix: Qualitative versus Quantitative Analysis**
How do the conjectures translate to built form? Precedent Matrix

National and International Wineries

<table>
<thead>
<tr>
<th>Demisus Vineyards, CA</th>
<th>Hanover House, Switz.</th>
<th>Laserna, Italy, Michael Boffo</th>
<th>Lommer, Langefals, Aust.</th>
<th>Peregrine Architecture Workshop</th>
<th>Boqueria, Spain, Daniel Libeskind</th>
<th>Clos Pegass, Calistoga, CA</th>
<th>Azalea Springs, Morpheap</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>NO</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>NO</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>NO</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

Illustration 3.22: Conjecture Matrix: Precedent Analysis
Parametric Winery Studies
Defining Subjective and Objective Goals

Programmatic constraints had to be defined to drive both the functional objectives of each space along with the subjective qualities that would emotionally charge these spaces. For reasons of simplification, three functional objectives were paired with three experiential objectives for each space, with each objective being broken into smaller and smaller sub-conditions. This splintering organization was to establish a perceived hierarchy in design conditions and help clarify precisely what was important for designing each space.

The initial intent was to study all five programmatic stages in this manner, yet only two of them were completed. The difficulty with defining these principles for each space independently was that there were a number of consistent objectives for all spaces such as room temperature, constant slope for gravity flow pumping, and low lighting for wine aging. In a sense, these functional objectives differ very little from space to space, and the experiential conditions thus take the role of delineating the unique characteristics of each program stage.

The charting of objective and subjective conditions was a good introduction into determining which conditions could be measured and which were better described. To help clarify these objectives, additional case study investigations helped visualize certain topics of natural and artificial lighting, materiality, and massing as seen in recently published projects.
PROCESS OF DETERMINING DRIVING CONDITIONS OF PROGRAM SPACES

ESTABLISH 3 EXPERIENCE CONDITIONS OF EACH SPACE (QUALITATIVE CONDITIONS)

ESTABLISH 3 FUNCTIONAL CONDITIONS OF EACH SPACE (QUANTITATIVE CONDITIONS)

WHAT ARE THE SUB-CONDITIONS RELATIVE TO EACH EXPERIENTIAL CONDITION?

WHAT ARE THE SUB-CONDITIONS RELATIVE TO EACH FUNCTIONAL CONDITION?

IDENTIFY HOW THESE CONDITIONS TRANSITION BETWEEN PROGRAM SPACES

CONDITION A

- Sub-condition A1
- Measurable condition

- Measurable condition
- Sub-condition A2

- Measurable condition
- Sub-condition A3

CONDITION B

- Sub-condition B1
- Measurable condition

- Measurable condition
- Sub-condition B2

CONDITION C

- Sub-condition C1
- Measurable condition

- Measurable condition
- Sub-condition C2

- Measurable condition
- Sub-condition C3

- Measurable condition
- Sub-condition C4

EXPERIENTIAL CONDITIONS

FUNCTIONAL CONDITIONS

illustration 3.23: Mapping Subjective and Objective Program Conditions
DRIVING CONDITIONS OF BARREL AGING PROGRAM SPACE:

**EXPERIENTIAL CONDITIONS**

**EXPERIENTIAL SUB-CONDITIONS**

**MEASURABLES**

**Low Lighting & Sound Levels**

- Minimal natural lighting
- Minimal artificial lighting
- Sound attenuation between perimeter and interior spaces
- Sound isolation characteristics (absorption)

- Lighting levels & locations, geographic orientation
- Luminance (direct & indirect)
- Luminance ratio
- Outdoor luminance levels vs artificial luminance levels

**Clear Entry and Exit**

- Limited number of alternative paths
- Pathway barriers prevent barrels from obstructing views
- Proximity of barrel storage to office program

**FUNCTIONAL CONDITIONS**

**FUNCTIONAL SUB-CONDITIONS**

**MEASURABLES**

**Controlled Temperature and Humidity**

- Promote thermal insulation for minimal thermal loss
- Space mechanically controlled for thermal comfort
- Program-based location for thermal needs

**Wine Barrels Stacked to Reduce Footprint**

- Vertical alignment of storage spaces
- Number of barrels proposed for storage
- Program-based location for thermal needs

**Gravity Flow Pumping**

- Virtual alignment of barrel spaces
- Comparison to alternative mechanical pumping processes
- Height of barrels stacked

Illustration 3.24: Mapping Conditions of Barrel Aging Program
DRIVING CONDITIONS OF BOTTLE FILTERING/AGING PROGRAM SPACE:

EXPERIENTIAL CONDITIONS
WHAT ARE THE FUNCTIONAL CONSTRAINTS?

LOW LIGHTING AND SOUND LEVELS

- Ambience of nocturnal lighting
- Minimal artificial lighting
- Sound attenuation between permits and assumed spaces
- Interior material characteristics (reflectance)
- Verbal zoom of natural light
- Transition of container walls transitions to accommodate multiple paths
- Transition of flooring materials for differing paths

VISUAL SEPARATION OF WORK AND VISITOR PATHS

- Note the dimension of path vs. work
- Visual transition to exterior view
- Container wall transitions to suggested changing program
- Vertical passage through space

LONGER PASSAGE OF VISITOR TRAVEL TIME

- Increased width and/or length of pathway
- Variation in window location, size, and number

FUNCTIONAL CONDITIONS
WHAT ARE THE FUNCTIONAL CONSTRAINTS?

CONTROL TEMPERATURE AND HUMIDITY

- Promote thermal isolation for minimal thermal loss
- Space mechanically controlled thermally
- Program-based location for thermal heating
- Minimal cavity space between container walls

VOLUME TO STACK BOTTLES

- Overall space height
- Overall space depth
- Least amount of vertical adjacency to other spaces
- Number of bottle proposed for storage
- Program-based location for thermal heating

GRAVITY FLOW PUMPING

- Least amount of vertical adjacency to other spaces
- Comparison of alternative mechanical pumping processes
- Weight of bottles/stacks

MEASURABLES
HOW CAN THESE CONDITIONS BE ANALYZED?

- Window size and location, orientation, obstructions, luminance zones
- Lighting location, intensity, distances of luminance targets
- Calculate anticipated sound from adjacent spaces and call desired level
- Calculate design luminance levels to determine 540 material options
- Determine location of zones or program element for light to not
- Determine variation of sectional design with wall construction types
- Institute variations in material installation patterns

ILLUSTRATION 3.25: Mapping Conditions of Bottle Filtering and Aging Program
Investigating the Qualitative Characteristics that Define the Design

Office of Valerio Olgiati, Valerio Olgiati

Making shells penetrable for dramatic interplay of light and shadow. Artificial lighting only introduced for evening operation.

Science Center, Jamrud/Nisnas AS

Strong interplay of natural and artificial lighting to create contrast for material cladding.

Ananti Golf & Hot Spring Resort, SkM Architect

Perimeter and clerestory glazing allows for diffused natural light. Artificial lighting held within structural ribs.

Ananti Golf & Hot Spring Resort, SkM Architect

Perimeter and clerestory glazing allows for diffused natural light. Artificial lighting held within structural ribs.
Investigating the Qualitative Characteristics that Define the Design

Materiality

BARO, OFFICE DA
PLYWOOD CEILING CONTAINS INFRASTRUCTURE
MATERIALS SUGGEST DIRECTIONALITY

LA MAISON UNIQUE LONGCHAMP, HEATHERWICK STUDIOS
RAFTS DRAW PEOPLE UP INTO THE STORE
MATERIALS SUGGEST DIRECTIONALITY

PREIKESTOLEN MOUNTAIN LODGE, HELEN & HARD AS
WOODEN WINGS DELINEATE SPACE AND VOLUME AND ACCENTUATE THE PLAY OF LIGHT OVER THE INTERIOR

WIEDEMANN/METTLE RESIDENCE, ARCHITEKTENPAAR
MATERIAL SIMPLICITY PROVIDES RICH CONTRAST AND FLEXIBILITY

Illustration 3.27: Qualitative Investigations: Materiality
The research to this point followed a systems approach to design, with pertinent conditions identified and arranged in a perceived hierarchy. The next move was to look at defining the character of the design with help from hand sketching. From earlier studies it was clear that the linearity of the program presented the most obvious organizing feature of the project, and that multiple iterations of the project could occur by altering this linear spine.

In this manner, the linear spine could either be straight, bent, or folded, simplifying the defining project parti. Beyond this, it also stood out that the walls parallel to the spine held opportunities to drive the design in terms of massing and mechanical housing. These container walls represent a fixed programmatic condition while other project components in between these walls are free to be loose and flexible.

Given the parallel support wall parti, longitudinal section sketches indicate several options for program space volume height and associated program crawl space. These early studies have suggested that the support wall parti could house mechanical and electrical ducts while allowing mechanical space below the plain of normal winery operations. This notion allows for the floor and roof planes to appear floating in between the two container walls.

Beyond the identification of a driving parti, these sketches additionally show the intent to use three different material assemblies as parametric variables. These material assemblies involve different structural capabilities, particularly in their abilities to span in bay width and depth. It is perceived that using these material assemblies will introduce the condition of dynamically changing structure in terms of depth and bay spacing to suggest further programmatic limitations.

Ultimately these sketches will continue to occur over the course
of the project with the intent that they are digitally encoded as dynamic rule sets for the parametric model.
An initial series of investigations into the Solidworks parametric platform studied how information was input and organized. As predominantly an industrial design tool, the software is a simple modeler of physical form. Solidworks relies on rule-sets to allow the user to produce and control component relationships. Qualitative gestures such as building orientation along a path, or linear program sizing can establish parameters for the winery program, as derived earlier in the winery program study. In these initial investigations, each rule set established ten iterations suggesting how the program might react once a primary dimension was altered. Though the study was shallow in design intent, it suggested a clear manner to organize program pieces dynamically with instantly quantifiable data feedback.
BIM Design Methodology: Rule Set 1

Understanding the SolidWorks process involves establishing rules governing how the design is formed. Rules follow is order of hierarchy, so the first rule is obviously the most important.

Rule 1: Program follows linear axis with established parallel boundaries

1. Axis
2. From Stage 5
3. From Stage 4
4. From Stage 3
5. From Stage 2
6. From Stage 1

Rule 2: Barrel aging program defined as a function of parallel boundaries

1. Axis
2. From Stage 5
3. From Stage 4
4. From Stage 3
5. From Stage 2
6. From Stage 1

Rule 3: Bottling and processing program defined as a function of barrel aging program

1. Axis
2. From Stage 5
3. From Stage 4
4. From Stage 3
5. From Stage 2
6. From Stage 1

Rule 4: Filling and filling program defined as a function of barrel aging program

1. Axis
2. From Stage 5
3. From Stage 4
4. From Stage 3
5. From Stage 2
6. From Stage 1

Rule 5: Storage and transport program defined as a function of barrel aging program

1. Axis
2. From Stage 5
3. From Stage 4
4. From Stage 3
5. From Stage 2
6. From Stage 1

Rule 6: Grape collection and crushing program described as a function of barrel aging program.

1. Axis
2. From Stage 5
3. From Stage 4
4. From Stage 3
5. From Stage 2
6. From Stage 1

---

Illustration 3.48: Solidworks Design Methodology: Rule Set 1
BIM Design Methodology: Rule Set 2

As the first set of rules focused first on the lateral boundaries of the form, the second set will focus on the size of the barrel used in the project.

1. Barrel Size
2. Program Stage 1
3. Curved Axis
4. Program Stage 4

Rule #2: The barrel storage room will be sized off of a variable number of barrelstrains along the length of the room.

1. Barrel Size
2. Program Stage 3
3. Curved Axis
4. Program Stage 4

Rule #3: A co-linear path will be set off of the barrel storage program to establish a midpoint.

1. Barrel Size
2. Program Stage 3
3. Curved Axis
4. Program Stage 4

Rule #4: Bottle and processing program defined as a function of barrel aging program coincident to the axis.

1. Barrel Size
2. Program Stage 3
3. Curved Axis
4. Program Stage 4
5. Program Stage 5

Rule #5: Bottle aging and distribution program as a function of barrel aging program coincident to the axis.

1. Barrel Size
2. Program Stage 3
3. Curved Axis
4. Program Stage 4
5. Program Stage 5

Rule #6: Crushing and fermentation programs as functions of barrel aging program coincident to the axis.

Illustration 3.49: Solidworks Design Methodology: Rule Set 2

<table>
<thead>
<tr>
<th>Barrel Length/Width and Height of Barrel Storage Room</th>
<th>Rule-Based Volume in Barrel Storage Program</th>
<th>Building Length and Program Areas and Volumes</th>
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</thead>
<tbody>
<tr>
<td>25 x 4</td>
<td>290</td>
<td>Width Stage 4 Area 40.000</td>
</tr>
<tr>
<td>30 x 4</td>
<td>240</td>
<td>Width Stage 4 Area 33.000</td>
</tr>
<tr>
<td>35 x 4</td>
<td>290</td>
<td>Width Stage 4 Area 39.000</td>
</tr>
<tr>
<td>40 x 4</td>
<td>330</td>
<td>Width Stage 4 Area 45.000</td>
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<tr>
<td>45 x 4</td>
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<tr>
<td>65 x 4</td>
<td>520</td>
<td>Width Stage 4 Area 75.000</td>
</tr>
<tr>
<td>70 x 4</td>
<td>560</td>
<td>Width Stage 4 Area 81.000</td>
</tr>
</tbody>
</table>
**BIM Design Methodology: Rule Set 3**

As the first rule set focused first on the lateral boundaries of the form, the second set will focus on the size of the barrel used in the project.

**Rule 1:** Barrels of the same length will be determined to establish a common measurement for each program.

**Rule 2:** The program will be defined as a function of barrel size, program stage, and an assigned axis.

**Rule 3:** The barrel storage room will be used as a variable number of barrels along the prescribed axis.

**Rule 4:** The fermentation program will be defined as a function of barrel size, program stage, and planned stage.

**Rule 5:** The collection and crushing program will be defined as a function of barrel size, program stage, and planned stage.

**Rule 6:** The bottle aging and distribution program will be defined as a function of barrel size, program stage, and planned stage.

**Rule 7:** The crushing and fermentation programs will be defined as a function of barrel size, program stage, and planned stage.

---

**Illustration 3.50:** Solidworks Design Methodology: Rule Set 3
After learning to encode the Solidworks with dynamic rule sets, the next step was to use the design parti defined earlier with sketches. Early solidworks models combined the idea of the container wall and vertical program space, linking the driving section sketch to the linear spine of the winery. Further modeling introduced the three wall construction assemblies to test against the support wall parti, given loose bay spacing dimensions. At this point, the model was starting to show how structural elements could dynamically derive a building form given manually scripted parameters.

The next step was to return to the winery program study of a 450-barrel winery to derive the parameters to link structure, parti, and program together. As a driver, the barrel-aging portion of the program was chosen to investigate different configurations that could be used to stack and layout barrels, becoming the first sets of variables for the project. Three, five, and seven-barrel configurations were chosen, which subsequently would define the bay spacing for this program element. To simplify the study, the bay spacing for this program space would be used throughout the winery, thus dynamically linking all program elements to the configuration of barrels stacked and laid out. Additionally, this program element would further derive the other program elements by establishing three-barrel capacities for the winery. If barrel storage increased, then it could be assumed that other program machinery and storage would also change dynamically.

The result of the barrel storage study was a series of variables for the five program spaces, those being capacity, bay width, and radius as considered for the bent bar iteration. The 27 resulting variable combinations have been organized for each space individually to study the resulting form. When the five program stages are combined into one
parametric solidworks model, the three initially chosen variables of bay spacing, barrel capacity, and radius of a bent linear spine were seen together. While the study is primarily limited to planar organization in the model, it illustrated that in order to achieve a solvable set of parameters, the radius of the bent form had to increase.

Borrowing from earlier interests on programmatic linearity, it was observed that the linear spine could be either straight, bent, or folded. While the bent spinal iteration had been tested, it was important to transition the previous study variables to show how a folded spinal iteration would work with the winery. In this study, the knuckle component was introduced to allow for a seamless transition between program elements. The variables of bay spacing and barrel capacity were maintained, while radius was altered to represent a variable of knuckle angles. If, for example, the angle were calculated at 180 degrees, the resultant form would be straight, and if the angle decreased to 135, the form would represent a 45-degree fold at each program element. For relatively arbitrary reasons, the angles of 180, 135, and 90

Illustration 3.51: Configuring the Parametric Model: Bent vs Straight Spine
degrees were tested to see the resulting forms.

The information produced in these parametric models can produce more than formal outcomes for the design input; by using imbedded tables, calculations, and linked typological model data, project information can be generated such as assembly heat loss, energy to operate, and material cost for construction. This information represents the information that a building information model would produce, but in solidworks this information must be manually organized, scripted, and linked. Further, while this information is important to identify boundaries of diminishing returns in design, the project has very little allegiance or concinnity to these numbers. This becomes the post-design ethical debate regarding whether the design output was worth the “amount of construction cost input.” While this conversation will become important, it is only worth noting the data modeling opportunity inherent with the parametric model as a means for later investigation.
Formal Plan Studies on Structure-Focused Assemblies

30 ft bay span with resultant form
35 ft bay span with resultant form
40 ft bay span with resultant form
45 ft bay span with resultant form
50 ft bay span with resultant form

30 ft bay steel column structure
35 ft bay steel column structure
40 ft bay steel column structure
45 ft bay steel column structure
50 ft bay steel column structure

30 ft bay steel assembly form
35 ft bay steel assembly form
40 ft bay steel assembly form
45 ft bay steel assembly form
50 ft bay steel assembly form

typical steel assembly detail
typical steel bay plan
typical steel bay plan with columns
typical steel bay plan with resultant form

Illustration 3.54: Formal Plan Studies: Structure-Centered Assemblies
Formal Plan Studies on Crushing Room Given Particular Variables

900 barrel-room capacity

3 bar 900 r1
barrel configuration: 3
total barrels: 900
radius 1: 100ft

5 bar 900 r1
barrel configuration: 5
total barrels: 900
radius 1: 100ft

7 bar 900 r1
barrel configuration: 7
total barrels: 900
radius 1: 100ft

3 bar 900 r2
barrel configuration: 3
total barrels: 900
radius 2: 200ft

5 bar 900 r2
barrel configuration: 5
total barrels: 900
radius 2: 200ft

7 bar 900 r2
barrel configuration: 7
total barrels: 900
radius 2: 200ft

3 bar 900 r3
barrel configuration: 3
total barrels: 900
radius 3: 300ft

5 bar 900 r3
barrel configuration: 5
total barrels: 900
radius 3: 300ft

7 bar 900 r3
barrel configuration: 7
total barrels: 900
radius 3: 300ft

1800 barrel-room capacity

3 bar 1800 r1
barrel configuration: 3
total barrels: 1800
radius 1: 100ft

5 bar 1800 r1
barrel configuration: 5
total barrels: 1800
radius 1: 100ft

7 bar 1800 r1
barrel configuration: 7
total barrels: 1800
radius 1: 100ft

3 bar 1800 r2
barrel configuration: 3
total barrels: 1800
radius 2: 200ft

5 bar 1800 r2
barrel configuration: 5
total barrels: 1800
radius 2: 200ft

7 bar 1800 r2
barrel configuration: 7
total barrels: 1800
radius 2: 200ft

3 bar 1800 r3
barrel configuration: 3
total barrels: 1800
radius 3: 300ft

5 bar 1800 r3
barrel configuration: 5
total barrels: 1800
radius 3: 300ft

7 bar 1800 r3
barrel configuration: 7
total barrels: 1800
radius 3: 300ft

2700 barrel-room capacity

3 bar 2700 r1
barrel configuration: 3
total barrels: 2700
radius 1: 100ft

5 bar 2700 r1
barrel configuration: 5
total barrels: 2700
radius 1: 100ft

7 bar 2700 r1
barrel configuration: 7
total barrels: 2700
radius 1: 100ft

3 bar 2700 r2
barrel configuration: 3
total barrels: 2700
radius 2: 200ft

5 bar 2700 r2
barrel configuration: 5
total barrels: 2700
radius 2: 200ft

7 bar 2700 r2
barrel configuration: 7
total barrels: 2700
radius 2: 200ft

3 bar 2700 r3
barrel configuration: 3
total barrels: 2700
radius 3: 300ft

5 bar 2700 r3
barrel configuration: 5
total barrels: 2700
radius 3: 300ft

7 bar 2700 r3
barrel configuration: 7
total barrels: 2700
radius 3: 300ft

Illustration 3.55: Formal Plan Studies: Crushing and Stemming Room Variables
Formal Plan Studies on Barrel Aging Room Given Particular Variables

900 barrel-room capacity

1800 barrel-room capacity

2700 barrel-room capacity

6 bays

84
Illustration 3.58: Formal Plan Studies: Bottle Aging Room Variables
Formal Plan Studies on Bottle Aging Room Given Particular Variables

900 barrel-room capacity

<table>
<thead>
<tr>
<th>Bar</th>
<th>Storage/Prep</th>
<th>Emp Break</th>
<th>Wine Bar</th>
<th>Sales</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>500 r1</td>
<td>250</td>
<td>250</td>
<td>75 ft</td>
<td>45 ft</td>
</tr>
<tr>
<td>5</td>
<td>900 r1</td>
<td>400</td>
<td>400</td>
<td>75 ft</td>
<td>30 ft</td>
</tr>
</tbody>
</table>

1800 barrel-room capacity

<table>
<thead>
<tr>
<th>Bar</th>
<th>Storage/Prep</th>
<th>Emp Break</th>
<th>Wine Bar</th>
<th>Sales</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1800 r1</td>
<td>250</td>
<td>300</td>
<td>95 ft</td>
<td>50 ft</td>
</tr>
<tr>
<td>5</td>
<td>1800 r1</td>
<td>300</td>
<td>300</td>
<td>95 ft</td>
<td>40 ft</td>
</tr>
</tbody>
</table>

2700 barrel-room capacity

<table>
<thead>
<tr>
<th>Bar</th>
<th>Storage/Prep</th>
<th>Emp Break</th>
<th>Wine Bar</th>
<th>Sales</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2700 r1</td>
<td>300</td>
<td>300</td>
<td>115 ft</td>
<td>50 ft</td>
</tr>
<tr>
<td>5</td>
<td>2700 r1</td>
<td>350</td>
<td>350</td>
<td>115 ft</td>
<td>70 ft</td>
</tr>
</tbody>
</table>

4 bays

radius 1: 100 ft
radius 2: 200 ft
radius 3: 300 ft

illustration 3.59: Formal Plan Studies: Packaging and Distribution Room Variables
Formal Plan Studies on All Program Areas Room Given Particular Variables - Bent Iteration

3 bar 900 r1  |  5 bar 900 r1  |  7 bar 900 r1  |  3 bar 900 r2  |  5 bar 900 r2  |  7 bar 900 r2  |  3 bar 900 r3  |  5 bar 900 r3  |  7 bar 900 r3

900 barrel-room capacity

3 bar 1800 r1  |  5 bar 1800 r1  |  7 bar 1800 r1  |  3 bar 1800 r2  |  5 bar 1800 r2  |  7 bar 1800 r2  |  3 bar 1800 r3  |  5 bar 1800 r3  |  7 bar 1800 r3

1800 barrel-room capacity

3 bar 2700 r1  |  5 bar 2700 r1  |  7 bar 2700 r1  |  3 bar 2700 r2  |  5 bar 2700 r2  |  7 bar 2700 r2  |  3 bar 2700 r3  |  5 bar 2700 r3  |  7 bar 2700 r3

2700 barrel-room capacity

46 bays

Illustration 3.60: Formal Plan Studies: All Program Space Variables Bent Configurations
Formal Plan Studies on All Program Areas Room Given Particular Variables - Folded Iteration

900 barrel-room capacity

1800 barrel-room capacity

2700 barrel-room capacity

illustration 3.61: Formal Plan Studies: All Program Space Variables Folded Configurations
Evaluating the Parametric Model

After considering program and site constraints, the next and most recent study has been to choose two of the possible winery variable configurations and to measure them on the two different site options. The primary reason for this study is to get an understanding of how all program elements, structural limitations, and site responses inform the architectural response to a winery design.

The first iteration tested was the bent winery that used the variables of 900-barrel capacity, 3 barrel bay spacing, and an 822 foot radius. Translated to plan, the program’s skeletal structure was defined with program spaces appropriately spaced to house the necessary winemaking components. Situated in site 2, the winery would only use less than a third of the site for grape growth. This configuration suggests a strong north-south axis, very similar to the desired vine planting in a winery. Approach to the site is directly north of the town of Neville, and directly from the southeast at the perimeter of the vineyard site. Skylights directly above delineate the visitor corridor and the building’s formation suggests a subtle exterior courtyard to the west.

The second iteration tested was the folded winery that used the variables of 2700-barrel capacity, 7 barrel bay spacing, and 90 degree angled fold. Situated in site 1.3, this configuration suggests that all land areas would be used for grape growth and would allow for direct visual proximity to the river. Approach to the site from the northwest suggests physical separation from the Ohio River to the south. Also apparent in this configuration study is the intent to distribute daylight through skylight apertures along the visitor corridor. Building sections additionally add information regarding how the winery will sit in the land for three of the program spaces as defined by their parametric constraints. It is interesting to note how the bay spacing, as defined by the barrel stacking
variable impacts the bottle-aging storage. At this point, issues such as day lighting strategies have not been formally evaluated. This study will turn the focus back to the hand-sketch mode of defining and organizing design objectives.
Illustration 3.64: Parametric Development 1: Bent Plane Skeletal and Floor Plans

Iteration Name: 3 bar 900 r2

Program Variables:
- Site 2.1: Northern Neville
- 900 barrel capacity
- 3 barrel bay width
- 822 ft radius to western wall
- Laminated Wood Construction

Scale: 1/32” = 1’-0”
Illustration 3.65: Parametric Development 1: Bent Plane Site and Roof Plan

Iteration Name: 3 bar 900 r2

Program Variables:
- Site 2.1: Northern Neville
- 900 barrel capacity
- 3 barrel bay width
- 822 ft radius to western wall
- Laminated Wood Construction

Scale: 1/64" = 1'-0"
Iteration Name: 7 bar 2700 f3

Program Variables:
- Site 1.3: Western Woodland Mounds
- 2700 barrel capacity
- 7 barrel bay width
- 90 degree knuckle fold
- Steel Construction

Folded Plane Design Iteration Investigation: Original Solidworks Sketches

Scale: 1/32" = 1'-0"
Program Variables:

Site 1.3: Western Woodland Mounds
2700 barrel capacity
7 barrel bay width
90 degree knuckle fold
Steel Construction

Iteration Name: 7 bar 2700 f3

Scale: 1/32" = 1'-0"
Iteration Name: 7 bar 2700 f³

Program Variables:
- Site 1.3: Western Woodland Mounds
- 2700 barrel capacity
- 7 barrel bay width
- 90 degree kruckle fold
- Steel Construction

Scale: 1/64" = 1'-0"
Folded Plane Design Iteration Investigation:  

**Iteration Name:** 7 bar 2700 f3

**Program Variables:**
- Site 1.3: Western Woodland Mounds
- 2700 barrel capacity
- 7 barrel bay width
- 90 degree knuckle fold
- Steel Construction

---

Cross Section through Fermentation Room  
Cross Section through Barrel Aging Room  
Cross Section through Bottle Aging Room
Site Driven Responses 1

The design transitioned from the parametric model to the site study to derive the next level of parametric rules through site constraints. Five sites were initially chosen as opportunities for the winery design, occurring east of the Greater Cincinnati Metropolitan area. Chosen for their topographic change, these sites would allow the winery project to use gravity flow winemaking by stepping the program stages into the sloped terrain. Upon further review, and in response to limiting the number of possible parametric variables, three of the five sites were eliminated from consideration.

One of the remaining site options is west of Woodland Mounds in a currently forested site while the other site is north of Neville, Ohio. Both of these sites allow for the three-barrel capacities used in the earlier parametric studies. Each of the sites were evaluated for topographic change, noting minimum and maximum slope opportunities and each site was laid out to accommodate the three different growth regions necessary to achieve a 900, 1800, and 2700 barrel wine capacity. The study further looked at which linear program iterations would be more conducive to the site. For the Woodland Mounds site, a smaller, more compact building iteration would sit better on the site while the Northern Neville site is more conducive to a less-dense, folded or bent configuration for the winery.
POSSIBLE SITE LOCATIONS FOR A WINERY AND VINEYARD IN THE OHIO RIVER VALLEY APPELLATION

IMPACTING FACTORS FOR SITE PLACEMENT: SIGNIFICANT GRADE CHANGE (100-200ft), FORESTED VS CLEAR EXISTING SITE FOR PLANTING, DISTANCE FROM MAJOR TRAFFIC, VISUAL CONNECTION TO RIVER

OHIO RIVER VALLEY APPELLATION

BORDERS THE OHIO RIVER FROM WHEELING, WEST VIRGINIA TO CINCINNATI AND CONTINUES ON TO EVANSVILLE, INDIANA.

illustration 3.70: Possible Winery Sites: Ohio River Valley
Possible Site Locations For a Winery and Vineyard In the Ohio Valley Appellation:

Site 1: Western Woodland Mounds

**DESCRIPTION:** Site is located between Coldstream Country Club and Woodland Mounds. Direct adjacency to the Ohio River and proximity away from dense urban development is fundamental for easy access and removed for privacy.

**Site 1.1:** Situated on the northern-most parcel of the Country Club, this site boasts vehicular access and an abundant plateau with land dropping off on all sides. Site is currently heavily forested.

- Acreage: 138.2 acres
- High Elevation: 815 ft
- Low Elevation: 565 ft
- Least Slope (from high pt): 2.8% Slope
- Greatest Slope (from high pt): 20.3% Slope

**Site 1.2:** Situated away from the main 8 Mile Rd access, this site boasts increased privacy from the east. Site tends to drop off steepest from plateau to the east, with the most generous slope from south to north. Least forested site.

- Acreage: 108.6 acres
- High Elevation: 845 ft
- Low Elevation: 605 ft
- Least Slope (from high pt): 3.3% Slope
- Greatest Slope (from high pt): 19.8% Slope

**Site 1.3:** Situated directly adjacent to the Ohio River, the site takes advantage of southern and eastern facing hillsides for dense growth with a small plateau at the northern central entry. This site appears to be the best of the 3 sub site options.

- Acreage: 162.7 acres
- High Elevation: 845 ft
- Low Elevation: 505 ft
- Least Slope (from high pt): 4.9% Slope
- Greatest Slope (from high pt): 26.8% Slope

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Illustration 3.71: Site Option 1: Western Woodland Mounds
Site 2: Northern Neville

**DESCRIPTION:** Site is located in the elevated hills of northern Neville, OH with direct visual connection to the Ohio River. The site boasts an abundance of unused land with decent slope for site drainage.

**Site 2.1:** Situated to the north of the main town of Neville, the site is sloped on all sides with a central plateau with a heightened sense of privacy as entrance to the site is off a secondary southern boundary road. This site is the largest and most suitable for future expansion.
- Acreage: 538.4 acres
- High Elevation: 888 ft
- Low Elevation: 495 ft
- Least Slope (from high pt): 2% slope
- Greatest Slope (over 100 feet): 17% slope

**Site 2.2:** Situated to the east of Neville with a southern face to parallel to the Ohio River, this site boasts of lower tree-coverage per acre than any other site. Entrance to the site is from the north or possibly from the southeast.
- Acreage: 306.3 acres
- High Elevation: 845 ft
- Low Elevation: 510 ft
- Least Slope (from high pt): 1.5% slope
- Greatest Slope (over 100 feet): 18%
Site 1: Western Woodlnad Mounds

Site Considerations:

Given the individual site constraints, the only appropriate winery is a 900 barrel capacity. If all 3 sites are combined for total grape harvesting capacity, the 1800 barrel and 2700 barrel capacity winery is an option. Additionally, in this consolidated 3 site configuration, the ideal location for the winery is Site 1.3.
Topographic Site Features For Winery and Vineyard:

Site 2: Northern Neville

Site Considerations:
Given the individual site constraints, both allow for the barrel capacities of 900, 1800, and 2700.

Site 2.1
- Acreage: 538.4 acres
- High Elevation: 888 ft
- Low Elevation: 495 ft
- Least Slope (from high pt): 2% slope
- Greatest Slope (over 100 feet): 17% slope

Site 2.2
- Acreage: 306.3 acres
- High Elevation: 845 ft
- Low Elevation: 510 ft
- Least Slope (from high pt): 1.5% slope
- Steepest Slope (over 100 feet): 18% slope
Probable Site Feature Layout For Winery and Vineyard:

Site 1: Western Woodland Mounds

Ideal Winery Iteration Configurations:

With the relatively constant slope of the site and the very small plateau, a smaller, more compact configuration would be more conducive for the site.

illustration 3.75: Site Option 1: Western Woodland Mounds
Winery Configurations
**Site 2: Northern Neville**

**Ideal Winery Iteration Configurations:**

With the relatively constant slope of the site and the very small plateau, a smaller, more compact configuration would be more conducive for the site.

**Ideal Winery Iteration Configurations:**

Given the site's generous plateau, nearly all configurations of bent and folded building iterations would work for this site. Generally, a longer building configuration would work well with this site.
Defining the Winery Experience

The design process transitioned towards singling out a site for the project, and the site west of Woodland Mounds was chosen for its views, proximity from urban densities, and broad southern and eastern-sloped hillsides. Once determined, the site was studied in terms of building and growth proximities along with investigating a number of different winery building forms. These forms were based off the linear schemes established earlier, and the studies attempted to flush out a number of additional site-response strategies such as defining entry and exit to site and defining the driving site topography.

As the site currently exists, there is an opportunity to enter the site from the northwest through a housing development, though this approach is limited because of its difficulty to navigate. Instead, the desired entry is a private path along the northeast originating from 8 Mile Road and passing through an existing valley. It appears this is the optimum location for both entry and exit, along with connecting the eastern and southern vineyard fields to the upper elevation of the site. These elevation considerations were broken into three primary territories, or plateaus, all based on topography and desired program proximities: upper, middle, and lower-plateaus.

The upper-plateau served as the primary entry to site and the beginning of the winery experience for visitors. Its advantage was to provide controlled views to the vineyard while additionally connecting the visitor visually with the river and Woodland Mounds. The lower-plateau served as the vineyard and was intentionally separated from visitor access to suggest security and seclusion of the vines. The middle-plateau served as the vertical edge condition between upper and lower plateaus, allowing for the elevated views of visitors and reducing from view the process of manicuring the vineyard. A sectional study looked at how a
illustration 3.77: Western Woodland Mounds
Site Context
The winery might be placed in each of the three plateau scenarios, though an instinctive reaction against placing it in the upper plateau established two possible linear building schemes.

These building schemes and site middle ground variables were next investigated through perspective sketches. To aid these perspective sketches, a Rhinoceros three-dimensional model was constructed and drawn over with additional design information layered on top. The perspective investigation placed parking to the northwest of the site and provided multiple pathways to the winery building that was located in both schemes at the southeast corner of the upper plateau. One of the linear schemes investigated placing the winery directly in the middle-plateau, to be access from above, with half of the facility production to occur parallel to the eastern vineyard field and the other half to the southern vineyard field. A wine tasting room would occur directly at the knuckle of these two production halves where entry from the upper plateau would occur. The second linear winery scheme investigated projecting the winery straight above the lower-plateau with entry and passage from the upper plateau. Unique to this orientation was an axis to the Ohio River along with strong visual connections to both vineyard fields. Visitors would walk on top of the winery building with the goal of reaching the end of the deck where a wine tasting room would serve as entry to the building and the best views to the site.
illustration 3.84: Hand Sketch: Site Entry Plan and Sections
illustration 3.85: Hand Sketch: Site Configuration 1

illustration 3.86: Hand Sketch: Site Configuration 2

illustration 3.87: Hand Sketch: Site Configuration 3

illustration 3.88: Hand Sketch: Site Configuration 4
illustration 3.89: Hand Sketch: Site Section
Describing the Upper Plateau

illustration 3.90: Hand Sketch: Site Section
Describing the Middle Plateau
Designing the Lower Plateau
illustration 3.92: Perspective Sketch: Site Entry
illustration 3.93: Perspective Sketch: Upper Plateau View
illustration 3.94: Perspective Sketch: Skyline Pathway
illustration 3.95: Perspective Sketch: Subterranean Pathway
illustration 3.96: Perspective Sketch: 
Lower Plateau Winery
Illustration 3.97: Perspective Sketch: Middle Plateau Winery
Illustration 3.98: Perspective Sketch: Upper and Lower Plateaus
The final winery project uses the design of an elevated bar nestled into the site’s upper plateau. With entry to the site from the north, the winery cantilevers over the vineyard below and extends out for extensive site and river views. The landscaping plan separates visitor and worker entries by establishing water retention reservoir which doubles as a means for vineyard drip irrigation. The winery sells itself by establishing a clear series of pathways, one of which occurs on the upper roof terrace where a journey takes visitors directly above the wine-making process. As visitors work their way from the crushing process to the grand finale of the wine-tasting experience, views into the program below are opened up at pavilion towers. These towers function structurally to support the cantilevered project while additionally allowing for vertical transit of winery materials. For visitors not interested in progressing along the entire length of the roof terrace, a light-weight metal catwalk allows for quick and easy access of the wine-tasting room at the winery’s cantilevered end.

In the end, the winery design functions well for this particular site, but could be modified for different sites by repositioning the pavilion towers to achieve visual connection throughout the site. If topography were less extreme, site entry might be reconsidered and the bar repositioned to eliminate unnecessary cantilevering. The final design ultimately makes use of many of the parametric rules established earlier in the research, and is represented using traditional design imagery.
Chapter 4: Concluding Statements

Hand-sketched and digitally created process drawing showing parametric academic design methodology for a winery in southwestern Ohio

Illustration 3.1: Parametric Methodology Palimpsest
Concluding Statements

This thesis research and design project is an investigation and evaluation of contemporary representation tools in architecture, particularly parametric modeling and building information modeling. The research included a component of historical background into how representation has changed politically, economically, and methodologically from the time of the Renaissance through the beginning of the 21st Century. Progression from a mythic understanding of design order to mathematical and scientific-centered organization explains how traditional ‘analog’ design tools have progressed to digital forms. Incorporation of digital tools signals a transition away from the hand-drawn architectural representations of the past. The tools further introduce new methods of architectural problem solving, relying on higher quantitative data input to develop higher levels of accuracy and opportunity in design.

To supplement the research, the design of a winery in Ohio sought to evaluate the practical use of the parametric tool for the design process. One of the fundamental questions coming out of the research was: through parametric design, how can the studies of topological relationships influence design outcomes, and could it replace the importance of predetermined form in design? With a similarity between the two contemporary architectural tools in their hierarchical organization, a question developed regarding the primary differences and benefits between them. Perhaps the most important question from the research questioned the appropriate balance between quantitative and qualitative design input.

Upon working with a parametric model to develop the winery design, the process study provided some insight into these questions, though reluctantly the parametric design process took a considerable amount of time to learn and understand rendering mixed results. The
resultant study proved that winery design decisions could be organized hierarchically to determine which conditions were more influential than others. For the winery, the organization of the program in a linear progression was the primary ordering principle, with a secondary condition of gravity flow wine-making that organized vertical adjacencies. As the other organizing principles were introduced, the program became structured around an efficiency to production. If conditions changed in the design hierarchy, program elements changed accordingly. These conditions, however, were resolved at a very low resolution due to the learning curve of the Solidworks platform, and the ideas researched about complete parametric control were never fully achieved.

In response to whether the tool benefited the winery design beyond traditional design tools, it should be explained that the design was comprised of both parametric and traditional tools to achieve an outcome. This was in part a result of the learning curve to the parametric tool, while additionally work that could be considered part of the “napkin sketch” parametric process. However, the idea of identifying the ordering principles of the winery for parametric constraints focused the design beyond traditional considerations and quickly identified areas to drive the design. Had the parametric model developed to a much higher resolution, it is assumed that a truly flexible design outcome could have been achieved, as is the suggested outcome of parametric modeling.

The debate regarding an appropriate balance between quantitative and qualitative design input proved to be an incredibly difficult issue to resolve. The early conjecture that all design could be quantified was dismissed early during the design process, as studies illuminated the defining program character with calculations alone. The conditions that were organized for the winery program focused on efficiency in wine-production, with limited insight into the experience desired for winery visitors. As the study continued, defining this experience became the biggest pursuit, and it was clear that this experience was based on qualitative input. While this qualitative input was never fully defined parametrically, it is assumed that this is capable.

In the end, the study of contemporary tools in architectural design raised more questions than were answered, though the tool’s relevancy was not discredited. It is still believed that the benefit of topological organization design hierarchies will make parametric modeling imperative to the future of the architectural profession. The study ultimately lends to ongoing investigation beyond this thesis research.
Appendix A: Works Cited
In the order as appearing in the body


Appendix B: Works Consulted

A. Books and Articles on Building Information Modeling:


Appendix B: Works Consulted Continued

B. Books and Articles on Integrated Practice:


C. Books and Articles on Future Construction Practices


D. Books and Articles on Parametric Modeling:


**E. Books and Articles on Design in the Academic Realm:**


**F. Books and Articles on Winery/Vineyard Program:**


Appendix B: Works Consulted Continued


Appendix C: Parametric Process Journal

Parametric Process Log:

In assessing the progress to date with the parametric studies, it will be important to discuss what has been done and learned through the process. It should not be surprising to find this account of the process might come across as clouded with issues in the technology, but it will be important to explain how all of the work applies to a bigger agenda supporting or not supporting the use of a parametric design pedagogy. It should also indicate areas where hand-iterative pedagogy would be much more beneficial, and countering this, where the parametric tool benefits the design process. As suggested in the title of the thesis, building information modeling is still of strong interest, but with the method chosen to design and particularly with the software used, a true building information model may only be alluded to at times. Because it is in the realm of data characterization, both building information modeling and parametric modeling share a similar ability to forecast different areas of information within specific scenarios. It might be beneficial to periodically discuss primary differences of data measured during this forecasting between the two modeling processes, given the feedback from the parametric model.

Winter Quarter, Week 8: March 1 – 7

After meeting with Anton today, the work on the bent-building iteration was reviewed and it was concluded that the information is at a point that the study can shift a little. I mentioned to him that I was looking at 2 new problems, one being the folded-building iteration, and the second being the issue of vertical program adjacency with respect to the desired gravitational flow process of wine-making. Anton and I briefly discussed how the folded-building iteration would require a new feature to the building: the knuckle. In order to make the sectional progression through the space without interrupting the structure, the folds would need to be transitioned with use of knuckles that essentially divided the angle between the two adjacent program elements.

This knuckle was modeled in Solidworks and quickly the program elements were filled in to model how the building might fold given use of these knuckles. Interestingly, this study varies from the bent-building iteration in that the variable of radius goes away, and instead the angle of the fold between program elements becomes the new variable. If this angle is 90 degrees, the building folds into itself, at 45 degrees it resembles an arc, and at 0 degrees the building is straight. The program is giving me issues at this point in trying to populate all of the different building configurations. I need to create a diagram showing these configurations, but haven’t done so yet.

Winter Quarter, Week 7: February 21 – 28

This week was spent investigating the program space requirements given the driving condition of barrel configuration in the barrel storage room, along with barrel capacity chosen for the winery. These two figures have a direct impact on the overall depth of the program spaces, which in the interest of this study was suggested to be uniform throughout the winery (barrel room, fermentation room, crushing room, etc all would have the same bay depth). The programming assignment from the fall quarter programming course was highly useful from the standpoint that it was proportionally laid out in a 450-barrel capacity winery. All of the machine components could easily be determined for an increase in barrel capacity; for example, with a 450-barrel winery, the fermentation room contains ‘x’ amount of fermentation tanks, but if the capacity doubles to 900, the amount of fermentation tanks double also. The bay depth configuration was necessary for calculating how many barrels/tanks/machines/etc could fit in the building profile at each program stage.

Before the work could be modeled, a hand sketch had to be rendered showing size approximations for each program space, and consequently for each bay-depth and barrel-capacity. Once this information was determined, each space was independently modeled in the Solidworks platform showing the two aforementioned variables, along with a third dimension of radial length of inside wall. In total, this allowed for 27 different combinations for each program space, and an illustrator file was composed to visualize how the space would change under each combination of variables. It is my hope that this work will become presentation quality, but at this time, the data heavy document has yet to be completely distilled into major lessons.

Upon finishing the individual program space files, one master file was composed showing all the different spaces together under the bent-building iteration. Here, the radius had to increase to prevent the spaces from
overlapping. Interestingly, it turns out that the minimum radius to prevent overlapping occurs at 411ft. This information is somewhat at a stopping point now and I plan on meeting with Anton on Monday to discuss this week’s latest progress. I hope to show that my process of working from hand-sketch to Solidworks modeling is paying off.

Additionally, I met with several of my studio peers to discuss my studies to date in an informal colloquium. My peers did not have a whole lot of input, but did ask how I thought the study would result. The notion that the parametric modeling can continue to refine and refine itself is fascinating, but at what point will there be a moment for design evaluation and conclusion? My answer to this question at this point is that I am assuming I will just drop pencils at a certain point with a model that is layered with earlier studies. Will this include physical models? How much of my work will be entirely Solidworks and hand-sketching? All of these are very good questions that I am still working towards the answer for.

Winter Quarter, Week 6: February 14 – 20

The week was spent working on a Solidworks file that investigated the bent winery iteration, looking at isolating bay spacing forms for the 3 different construction assembly types. The bay spacing’s were derived from loose structural calculations; a quick review of Tom’s Structures 4 coursework provided approximate spanning dimensions for certain materials. In the guide, figures were rough approximations, but held that steel construction could span up to 1500 square feet, laminated wood up to 1200 square feet, and concrete up to 1000 square feet. The design arbitrarily established 8 bays for a segment of the program and the file was successful in dynamically linking bay depth to bay width. By changing bay depth, the arc of the bent form changed correspondingly to suggest variations in the form. The file additionally applied a sectional profile that swept along the planar layout to show how the form massing would result.

On Thursday the file was discussed with Anton, and the biggest development was that the file was an attempt to define form, but did not tie it back to program space requirements. Structural values alone disconnect the study from the programming information already derived. Anton suggested that instead of divorcing structural requirements from program requirements, perhaps the opposite could derive the form, so that the space necessary for the barrel storage program could drive the resultant form. Here, the main variables would maintain an arbitrary number of structural bays (6 instead of 8) while the primary variables would be barrel spacing configurations. If, for example, the barrels were set up to accommodate 5 barrels per sectional row, then the length of the overall space would change accordingly.

On Friday a new file was started, as suggested above, based on 3 primary variables. The concept remains that by deriving an appropriate order to linking the information, the resultant form can still show both programmatic constraints while satisfying a dynamic structural agenda. Attached below is documentation resulting from the file.

What is interesting in the development is an understanding of certain limitations that result from the variables affecting the configurations. As noticed in the lower hand corner of the diagram, it is clear that variables such as capacity, radius, and barrel configuration restrict the program from finding certain solutions. These represent a boundary of diminishing return. It should be mentioned that this study is only of the barrel room, but the resultant rules from the file will be expected to drive the other 4 program elements. Primarily, the building sectional profile will derive the same bay depth in other program segments, with the hope that structure may be rendered differently for width spanning elements. It remains expected that the general sectional profile will remain intact, satisfying a driving element to the process.

Perhaps most interesting about this week’s progress is that it showed a complete flow through the process of project sketching (of the material bay spacing exercise) along with a resultant Solidworks file. Upon review, observations were made about the disconnect in the program and structural drivers, and a brief formal study showed how to link the two and maintain a driving language for the rest of the project.

Work this week will be to continue reviewing the most recent formal study. The idea is that if the rules for this program element for this building iteration (bent form) are derived, the remaining program elements can be derived uniform for the 3 different building iterations (bent, fold-
ed, or straight). At this point, it is all about nailing down the dynamic rule set, in the appropriate order, and to continue deriving the concurrent program elements. The obvious program element to tackle next is the wine fermentation stage, where barrel capacity will derive appropriate size and number of fermentation tanks and filter-processing machines.

Perhaps next week program adjacency issues may be addressed. This will take slope of site into consideration, as the program will ultimately step down from process to process according to the necessary drop for gravitation flow wine-production. Site will have to be readdressed as for a location, but this element continues to be less important in the design process in comparison to determining parametric constraints.

Additionally, a paper was written to investigate the difference between Peter McCleary’s understanding of transparency and opacity in relation to the technique of parametric modeling. After reviewing his dialogue, it appears clear that technology is preventing a transparency in design, especially with the notion of prevision-valued design. Removal of the human from the built environment is the clear implication unless one dissect McCleary to differentiate between the designer, contractor (builder), and the client (user). Variation in the understanding of illuminati and layman might differentiate these users, but the author’s 3 part dialogue between technic, technique, and technology force a varied perspective of parametric modeling’s impact. A mutual value is inherent in the modeling technique for the designer and builder, yet a disconnect remains between this group and the corresponding building users. One take is due to form-centered designs where the architect must understand the implications for his/her form, resolve the possibilities for structure, and provide directions for fabrication down to the contractor. This represents a science-applied approach to design, and further separates the concern of the user understanding the space from the designer organizing the space. For true and total transparency, both user and designer/contractor must be able to maintain equal understanding of the design. In most design, there is not sufficient need for this result, but it does not make the result impossible to attain. This might answer McCleary’s question of whether we can return to transparency as architects (designers), but moreover it considers us to think differently about how we produce and provide design. Perhaps this is better understood as a new categorization of transparency and opacity.

Winter Quarter, Week 5: February 7 – 13

Nearly two weeks have passed since the mid-term thesis project review, and during this time several Solidworks models have been made to investigate the methods of codifying the hand sketches preceding the review. One model focused on linking 3 dimensions with a ramp interface in the solid-bar iteration of the project. The second model investigated a sweeping section profile to suggest how a bent-bar iteration of the project might be manifested. The third model was the most important because it focused on the three construction assembly types and linked them in plan by bay spacing. The key idea with this model was the ability to alter the dimensions of one node of the plan as defined by the wall construction assembly types and the entire plan would re-organize around this information.

After talking to Anton on Friday, it was clear that additional sketches need to be introduced, along with several files being created. The bay spacing can be thought of in terms of material limitations, so 3 different sketches for different bay spacing’s could be introduced in one file. Likewise, construction assembly types need to be isolated in individual sketches rather than in their current overall sketch. This allows them to perform independently of each other. Beyond this, information needs to be added into the models linking the section profile, construction type, and path along the program. The general idea is that additional information needs to be codified and linked dynamically to see limitations of the design.

The notion that qualitative information needs to be defined has been taken care of by the hand-sketches that suggest a cavity wall construction, with main production bay spaces, buried mechanical space, and lateral cross-program passage space for visitors. The site will add a level of characterization/qualitative data, but this will occur primarily in the calculation of the site slope.

To a large extent, the project has been, and will continue to be clouded by understanding the Solidworks platform, along with understanding how parametric modeling functions. The idea of dynamically linking a broad idea with moderate flexibility and a definitive vision is being flushed out.
Appendix C: Parametric Process Journal Continued

The next 2 weeks include further work through the technology, and includes setting up models for all of the different winery forms (solid, bent, bar) as explored in the bent bar dynamic.

Winter Quarter, Week 4: Jan 31 – Feb 6

This week was mid-term review, and the parametric information displayed consisted of work done at the end of the fall quarter, and project setup done over the first 4 weeks of this quarter. Work in the parametric Solidworks platform is very little, as the past 2 weeks have been devoted to working through hand-sketches to derive the character of the winery project. Sketches of 3 construction assemblies, sectional proximity studies, and an overall cavity wall section sketch were drawn to suggest a definite vision for the winery. During the review, it was stated that this information needs to be codified in the Solidworks platform, so this was the launching off point for the following 2 weeks.